



SPACEWATCH

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SPECIAL REPORT

“NewSpace”
phenomenon
and the emerging
cyber threat in space
systems



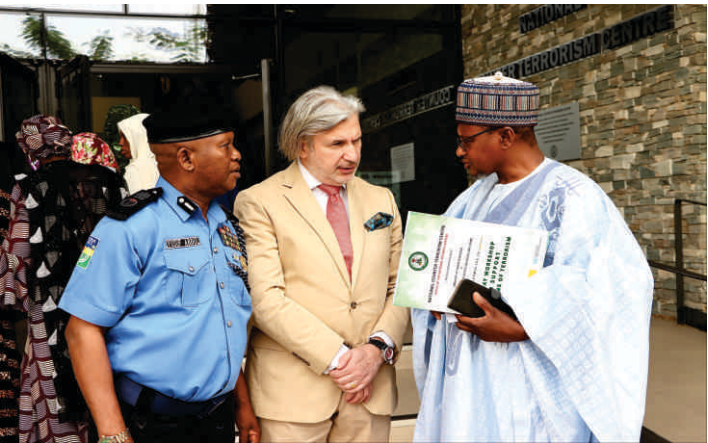
Spacewalk!



WHAT ON EARTH
IS THE VALUE OF SPACE?



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Etlaq Spaceport, the region's first commercial spaceflight hub



As a space journalist, Sarwat Nasir had covered numerous launches from Baikonur and Florida, including milestone missions such as the UAE's two astronauts blasting off. But standing in Duqm, she felt something different, the beginning of a new chapter, where the region is not only participating in space flight but building the infrastructure to lead it.

Getting here is not your typical work trip. she chose to drive, following a narrow road flanked by desert and mountains, with camels lazily crossing the path and the Arabian Sea hidden just beyond the ridges. But

there are other ways to reach the spaceport - visitors can fly into Muscat, then take a short connecting flight to Duqm. From there, it's about a 90-minute drive.

While Etlaq lies in a remote stretch of coastline, there are good accommodation options not too far away. About two hours from the spaceport, visitors will find resorts such as the Crowne Plaza and Park Inn by Radisson, along with several locally branded hotels. In December, Etlaq hosted its first test flight - a

6.5-metre rocket that launched successfully from its pad in Duqm. That moment set the stage for five more launches planned this year, giving start-ups a chance to test their rockets, while Omani engineers sharpen their skills before the spaceport begins full commercial services, scheduled for the end of 2027. A second launch, a small one-metre rocket hop test, was scheduled to take place during my visit as part of a three-day public event. But strong winds meant it had to be postponed, a reminder that space launches are never guaranteed. Weather or last-minute technical issues can easily cause delays, a reality she

has witnessed first-hand. The launch of Emirati astronaut Sultan Al Neyadi, for example, was once called off minutes before lift-off at Florida's Kennedy Space Centre, only for the next attempt to be successful.

In countries like the US, the Federal Aviation Administration has strict licensing rules and long approval processes that can delay take off for months. But here in Oman, with fewer regulatory bottlenecks, regional and international start-ups now have a rare chance

to test their systems faster, giving them a head start in the global market.

But what brought her here wasn't just the prospect of a rocket launch - it was also the people. Specifically, the schoolchildren and families who took part in Oman's first spaceport fanzone, called Etlaq FX. Spread across four large tents only 3km from the launch pad, the event was designed to bring the public closer to space - something the US and Russia have long embraced but which has never really happened in the Arab world.

Pupils from across Duqm participated in activities such as collecting stamps in their own 'space passports' and writing about or drawing their dreams to be stored in a time capsule. One tent was run by Omani Archives and another had vendors from nearby villages, offering hands-on experiences and games.

It felt like a space fair but with local flavour. There was no flashy tech or glossy corporate displays. Instead, there were handwritten signs, excited schoolteachers and community members who genuinely wanted to be part of something bigger than themselves. "We think the spaceport will be beneficial for the future of Omani youth, so we felt it was important to be involved," one vendor village told me.

Even without a launch, the energy was unmistakable. This was the first time a public launch viewing experience was becoming a reality in the Middle East. And it wasn't just about watching rockets - it was about showing young Omanis that this is their space story, too. That they don't just have to read about launches in places like Florida, Baikonur or Japan. They can one day run them, design the rockets and maybe even fly on them.

She left Etlaq with sand in my shoes, sunburn on my neck and the feeling that I had witnessed the start of something. It may be early days but the countdown has definitely begun.

An Ideal Platform for Space Launches

The Sultanate of Oman boasts an ideal location for space vehicle launches, with its proximity to the equator reducing fuel consumption for spacecraft as they launch in alignment with Earth's rotation. Oman's coastal launch sites overlooking the Indian Ocean and distance from populated areas have attracted international space companies seeking optimal launch locations.

HH Sayyid Azzan Qais Al Said, Founder and CEO of the National Aerospace Services Company "NASCOM" and "Etlaq" Spaceport, stated that "Etlaq" pioneered the first Middle Eastern space launch with "Duqm-1," marking Oman's inaugural step toward becoming a global space access hub. The 18-degree latitude spaceport enables multi-orbit launches, including equatorial, sun-synchronous, polar, medium Earth orbit (MEO), and geostationary orbit (GEO).

HH Sayyid Azzan revealed that while Etlaq's master plan is set to be operational by 2027, the

Genesis Program, launched in 2024, currently enables experimental launches within 14 weeks of planning. The program has expanded within the past year to include a second launch pad for experimental missions and a Launch Vehicle Integration Hangar. HH Sayyid Azzan added that Etlaq Spaceport provides not only the physical launch infrastructure and ground facilities required by launch service providers, but also integrated logistical support and a strategically advantageous location. These elements make the spaceport a compelling destination for global aerospace companies.

In parallel, Etlaq is deeply invested in developing local talent and building national capabilities in the space industry; strengthening in-country value and establishing an expert Omani workforce to power the future of space in the region.

Discussing upcoming launches, HH Sayyid Azzan Al Said shared that the team is preparing for the second mission in the "Duqm" mission series, "Duqm-2". The mission will be conducted using a launch vehicle designed by Stellar Kinetics, an international entity with offices in New Zealand, Oman, and Portugal, and will be carried out using the guided, two-stage experimental suborbital vehicle, Kea-1. International coordination is essential, particularly for orbital launches, to ensure compliance with space guidelines and global notification systems.

Prior to launch, a notice is issued to personnel concerned with flight operations to inform them of upcoming space launch activities and manage airspace traffic. A maritime notice is also issued to establish an exclusion zone on nearby waters for navigational safety. Public notifications are conducted as part of our standard safety procedures and a safety radius is established for all personnel at the launch site.

Each mission is assigned a specific launch window to account for variability in launch conditions, such as mission readiness and weather conditions, and it is typically up to a two-week period in Etlaq's Genesis Program. Given the number of variables and safety measures involved, delays are not uncommon in the space industry. Whether due to weather, technical adjustments, or regulatory clearance, such delays are a normal and expected part of ensuring mission success and safety.

Dr. Saud Humaid Al Shuaيلي, Director General of Policies & Governance and Head of the National Space Program at the Ministry of Transport, Communications, and Information Technology emphasized that Oman's space launch project aims to attract global space investments while building national capabilities in spacecraft engineering, supporting Oman Vision 2040.

Dr. Saud also mentioned that the Ministry is working with local partners to develop the

national launch ecosystem as part of its vision to establish Oman as a regional hub for space applications. On a strategic level, the ministry aims to localize space science and technology by linking local institutions with leading global space providers, thereby strengthening Oman's position in space and advanced technology sectors, and enabling the transfer and localization of cutting-edge technology.

Furthermore, a representative at Stellar Kinetics stated that the upcoming mission will be the inaugural launch of the Kea-1 vehicle, offering a unique opportunity to test orbital class systems such as stage separation mechanisms and active guidance under unprecedented timelines. The mission also aims to achieve microgravity conditions to support university-led research via two onboard scientific payloads developed by international partners. The Kea-1 vehicle stands at approximately 12 meters tall and is targeted to reach an apogee of 500 kilometers above Earth's surface. This mission aligns with Etlaq's vision to strengthen international partnerships and broaden the horizons of research collaboration in the space sector.

Roles of Oman's Civil Aviation Authority

Oman's Civil Aviation Authority (CAA) has introduced a framework to approve commercial space launch activities, marking the first initiative of its kind in the Middle East. Etlaq Spaceport, the region's first commercial spaceflight hub, has welcomed the announcement, highlighting its significance in positioning Oman as a regional leader in the growing space economy which aims to be a global leader in accessible space launch and sustainable space exploration. The recently issued Civil Aviation Directive (CAD 5-01) sets out the process for coordinating spaceflight activities within Oman's airspace. Under the directive, companies seeking launch approval must submit an evidence-based safety case to the CAA in order to reserve launch windows in the Muscat Flight Information Region (FIR). Applications aim to be processed in as little as 45 days, giving operators one of the fastest approval cycles globally, while maintaining rigorous aviation, maritime, and ground safety requirements.

H.H. Azzan Kais Al Said, CEO of Etlaq Spaceport said: "This announcement is a landmark moment for the Sultanate of Oman and for the global space community. By formalizing a fast, clear, and internationally credible launch approval process, Oman is showing that it is serious about space launch, and that it is ready to host the world's most ambitious missions. We are proud to stand at the center of this transformation and to welcome partners from around the world to join us on this journey."

The spaceport will coordinate directly with the Ministry of Transportation, Communication, and Information Technology (MTCIT), CAA, and the National Space Program, to facilitate timely authorisation of launches. Behind the directive is a coordinated national effort that brings together aviation, maritime, environmental, and security authorities to provide launch service providers with a clear, unified process backed by inter-

governmental coordination. Importantly, the framework places no limit on the number of launches per year on either the launch service provider or Etlaq Spaceport, allowing the freedom to expand launch cadence as demand grows.

Raul Verdu Lidon, co-founder and Chief Business Development Officer of PLD Space, a pioneering Spanish launch service provider, also welcomed the announcement: "This capability at the spaceport that Etlaq is developing in Duqm, Oman will provide us with a significant competitive advantage in our future operations. With a growing number of customers requesting fast-responsiveness launches, this will become a key differentiating factor. We are pleased to see the Etlaq team delivering on its commitments."

The new framework directly addresses an international launch capacity shortage, with launch vehicles and their satellite customers increasingly facing longer waiting times to reach orbit. It also responds to a growing trend in the space industry around responsive launch - the ability of governments or private operators to rapidly launch new or replacement satellites for a variety of reasons, including national security. Oman's fast-track approval cycle positions Etlaq Spaceport as a cost-competitive and flexible option, offering providers the chance to book missions at short notice while avoiding lengthy delays.

Rawya Al Adawi, Act Director General of Civil Aviation Regulations, said: "The Civil Aviation Authority is pleased to support the safe and coordinated integration of space launch activities within Oman's airspace. The publication of Civil Aviation Directive CAD 5-01 ensures that airspace use during launch operations is managed in line with international aviation safety standards. This initiative reflects Oman's commitment to facilitating emerging sectors like space while maintaining the highest level of safety for all airspace users. The CAA remains focused on its role of safeguarding national airspace and enabling cooperation among all concerned entities to support the Sultanate's wider vision for innovation and technological advancement."

Dr. Saoud Al Shoaيلي, Director General of Policies & Governance and Head of the National Space Program, said: "The National Space Program fully supports this project, as it represents one of the key initiatives under the Oman Space Policy and Executive Program (2023–2033). The issuance of the Civil Aviation Directive (CAD 5-01) marks a significant milestone toward the development of the forthcoming National Space Law. This directive enables Etlaq Spaceport to establish its operations without regulatory barriers, thereby facilitating the participation of international launch service providers and advancing Oman's position as a regional space hub."

Dr. George Nield, Chairman, Global Spaceport Alliance added: "The introduction of this launch framework positions Oman to become a vital node in the world's spaceport network. A clear, efficient, and safety-driven process like this is essential to attracting innovation, investment, and international collaboration in space launch and exploration. Etlaq Spaceport, a proud member of the Global Spaceport Alliance, is leading by example as it helps connect Oman's national vision to the broader global launch community."

Meet ESA Astronaut Sophie Adenot, the First French Woman to Walk in Space



European Space Agency astronaut Sophie Adenot has officially made history as the first French woman to walk in space. During U.S. Spacewalk 97 outside the International Space Station, Adenot spent over six hours performing maintenance, marking a major milestone for European spaceflight. In 2026, it's Sophie Adenot's turn, the second French woman to reach for the stars to join the exclusive club of European astronauts, after emerging victorious from a selection process involving some 22,500 candidates.

In the intervening three decades, Sophie Adenot undoubtedly dreamed of the clouds, perhaps even of the Moon. On the occasion of the first flight to the International Space Station (ISS) since Thomas Pesquet's in 2021, she is participating in the Epsilon mission, which began on February 13, 2026.

Astronaut Sophie Adenot reached a major career milestone on August 18th 2026. She stepped outside the International Space Station (ISS) and became the first French woman to walk in space.

Adenot is now the second female astronaut from Europe to perform an extravehicular activity. She worked alongside NASA astronaut Anil Menon for 6 hours and 23 minutes outside the station during US Spacewalk 97.

Sophie Adenot is the second French woman astronaut in history, after Claudie Haigneré who made her first flight aboard the Mir station in 1996. She was one of five new astronauts selected to represent the European Space Agency (ESA).

Anyone asking who Sophie Adenot is will find a story built on years of test piloting military helicopters and earning top engineering degrees before joining the European Space Agency (ESA).

The main goal of the spacewalk was simple, repair and upgrade the communication gear of spacestation. Adenot worked near the station's central truss to swap out an old antenna unit that handles high speed data transmission back to Earth. "There was only nothingness": Sophie Adenot on the raw reality of stepping into space.

French astronaut Sophie Adenot completed her third spacewalk outside the International Space Station on September 1. She joined NASA astronaut Jessica Meir for a 6 hour, 49 minute excursion, her third outing in three weeks. Speaking to reporters from orbit shortly after, Adenot spoke frankly about the severe physical toll of working in microgravity and the magnetic pull of stepping out into open space, calling it an experience unlike any other.

The 42-year-old engineer from Burgundy was selected alongside one other woman and three men. Picked from more than 22,000 candidates, they will join the seven active European astronauts, including Frenchman Thomas Pesquet.

"It's a pretty incredible moment, I've been dreaming of space since I was a little girl...it's hard to realize what's going on!" Sophie Adenot told the press after the announcement in Paris on Wednesday evening.

Raised to be curious about everything, Adenot grew up with the "soul of an explorer". She graduated from the National School of Aeronautics and Space and has flown 3,000 flight hours as a helicopter test pilot in the Air Force.

Adenot also completed a masters at MIT in the United States on how to design a centrifuge to help astronauts train for different levels of gravity.

Adenot made history on August 18 as the first French woman to conduct a spacewalk. She is the fifth French citizen overall to perform an extravehicular activity, following Jean-Loup Chrétien, Jean-Pierre Haigneré, Philippe Perrin, and Thomas Pesquet. Adenot is currently more than 80 days into her long-duration mission aboard the station. She flew as part of SpaceX's Crew-12 flight, which the European Space Agency designated mission "Epsilon."

Adenot's first spacewalk paired her with NASA astronaut Anil Menon on August 18. The duo spent 6 hours and 23 minutes attempting to replace a failed space-to-ground antenna on the station's exterior. Stuck mounting bolts and jammed electrical connectors prevented them from completing the swap.

A colonel in the French Air and Space Force, former fighter pilot and test pilot, Sophie Adenot joined ESA's European Astronaut Corps in 2024. After completing training in record time of just two years and ten months, she is about to embark on an eight-month mission, which could become the longest ever completed by a European astronaut.

NASA scheduled an immediate follow-up excursion to resolve the issue. Adenot and Menon ventured outside again on August 25, successfully finishing the antenna replacement in roughly six and a half hours. The back-to-back spacewalks demanded intense physical effort. "Today, even holding a pen hurt," Adenot said during a press briefing following the second excursion.

For her third spacewalk on September 1, Adenot stepped outside with Jessica Meir. The pair replaced a navigation retroreflector on the station's Harmony module and swapped out a high-definition exterior camera.

They also installed electrical jumper cables and began preparation work to eventually replace the cooling radiator on the Alpha Magnetic Spectrometer. During the outing, Adenot experienced restricted

mobility in her left shoulder. Meir inspected the suit joint and determined that a glove heater harness had caught inside the fabric. Unzipping part of the suit layer freed the harness and restored full motion. The crew completed their task list and returned to the airlock shortly after.

When reporters asked if three excursions in quick succession made the work feel routine, Adenot did not hesitate to disagree. "It's impossible," Adenot said. "The only difference when you reach the third is that you know what to expect and you're less afraid of the unknown. But you could never get bored of such an amazing experience."

She offered a vivid comparison to explain the psychological impact of stepping into open space: "When you look out the window and you're on the edge of a cliff, you can find that beautiful and impressive, but you're safe inside the car. Going out on an EVA is like opening the door and suddenly being faced with nothingness. It's a totally different feeling."

Between spacewalks, Adenot's daily routine includes managing plant-growth experiments. Mission controllers link data from these experiments to classroom lessons on microgravity across elementary and high schools in Europe.

The ESA explained that this is the 282nd spacewalk to occur as a means of supporting space station assembly, maintenance and upgrades. Another spacewalk is scheduled for 25 August and will be the fifth of the Epsilon mission. Referencing the mission in an ESA livestream, Menon said: "We got into this with the mindset that we wanted everything to go perfectly. Things were a lot different than expected, but what I would say that I am really impressed with is that all of those contingencies were well thought out."

Adenot, was joined by NASA's Anil Menon, during the six-hour, 23-minute spacewalk outside of the International Space Station in order to remove a failed space-to-ground antenna. The antenna was designed to track NASA's Tracking and Data Relay Satellite, however, the device has failed to do so for months.

While the pair managed to remove the device, stuck bolts and connectors on the failed antenna delayed the work, preventing Adenot and Menon from installing the new antenna as planned.

The plan was revised with Mission Control advising the crew to perform a 'long-duration tie-down' on the ISS's truss structure, rather than transporting the failed antenna. It was decided that the installation of the spare antenna would be carried out on a future spacewalk.

Prior to her excursion, in a post on social media platform X, Adenot said: "A successful EVA [extravehicular activity] starts long before the hatch opens and that's where my focus has been these past few days, rehearsing, preparing and focusing."

Her stay at the ISS comes at a pivotal moment in space history: the ISS is aging, its planned retirement looms on the horizon of the next decade, and the question of its replacement is now fully on the table.

This transition raises a major challenge: what architectural model should guide future space stations? How can we design habitats capable of ensuring protection, autonomy, health, and long-term well-being?

For several years, the Jacques Rougerie Foundation – Académie des Beaux-Arts has placed these questions at the heart of its International Architecture and Innovation Competition. The jury of the Space Prize notably includes two leading figures in space exploration: Claudie Haigneré, the first European woman to travel to space, and Jean-François Clervoy, a veteran of international space missions. Their involvement on the jury reflects a strong conviction: space exploration cannot be purely technological. It must incorporate architectural, environmental, and profoundly human considerations.

Placing humans at the center of space development means addressing artificial gravity, radiation protection, energy and food autonomy, as well as comfort, culture, and artistic expression. One may recall that Thomas Pesquet brought his saxophone into orbit, a reminder that creativity always accompanies exploration. Tomorrow, what cultural, artistic, or architectural forms will contribute to the psychological balance of crews engaged in long-duration missions?

Space, like the underwater world, is one of the great frontiers explored by the Foundation. Through a multidisciplinary approach combining the arts, sciences, and technologies in service of life, it supports a new generation of creators across five continents who are capable of imagining present and future living environments on Earth, in the ocean, and beyond.

Role models, teachers

Her grandfather, a mechanic in the Air Force was one of the many people who inspired her. "I would never have gotten there if I hadn't had role models," said the astronaut, pointing to the scientist Marie Curie and astronaut Claudie Haigneré. She also credits her success to "fantastic school teachers" who helped her to have confidence and later encouraged her to apply for the ESA.

Adenot spent 15 years giving lectures about the importance of science and was awarded the French National Order of Merit in 2022 for being an ambassador for gender equality in science. From her new profession, she expects "a lot of science, technology, and also to be able to pass on passion to young people".

Enthusiasm for space exploration

With her new colleagues, she will have to wait until spring 2023 to start training at the ESA European Astronaut Center in Cologne with a first mission in orbit probably from 2026.

"It's a new world, with a lot of unknowns, I'll learn the job as I go. I'm delighted to follow in Thomas Pesquet's footsteps," Adenot commented. Pesquet said he was proud to see a Frenchwoman selected, as well as a second of his compatriots, Arnaud Prost, 30, who joins the reserve corps of the ESA.

"They have sturdy health, incredible skills, amazing CVs and above all, they passed psychological tests which scared me in retrospect", Pesquet, adding a word advice for the new recruits to be "patient" before their first flight - he had to wait seven years. The five new ESA astronauts will begin with a visit to the International Space Station (ISS) initially - the few places for future lunar missions will be reserved for the previous generation already experienced in low orbit stays.

The competition is fierce. Just four to six people will be chosen as Europe's next astronauts, with a reserve team of about 20. The candidates will undergo intensive screening over the next year, with a final decision expected in late 2022.

"We've all been astonished" at the number of applicants, ESA Director General Josef Aschbacher told a news conference. "It's a very strong expression of interest and enthusiasm that people have across Europe for space."

The European agency has sent only two women into space to date, Claudie Haigneré and Samantha Cristoforetti but wants that number to grow. On board the ISS, Sophie Adenot will carry out some 200 scientific experiments, in key fields such as medicine, biology and the physics of materials. This work will contribute to advances in research and their real-world applications on Earth.

Among these projects is ChloriSS, an educational experiment developed by the French space agency (CNES), combining space research and school teaching. Alongside the experiment conducted in microgravity on the ISS, 4,500 schools, with 160,000 students, will conduct the same protocol on Earth. The aim is to pique curiosity in scientific professions and foster greater diversity in related subjects. "I am saying to young women and girls we need you in science".

France plays a key role in the European Space Agency (ESA), to which it is the second-largest contributor. This ambition will be on show when Paris hosts a major international space summit in 2026. The summit will illustrate France's desire to strengthen international cooperation in this strategic field.

This mission writes Sophie Adenot into a new page in the history of French space exploration. Her name will be added to the list of French astronauts who have already docked on the ISS.

Twenty-five years after Claudie Haigneré, the first French woman to land on the station in 2001, then Thomas Pesquet, a major figure in French space travel, whose first trip to the ISS was in 2016, Sophie Adenot is the second French woman to take part in a long-term mission to space. Her career is a reflection of French excellence and the growing presence of women in science.



SPECIAL REPORT

Unraveling the mysteries of the Universe

Are we truly alone in the Universe? It is this haunting question that Nathalie Cabrol, scientific director of the SETI Search for Extraterrestrial Intelligence center, attempts to answer in her book, * *At the Dawn of New Horizons*. Here, the narrative leaves Orion and returns to our solar system, where Mars, the moons Europa and Titan still hold so many secrets, as science strives to unravel the mysteries of exoplanets. To contextualize our current knowledge, each destination is considered a piece of a much larger puzzle. Through missions such as Juice (Jupiter Ice Moons Explorer) to Jupiter's icy moons, Dragonfly to Titan, and Perseverance to Mars, the French National Centre for Space Studies (CNES) is actively involved in this collective quest, where the search for traces of life has become a major scientific driver.

The origin of Mars' two small moons, Phobos and Deimos, remains shrouded in mystery. Did they, like our Moon, form from a colossal impact between the Red Planet and another celestial body during the early days of the Solar System? Are they asteroids captured in orbit by Mars?

In a relatively short span of time, mankind has travelled from profound ignorance of our planet and the world in which we live to a rather detailed picture of not only our earth, but the solar system, the universe, and the forces that underlie the workings of most physical things. Not only do we have great understanding of the very large, such as clusters of galaxies on the fringes of the universe, but of the very small, such as quarks and gluons which comprise some of the subatomic particles and forces of nature.

Astoundingly, given the long amount of time we have inhabited this planet, most of this scientific knowledge has been acquired only within the last 400 years, ever since Galileo gazed upon the heavens through the newly invented telescope.

In fact, the two major pillars of science today, namely relativity and quantum mechanics, were discovered just within the last 100 years. And in only the last 20 years, scientists have been working to unravel the secrets of superstring theory, which may prove to be the final frontier in our quest to understand the ultimate laws of nature.

Exploring the Universe isn't just about searching for habitable worlds. It's also about venturing into objects that defy intuition. Astrophysicist Jean-Pierre Luminet confronts science fiction with science. However, spectacular the journey of the

actors in Christopher Nolan's film *Interstellar* may be, is it truly credible? The scientist meticulously examines the images using equations and observations.

The first great theory: Aristotle and Ptolemy

In his work, *On the Heavens*, Aristotle proposed that terrestrial, or earthly, things were completely different than celestial, or heavenly, things. The natural state for celestial things was to be in motion, and the natural state for earthly things was to be at rest. The earth was round and located at the center of the universe, and the fixed stars rotated about the earth on a celestial sphere that surrounded the earth.

Earthly things were made up of four basic elements: water, earth, fire, and air. Earth and water flowed toward their natural resting place at the center of the earth, with water resting on top of earth. Fire and air's natural state was to rise toward the heavens.

In 150 AD, Ptolemy published his *Almagest*, which provided the mathematics to explain the motions of the wandering stars, which included the moon, sun, and the planets. Mathematics was to become the language of physics, and Ptolemy's detailed calculations became part of Ptolemaic/Aristotelian theory.

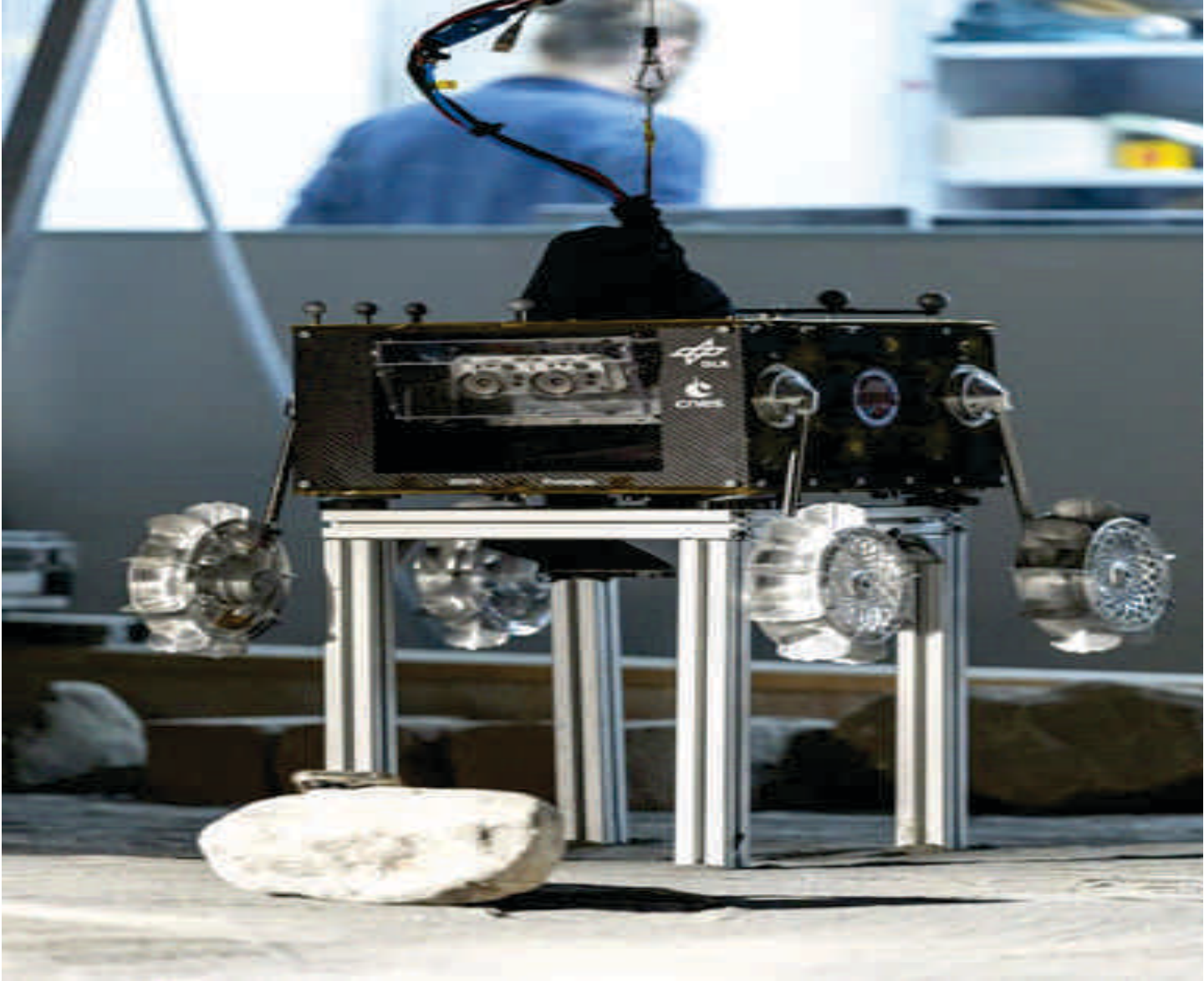
In Ptolemy's model the earth is a sphere, and the sun, moon, and planets are spheres that rotate in perfect circles around the earth. The Aristotelian idea that circular motion was perfection was to stay with science until the 16th century.

Although other ancient Greeks had suggested that the sun was really at the center of the earth, and that the earth rotated about it, the Aristotelian/Ptolemaic theory of the solar system came to be accepted and it held sway in science for about 1400 years.

The second great theory: the Copernican system

One of the problems with Ptolemy's perfect spheres and circular motion was that he had to devise many deviations from the trigonometry he used to account for the unusual motions of the roving stars, which we now know are planets.

Many scientists realized something was wrong with the theory, and finally a Polish priest named Nicholas Copernicus revived the ancient Greek idea that placed the sun at the center of the universe and had the earth and planets rotating



about it. His work, *On the Revolutions of the Celestial Orbs*, was published in 1514. Although this was a significant step forward in science, its significance was not generally appreciated until the Italian astronomer, Galileo, looked through the newly invented telescope in 1609 and discovered the moons of Jupiter.

Jupiter and its moons looked like another solar system to Galileo, and he began to publicly support the idea that the earth and the other planets must rotate about the sun. As he was the greatest scientist of his day, his support for

Copernican theory alarmed the Pope, whose Catholic Church supported Aristotelian theory. Galileo was summoned to Rome and ordered to recant, which he did. Galileo died several years later, still under house arrest because of his theory.

The third great theory: Newton's mechanics

The 1600s began an age of great scientific discovery. Frenchman Rene Descartes published his *Principles of Philosophy*, German Ole Roemer was able to determine a

reasonably accurate speed of light, and a host of scientists in countries throughout Western Europe theorized and experimented in an effort to understand the laws of Natural Philosophy, which is what we now call science.

But it was not until 1687, when Englishman Sir Isaac Newton published his *Mathematical Principle of Natural Philosophy*, that a great and powerful new theory called classical mechanics, sometimes called Newton's mechanics, was born. Newton's *Principia* (it was published in Latin) was probably the most important scientific work ever published, and it laid the foundation for modern

science. In it he outlined his laws of motion and his theory of gravitation. Because an appropriate mathematics did not exist to explain his new laws, the brilliant Newton invented the calculus.

Newton not only explained how the planets orbited the sun in ellipses, but his universal law of gravitation gave precise calculations to show how every object attracts every other object: the force is proportional to their masses and inversely proportional to the square of the distance between them.

It was a universal law, Newton said, and it applied as equally to an object falling on earth as it did to a planet orbiting the sun. He said an object's weight was a combination of its mass and the force of gravity.

The fourth great theory: Einstein's relativity

Newton's classical mechanics worked well until the latter part of the 19th century. But new discoveries of the laws that govern electromagnetic waves contradicted some of Newton's laws. For example, in 1864 James Clerk Maxwell published his four Maxwell's equations which showed that electromagnetic radiation travelled at a constant speed, which seemed to violate Newton's law that speed had to be relative to something fixed. Maxwell realized that light was merely a form of electromagnetic wave.

But, just as waves in water need water to travel through, and sound waves need air to travel through, for light to consist of waves it was thought there had to be a medium for them to travel through. So an ether was postulated that filled the universe so light could travel through space. The existence of this ether was necessary so Newton's theory would not be violated.

But in 1887, in a famous experiment using light to measure the speed of the earth through the ether, it was discovered instead that the speed of light did indeed seem to be constant, regardless of the earth's movement, in accordance with Maxwell's equations.

Then in 1905 Einstein introduced his special theory of relativity, which dispensed with the idea of an ether and stated that the speed of light was constant at 186,000 miles per second about 670 million miles per hour, and it did not have to be relative to anything.

The fifth great theory: quantum mechanics

The imprint of Einstein's genius was not just his theories of relativity. He made significant contributions to quantum mechanics, which is the most successful scientific theory of all time.

Quantum mechanics governs, among other things, the behavior of integrated circuits, which are the key components of computers, and it underlies our ability to probe human DNA and control nuclear power. Not to mention that it allows us to have the lasers which operate CD players and the bar code readers in grocery stores.

It was Max Planck who, in 1900, first suggested the idea of quanta emissions of energy in discrete packets. In 1905 Einstein said light consisted of particle-like quanta, even though most scientists considered light to consist of waves, not particles. Quantum mechanics is a theory that says energy is emitted or absorbed only in discrete packets called quanta. The quanta can travel from point A to point B by any of an infinite number of routes, each route being

determined by a mathematical probability associated with the route. We now know the energy associated with quanta acts both like a wave and a particle.

One of the key elements of quantum mechanics is the uncertainty principle, which states that either a particle's position or velocity can be measured precisely, but not both. In a nutshell, quantum mechanics states that nothing can ever be known for sure because you can only have a certain probability that a specific event will occur, and that matter, in its most basic form, behaves in a way that is inexplicable.

This dialogue between imagination and scientific rigor reminds us how major astrophysics missions such as the European satellite Gaia or Euclid, enrich our understanding of extreme phenomena, long confined to the theoretical realm. Like the film's protagonist, embark on a groundbreaking space mission to the heart of a black hole.

However, exploration inevitably brings danger. And that's precisely the heart of Andy Weir's *The Last Chance Project*. In this science fiction novel, humanity's fate rests on a desperate space mission. The story explores highly topical issues: long-duration manned spaceflight, international cooperation, and Earth's dependence on its star. Solar observation missions, like solar orbiter, and discussions surrounding future manned missions demonstrate that these scenarios are not merely the stuff of imagination. Blending fiction and suspense, the author tackles very real questions about the survival and future of our civilization in a constantly changing cosmic environment.

As with *"The Martian"*, his previous bestseller, the plot of this new book has been adapted for the screen, with a release scheduled for France this spring.

Before it becomes a matter of engineers and orbital trajectories, space exploration is first and foremost a matter of narratives. Those produced by scientists, writers, and sometimes both. A common ambition emerges in several recent popular science and science fiction works: to understand our place in the Universe and to push back, step by step, the frontiers of our knowledge. This objective is clearly illustrated by current and future space missions, particularly those to which CNES contributes.

The Mars Mission to Mars MMX is headed to Phobos in late 2026 ! This mission, initiated by the Japanese space agency JAXA, aims to explore the moons of Mars. One of the modules on board is the small Idefix® rover, co-developed by CNES and the German Aerospace Center (DLR). It will attempt to land and explore Phobos, whose soil composition is still unknown. As launch approaches, the French and German teams are conducting extensive testing on the rover.

Last November, four engineers from CNES traveled to Germany, near Munich, to conduct tests on an Idefix® prototype. The tests took place at the DLR's *Planetary Exploration Laboratory* (PEL), on a replica of Phobos's terrain. At the base of operations, the flight software and command and control team provided remote support from Toulouse. Clément Brysbaert, Idefix® system manager, takes us

behind the scenes of this mission.

Preparing Prototypix

The engineers arrived at the DLR center, the German Aerospace Center, located in Oberpfaffenhofen, near Munich. There, the DLR has recreated a terrain similar to that of Phobos, the Martian moon where Idefix® will land. Obviously, the gravity is different: on Phobos, it is about 1,800 times weaker than on Earth! We are here for four days to work "under representative conditions" on a prototype of the rover called Prototypix.

On the rover, DLR is developing the chassis, the locomotion system, and two instruments. CNES is providing the four cameras, the sensor, and the solar panels, as well as the rover's core components. We therefore brought with us cameras representative of the flight. These are two "NavCams" meaning navigation cameras located at the front, which act as the rover's eyes and will allow us to acquire stereoscopic images.

After a Prototypix preparation meeting, engineers go to the field to prepare the tests. What interests them is the rover's autonomous navigation: Idefix® will carry software that allows us to send it remote commands; it will then independently choose the most appropriate path. For instance, if it detects a large rock in its path, it will go around it. In order to do this, they took images with the two NavCams, which provide stereoscopic views of the terrain. These images will then be used by the autonomous navigation software. This is what we came to test at the DLR, on the famous PEL site.

A problem to solve

Once engineers are conducting their first tests. Using the autonomous navigation system, they took images with the NavCams, send commands to the "loco", the rover's locomotion system, take more images. But we quickly realize that there is a problem with the stereoscopic image rendering and manage to identify it: in the flight software, the left and right cameras are reversed! After this correction, testing resumes. Autonomous navigation allows for automatic adjustment of image exposure, detection of obstacles and dangerous areas shadow zones, and autonomous driving.

They alternate the tests with those of the DLR. These joint trials also allow us to exchange best practices. For example, the DLR uses our 3D scanner, which allows us to reconstruct the terrain in three dimensions, and we use their tracking *system*, which allows us to follow the rover's progress across the Phobosian terrain. At the end of the day, they headed to discover local specialties for a well-deserved evening!

The heliotropic sequence

This is the third and final day of testing and it's time for the team to test the "heliotropic sequence". The Prototypix is not saluting the Sun! But on Phobos, his big brother Idefix® will bow in the direction of our star in order to recharge his batteries optimally. By having the prototype perform this maneuver, they are capturing continuous images using NavCams, which will allow us to test the rover's autonomous navigation software. These results will then be useful to the CNES teams in Toulouse for conducting simulator tests.

This simulator, along with the test model called the " flat rover ", are validation tools currently running at full capacity for ongoing testing. But we'll tell you more about that in a future episode! It's the end of the day and time for the engineers to take the last flight of the day back to Toulouse.

The autonomous navigation software will then be finalized and general testing can be carried out.



STARTUP SPOTLIGHT

Building rockets to fly and fly again



When Tom Feldman and I founded Stoke in 2019, there were already something like 150 rocket startups. On the surface, the last thing the world needed was company number 151, says Andy Lapsa, CEO and co-founder of Stoke.

But then we did the math. What we found gave us enormous conviction that the future of space will be defined by fully and rapidly reusable rockets that operate with aircraft-like frequency, and the time to build them is now. Five years later, that conviction has only deepened. The partially reusable rockets of today are an important stepping stone, but they are not the destination. Any launch system that wasn't designed from the outset for full and rapid reuse will soon be left behind. Surprisingly, we couldn't find another

startup building a credible path to this future. Somebody had to do it, so why not us?

The economics of rapid reusability

There are two primary cost drivers in space launch, first the cost to manufacture the rocket, and the fixed cost of everything else, factories, test facilities, launch complexes, labor. The first is intuitive. Rockets are multi-million-dollar precision machines built to contain some of the highest sustained energy densities produced by humans second only to certain nuclear devices. These are not paper cups, and it makes no sense to throw them away after a single use.

The second driver, the cost of everything else is less visible but just as critical. Regardless of

whether you build one rocket or one hundred, you need the same core infrastructure. These fixed costs often add up to billions of dollars that are rarely acknowledged in the headlines, which typically focus on marginal cost alone. But in any real business, fixed costs can't be ignored.

The economics work like this: Each launch helps amortize the cost of infrastructure. If you launch once, that launch bears the full burden. Launch a thousand times, and each launch only has to contribute 0.1%.

This is why flight frequency is almost as important as reusability itself. A 2016 U.S Air Force study modeled this relationship and found that, with full reusability and a high flight cadence, launch costs can be reduced from today's multi-thousand dollars per kilogram to just a few hundred. And

this isn't a theoretical promise air travel proves it daily.

A Boeing 737 costs more to produce than a Falcon 9, but the 737 moves passengers and cargo anywhere in the world for under \$3 per kilogram. Given its importance to the cost economics, flight frequency deserves just as much attention as reusability. Yet historically, launch frequency has been hard to scale. More launches have meant that more rockets, more or bigger factories, more test facilities, more staff, and more fixed costs would be required. That's why, as shown in Figure 2, no company has been able to launch more than 20 times per year without first achieving at least partial reusability even at the micro-launcher scale.

This is where reusability becomes transformational. It's not just about recouping hardware costs; it's about enabling higher launch rates without scaling up infrastructure. That's how SpaceX has increased flight cadence while others have plateaued.

But even that system has limits. Each Falcon 9 launch still requires a new second stage (which means a new structure, new engine, new fluid systems, new avionics, and one-off test verifications of all of the above). Second-stage production and verification are now Falcon 9's flight-rate limiter. The only way to keep scaling and keep costs dropping is to reuse the entire vehicle. That's never been done before, but it's time. No company has scaled flight frequency beyond 20 launches

per year without first achieving at least partial reusability.

Cost, availability, and reliability: a virtuous cycle

Three things matter most to customers of any transportation system: cost, availability, and reliability. For decades the cost of launch has been the major barrier, but availability isn't far behind. Current lead times for launch are 18 months or more. Even then, available destinations are limited. Imagine trying to conduct business or even sending packages at the holidays — with those conditions. Most people wouldn't do it. In that situation, transportation only makes sense for a small number of use cases.

Full reusability changes that. Higher flight rates not only lower costs but also create more availability for customers. It's a win-win that is impossible to ignore. And the benefits go even deeper.

Reusability also fundamentally changes the drivers of reliability, another area where our industry has struggled. Despite decades of progress, failure rates remain persistent; in each year since 1980, between 2% and 8% of orbital launch attempts failed to reach their intended orbit.

Perfection in scaled manufacturing is very hard to achieve, regardless of the industry. That's why automotive lemon laws exist. That's why aircraft go through extensive flight acceptance test protocols before being placed into service. And that's why flight-proven reusable rockets will change the fundamentals of reliability in our industry.

In fact, we're already seeing this play out. SpaceX is the gold standard in launch today, with an industry-leading combination of reliability and flight cadence. Out of the past 300 Falcon 9 launches, only three have failed to achieve their mission. Every one of those failures was due to a malfunction of the disposable second stage, the part of the rocket making its maiden voyage on every flight. The reusable first stage has a perfect record of success in that span.¹ If the same is achieved with the second stage, spaceflight becomes dramatically more reliable.

Why We Created the World's First Bulletproof Heat Shield

At Stoke Space, we're working on something that could change the way rockets and access to space work forever. It's no secret that making rockets reusable is one of the biggest challenges in aerospace and only a few companies in the industry are focused on changing the game. While the idea of landing a rocket and flying it again sounds simple, the reality is far more complicated, especially when it comes to the second stage.

And the better you are at one, the better you'll be at the others. If space is to become a truly scalable economy, it's impossible to believe that there will be any other end state.

The time is now

As a civilization, we've been launching rockets for over 70 years. Until recently, however, there was little incentive to

reduce launch costs. Historically, most missions were used for multi-billion-dollar government-funded projects where the \$200 million launch cost was just a rounding error for the overall program. Times have changed.

Thanks to the advances and miniaturization of modern electronics, satellites today are smaller, cheaper, and more numerous. Now, launch represents between 30% and 70% of the total cost of deployment for commercial satellite constellations. In most cases, it's the single largest expense. This is why the economic incentive to reduce launch costs has never been stronger.

From Earth sensing to commercial GPS, global connectivity, life-saving drug manufacturing, sustainable energy production, and strategic national security capabilities, space is primed to be a major extension of the global economy. As with any market, though, it only works if there is healthy competition between multiple players in multiple verticals. This is why improved access to space is so important; lower launch costs, more availability, and better reliability lowers the barrier to entry for a wide range of new and important businesses.

Meanwhile, a new generation of engineers unburdened by legacy thinking and trained to reason from first principles is ready to build what's next. Many of them have already cut their teeth on bringing revolutionary components, subsystems, and entire vehicles from cradle to grave. They understand what works through practical experience, and they have a vision for how things can be improved on their next attempt.

The technical foundation is there. The business case is clear. The talent is available. Now is the time to deliver on the long-promised future of spaceflight. And that's why we're building Stoke.

shield comes in.

What makes a heat shield so important

Think of a rocket reentering the atmosphere like a car speeding downhill. The faster it goes, the more heat builds up to slow it down. Pushing on the brakes hard to slow it down causes the brakes and tires to heat up and continue getting hotter and hotter. This is similar to what happens to a second stage upon re-entry; without some level of overheating protection, the rocket would melt and break apart before it ever had a chance to land and be reused.

Most rockets today use heat shields made from ceramic tiles or materials that burn away during reentry. It works, but these solutions are fragile, expensive, and time-consuming to replace. This causes massive delays in refurbishment and reuse, and even then presents a reliability challenge. Imagine a car that needed all new tires and brake pads every time you drove it downhill. It's doable, but it's not ideal. So instead of sticking with traditional designs, we rethought the heat shield from the ground up.

At Stoke Space, our approach is different. We've designed a metal heat shield that's not only incredibly tough but also built to be used again and again, according to Andy Lapsa, CEO and co-founder of Stoke. Instead of breaking apart or wearing out, it stands up to the heat and stress of reentry and comes back ready for its next flight.

But we didn't stop there. We combined the heat shield with the rocket's engine, creating a single system that works together to protect the rocket and provide propulsion. Imagine a car where the engine cools the brakes while driving downhill it's that kind of integrated thinking that sets our design apart, he said.

At Stoke Space, we've started with the second stage because we believe solving this piece unlocks the future of 100% reusable rockets. Our work is still in progress, and we have a lot left to prove, but we're confident in the path we've chosen. Our goal isn't just to make a rocket that flies. It's to make a rocket that flies, lands, and flies again, over and over and over, the same way a 737 takes off, flies and lands then fuels up and flies again.

Stoke Space has been allocated historic launch complex 14 at cape canaveral

In 2023, Stoke Space, announced they have been allocated Launch Complex

14 at Cape Canaveral Space Force Station in Florida by the Space Launch Delta 45.

"We are over the Moon excited by this opportunity," said Julia Black, Director of Range Operations at Stoke Space. "To be trusted with the reactivation of the historic Launch Complex 14 is an honor, and we look forward to adding to its well distinguished accomplishments for America's space program."

On February 20, 1962, John Glenn became the first American to orbit Earth when he launched from site 14 on the Mercury-Atlas 6 mission. He successfully circled the Earth three times in the Friendship 7 capsule, before re-entering the atmosphere and splashing down in the Atlantic Ocean. Glenn's historic flight occurred at a critical time during the space race when President John F. Kennedy vowed to land Americans on the Moon by the end of the decade.

"We're standing on the shoulders of giants," said Andy Lapsa, Co-founder and CEO of Stoke Space. "And we're beyond humbled by the historic significance of LC-14. The opportunity to reactivate this site is a profound responsibility that our entire team holds in the highest regard. As we bring LC-14 back to life and carry its legacy into the future, we will be sure to do so in a way that preserves its existing history and pays homage to those who came before us." Stoke's fully reusable upper stage is a novel design capable of delivering cargo to and from orbit, and this announcement enables them to continue moving rapidly through their development program.

Several companies have already shown it's possible to recover and reuse the first stage, and SpaceX is making huge strides in this area with their Starship second stage and Super Heavy booster. Even before that, NASA's Space Shuttle laid the groundwork for reusability. But "rapid" reuse of the second stage, the part that goes all the way to orbit and back, remains a challenge, and we are laser focused on the solution.

Stoke Space's \$260 million investment is about more than just reusable rockets: it is an investment in a new era of engineering productivity. Developing groundbreaking hardware isn't just about innovative designs: truly executing means building fast, iterating quickly, and maintaining robust traceability, all while tracking nuts and bolts.

In 2025 we're thrilled to be significantly expanding the Fusion by Stoke Space team, so that we can continue to drive lessons learned into the product from the hundreds of high-cadence team members that we support each day.

Since 2021, "We've been reimaging traditional engineering processes from the ground up, and capturing these lessons as design principles within the Fusion by Stoke Space software ecosystem", he said. We are thrilled to be leading the way – to and from space, and to a faster, better future for all who build.



HOW DO PEOPLE ACROSS THE WORLD FEEL ABOUT SPACE?

24%

I feel overwhelmed when
I think about space

38%

I wish I knew more
about space

34%

I feel excited
about what could
happen in space

18%

I feel nervous about what
could happen in space

11%

I feel terrified
about what could
happen in space

35%

I'm hopeful about
the possibilities
of space

SPECIAL REPORT

Big brother: reality TV in the twenty-first century



'Big Brother Africa' is a reality television show in which a group of persons are brought together in secluded large house, isolated from the outside world, and made to live together while being continuously watched by television cameras. The concept was borrowed from George Orwell's novel of 1984 titled 'fictional dystopia of Oceania' in which he described a world of never-ending surveillance. In the novel, the dictator who watched over the citizens of Oceania was called Big Brother; his terrifying slogan was 'Big Brother is watching you'. In the Big Brother television show, contestants

confined in the house compete to escape eviction in order to win the prize money. The reality TV show debuted on the African continent in 2003 and has remained an annual event till date.

The house is equipped with cameras and microphones that record the houseguest's every move and conversation. This creates a sense of constant observation and allows the audience to witness the impact of cultural identity language. The show is a compilation of edited strategic conversations, physical and mental competitions, and the live evictions of the houseguests. *Big Brother* is known for its

voyeuristic nature, as viewers can watch the housemates' interactions, conflicts, alliances, and personal dramas unfold in real-time.

Big Brother Africa is a constructed reality. The house they live, the circumstances in which they live and the concept of an invisible eye dictating their actions is unreal. However, the events that go on in the house are to an extent real, in the sense that, the behavior or reaction of housemates is not rehearsed, scripted or pre planned. The audience decides who

they believe is putting up a show for the sake of the cameras and the prize and who they believe is being real irrespective of the cameras.

A typical day in the Big Brother house begins with housemates emerging from their rooms to attend to their morning routines, including breakfast and personal care. Following this, there may be exercises, after which housemates gather for tasks assigned by Big Brother via an overhead speaker. These tasks can range from reciting poems to engaging in team-based physical activities. Housemates also have private one-on-one sessions with Big

Brother, where they share their thoughts and nominate housemates they would like to see evicted. The day progresses with housemates preparing their meals and collaborating on group projects. At night, housemates retire to communal sleeping areas, divided by gender.

The show is typically comprised of three one-hour episodes a week. Two of the episodes are recorded within the week and edited for an audience. These two episodes often contain a Head of Household competition wherein one

person wins immunity for the week and the power to nominate two of their fellow houseguests for eviction during the live episode.

After nominations are made, there is a Power of Veto competition where six houseguests, the Head of Household, two nominees, and three houseguests selected by random draw compete for the golden power of veto, which ensures the winner's safety for the week and allows them to either leave the nominations the same or remove one of the nominations.

If this occurs, the Head of Household must choose another houseguest to nominate. After this competition, the houseguests have a few days to strategize, form alliances, and plead their case to stay in the house before the live vote and eviction. The third episode contains the live eviction, a brief interview of the evicted houseguest, and often a teaser of the next Head of Household competition.

The winner is crowned at the end of the season when there are only two contestants left in the game. The previous seven to nine players evicted from the house go to a separate house where they remain isolated from the outside world called the jury house. The season finale is a live television show where the third-place winner is evicted to join the jury.

All of the jury members vote for the winner of the season after being able to ask two approved questions and hearing a live final argument from both remaining players. The jury has the power to pick the winner, which highlights the vitality of houseguests to win the physical and mental competitions, but also have a strong social game wherein people whom they voted to evict from the house would want to vote for them to win the show and its accompanying monetary prize.

The foundation of the Big Brother experience lies in the intriguing premise that its players start off as complete strangers to one another. This unique concept demonstrates the social experiment element of the show wherein having solid interpersonal relationships with the other houseguests is paramount. Regardless of their backgrounds, contestants come together in the Big Brother house without any preexisting connections or relationships. In this unique environment, they are thrust into a situation where they must interact socially, form alliances, and navigate complex dynamics under the watchful gaze of millions of other strangers viewers from around the world who tune in to witness this social experiment unfold.

viewers to fantasize about gaining celebrity status by being on television. Since the maiden edition of Big Brother Africa in 2001 featuring a Nigerian for the first time, reality TV shows have become the 'new big thing.' Reality shows now abound in the country.

With the expansion of satellite television in Africa, the popularity of Big Brother Africa has continued to grow.

In South Africa, Big Brother Mzansi double trouble 2015 was launched by M-Net and the production company Endemol and aired on channel 197 and 198 on DSTV. In the show, a group of people called housemates live together in a specially constructed house that is isolated and cut off from the outside world where they do not have access to their phones, laptops or social media networks. During their stay in the house, contestants are continuously monitored by live, in-house television cameras, as well as personal audio microphones recording their every move 24hours a day. Big Brother Naija projects the good culture of Nigeria and Africa.

Impact on viewers

As the viewers enjoy the show, they become witnesses to the behavior of the contestants and become privy to information not all of the players know based on their limited knowledge of game twists and contestants' private confessionals. The viewers can reflect on what is going on in the game, which leads them to root for players they feel are playing the best game. This reflection can lead to self-awareness and self-reflection, encouraging them to contemplate their behaviors and relationships in the context of the social dynamics portrayed on the show.

While watching the show, the viewers may find themselves fostering empathy for players with differing racial, gender, and religious backgrounds than their own. This show provides viewers the opportunity to watch and learn about people with various backgrounds that they may not have encountered previously. The format of the show allows the viewers to watch the players continuously, which may help people of different backgrounds see similarities between themselves and the contestants. This could lead to increased tolerance and compassion for people from different walks of life all through the simple watching of a reality competition show.

Big Brother's overall popularity has led to the formation of communities of viewers over its many seasons of competition. Fans from all over the country gather in online communities to analyze player strategy, create polls to share their favorite players and listen to podcasts hosted by previous players commentating on how the game is progressing from season to season. The viewership/fan base culture allows people to come together from all over the country and utilize language in a powerful sense of unity

The show sheds light on various social issues in society. The contestants have conversations broadcast to the country,

Seeing ordinary people on shows allows

focusing on specific racial, religious, and gender ideologies. One of the major ways the show has accomplished this feat is through its diverse casting. When people representing a variety of ethnicities, sexual orientations, and backgrounds are living together, there is a vast amount of potential conversational content. This can help foster conversations among the contestants that challenge societal stereotypes and promote inclusivity in their "house society." The viewing of this by America can help aid similar missions in real-time.

In the Big Brother house, contestants are stripped of their familiar social circles and support networks. They are forced to rely solely on their social skills, intuition, and adaptability to navigate the challenges presented to them. This level playing field amplifies the intensity of the experience as contestants grapple with the uncertainties of forging connections with people they have never met before.

Under the scrutiny of millions, contestants in Big Brother are observed for their strategic gameplay and closely examined for how they manage their interpersonal relations. The viewers dissect every conversation, alliance, disagreement, and emotional moment. This intense public scrutiny adds layers of complexity to the interactions among contestants. They must balance their authentic selves with the awareness that their every move is being analyzed, making the social dynamics within the house a delicate dance between genuine connections and strategic calculations.

Gossip in the Big Brother house extends beyond mere strategy; it also reflects the human nature of the contestants. It demonstrates their emotional vulnerabilities and interpersonal insecurities. Gossip often becomes a way for contestants to cope with the stress of the game, allowing them to vent frustrations and express their feelings about their fellow housemates. The pressure cooker environment of the Big Brother house amplifies the impact of gossip, as emotions run high, and small pieces of information can quickly escalate into significant confrontations. This emotional intensity not only adds drama to the show but also provides viewers with a glimpse into the psychological toll the game takes on the contestants.

Everyday discourse within the context of the show Big Brother is vital for furthering the social game. Gossip is one of the many vehicles that is used to aid the contestants in sharing both personal and game-related information. The interactions and conversations that take place in the house mirror the complexities of human communication, revealing the diverse range of personalities and perspectives present in any season. These discussions often reveal alliances, rivalries, and shifting

loyalties, providing essential context for viewers to understand the evolving alliances and conflicts within the game.

Contestants experience a wide array of emotions, including joy, frustration, fear, and vulnerability, which are openly expressed through their conversations. These emotional exchanges provide a humanizing element to the contestants, allowing viewers to empathize with their struggles and triumphs. As viewers witness the contestants navigating the challenges of the game, they become emotionally invested, enhancing the overall viewing experience, and making the show relatable on a personal level.

Many youths now suddenly discover their supposedly hidden talents which reality television programmes provide them with. When they see their favourite housemates showcasing certain talent, they are pushed into discovering what they are good at. So, Big Brother becomes a motivation for people to discover their talents.

A key factor in Big Brother Naija's continued relevance is its engagement with content creators across digital platforms. In an era dominated by social media, platforms like Instagram, X, YouTube, and TikTok have become crucial spaces for content creators who actively shape public opinion around the show. Content creators, ranging from vloggers and bloggers to meme-makers and critics play an influential role in amplifying the conversations surrounding Big Brother Naija. They produce content that critiques, analyzes, and celebrates the show, often sparking discussions among their followers.

These creators also use their platforms to express personal opinions, rally support for their favorite housemates, and engage in debates about the show's social, political, and cultural implications. Their posts, ranging from critiques and memes to fan-driven discussions reflect broader societal views on topics such as identity, morality, gender roles, and politics.

Big Brother Africa, with an estimated viewership of more than forty million across Africa is a reality television programme in which contestants are selected from different countries located in Africa and placed in an isolation from the outside world, and made to live together while being continuously watched by television cameras.

Reality television show has in recent time significantly proved to be a favourite among the youth particularly those who fall within the range of age 18-25. Young people are so interested in reality show that they actively participate in reality shows by constantly watching them, acting like reality show celebrities, following these shows on social media platforms.

For instance, when a reality star wears a certain hairstyle, pair of earrings, clothing, or shoe, it is likely to see people mimicking that same trend. This means that young people do not only have a strong attitude towards reality shows, their attitudes are also influenced by the shows.



SPECIAL REPORT

The rise of “Dark Vessel” activity in maritime trade

At any given moment, tens of thousands of vessels are underway across the world’s oceans. Cargo ships, tankers, fishing fleets, ferries, research vessels, and naval assets crisscross shipping lanes and open water in a constant flow of commerce and activity. A meaningful share of them are not visible to the systems most organizations rely on to see them. That invisibility is rarely accidental.

The Automatic Identification System, or AIS, remains the backbone of most vessel tracking. It was never built for security. AIS was designed in the 1990s as a collision avoidance tool, a way for ships to broadcast their identity and position so other ships would not run into them. It works well for that purpose. It works poorly as a surveillance system, and the people who most need to stay hidden understand its limitations better than anyone.

Vessels disable or manipulate AIS for a range of strategic reasons tied directly to sanctions evasion and concealment. Turning off or altering transmissions allows operators to avoid enforcement, obscure the true origin of cargo, and conceal ship-to-ship transfers taking place outside regulated ports. In many cases, it also helps vessels avoid regulatory scrutiny altogether, particularly when operating in high-risk or sanctioned regions. These practices are well documented across shadow fleets, where AIS shutdowns and spoofing are routinely used to hide illicit activity and misrepresent vessel location.

This is the case for space based maritime intelligence: a fused, multi-sensor approach that does not depend on a vessel’s willingness to announce itself. Below, we look at why AIS-dependent surveillance leaves critical gaps, what dark vessel behavior actually signals, and how a modern intelligence architecture turns fragmented observations into operational understanding.

AIS transmits a vessel’s identity, position, course, and speed over VHF radio. Satellites and coastal receivers pick up those broadcasts, and the resulting picture looks comprehensive. It is not. The system is cooperative by design. AIS relies on vessels to transmit accurate information, and a captain can physically switch the transponder off. Although many vessels are legally required to operate AIS, the system itself cannot prevent disabling, manipulation, or false reporting.

A dark vessel operates without accurate, verifiable identity or position reporting, often by disabling or falsifying AIS. Deliberate concealment may signal efforts to evade enforcement, sanctions, or oversight while limiting visibility for government and commercial operators.

It does not depend on the vessel’s cooperation. However, synthetic aperture radar detects

vessels through cloud cover and darkness. Radio-frequency sensing picks up emissions from onboard systems, while optical imagery helps identify what SAR and RF have located. A vessel can silence AIS, but it cannot easily disappear from every sensor.

Vessels can transmit false identities, falsify positions, or clone the identity of a legitimate ship operating elsewhere. Analysts have documented tracks in impossible places, including ships apparently circling in the Utah desert, and a falsified track showing a British warship entering Russian-occupied Crimea days before it actually transited those waters. Bad actors exploit these gaps deliberately. Illegal, unreported, and unregulated fishing fleets go dark when they cross into protected waters or exclusive economic zones. Sanctions-evading tankers disable transponders before ship-to-ship transfers on the open ocean, then reappear hundreds of miles away with a different cargo manifest. Gray-zone state actors use commercial-looking vessels for activity that would draw a very different response if attributed to a naval flag. The deeper problem is structural. When surveillance depends on a single self-reported data source, every blind spot in that source becomes a blind spot in the operating picture. Homeland defense agencies lose visibility on approaches to critical infrastructure. Insurers underwrite risk on incomplete information. Enforcement agencies dispatch limited assets based on what they can see rather than what is actually happening. The gap between the tracked picture and the real picture is where the threat lives.

A dark vessel is any vessel operating without a verifiable, accurate transmission of its identity and position. In practice, this takes several forms: AIS switched off entirely, AIS transmitting falsified data, a vessel loitering in an area with no legitimate operational reason, or two vessels rendezvousing in open water outside any port or established transfer zone.

Each behavior is a signal, not a conclusion. Transponders fail, and vessels may drift while undergoing repairs. An isolated transmission gap is not proof of wrongdoing. What makes the behavior meaningful is context and repetition. A tanker that goes dark in the same maritime corridor on every transit, always for the same duration, always emerging with a changed draft, is telling a story. A fishing vessel that loiters at the boundary of a protected marine area for six hours before its transponder resumes is telling a different one.

An AIS-only picture of the maritime domain is

a picture of the vessels that agreed to be seen. For enforcement agencies, defense planners, insurers, and commercial operators, the vessels that did not agree are usually the ones that matter most. The common thread across every use case: fragmented, single-source data produces fragmented understanding. A modern intelligence architecture fuses multiple vantage points into a shared operational picture that supports informed decisions across sea, air, and space. What was once a specialized capability is quickly becoming a security baseline.

Rise of autonomous intelligence across domains

A vessel goes dark near a sanctioned region. An infrastructure disruption begins cascading across connected systems. A supply chain bottleneck starts affecting production timelines thousands of miles away. Modern operational risk moves fast. For years, organizations invested heavily in visibility tools that improved awareness across maritime operations, logistics networks, defense environments, and critical infrastructure. But visibility alone does not prevent disruption. Today’s challenge is reducing the time between signal and response.

Autonomous intelligence represents the next evolution of operational awareness: AI-driven systems that fuse geospatial, terrestrial, and behavioral data in real time to identify anomalies, surface emerging threats, and support faster decision-making. In increasingly dynamic environments, organizations need more than dashboards. They need systems capable of helping teams act before risk spreads.

Most organizations are struggling with the speed and complexity of turning their data into actionable decisions. Across maritime security, defense, infrastructure, logistics, and supply chain operations, teams already have access to satellite imagery, AIS transmissions, RF signals, sensor networks, and historical operational data. The challenge is that visibility alone does not automatically produce faster or better outcomes. Many systems still operate on a lagging model: collect data, analyze it after the fact, and react once disruption is already underway. In dynamic, time-sensitive environments, that delay creates operational vulnerability. The bottleneck is no longer data collection. It is time-to-decision.

Dark vessel activity is closely tied to sanctioned trade flows involving countries such as Iran, Russia, North Korea, and Venezuela. Across these regions, shadow fleets use layered tactics including AIS manipulation, ship-to-ship transfers, and flag changes to move oil and other commodities through global markets while obscuring origin and ownership.

This activity is especially prevalent in oil and commodity markets, where cargo can be blended, transferred, and rerouted multiple times before reaching its final destination. Each step adds another layer of ambiguity, making it increasingly difficult to trace the true source of goods using traditional tracking methods. However, traditional surveillance systems struggle to keep pace with these tactics because they rely on incomplete signals and delayed analysis. AIS gaps create blind spots that degrade data quality and limit visibility into vessel behavior. At the same time, many platforms lack the ability to model behavior over time or detect subtle anomalies such as loitering, evasive routing, or coordinated rendezvous patterns. High latency between data capture and alerting further reduces effectiveness, as suspicious activity is often identified only after it has already occurred. The result is a fundamental mismatch: legacy systems operate on static, delayed inputs, while modern evasion strategies are dynamic, adaptive, and designed to exploit exactly those limitations.

Why visibility alone breaks down

Visibility tools are valuable, but they are often retrospective by design. Traditional supply chain visibility software can show where goods are, where delays occurred, or how routes changed. That information matters, but it may arrive after the issue has already affected inventory, production, or delivery timelines. A port slowdown can affect downstream logistics. A vessel going dark can obscure cargo origin. A disruption at an energy asset can influence regional operations. An infrastructure issue can cascade across connected systems. This matters because many global systems are deeply interconnected. CISA notes that disruption in one infrastructure system can create cascading impacts across other critical systems. UN Trade and Development also reports that global shipping carries over 80% of world trade and remains under pressure from fragile growth, rising costs, and uncertainty. This is the environment organizations are operating in now: more connected, more contested, and less forgiving of slow response.

The need is shifting from visibility to active monitoring. Organizations do not just need to know what happened. They need supply chain monitoring software that detects early signals, identifies likely consequences, and supports action before disruption spreads.

How space-based intelligence closes the gap

No single sensor sees everything. The value of space-based maritime intelligence comes from combining vantage points that compensate for one another’s weaknesses.

Electro-optical satellite imagery shows a vessel’s appearance, size, and configuration, as well as whether it is underway or moored alongside another hull. It requires daylight and clear skies.

Synthetic aperture radar sees through cloud cover and darkness, detecting radar reflections from vessels regardless of weather or time of day. It reveals presence but not always fine detail.

Radio frequency detection picks up the electromagnetic emissions a vessel produces even when its AIS transponder is off, since radars, communications equipment, and navigation systems all radiate. RF detection can help locate those emissions without requiring the vessel’s cooperation.

Layer these together, and a vessel that has disabled AIS is still detectable. RF can help locate its emissions, SAR can confirm a vessel at or near those coordinates, and optical imagery characterizes the target on a later pass. What no single sensor can establish, several sensors together can.

Orbit solves a problem of reach. Patrol vessels and maritime aircraft are expensive, limited in number, and constrained by range and endurance. Vast areas of the open ocean and the exclusive economic zones of smaller coastal states receive almost no persistent physical patrol coverage. Satellites face none of those constraints. Coverage from space can extend to waters that no fleet could economically monitor, which is precisely where illicit activity often concentrates.

From vessel tracking to operational understanding

More data is not the objective. Faster sense-making is. Every organization working in this space is already awash in feeds. The bottleneck is not collection; it is the analyst time required to turn observations into judgments. Automated detection reduces that burden by flagging vessels whose behavior deviates from expected patterns. Behavioral anomaly detection compares a vessel against its own history and against the normal behavior of comparable vessels in that area. Intent characterization takes the next step, offering an assessment of what the observed behavior most plausibly means. Dark vessel activity is reshaping how sanctioned trade moves across global markets. In 2025 alone, shadow fleet tankers accounted for an estimated 6–7% of global crude oil flows, highlighting just how embedded these tactics have become in maritime commerce. At the same time, shipments tied to “dark shipping” have surged, with sanctioned oil movements via these methods more than doubling in recent years. This growth reflects a clear shift: evasion is not opportunistic. It is systematic, coordinated, and increasingly difficult to detect with traditional tools.

Decision support is the endpoint. An operator does not need another dashboard. They need a prioritized



set of contacts worth attention, with the supporting evidence attached and the reasoning traceable. The distance between a raw feed and a decision is where most maritime intelligence programs succeed or fail.

The field is moving toward maneuver detection and intent characterization across domains. Maritime activity does not occur in isolation from air and space activity, and a vessel’s behavior is often best interpreted alongside what is happening above it. Multi-domain correlation helps operators answer more complex questions about the evolving threat picture.

Ship-to-Ship transfers are one of the hardest activities to detect

Ship-to-ship (STS) transfers sit at the center of many sanctions evasion strategies, and they remain one of the most difficult activities to identify. Unlike port activity, which is recorded and regulated, STS transfers often occur offshore, outside formal oversight, and are frequently coordinated to avoid detection entirely. The real challenge here is *timing*. Many transfers are intentionally executed during AIS gaps or in areas with limited monitoring, leaving behind incomplete or misleading data trails. When combined with delayed analysis and fragmented data sources, even sophisticated operations can appear routine or go unnoticed altogether. Understanding why these transfers are so difficult to detect starts with their role in compliance risk, and the limitations of relying on

AIS alone.

Ship-to-ship transfers are a primary method for obscuring cargo origin. They allow sanctioned goods to be moved between vessels outside regulated ports, making enforcement significantly more difficult.

However, many legacy maritime surveillance systems still rely on batch-based updates, introducing delays that can range from hours to longer depending on data pipelines. Even when proximity events are flagged, delays in detection reduce their value. By the time analysts review the data, the transfer has already occurred, the vessels have dispersed, and evidence is harder to verify. In many cases, this delay removes any opportunity for timely intervention or escalation, limiting the ability to act on the risk.

Maritime intelligence as shared infrastructure

It is tempting to treat maritime intelligence as a niche discipline, useful for fisheries enforcement and little else. That framing is far too narrow. Maritime domain awareness is one expression of a broader shift toward commercial intelligence infrastructure: persistent, sensor-agnostic, commercially operated capability that governments and private organizations can draw on without each building bespoke systems from scratch.

The same architecture that detects a dark fishing fleet supports sanctions monitoring, port security, critical undersea infrastructure protection, and allied information sharing.

Shared awareness is the point. When a coastal state, a coalition partner, an insurer, and a federal agency are working from a common, traceable picture, the friction that adversaries rely on begins to close. Illicit actors depend on the seams between jurisdictions and between datasets. Shared infrastructure helps close those seams. Privateer’s sea-to-space positioning reflects that logic. The architecture that makes sense of contested activity on the water is the same architecture that makes sense of contested activity in orbit: multi-sensor collection, rigorous fusion, verifiable provenance, and outputs built for decisions rather than for display.

AIS data remains the foundation of most maritime surveillance systems. It provides broad coverage, standardized reporting, and a consistent way to track vessel movements across global waters. However, AIS was built on one critical assumption: that vessels participate honestly and continuously. That assumption no longer reflects how maritime activity actually operates.

Today, AIS data is routinely manipulated, selectively disabled, or delayed, especially in regions tied to sanctions enforcement and high-risk trade flows. You may have heard of “AIS spoofing” in which vessels appear compliant while masking their illegal activity by falsifying their position, transmitting implausible routes, fabricating voyage histories, or even broadcasting another ship’s identity. As a result, systems that rely on AIS alone are left interpreting incomplete signals, often after key events have already occurred.



SPECIAL REPORT

Dark vessel activity exposes how easily existing systems can be manipulated. AIS-only platforms were never built to detect deliberate concealment, coordinated evasion, or behavior designed to avoid scrutiny. As a result, critical signals are missed, alerts arrive too late, and risk exposure grows without clear visibility. By combining satellite data, geospatial intelligence, and AI-driven behavioral analytics, maritime players can deliver continuous, low-latency monitoring designed to detect suspicious activity as it unfolds, not after the fact.

Why visibility alone is no longer enough.

Again, traditional maritime systems often rely heavily on AIS tracking. But AIS data is not always accurate, continuous, or reliable. Vessels can disable transponders, spoof identities, or create tracking gaps that obscure suspicious activity. OFAC has identified AIS manipulation as a major sanctions and compliance concern.

AIS-only systems may miss suspicious behavior during manipulated transmissions or periods of limited visibility. Visibility does not always explain what happened between signals. Autonomous intelligence changes that model by combining AIS data with RF signals, satellite imagery, historical behavior, and anomaly detection to identify high-risk activity in near real time. This shifts maritime compliance software from passive tracking toward active operational decision support.

However, AI is accelerating decision cycles across industries. That matters because static analysis cannot keep up with dynamic threats. A report delivered hours or days later may still be accurate, but it may no longer be useful for action

This is the core value of moving from visibility to action. Many risks do not unfold in isolation. A suspicious vessel movement may connect to sanctions exposure. A supply chain disruption may affect sourcing, inventory, and production. A physical infrastructure event may trigger financial, operational, and safety consequences. The faster a system can interpret the signal; the faster teams can act. That creates several operational advantages including faster interventions, reduced risk, exposure, better allocation of human attention, more resilient operations, stronger continuity, and planning.

Implications for supply chains and infrastructure

Global systems are increasingly interconnected, meaning a single disruption can quickly spread across supply chains, transportation networks, energy operations, and critical infrastructure. That shift is changing what organizations need from monitoring platforms. Visibility alone is no longer enough when disruptions emerge in real time.

Autonomous intelligence helps organizations move beyond static status updates by identifying abnormal activity, detecting early warning signs, recognizing bottlenecks, and supporting faster operational decisions. Instead of reacting after disruptions occur, teams can focus on what is

changing now and how to respond before problems escalate.

Visibility is now expected. Organizations already assume they should be able to see assets, monitor activity, and access operational data. The next phase is systems that can interpret what they see and help teams act before risk becomes disruption. Autonomous intelligence is the bridge between awareness and action. It brings together geospatial intelligence, AI-based analytics, and decision intelligence to reduce the time between signal and response. Leading startup, Privateer was built for this kind of environment. By fusing satellite, terrestrial, and customer data with AI-driven analytics, Privateer helps organizations turn complex activity into actionable intelligence across sea, space, land, and beyond.

Why maritime surveillance software is failing to detect dark vessel activity

A vessel disappears from the Automatic Identification System (AIS) just long enough to complete a ship-to-ship transfer. By the time it reappears, its cargo has changed hands, its origin is obscured, and the trail is effectively broken. Nothing looks obviously wrong in the data, unless it's known where and when to look. This is the reality of modern maritime risk. Global maritime trade depends heavily on vessel tracking technologies to maintain visibility across supply chains, enforce sanctions, and manage risk. However, illicit activity at sea is not slowing down. Instead, it's becoming more coordinated, more deliberate, and harder to detect.

According to organizations like the United Nations Office on Drugs and Crime, tactics such as AIS manipulation, ship-to-ship STS transfers, and "dark vessel" operations are increasingly used to move sanctioned oil and commodities.

Still, many organizations rely on AIS-only monitoring systems that were never designed to detect intentional concealment. The result is a critical gap: compliance teams, insurers, and maritime stakeholders are working with incomplete and frequently delayed visibility into vessel behavior. When detection lags behind activity, the window to act has already closed.

Modern platforms need to move beyond basic vessel tracking and actively identify anomalies within AIS data. This includes detecting unusual course deviations, unexpected changes in speed, extended periods of AIS silence, and inconsistencies in vessel identity. Rather than treating AIS as a static feed, effective systems analyze it as a dynamic signal that can reveal patterns of manipulation. Detection should extend beyond individual data points to include behavioral analysis

over time. This means identifying patterns such as prolonged loitering, coordinated rendezvous behavior, and routing decisions that deviate from expected commercial activity.

By modeling how vessels typically operate, platforms can surface behavior that signals elevated risk. Modern surveillance platforms must assess risk even when AIS data is incomplete or unavailable. This requires predictive modeling during signal gaps, identifying vessels with known or potential sanctions exposure, and applying contextual risk scoring based on historical activity. The goal is to maintain visibility even when traditional tracking signals disappear.

However, no single data source provides a complete picture. Effective platforms integrate AIS with satellite imagery, geospatial analytics, and port and registry data to create a more comprehensive view of vessel activity. By correlating these inputs, systems can validate behavior, reduce false positives, and uncover patterns that would otherwise remain hidden.

Again, low-latency processing is a requirement for operational relevance. Systems need to ingest data in near real time, monitor activity continuously rather than in periodic batches, and generate alerts as suspicious behavior unfolds. Without this level of responsiveness, even advanced analytics arrive too late to support meaningful action.

For many insurers, maritime compliance historically centered on screening vessels at the point of claim. If a vessel raised concerns, there was time to investigate, often by piecing together AIS data, satellite imagery, and third-party insights across multiple systems. That model is changing. Regulators are increasingly expecting insurers to proactively monitor their portfolios for sanctions exposure and suspicious activity, not just react after an incident occurs. This includes identifying high-risk behavior in near real time, terminating coverage when necessary, and reporting concerns before a claim is ever filed. Time to insight now directly impacts risk exposure. Delayed detection can leave insurers unknowingly covering non-compliant vessels, creating regulatory and financial consequences. Workflows that rely on stitching together multiple tools once manageable in a reactive model introduce too much latency in a continuous monitoring environment. The question is no longer whether risk can be identified. It's whether it can be identified fast enough to act.

How satellite data and geospatial AI are transforming dark vessel detection

Satellite data extends visibility beyond the limits of self-reported signals. It allows organizations to detect vessels operating without AIS, monitor activity in remote or sanctioned regions, and independently verify vessel presence. This provides an invaluable layer of validation in environments where AIS data cannot be trusted. Geospatial AI makes it possible to detect complex

behaviors that are difficult to identify through manual analysis or rule-based systems. This includes recognizing loitering patterns, identifying potential ship-to-ship transfers, and flagging evasive routing behavior. These insights are derived from movement patterns and spatial relationships, not just transmitted signals.

When combined with low-latency systems, satellite data and AI-driven analytics enable real-time alerting, automated anomaly detection, and faster compliance investigations. This shift reduces reliance on retrospective analysis and allows organizations to respond to risk as it develops. In summary, maritime surveillance is evolving from passive tracking to predictive intelligence.

Organizations responsible for sanctions compliance, underwriting, and cargo risk assessment increasingly require behavioral vessel analytics, multi-source geospatial intelligence, AI-driven anomaly detection, continuous dark vessel monitoring and low-latency data processing and alerting. The difference is fundamental. Legacy systems tell you where a vessel was. Modern platforms help you understand what it is doing and what it is likely to do next.

Privateer launches TerraScope Maritime, a multi-source tool to better analyze ocean activity

A global fleet of observation satellites floats just off the atmospheric shoreline. Yet, our view of what's happening on Earth's seas remains far too dim. With present gaps in ocean monitoring and tracking, it's difficult to reliably identify and avoid disruptions to supply chains, risks to vessels, and environmental impacts. Ships that could be involved in illegal fishing or drug and human trafficking are difficult to spot, and even more so to keep in view when they turn off navigation and tracking systems. These 'blind spots' are a complex problem in search of a robust solution.

Bringing together its industry-leading capabilities in AI modeling, computer vision, space domain awareness, and data visualization, Privateer now offers a radical new ability to track, analyze, and predict activity on the ocean with a blend of data sources from sea to space. TerraScope Maritime's rapid insights offer applications from supply chain, insurance, and ESG to defense and law enforcement.

"Our ethos is very simple: know better, do better – and we have put our capabilities into a maritime insights tool that will enable commercial and government customers alike to do exactly those two things," says Privateer General Manager and Chief Revenue Officer Declan Lynch. "Combining advanced analysis of multi-domain data with our ability to provide an unbroken 'chain of custody' gives the most complete picture yet of what's happened before, happening now, and likely to happen next on the seas."

TerraScope Maritime is the first in a suite of domain-specific offerings growing out of the TerraScope geospatial analytics platform pioneered by Privateer subsidiary Orbital Insight. While TerraScope's advanced algorithm enables speed, cost, and



accuracy of information from a comprehensive range of sources, these features will also rely on something unique to the field: the space object tracking of Privateer's Wayfinder application.

Wayfinder's ability to predict the location of operational satellites up to five days out helps inform a seamless 'handoff' from one data source to another, keeping objects of interest in view and overcoming the price and scale limitations of individual satellite operators. The resulting more-robust data set then folds in with terrestrial for a truly complete all-domain picture.

This combined power of space domain awareness and Earth observation optimizes for collection of information to feed the most thorough analysis.

This commercial capability is already selected by the National Geospatial-Intelligence Agency for its first Commercial Solutions Opening, but that's just the beginning.

TerraScope Maritime is a tool made to help NGOs working on humanitarian and conservation issues, inform companies seeking to streamline operations and shrink their environmental footprint, and deliver the information government agencies need to provide for their constituents.

Declan concludes: "This already-built product will allow, through a single easy access point, the power of holistic information to open new avenues for efficiency, growth, and the greater good."

Privateer Space, the space decision intelligence platform already leading tracking and visualization through its public Wayfinder app, a bold new vision for the future of the space-based and space-derived economy: an orbital network of globally accessible and actionable satellite data, mined for advanced insights with a suite of artificial intelligence software, and powered in part by proprietary hardware set to launch into orbit on a SpaceX Falcon 9 in late 2023.

Pono, an edge compute, storage, machine learning, and data transmission module available to satellite operators as a hosted payload, will serve as a pillar of Privateer's approach to optimizing the space environment while bringing valuable but disparate satellite data to the Global 2K, commercial, and consumer markets. Built with off-the-shelf components and integrated with Wayfinder, Pono offers operators conjunction analysis, dynamic tasking, and autopilot capability.

Concurrently, their assets' high-value data streams feed into Privateer's API-based, AI-infused marketplace, making breakthrough applications of space data available at scale and at lower cost to both a wide range of industries and individual developers and researchers.

"With Wayfinder as the guide and Pono as the engine, Privateer is linking 'for space' and 'from space,' data drivers and data users, Silicon Valley and space, and economics and sustainability in the orbital environment," Privateer CEO Alex Fielding said. "This is about refining and redefining how we, as a society, can maximize the life and utility of our satellites to enable new applications – with implications reaching from ESG to insurance, agriculture to energy, and beyond – while standardizing norms of behavior in space."

The first Pono prototype will reach space as a hosted payload on D-Orbit's ION Satellite Carrier space tug. During a months-long series of tests on orbit, Privateer will assess the ability of its machine learning workloads to gather and process data and how radiation in orbit affects the hardware, validating the platform's design and measuring its performance. Data from the testing will inform updates to software design and fine-tune the hardware's fault tolerance and

redundancy. Following this iterative development, a second prototype is planned to launch in H1 2024. Waitlist access will open in mid-2024 before Pono subsequently becomes operational and available to customers in early 2025.

Maui-based Privateer was co-founded in 2021 by tech and space veteran Fielding, Silicon Valley titan Steve Wozniak, and renowned astrodynamist Dr. Moriba Jah to serve as the data engine for sustainable space economy growth. Combining Pono and Wayfinder's capabilities 'for space' with the APIs and microservices that fuel Privateer's opportunities for data users and developers 'from space,' the company's mission aims to not only fuel progress on Earth, but ultimately also reduce the amount of single-use satellites launched into orbit.

"Building a data ride-sharing economy *in and from* space, paired with our on-orbit AI, enables Privateer to give away the safety, sustainability, and optimization technology that helps earn satellite operators more customers while giving a global user base a way to access space that traditionally has been reserved for large governments only," Wozniak said. "This is similar to when GPS technology became available to the masses and we expect it to have a similar impact."

Are farmers ready to leverage the insights of IoT?



The agriculture sector is adopting new technologies at a startling rate. It may be the oldest of all industries but the potential of new and emerging technologies to transform day-to-day operations in agriculture is immense, writes Jim Morrish, a founding partner at Transforma Insights.

Agricultural contexts tend to be characterised by production distributed over a wide area, making the industry particularly well-suited to IoT-type solutions that avoid the need for in-person monitoring and control. For millennia, the dread of a failed harvest could spell disaster for a country and its people. The unpredictability of the weather, disease, drought, these are all challenges that farmers have always faced. However, today, technology is enabling them to deal with these in a highly effective way. The deployment of satellite IoT and other technologies enables the collection of critical data, its storage, processing and analysis, so that this information can then be used by the farmer to inform his or her decisions.

Using drones and sensors, everything from moisture content in the soil to the health of livestock can be monitored and made available to farmers at the push of a button. The networked farm is offering farmers a meaningful and cost-effective way of dealing with the complex business of running their businesses. *As the drive towards sustainability takes on the front row, remote grain monitoring protects crop quality. By using direct-to-satellite IoT sensors, operators receive early alerts on temperature, humidity, and CO₂ changes to stop spoilage before it destroys commercial value.* Growing grain is only half the challenge.

Once wheat, maize, soybeans, rice, barley or sorghum enters storage, its quality and much of its commercial value depends on what happens inside the silo. After harvest, stored grain

remains biologically and physically active. Temperature differences move air and moisture, insects generate heat, fungi develop in damp areas and condensation can form beneath the roof. Small pockets of deterioration can spread unnoticed through a much larger volume.

However, early detection is therefore critical. Yet many silos are located on remote farms, at rural aggregation points or along transport routes where cellular connectivity is unreliable or absent. Satellite-connected monitoring can provide visibility where conventional networks cannot.

The IoT value chain begins with monitoring, using sensors and drones. Information is gathered from all parts of the farm such as vehicles, silos, livestock, crops and soil pH levels and moisture. This information is gathered and collated and

recorded locally. This local information can then be merged through international connectivity, provided by satellites.

Digital farming is poised to bring about an unprecedented revolution in agriculture by illuminating, predicting, and significantly influencing the continuum of cultivation issues across the modern farm. With the progression of predictive algorithms, analytics, and cutting-edge technologies, modern agriculture is pursuing ways to precisely and scientifically deal with harmful pests and plant diseases.

Protecting the harvest

After harvest, temperature and moisture are the foundations of grain-condition monitoring, although they describe different risks. However, temperature is often the most useful early-warning measurement. Grain is a good insulator, so heat

generated by insects, fungi or respiration can remain concentrated in a localised hotspot.

Left unchecked, pests, invasive species, and diseases have the potential to devastate entire agricultural industries, eliminating jobs, threatening our food supplies and costing billions. Luckily, However, data acquisition and analysis solutions provide an efficient and cost-effective way to gather data not only at the individual farm or field scale, but also enabling accurate aggregation of data over regional and national scales.

The resulting actionable, farm management information enables farmers to make more informed and appropriate decisions, quickly and accurately, saving time and precious resources such as labor, fertilizer, irrigation and crop protection costs. From a farm management perspective, 'early warning', or knowledge of the crop health prior to the visible manifestation of the effects of crop stress, is of great value.

A sensor warning relative to neighbouring points may indicate deterioration before it becomes visible during sampling or unloading. Temperature data can reveal biological activity, stratification and aeration performance, aligning with established grain storage cooling and moisture targets to help operators decide when cooling, turning or unloading is required.

Moisture content also determines how safely and how long grain can be stored. Safe limits vary by commodity, temperature, intended use and storage duration. Relative humidity is not identical to grain moisture content, but humidity and temperature together can reveal water ingress, condensation risk and changing equilibrium conditions. Warm air can carry moisture towards a cooler surface, creating condensation beneath the roof or a damp layer near the top. Grain that was sufficiently dry when loaded can therefore develop dangerous localised wet areas.

Similarly, carbon dioxide provides another indication of biological activity because grain respiration, insects and fungi all produce CO₂. An abnormal rise may signal deterioration before temperature changes substantially. It is particularly useful in sealed or hermetic storage, although readings must be interpreted alongside fumigation or controlled-atmosphere processes.

A complete system might also monitor grain level, fan operation, hatches, water ingress, power, equipment faults and external weather. This shows not only whether a silo is warming, but also whether ventilation was working effectively.

Warm, damp grain favours storage moulds, particularly *Aspergillus* and *Penicillium*. *Fusarium* infection often begins in the field but can remain commercially significant after harvest. Some fungi produce mycotoxins, including aflatoxins, fumonisins, deoxynivalenol, zearalenone and ochratoxin A. These contaminants are subject to strict regulatory limits under European Food Safety Authority guidance on mycotoxins, making contaminated grain unsuitable for food, animal feed or export markets.

Sensors do not replace sampling or laboratory analysis. Their preventive value lies in identifying

abnormal trends and environmental conditions that favour fungal development before contamination becomes widespread. Common stored-grain pests include weevils, lesser grain borers, flour beetles, grain beetles and moths. They consume and contaminate grain, reduce germination and generate additional heat and moisture. Cooling slows insect development, while monitoring enables more targeted fumigation and can reduce reliance on repeated treatments that contribute to phosphine resistance.

As agricultural production faces environmental and demographic challenges, demand for connectivity enabling smart agriculture will be significant. However, technology adoption by farmers is often slower than in the industrial sectors, especially in developing countries. For this reason, the segment will emerge slowly and growth will be concentrated in the second half of the period

The emerging connected car market represents a significant opportunity for satellite operators. During the beginning of the period, it will be primarily a niche market, as satellite networks will serve as a back up to connect high-end consumers' cars. However, as cars become more and more dependent on automation features, constant connectivity will become a requirement. Following this, hybrid solutions will progressively become the growth driver by the end of the period. Regarding smart cities, as urban areas are covered by cellular networks, satellite networks will mainly play a role in connecting urban transport, via hybrid networks.

However, decreasing service costs and allowing for low battery consumption in order to get closer to terrestrial solutions will be the main strategy focus for satellite operators. In addition, business models where satellite operators charge per connected low data emission device, and not per data transmitted, will be relevant as it closely matches terrestrial operators' business models.

Disrupting M2M/IoT via Satellite

Historically, M2M and IoT via satellite has exhibited stable growth driven by SCADA (Supervisory Control and Data Acquisition) use cases, such as utilities and basic location tracking of fleets. However, in the last few years there have been a number of new technologies which have been introduced which will disrupt the existing satellite M2M/IoT market. These include the proliferation of terrestrial networks, a future of increasing numbers of small satellite constellations, including those focused on IoT applications, and LPWA (Low Power Wide Area) networks which are currently undergoing a rapid footprint expansion. This will require operators, distributors and the much of the M2M/IoT value chain to update their business models to remain relevant in a future of greater technological diversity and competition.

This is of particular interest in Asia-Pacific, which has potential for strong M2M and IoT via Satellite market growth. NSR is forecasting M2M/IoT via Satellite to reach over 1.5 million units in the Asia Pacific region alone by 2026, up from just under 560,000 units in 2016. Corresponding revenues are likewise expected to increase from \$172 million to \$490 million by 2026. This represents

the fastest growth of any region, and consists of the largest number of in-service M2M/IoT terminals outside of North America. This growth is expected to occur despite challenges from newer technologies competing directly for satellite M2M/IoT. Partnerships with new operators will help satellite M2M/IoT grow, leveraging the complementary nature of newer technologies to satellite's advantage, in addition to growing the overall market pie for M2M/IoT, via both satellite and terrestrial.

Thinking Small (and Nano)

Small satellite constellations are one of the key drivers of potential disruption in the M2M and IoT via satellite space. In the last year, many announcements have been made by such constellation hopefuls aiming to dedicate small satellites to the needs of IoT end users. These include Helios Wire, ELSE, Hiber formerly Magnitude Space, eightyLEO, Kepler Communications and many more. These constellations aim to bring down the costs associated with utilising satellites for M2M/IoT connectivity, thus growing the market in the process.

The initial focus of such constellations will be on applications which are not latency sensitive such as basic agriculture usage and asset tracking of non-critical payloads. Higher latency is also acceptable in a range of other applications such as mining and shipping.

These applications will provide initial revenue streams, before additional satellites are added to their constellations for greater levels of reliability and service. Whilst latency and high level SLAs (Service Level Agreements) are not critical for applications like agriculture, initial latency on test satellites may exceed 10 hours, resulting in a greater lag between launch and high levels of revenue ramp up. Kepler Communications has stated that with an initial two satellites in orbit, there will be approximately 12 hours of latency for users of the service, which is much longer than what end-users would expect who will want solutions that "just work". It will be a challenging ask for customers to accept such long latency times for all but the most specific applications in the early stages of small satellite constellations, such as pipeline monitoring in remote and unmanned areas. This is especially the case when major MSS satellite operators already provide lower latency and highly reliable offerings, not to mention the current offerings from terrestrial M2M operators, which offer low latency services.

Other applications such as public safety, mission critical telemetry, and command and control usage oftentimes require near real-time usage, to the advantage of players such as Inmarsat and Iridium. Nonetheless, the potential for disruption to existing operators from small satellite constellations increases as further small and nanosatellites are launched and able to provide proven, reliable and low-cost solutions.

Traditional operators will still be able to benefit from upcoming constellations. Magnitude Space, for example, has signed an MoU with Iridium, with the potential to offer complementary solutions between the two. The business case for such constellations has yet to be proven. However, low cost terminals and long battery life will be key to the success of small satellite IoT constellations.

While there is significant potential for small satellite constellations to have a role in the M2M/IoT via satellite ecosystem, NSR believes the small satellite IoT market will be smaller than many expect, with the market opportunity between "I must have a reliable always-on satellite connection at all costs" and "I'll just use a terrestrial network due to cost" relatively small. Thus, NSR believes the trajectory of terrestrial communications will be a greater disruption to existing satellite operators and the associated ecosystem.

In the near term, there will be increasing levels of disruption and competition from all angles – between service providers, existing MSS satellite operators, small satellite IoT constellations and terrestrial networks (which are becoming more and more optimized for IoT demand). The disruption coming in the short term shouldn't be something feared, and instead be viewed as an opportunity for all players in the M2M/IoT via satellite value chain. By partnering with up-and-coming technologies, operators and service providers will be able to provide complementary services, benefiting all parts of the value chain and in the process growing the overall M2M/IoT market pie.

It is easy to forget with increasing levels of disruption ahead, that the value proposition of satellite communications for M2M and IoT applications remains firm, security, reliability and reach – which will continue to be drivers for growth however operators will need to continue to innovate in order to not become left behind by the competition and to ensure a virtuous cycle of growth continues.

Terrestrial solutions remain the largest challenge for satellite-based M2M/IoT solutions, including both network operators themselves, and Mobile Virtual Network Operators (MVNOs). Airtime pricing is generally lower than satellite usage, but what is more striking is the significantly lower cost of terrestrial M2M/IoT terminals. This is especially important when being rolled out to large transportation fleets. In addition, eSIMs have the potential to grow the market in competition with satellite services. By being embedded, they can be shipped with OEM devices and equipment, and increase utilization of M2M services. eSIMs can also be provisioned over the air, and be updated to be used on multiple networks, to avoid roaming and prevent other more complex support issues. This will be yet another form of disruption to the satellite M2M/IoT sector, especially for transportation, as satellite is one key way to avoid roaming charges on terrestrial networks.

OEM partnerships and greater levels of distribution with satellite M2M will be key to grow markets against this backdrop, especially for the transportation and heavy machinery sectors. This includes partnerships with hardware and auto manufacturers such as Caterpillar and John Deere, which integrate M2M solutions into their equipment at the OEM level. This is especially important to reach customers in construction and agriculture, where aftermarket solutions have reduced take-up rates. While terrestrial networks are generally considered a threat for M2M and IoT via satellite, opportunities do remain, especially with dual mode terrestrial-satellite services. Such combined terminals have their role in specific applications, most notably in mobile applications.



INDUSTRY REPORT

A new way to see, understand the emerging oil and gas industry



Offshore satellite communication is a game-changer for the oil and gas industry. Traditionally, these operations relied heavily on radio and terrestrial networks, mediums often prone to limited coverage and unreliable connectivity. The introduction of satellite solutions for offshore operations has transformed the way information is exchanged and managed in these high-pressure environments. Maritime satellite technology forms the backbone of offshore connectivity. These advanced systems use geostationary satellites to provide seamless coverage over vast expanses of our, otherwise unreachable, ocean. The technology utilises a network of strategically positioned satellites, ensuring uninterrupted communication, regardless of the location of offshore rigs and platforms.

In an increasingly fragmented world, oil and gas companies are turning to technology to solve a vast new swathe of problems. Because of this,

the factors behind investment into digitalisation are changing, according to a report by Danielle Edwards, VP Commercial Satcom at Open Cosmos.

During offshore operations, equipment downtime can be costly, both in terms of time and money. Satellite connectivity solutions work to streamline maintenance practices with their remote monitoring capabilities. Sensors installed on equipment work efficiently to transmit real-time data, providing a comprehensive view of its current health and performance.

This information enables predictive maintenance, ensuring that potential issues are addressed before they can escalate. As a result, there is a significant reduction in the likelihood of costly equipment failures and unplanned downtime. By proactively identifying and rectifying potential problems, time and resources are saved, enhancing the overall reliability of

operations. Where previously digitalisation made sense because it reduced costs and increased efficiency, it is now much more about adding a layer of protection against emerging risks. Whether it be an increasingly volatile climate, complex supply chains, unclear regulatory guidelines or trade restrictions, the world today is unpredictable and highly competitive. Changing by the day, these factors contribute to a general sense of growing uncertainty across the oil and gas industry.

Along with government and defence, the oil and gas industry was one of the earliest adopters of satellite technology, sitting at the cutting edge of what satellites can enable in the field. But the growing uncertainty across the industry means oil and gas companies are evaluating new innovations in space to increase their resilience.

Whilst the use of satellites is nothing new in oil

and gas, the barriers to adoption remain, holding the industry back from seamlessly integrating the most modern and innovative option afforded by the latest developments in space.

Growing business integration

The Nigeria's Trans Niger Pipeline project is responsible for the transportation of 180,000 barrels of crude oil per day which is quite a large number. Therefore, the project is also accountable for a large percentage of Shell's natural resources and thus their activity in Nigeria is to ensure production. The project has caught the attention of different media in the last year due to the fact that in the transportation loopline that Shell constructed, several leakages have been monitored resulting in pollution of the local environment.

Shell already constructed the loopline at an alternative route because the region has high risk of bypassing, sabotage and illegal refining. For this reason, the firm blamed these reasons for the leakages but some environmental campaigners blame the old loopline infrastructure for it that was already there for different projects.

With this project, Shell extended its presence in Nigeria since it has already been active within the country since 1936. Shell has been operating by its fully owned subsidiary named 'Shell Petroleum Development Company of Nigeria', which renewed and won new contract over the years to extend Shell's presence in the country. The investment made for this particular project is expected to be \$1.5 billion, needed to secure the pipeline better against sabotage and thievery and adapt it to the new project. SPDC has formed a joint venture with the Nigerian National Petroleum Corporation (NNPC) were the division of control is: Nigerian National Petroleum Corporation 55%, Total E&P Nigeria Ltd, 10%, and Nigerian Agip Oil Company totaling 5%.

The Majnoon oil fields in the south of Iraq belong to the world's largest oil fields. Royal Dutch Shell won the contract in January 2010 to be lead operator and has an interest of 45% in this oil field. The contract was won by a subsidiary of Shell called Shell Iraq Petroleum Development (SIPD). A 20-year deal, where Shell is providing the technical assistance needed in the development of the oil field was sealed with this contract.

This oil field has reached a number of 210,000 barrels of oil per day, a higher number than was originally calculated and containing an estimated number of 38 billion stock tank oil initially in place. Shell is operating in this deal on behalf of an operating consortium including the Royal Dutch Shell, Petronas and Missan Oil Company, which is the NOC of Iraq. Since this oil field is one of the largest in the world, it is assumed that Shell aimed for source control in order to control a significant amount of new resources and thus to be able to increase production or stabilize current production in the future.

Similarly, the Malaysia's Gumusut-Kakap Sabah is project is located offshore Malaysia and complies an oil source at 1220 meters depth underwater. Drilling to this source at this location, Shell is aiming for a peak annual production of 135,000 barrels per day. Shell has been active within the Malaysian market for over 120 years. This project, where the firm will drill for oil sources in deep-water, will be the first deep-water project for Shell to operate in Malaysia.

Because this type of project is one of the key fields of expertise the company has, the firm has a great chance here to expose the firm to the Asian region and thereby possibly enables future projects to be granted to Shell. As stated on Shell's website "Shell is playing an active role in developing a deep-water service industry in Malaysia by bringing its technology and expertise into the country". This could be seen as a possible secondary

motive for the firm. Primary motives are in this case equal to the previous discussed projects where the main intention is to control a certain amount of natural resources to be used for boosting current production and/or securing future production.

Shell announced an investment in Malaysia of RM5.1 billion for the development of three project where this particular one is part of. The division of interest in this particular project is as follows: Shell 33%, operator, ConocoPhillips Sabah 33%, Petronas Carigali 20%, Murphy Sabah Oil 14%. Murphy Oil Corporation has been the discoverer of the source, which informed Shell about this opportunity.

Support from the sky

Today, satellites are playing an increasingly critical role in providing oil and gas companies the situational context they need to operate safely and sustainably. Traditionally viewed solely as a means of providing communications to remote assets, satellites are now delivering a much broader set of capabilities. This could be providing highly resilient connectivity for secure communications, collecting data from thousands of IoT sensors deployed across hard-to-reach environments, understanding environmental trends through Earth observation imagery or even providing the real-time situational awareness required to keep crew safe.

In their vast scope, satellite technologies have quickly become a crucial part of how digitalisation is helping oil and gas companies respond to emerging threats like dramatic weather changes, critical remote maintenance or cyber-attacks.

However, integrating these complex, wide-ranging use cases into a single capability has proven difficult. This is because, until relatively recently, the satellite industry has operated in a vacuum of sorts. Whilst the technology solutions were innovative and advanced, they could be difficult to directly map to customer demand.

Often, separate capabilities are siloed and therefore tricky to package and integrate into existing technology stacks. The increased complexity and cost that comes along with that limitation restricts access, and many global industries still perceive the use of satellites as an expensive, niche solution, used as backup or only where there is absolutely no other options.

But things are changing. There are satellite companies working hard to shift priorities and meet customers where they are. The key here is enabling customers to overcome the barriers to entry by making it easy to integrate satellite technologies into everyday operations. And to achieve that, integration is key.

Delivering an integrated satellite offering means combining different capabilities into a single, layered architecture. If a customer needs high-speed broadband, then they can have it. If they need IoT sensors, then they can have them. If they need Earth observation images, then they can get that as well. Multiple technologies stack on top of each other, unlocking a vast swathe of new capabilities at better value. As well as being layered, this architecture needs to be open, so that companies can easily integrate the technology into their daily operations.

On thin ice

To understand how this would work in practice, it is worth investigating a real-world scenario in the high-altitude Arctic. The Arctic polar region is one of the most ecologically fragile and climate-sensitive environments on Earth. One mistake could have catastrophic consequences. Just one leak or blowout could devastate local ecosystems in a matter of hours.

As oil and gas companies progress their digitalisation efforts, there are increasing risks of cyber-attacks. Just last year, research from IT security provider Zscaler found that ransomware attacks on the oil and gas industry had risen by a staggering 935% year-on-year.

The rapidly growing threat of ransomware is in part fuelled by digitalisation. The attack surface, or the number of points where a threat actor can hack into a system or network, has been expanded greatly by the integration of technologies like automation. So even though a new goal of digitalisation is to increase resiliency, it has also inadvertently exposed oil and gas companies to new and pervasive threats.

For an oil rig in the Arctic, a cyber breach or network blackout is more than just an IT headache, but an impending environmental disaster as it impacts processes across the site from operations monitoring, command and control, and health and safety. Satellite technology has a major role to play in ensuring digitalisation meets its goal of increasing resilience by preventing events like these, rather than exposing companies to a dangerous risk.

A new combined approach

Where this layering is already proving effective is the integration of broadband connectivity, IoT sensor networks and Earth Observation into a more unified architecture. Traditionally, these functions have been procured separately: satellite connectivity from one provider, IoT monitoring from another and Earth Observation data from a third. Bringing these functions together shortens the path between detection and response, particularly where environmental conditions change quickly, and operational decisions need to be made in near real time.

Security is one reason this unified architecture matters. Remote industrial assets often rely on public internet-facing infrastructure, VPNs or routing hardware to transmit operational data. More closed, private satellite-based architectures offer an alternative by reducing dependence on public-facing networks and limiting potential attack surfaces.

Reducing latency is also crucial. High-latitude operations have historically been constrained by the limitations of geostationary satellite coverage, which can be slow and inconsistent at northern extremes. Low Earth orbit systems offer a different model, with lower latency and more reliable coverage across polar regions, making it easier to support continuous monitoring, rapid alerts and remote interventions.

With these options in place, oil and gas operators can focus on what they do best. And whilst the benefits of this model are clear, economics and ease may still be stumbling blocks.

Meeting the industry

If the new direction of digitalisation across oil and gas is enhancing resiliency, then satellite technology has a major role to play. But if satellite companies want to be part of that journey, then they need to map their solutions directly to the oil and gas industry's core challenges. Integrating satellite technology into everyday operations needs to be a seamless process: it cannot be siloed. Operators must be able to select the capability that suits their specific needs.

Oil and gas companies are already starting to see what satellites can offer without the barriers to adoption, and as confidence in the technology increases, the industry will become safer and more secure as a result.

Emergency response coordination

In the event of an emergency, swift and precise communication is an essential foundation for successful response. Offshore communication solutions are engineered for rapid coordination when it matters most. Whether facing a fire, equipment failure, or any other unforeseen emergency, satellite technology acts as a seamless messenger between offshore platforms, support vessels and onshore response units.

This method of instant communication ensures that every detail is relayed between parties in real time for an effective response. Quick response times can mean the difference between a contained incident and a catastrophic event when onboard a rig.

Offshore operations are susceptible to changing weather conditions and natural disasters. To navigate safely through these unique challenges, receiving precise information is paramount. Satellite data provides accurate and timely weather forecasts, allowing operators to plan operations around potential hazards, avoiding unnecessary risks.

Additionally, early warning systems act as a frontline defence, ensuring the safety of both personnel onboard and equipment. When it comes to the elements, being one step ahead can make all the difference, and this technology ensures teams are prepared for whatever conditions may arise.

Offshore satellite communication has revolutionized the oil and gas industry, creating a working environment that promotes enhanced safety and efficiency. Through the use of maritime satellite technology, offshore operations now have access to reliable and seamless connectivity, regardless of their location. This has translated into real-world benefits, including improved safety protocols, rapid emergency response and improved operational efficiency.

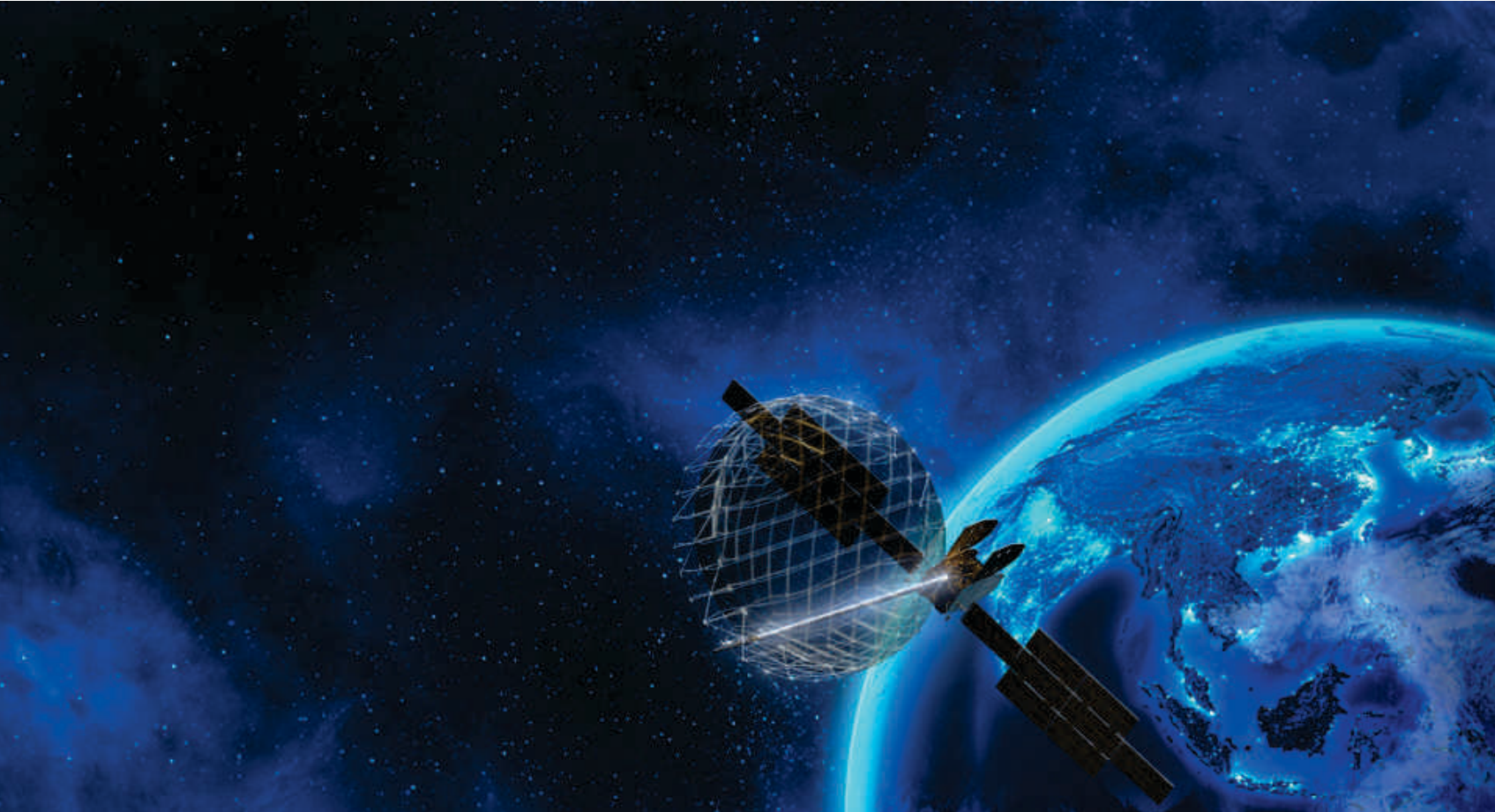
As the industry continues to evolve, it is essential that offshore operations embrace the full potential of satellite technology. By leveraging the data and capabilities offered by this innovative communication technique, the oil and gas sector can further enhance its position in global energy production.

With a proven track record of delivering cutting-edge satellite technology, Global Satellite are revolutionizing the way offshore oil and gas operations stay connected. Our state-of-the-art maritime systems ensure complete coverage in even the most remote areas of the ocean, guaranteeing uninterrupted communication for critical operations.

Global Satellite provides comprehensive solutions tailored to meet the unique demands of the oil and gas industry. Services we offer include real-time monitoring, surveillance, remote diagnostics, and asset tracking.

INDUSTRY REPORT

OKAPI:Orbits: A startup's mission to make space safer



Founded in 2018 in Germany, OKAPI:Orbits is a software-as-a-service SaaS startup that provides cutting-edge space situational awareness and space traffic management solutions to address the growing issue of space debris. The company offers satellite operators a comprehensive plat-form for mission design and collision avoidance, ensuring safer and more sustainable space operations.

Now, Christopher faces a pivotal decision: how to balance the exploration of nascent markets like on-orbit servicing and cislunar space with the exploitation of current markets, such as near-Earth orbit space situational awareness.

On 4th October 2016 at 4 PM: Christopher sat down on the bench in front of the Carl Friedrich Gauss statue. He was in a park next to the Technical University of Brunswick, a place where he often found his inspiration. The German aerospace engineer was a PhD candidate at the Institute of Space Systems of Technical University of Brunswick and

specialized in space debris and space situational awareness where he worked on projects with the German Aerospace Center DLR. The goal was to understand which sensors and algorithms could be used most effectively to track space debris and create accurate space debris catalogs.

Over the last few years, the pace of planned satellite deployments has accelerated significantly. New constellations, often hundreds or thousands of spacecraft, are announced with increasing regularity, reshaping Space Traffic Management from a niche concern into a central pillar of space operations. When thousands of active satellites share the same “orbital highways”, interactions become more complex and more frequent: today, roughly 66% of all conjunctions in LEO involve two operational satellites. In such an environment, a single collision can have catastrophic long-lasting consequences,

as the well-known Iridium-33/Cosmos-2251 event reported in 2009, the Fengyun-1C in 2007 and Kosmos-1408 in 2021 ASAT have shown.

Still, Traffic Management is only part of the broader challenge. Decades of accumulated debris remain in orbit, and preventing the creation of new debris, through deorbiting guidelines, passivation, discouraging destructive anti-satellite tests, and requiring maneuverability, is becoming more important than ever. Yet mitigation measures like design-for-demise and best practices alone do not sufficiently address the environment operators navigate today. Earth's orbits already contain **more than** 54,000 catalogued objects, about 1.2 million fragments between 1-10cm and over 140 million pieces smaller than 1cm, according to ESA statistical models. Beyond emerging active debris removal solutions, the most immediate way to prevent further escalation is ensuring

timely and effective collision avoidance maneuvering.

Trackability remains a fundamental limitation: we can only avoid what we can observe. Detecting debris smaller than 10cm is particularly difficult, and improving tracking, including through space-based sensors that reduce blind spots, is a growing priority. Even when objects are tracked, orbit predictions, especially in LEO, can shift quickly due to drag, solar activity, object geometry, or model differences.

These uncertainties directly shape operational decisions: how and when to maneuver, and whether a conjunction alert is credible enough to act on.

At the recent Space Debris Conference (SDC) in Riyadh, experts from 75 countries underscored the urgency of strengthening international cooperation to preserve long-term orbital sustainability. As part of the Debrisolver competition at SDC, participants examined a one year period in which more

than 500,000 Conjunction Data Messages were generated for objects linked to the Long-March 6A fragmentation event, a single break-up in September 2024 that produced thousands of fragments.

Of those Conjunction Data Messages, 4% predicted a Time of Closest Approach within 24 hours of the first alert, meaning operators might have had only hours to assess risk, coordinate internally, plan, upload, and execute a maneuver. This compresses an already high-pressure workflow into an even tighter window.

And debris is not limited to LEO. The Intelsat 33e break-up in GEO demonstrated that even high-altitude orbits traditionally viewed as stable can experience fragmentation events with long-lived hazards. Space sustainability is a multi-orbital responsibility, and robust debris data is essential everywhere.

For operators, this reinforces the need for timely, accurate Space Situation Awareness data. This is why integrating multiple independent data sources is one of the most effective measures to reduce risk. Within our platform, users get access to a proprietary catalogue that delivers unique insights derived from diverse, high quality data sources, including telescopes, radars, and laser-based sensors.

By combining these complementary observation modes, operators benefit from enhanced redundancy, broader coverage, and a clearer understanding of the space environment to support confident decision making.

Being aware of the rapid increase in satellite launches, he thought about the possible consequences like higher collision risks. “Why don't we use the algorithms we are developing and using now, also for the space traffic market and commercialize it?” he wondered to himself. “After all, when we can simulate the debris cataloging algorithms, then we can also apply them.”

Together with his fellow students Kristina Nikolaus, Jonas Radtke, and Sven Müller, Christopher worked on this project and became part of the EXIST program in Germany. By 2018, OKAPI:Orbits was officially founded and launched its first product OKAPI:Aether in the same year. By October 2024,

OKAPI:Orbits had 33 employees from 14 countries. With 5.7 million Euros in seed funding from 2022, OKAPI:Orbits accelerated its global expansion and the rollout of advanced software capabilities. OKAPI:Orbits had a seven figure Euro annual recurring revenue and profit margins comparable to other B2B Software-as-a-Service SaaS start-ups.

As a gust of wind shook some autumn leaves from the trees, swirling them upward and carrying them effortlessly

before they scattered in new directions, Christopher found himself confronted by a pivotal question: How can OKAPI:Orbits not only sustain its leadership in space traffic management but also become a forerunner in nascent markets like OSAM and cislunar space? The answer would shape the company's long-term strategy and its role in the future of space exploration. It was September 2024. Christopher went on a walk after a long working day.

Together with his co-founders Kristina Nikolaus, Jonas Radtke and Sven Müller, he founded OKAPI:Orbits GmbH in 2018, a leading firm in space situational awareness (SSA) and space traffic management.

OKAPI offers conjunction event analysis and collision avoidance services for satellite and spacecraft operators. The German company based in Brunswick provides these services for satellites in lower Earth orbits LEO up to geostationary Earth orbit GEO. While passing the Gaussbergpark near his alma mater, Christopher reflected on the rapid evolution of the New Space industry. Once dominated by the public sector, space has shifted to a commercial industry driving innovation through competition.

As new businesses emerge, satellite mega-constellations like Starlink increase the risk of orbital congestion and hazardous environment in space. Christopher thought about the future of his software company. While OKAPI:Orbits' software addressed current market needs, could the same algorithms be adapted for emerging opportunities in nascent markets such as on-orbit servicing, assembly, and manufacturing and cislunar applications markets that are still in the exploration and demonstration phase, showing both immense potential but also high levels of uncertainty.

Christopher thought to himself that if OKAPI:Orbits could even capture a small share of these markets, it could lead the company to new heights of growth.

Before a satellite can get launched to orbit, the first step is the mission design. The satellite operator must first decide on the purpose of the satellite. With this follow many important parameters which must be determined. Which orbit is the best one for the mission (LEO or GEO)? What scientific instrumentation will be required, how much onboard power is needed, and which thrusters are needed for maneuvering?

How will data be sent to the Earth and finally, what is the estimated lifetime of the satellite and what happens at the end of its lifetime deorbiting or graveyard orbit? Also, the right launch vehicle must be chosen. It must be rigorously determined where and when it should be launched for both saving fuel and using the right trajectory as well as keeping the mission safe. If the mission design is bad, the satellite might not reach the desired orbit and not be able to execute the mission.

A good mission design includes a statistical analysis of all the possibly required

maneuvers. The service OKAPI:Soteria is OKAPI's offer for the very beginning of a satellite launch. It mainly helps in mission design in terms of maneuver strategies and fuel management. Key focus is to plan the mission for safe operations and in compliance with all relevant space debris mitigation re-quirements. Furthermore, Soteria provides strategies for de-orbiting or re-entry. The services of Soteria can be summarized as follows: After a complete and coherent mission design, the satellite must be built and tested. When the satellite is ready, it can be launched.

Space gets commercial

With the “Space Race” in times of the cold war, the Soviet Union launched the very first satellites Sputnik 1 in 1957. The early space industry was more government-driven, focused on military or observation purposes.

When the Commercial Space Launch Act of 1984 was signed on 30. October 1984, this opened door for the first commercialization of space activities by the NASA by partnering with private launch providers. The Space Shuttle Challenger disaster in 1986 enforced this shift, contracting more private companies. In Europe, the foundation of Arianespace in 1980 marked the first commercial space transportation company worldwide, although not private.

Technological innovation made access to space easier and cheaper: In 2015, SpaceX's Falcon 9 revolutionized the launch vehicle industry by its partial reusability and reliability 4, pushing down the launch costs by over 95%. Moreover, satellites became miniaturized, exemplified by so called CubeSats which qualify for ride-sharing launches using the remaining capacity of launch vehicles already launching another payload.

In general, the space economy can be divided into upstream, especially satellite manufacturing and launch services and downstream, the communication, navigation and Earth observation activities. Today, private companies have emerged as key players in the New Space economy. Media-friendly companies like SpaceX, Virgin Galactic and Blue Origin dominate headlines, often financed by digital economy billionaires with high marketing budgets. However, also smaller companies like Rocket Lab small satellite launcher, Relativity Space 3D printed rockets, Axiom Space building the successor of the ISS and OKAPI:Orbits compete and collaborate with the traditional established “Old Space” companies like Boeing, Northrop Grumman or Lockheed Martin.

This opens the door for completely new business models or augmenting existing business models. 10 The New Space market offers enormous potential since it is still in its infancy, however, start-ups should be aware of complex bureaucratic processes, high funding requirements because of high R&D costs and high uncertainty of the market. Start-ups often fall behind established companies in terms of their network and

governmental connections which are crucial to the industry. In the next decade, more than 30,000 satellites from private operators are about to be launched, not including the governmental constellations. However, with higher space activity and more congested orbits, the more important is space safety as an industry. Space Situational Awareness therefore, entails space surveillance and tracking of objects 21 which is crucial for ESA's space safety program.

As a result, the potential consequences of the hazardous environment in space can be satellite losses which can then disrupt satellite services like communication, Earth observation and navigation. Especially in Low Earth Orbit LEO, Space Situation Awareness has become very important since there are the most satellites due to the constellations. The commercial Space Situation Awareness services and data sales are estimated to be around 2.5 billion USD for the providers over the next decade. The SSA market experiences a recently higher awareness because nations recognize the importance of protecting their own space assets.

However, reliable space systems are essential because they contribute to sovereignty on a nation's level. A growth in importance of this field can be also seen in the equity investments into Space Situation Awareness companies like LeoLabs running into 29 million USD, adding up to a total funding of over 120 million USD. SSA, space debris management and on-orbit servicing are considered as emerg-ing space industry sectors.

OKAPI:Orbits offers products and services for every phase of a satellite's life

OKAPI:Orbits offers SSA solutions for every phase of a satellite's lifetime. That includes services for risk monitoring and mission design from the launch of the satellite until its de-orbiting.

OKAPI:Soteria helps customers in the mission design phase to effectively plan the mission in terms of compliance with space debris mitigation requirements, debris impact analysis and practical matters like orbit selection, fuel planning and maneuver strategies. At the end of the satellite's life, it assists in planning the deorbiting or relocation of the satellite. The product OKAPI:LEOP targets the Launch and Early Orbit Phase in which it helps customers to quickly establish contact with their satellites after they got released from the launch vehicle. This helps to minimize the risk of satellite loss in this early phase of satellite deployment.

OKAPI:Aether is the main tool for collision avoidance and risk management. It offers auto-mated maneuvering recommendations to satellite operators which face critical conjunction events. OKAPI:Astrolabe serves

as the coordination platform for satellite operators during critical conjunction events to communicate with other operators about the maneuver planning and compliance with safety protocols.

After the satellites are successfully maneuvered into their target orbit and are ready to operate, the actual purpose of the satellites follows, namely the execution of the mission. However, the satellites will not be able to keep their orbit without some measures taken. For GEO orbits, the satellites will have to use their small thrusters to keep their orbit due to gravitational influences from the Moon, the Sun, and the Earth, as well as solar radiation pressure.

OKAPI:Orbits offers a combination of this station keeping together with space debris collision avoidance maneuvering to only use the thrusters once. In LEO, satellites have the challenge of avoiding space debris and other active satellites which might imply some collision avoidance maneuvering.

OKAPI:Aether is the product which offers exactly that to the satellite operators. It was the first product of OKAPI:Orbits and has been deployed since 2018. The product offers satellite operators risk prediction and management tools and provides them with collision avoidance features. Aether is part of OKAPI's Space Situation Awareness platform. The customers receive critical conjunction messages in case of sufficient probability of a conjunction event. Then, they can look at their tailored maneuvering recommendations considering the spacecraft's constraints and capabilities like limits in propulsion systems.

The business model

OKAPI:Orbits has SaaS business model serving Business-2-Business and Business-2-Government market respectively. Generally, OKAPI:Orbits offers quantity discounts for all offered products, depending on the number of launched satellites. For the product OKAPI:LEOP, OKAPI:Orbits charges per satellite per launch. In case of customers deciding against OKAPI:LEOP but then having trouble in the LEOP phase to identify and establish connection to their satellit(s), OKAPI:Orbits offers OKAPI:LEOP Emergency for an extra premium.

OKAPI:Aether and OKAPI:Astrolabe come with three pricing tiers which differ in their integrated function. Additionally, to the automatic reports offered in the software, OKAPI:Orbits offers elaborate reports for the conducted analysis. OKAPI:Orbits' value proposition lies in its high-quality, verified data from multiple sources and comprehensive offerings across a satellite lifetime, from mission design to de-orbiting. Another unique value proposition of OKAPI:Orbits is its coordination platform OKAPI:Astrolabe, facilitating communication in case of conjunction events between customer satellites.

The Business-2-Gpvernment segment



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generates two thirds of OKAPI:Orbits' revenues with main customers like ESA, Europe Defense Fund and European Innovation Council. The remaining third comes from commercial satellite operators, particularly SmallSat operators. They can be segmented according to their stage of the launch process, the destination orbit and the size of the constellation, favoring for constellation operators which ensure high revenue volumes and recurring revenue. Furthermore, institutional players like research organizations and insurance companies are cus-tomers of OKAPI:Orbits.

OKAPI:Orbits' competitors

OKAPI:Orbits competes tightly with the Portuguese start-up Neuraspace which also offers space traffic management services powered by AI leveraging fusion data from different sources. They additionally have telescopes for tracking objects in LEO. Another European core competitor is Aldoria which offers similar Space Situation Awareness services and also solutions for proximity operations. The company is well funded with 22 million EUR and owns their own optical telescopes.

The core US competitor is Slingshot Aerospace which is the highest funded core competitor with 149 million EUR and offers a vast range of SSA services including AI powered spacecraft outlier analysis. It works closely with governmental institutions like the US DARPA and US Space Force. 19 Its unique value proposition lies in their quality data and independence due to their proprietary ground sensors network and the provision of educational programs.

Satellites are launched into space using rockets. One common method is the ride-sharing "piggy-backing" option, often offered by private launch providers like SpaceX and facilitated by companies like Exolaunch. After reaching space, the satellites need to get separated from the launch vehicle, activating their solar panels and communication systems.

This period after launch is called the Launch and Early Orbit Phase (LEOP). The requirement for maneuvering the satellites to their intended orbits is to establish a signal to the satellite. If this signal cannot be established or is not reliable, then there is the threat of losing the satellite and causing damage.

In cases of batch releases, multiple satellites getting released at the same time, this process of identifying the own satellite gets much more difficult. Opera-tors who want to use public data often must wait for days or weeks. There are multiple steps which are critical for mission success: Successful separation from rocket upper stage, and the satellite dispenser; identifying the own satellite from many released objects,

establishing first contact, successfully maneuvering to the target orbit.

OKAPI:LEOP stands for "Launch and Early Operations" and got deployed in 2024 for the first time. This product aims to prevent satellite losses through quick and reliable orbit determination. With the product satellite operators get supported in identifying and establishing con-tact to their own satellites. After that, OKAPI:LEOP helps the customers to safely maneuver into their target orbit.

Space debris problem and OKAPI:Orbits' role

"When we started, we thought companies would understand the need for collision avoidance. But what we found was that we first had to educate the market on why space debris is a problem at all." – Christopher Kebschull. Imagine over one million projectiles ranging from a heavy machine gun to naval and tank gun. Imagine over 40,000 projectiles in the caliber of heavy artillery weapons. Finally, imagine more than 130 million small to medium caliber bullets. This can be taken as a militaristic description of the situation in the Earth's orbits. And of these objects, only about 35,000 are being tracked by Space Situation Awareness service providers.

From orbit, debris consists of multistage rocket launches, defunct satellites and breakups of spacecraft and rocket parts and reaches over 28,000 km per hour, almost seven times faster than a bullet, implying that even the smallest parts of debris can have devastating effects on the target. A more congested orbit increases the risk of the Kessler syndrome, describing the worst-case scenario of a chain reaction of collisions making certain orbits unus-able.

Earth's orbit is recognized as a finite resource according to Committee on the Peaceful Uses of Outer Space 2019 and one of the most critical issues in space sustainability. The international governmental forum IADC therefore coordinates activities related to space debris and proposes best practices to mitigate space debris.

OKAPI:Orbits tackles this problem from a software side, "focusing on improving our data sources and fusing different datasets to offer even more precise solutions" Christopher reflects aiming to provide a uniform database. Additionally, OKAPI:Orbits signed the Zero Debris Charter in June 2024. With their solutions, OKAPI:Orbits helps tackling space debris by preventing collisions and raising awareness for space sustainability and space debris.

For OKAPI:Orbits, supporting collision avoidance means supporting the people making these decisions every day. Operators work under tight timelines and imperfect information, balancing risk, mission continuity, and operational constraints. The community is steadily moving toward more autonomous operations: leveraging AI, predictive modeling, and automated maneuver planning; but **these systems are only as reliable as the clarity of the underlying data and processes**. By providing access to multiple data sources, transparent analytics, and decision focused guidance, we aim to act as a steady partner and contribute to a safer, more sustainable orbital environment.

OKAPI:Orbits' strategic challenge in nascent markets

OKAPI:Orbits has established itself as a leader in Space Situational Awareness (SSA) services, particularly in collision avoidance, making it an important contributor to space safety and sustainability. However, in the rapidly evolving New Space industry, where trends are shifting and new sub-industries rapidly emerging, OKAPI:Orbits faces a strategic challenge: How can OKAPI:Orbits not only sustain its leadership in space traffic management but also become a forerunner in nascent markets like on-orbit servicing and cislunar space?

OKAPI:Orbits' advanced algorithms position it to explore high-potential markets like on-orbit servicing and cis-lunar space. But what are these opportunities and how can OKAPI:Orbits, a relatively young company, capitalize on them without sacrificing its current foothold? And how can it navigate a competitive landscape that includes potential entrants from well-funded government agencies and established industry giants? The core of OKAPI:Orbits' strategic dilemma hence lies in balancing ambidexterity.

OKAPI:Orbits' software including the algorithms are applicable to other use cases after adaptations since the dataset is the most important. The major challenge will probably not be in adapting the software to new markets but instead in allocation of the resources to existing and new markets for example in form of marketing: "This market education, where we first have to explain to people what's happening up there - we completely underestimated that" adds Christopher.

After OKAPI:Orbits' Series A, he must agree with his co-founders about the use of the new capital and future strategic path of the company since this challenge will probably persist also in nascent markets.

OKAPI:Orbits brings debris risk analysis into real world decision making

As Earth orbit becomes increasingly congested, managing collision-risk has evolved from a mission design activity into a day-to-day operational challenge. Software originally

developed by the European Space Agency to support debris risk analysis and debris mitigation compliance has provided the foundation for tools now used by industry in operational satellite missions, enabling responsible decision-making in an increasingly complex orbital environment.

At the center of this transition is Debris Risk Assessment and Mitigation Analysis, ESA's debris risk analysis tool developed since 2004 with contributions from European industry through various ESA projects. Debris Risk Assessment and Mitigation was developed by ESA to provide mission designers and operators with a unified, scientifically grounded capability for analysing space debris risk and supporting compliance with debris-mitigation requirements. As operational demands have increased, this analytical foundation has proven essential beyond the design phase.

Through collaborative project work with ESA and by integrating Debris Risk Assessment and Mitigation calculations with its own expertise, data models, and software infrastructure, OKPAI:Orbits developed capabilities that evolved into OKPAI:Orbits, a commercial software solution designed to support operational mission design. Building on this foundation, OKPAI:Orbits:Soteria not only applies Debris Risk Assessment and Mitigation -based analyses but also integrates additional mission design and operational features beyond DRAMA itself, enabling operators to assess debris-related risks within a broader mission planning and operational context.

Soteria applies established analyses based on ESA-developed debris risk methodologies an operational context, supporting mission planning, regulatory and licensing processes, and ongoing operational assessments throughout the satellite lifecycle. By combining research-based analysis with operational workflows, Soteria helps operators assess debris-related risk, understand uncertainty, and support informed decisions in a high-stakes mission decisions.

Patrick Fülöp, Programme Manager at Remared for the HULEO Mission, currently using OKPAI:Soteria highlighted the operational value of this approach: "OKPAI:Soteria supports our debris risk assessments and regulatory processes throughout the mission lifecycle."

This evolution from ESA-developed software to operational commercial use illustrates how ESA tools can enable tangible business applications while supporting safe and sustainable space activities. As the orbital environment becomes more congested, the availability of reliable, scientifically grounded analytical tools is critical for responsible space operations and long-term space safety.

By fostering collaboration between ESA and European industry, and by enabling companies such as OKPAI:Orbits to combine publicly

developed research with proprietary expertise, ESA helps translate advanced analytical tools into operational commercial services. Through solutions like Soteria, OKPAI:Orbits emonstrates how industrial innovation can build on ESA research to support safer, more sustainable and responsible space operations.

The on-orbit servicing, assembly, and manufacturing Industry

"In-orbit servicing is the logical continuation of ESA's sustainable approach to space. Extend-ing the lifetime of satellites lets space operators generate more data and revenue from existing space assets, greatly improving both the sustainability and our competitiveness in space," says Josef Aschbacher, ESA General Director.

On-orbit servicing, assembly, and manufacturing describes all activities in a space-for-space economy, so space players producing something for other space players in space, including satellite refueling, repair, maintenance, and upgrades of satellite components.

On-orbit servicing, assembly, and manufacturing contributes to space sustainability by reducing the need for new satellite launches, by extending the satellites' lifetime and hence being more cost-effective, especially for more sophisticated satellites. It enhances the resilience of satellite constellations, which is of particular importance for defense and national security. It is also critical for deep space missions to Moon, Mars and beyond, supporting the assembly of large structures that cannot be launched as a whole. Northrop Grumman successfully demonstrated a satellite's lifetime extension with its Mission Extension Vehicle-1 in 2019 and one year later MEV-2 at a fraction of its replacement costs. In October 2024, D-Orbit signed a contract over 119 million EUR with ESA for Europe's first commercial on-orbit servicing mission "RISE" aiming to extend a GEO satellite's lifetime.

On-orbit servicing, assembly, and manufacturing and Space Situation Awareness receive a valuation of 4 billion EUR from 2023 to 2032. So far, the On-orbit servicing, assembly, and manufacturing market relies mostly on public investments with private investments exceeding 300 million USD for 15 European companies. Customers are governments, commercial satellite operators, and other On-orbit servicing, assembly, and manufacturing companies. However, some companies like SpaceX aim for vertical integration, owning the technology for themselves than offering them as a service.

The future of On-orbit servicing, assembly, and manufacturing

However, on-orbit servicing, assembly, and manufacturing market faces a significant chicken-and-egg problem: Current satellites in orbit were not designed to be serviced which makes it hard for



on-orbit servicing, assembly, and manufacturing service providers to demonstrate their capabilities and to attract investments. However, satellite operators also hesitate to invest into serviceable designs if there is no reliable, proven servicing market making it inevitable for one party to go the first step to break this cycle. The ESA engineer Ross Findlay predicts satellite designs will evolve to be more serviceable, creating opportunities for satellite design firms.

Again, the reduced satellite production and launch costs may lead some operators to favor launching new satellites over servicing older ones. High initial investment and operational costs at this stage needed for advanced robotics and autonomous docking technologies further challenge market growth. The fundamental driver for on-orbit servicing, assembly, and manufacturing services, however, is regulatory compliance. Stricter rules could incentivize services like active debris removal and promote standardized docking mechanisms. Therefore, awareness and legal obligations are likely to increase demand for on-orbit servicing, assembly, and manufacturing services.

Space Situational Awareness is critical to on-orbit servicing, assembly, and manufacturing operations ensuring accurate positioning for proximity operations like docking and collision avoidance. At the same time, on-orbit servicing, assembly, and manufacturing activities can enhance SSA capabilities through the deployment of space-based

sensors, enabling more precise tracking of space objects compared to ground-based systems.

On-orbit servicing, assembly, and manufacturing might revolutionize satellite design towards higher serviceability with modular components leading to innovation transfer to terrestrial industries like industrial robotics and remote maintenance. The market is likely to take off and become commercial with the necessary regulation and awareness, contributing to the sustainability goals in space and delivering significant economic potential within the next five to ten years.

A new big world, but where to go?

It slowly grows darker, and the Moonlight filters through the trees, casting silver streaks on the leaves. Christopher has been reflecting for a long time, but now it's time to move. For OKAPI:Orbits, however, the direction is far from certain. No one can predict the future, and yet the words of the philosopher Lucius Annaeus Seneca come to mind: "If one does not know to which port one is sailing, no wind is favorable." The questions before him feel endless.

How can OKAPI:Orbits strengthen its leadership in the near-Earth Space Situation Awareness market and raise awareness among satellite operators about the pressing issue of space debris? What does sustainability in space truly mean, and how can the company instill a sense of responsibility and urgency

within the space industry? At the same time, there is the question of exploring nascent markets. Could on-orbit servicing, assembly, and manufacturing or the cislunar space economy offer OKAPI:Orbits unparalleled opportunities or over-whelming challenges? Can OKAPI:Orbits help shape and define these emerging industries, rather than merely entering a mature, contested market? Becoming a leader in such uncharted territory could unlock enormous growth, but it also demands thought leadership, bold vision, and innovative strategies. Finally, how can OKAPI:Orbits strike the sensitive balance between consolidating its position in current markets and boldly venturing into new ones?

With limited resources, the company must make tough trade-offs, prioritizing carefully and taking calculated risks. With these questions swirling in his mind, Christopher stands, brushes the leaves from his coat, and begins to walk. The path ahead may be uncertain, but it is full of potential - much like the future of OKAPI:Orbits. As Christopher disappears into the quiet

When the satellite reaches the end of its operational lifetime, measures must be taken to comply with the space debris mitigation rules defined by IADC. These measures include preferably direct re-entries of LEO satellites or decommissioning of GEO satellites into graveyard orbits. Exactly these re-entry and de-orbiting strategies are part of the mission analysis in the product Soteria. Using detailed analysis and simulations, OKAPI:Orbits puts the focus on quality and safety. The result is optimal time and maneuvers for these end-of-life measures.



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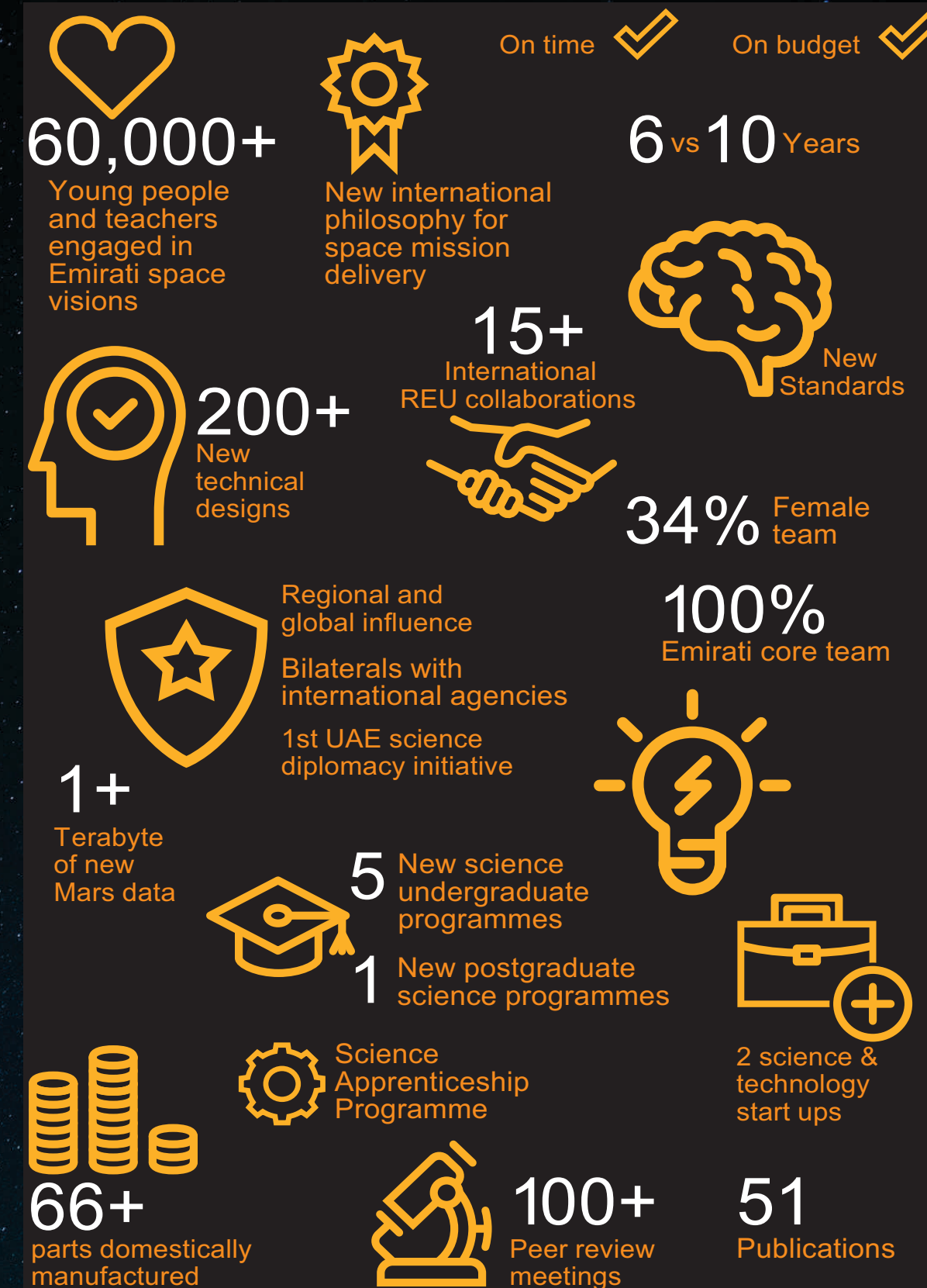
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INDUSTRY REPORT

Satellite direct-to-device services



Satellite Direct-to-Device (D2D), also called Direct-to-Cell, is an emerging complement to terrestrial wireless networks, extending basic connectivity to areas where tower construction is not practical. While promising, D2D is not a replacement for traditional cellular infrastructure, it serves as a fallback option for remote and emergency use. In recent years, technological innovation in satellite communications has created the potential for new connectivity services to be provided from space.

As of August 2025, SpaceX's Starlink satellites are serving over 7 million customers worldwide, with more than 2 million of these customers in the US. Starlink provides broadband data transmission for streaming video and Internet access. However, with a typical monthly cost for residential service of up to \$120 in the US, the Starlink broadband service is more expensive than terrestrial broadband

alternatives, like fiber, cable and fixed wireless access. Unsurprisingly, Starlink is mostly used by households in rural areas where limited or no terrestrial broadband services are available.

A new type of satellite service is now attracting attention, which is referred to as Direct-to-Device (D2D) or Direct-to-Cell connectivity, and allows communications direct from a phone to a satellite, without relying on the large dish that is needed for Starlink's broadband service. Dedicated satellite phones such as those sold by Iridium have been marketed since the late 1990s, but are relatively large, expensive and do not offer the features expected on today's modern smartphones.

However, in late 2022 Apple introduced emergency messaging capabilities via satellite on the iPhone 14, in partnership with the Globalstar satellite constellation. These services were initially limited to only sending texts to the emergency services for iPhone users who were outside terrestrial network coverage, but the

feature has saved numerous lives, most famously in the Lahaina, HI fires in August 2023. More recently, with the launch of the iOS 18 operating system in fall 2024, Apple extended the messaging capability to support two-way non-emergency texts and iMessages.

A second D2D/DTC service was launched by Starlink, in partnership with T-Mobile in July 2025, after beta testing of a basic texting service began in February 2025. Starlink's satellites use a small block of T-Mobile's terrestrial PCS spectrum to provide service. Another similar D2D service using terrestrial cellular spectrum is planned by AST SpaceMobile, in partnership with AT&T and Verizon. The AST service is still at an early stage, with only 6 satellites launched to date, and larger, more capable satellites are under development to provide full commercial service. As a result, the current coverage is very intermittent and service is not available to the general public.

At present, Apple's service only allows for basic texting and does not support voice or other data

services. The service only works outdoors and outside the coverage of terrestrial networks, and requires the user to point the phone in the direction of the satellite to establish a link so that messages can be sent and received. In February 2025, Globalstar ordered more advanced satellites to provide additional capacity for Apple, but the iPhone-based services will still be limited to relatively low data rates and it is unclear whether voice will be supported.

The Starlink DTC service supports texting, including picture messaging on some phones, and is now expanding to support certain apps such as weather and mapping, as well low bandwidth voice and video calling through WhatsApp and X. It is important to realize that this service is completely different to Starlink's broadband service: it uses lower frequency spectrum to enable communications directly with a phone, rather than via a large dish. Starlink currently only uses a small paired 5MHz block within in the US, which means that the capacity of the system is very low. Although Starlink has demonstrated peak download speeds of up to 17Mbps during testing, Elon

Musk acknowledged that "this is the current peak speed per beam and the beams are large, so this

system is only effective where there is no existing cellular service." In other words, all of the hundreds or thousands of customers within a beam that is 12-20 miles across must share this bandwidth, and just like in a terrestrial cellular network, the spectrum must be re-used between adjacent beams, further limiting the available download speed for any individual user, in most cases to 1Mbps or less, with upload speeds even lower. For comparison, the average download speed experience for individual terrestrial mobile users in the US in fall 2024 ranged from 46Mbps to 158.5Mbps. In addition, just like Apple, T-Mobile tells potential customers that they need to be able to "see the sky" to be able to connect to the Starlink D2D service.

In September 2025, SpaceX announced a deal to acquire a paired 25MHz block of spectrum from EchoStar, which will support a more advanced second generation of Starlink's DTC constellation. SpaceX plans to launch thousands of new satellites in the coming years, each with 20 times more capacity than the current satellites, and the new constellation is expected to have more than 100 times the capacity of the first generation system.

SpaceX expects this new system to provide "a comparable experience to current terrestrial LTE service" in other words more similar to 4G rather than 5G service, and states that it will "augment" rather than substitute for high capacity terrestrial 5G networks. Once the constellation is completed, which will take at least two years and perhaps longer depending on when the new Starship rockets are ready, users' typical download speeds are likely to be measured in the single digit Mbps, while upload speeds will be even lower.

AST has demonstrated similar speeds to Starlink's current service of up to 21Mbps in a 5MHz block of spectrum, and this has allowed the company to complete short two-way video calls, although at present the video quality appears to be relatively low. AST has claimed that it will ultimately provide "broadband from space to your phone" but the same laws of physics that constrain Starlink's performance large beams and restricted spectrum, resulting in a limited amount of capacity that must be shared by hundreds or even thousands of users will also apply to AST. In fact, AST's current beam size 48km or 30 miles diameter is even larger than Starlink's beams, though AST now plans to acquire additional satellite spectrum to enhance capacity in future generations of satellites.

AT&T signed a commercial agreement to provide cellular service from space with AST SpaceMobile in May 2024 and in October 2025, Verizon signed a similar deal. As an interim measure, Verizon is providing satellite texting services on certain Android devices through a partnership with Skylo and

once again tells potential users that they "must be outside with line of sight to the satellite".

Market analysis

The global mobile satellite services market size was valued at USD 6.31 billion in 2025 and is estimated to increase from USD 6.72 billion in 2026 to USD 11.12 billion by 2034, demonstrating a CAGR of 6.50% between 2026-2034. North America dominated the mobile satellite services market with a market share of 34.67% in 2025.

Mobile Satellite Services (MSS) refers to a range of telecommunication services that utilize satellite technology to provide two-way voice and data communication solutions for mobile and remote users. The MSS operates in the L-band sufficiently low in the frequency spectrum to avoid the rain fade associated with high-bandwidth fixed Ku and Ka-band satellite systems.

MSS terminals range in size from handheld devices to laptop devices. Unlike traditional terrestrial networks, MSS enables connectivity in areas where there is limited or no terrestrial infrastructure, which makes it particularly valuable for users who require communication services while on the move or in remote areas. MSS encompasses a range of services to meet diverse communication needs. These services include voice communication, messaging (text and multimedia), broadband data services, and location-based services. Mobile satellite services are often used in various sectors, including maritime, aviation, military, emergency response, and others. The growing need for high-speed broadband connectivity in areas lacking terrestrial infrastructure is expected to fuel the demand for mobile satellite services from 2026 to 2034.

Direct-to-Device (D2D) communication and High-throughput Satellites (HTS) technology are key trends gaining popularity in the market. D2D allows satellite services to reach end-user devices without the need for intermediaries and also eliminates the need for extensive ground infrastructure.

This trend enhances the versatility and accessibility of MSS in various applications. D2D helps in minimizing latency by establishing direct links between satellites and user devices, which results in improved quality of service for real-time applications. This plays a vital role in sectors, such as emergency response, where timely and reliable communication is critical.

For instance, in November 2023, Viasat Inc., a U.S.-based satellite communications company, and Skylo Technologies, a leading provider of Non-terrestrial Network NTN services, announced the launch of the world's first global direct-to-device network. For the first time, the companies' global infrastructure agreement will enable Mobile Network Operators MNOs, device manufacturers, and chipset manufacturers to

launch 3GPP Release 17-compliant products within Viasat's global network. The new network combines Skylo's industry-first Release 17-based satellite technology with a constellation of geostationary L-band satellites and other satellite carrier partners. The new network will support and unlock smartphone services, Potentially for large-scale Internet of Things IoT, automotive, and defense applications.

Satellite D2D spectrum

When someone is using their phone on a terrestrial cellular network, they are communicating with a nearby tower, which is at most a few miles away. In comparison, the satellites used for D2D services are hundreds of miles away: Globalstar's satellites are 880 miles above the earth's surface, Starlink's satellites are just over 200 miles above the earth and AST plans to launch most of its satellites to an altitude of around 430 miles. The power of a signal falls off in proportion to the square of the distance traveled, which means that a satellite transmitting from one hundred times further away than a terrestrial cell tower will produce a signal 10,000 times weaker than the terrestrial tower. Some of this difference is compensated for by using more power on the satellite, along with a large antenna that focuses the beam on a particular location.

However, for a given amount of spectrum, less data can be encoded in a weaker signal than in a stronger signal. In addition, the signal will not be able to penetrate reliably into a building, where according to T-Mobile "more than 80%" of network traffic "typically takes place." Instead users will at best be able to obtain intermittent coverage when they are standing near a window and a satellite happens to pass by on that side of the building.

Because the beams produced by the distant satellite spread out further, they are covering an area much larger than a typical terrestrial tower. A terrestrial tower in a suburban area may only cover a region that is 2-5 miles across, or 3-20 square miles, while a single satellite beam may cover a region that is 12-30 miles across, an area of 100-600 square miles, or 30 times greater. That means up to 30 times more people will have to share the same amount of capacity.

In addition, making significant amounts of spectrum available for satellite use is very difficult. Mobile operators now use hundreds of megahertz of spectrum in the US to provide service. Some of the higher capacity bands, such as the recently licensed C-band spectrum from 3.7-3.98GHz, are poorly suited to D2D service because the weaker power of satellite beams will not allow these frequencies to penetrate obstructions and support service inside buildings and cars or even under trees.

Lower frequency spectrum is also very valuable: the paired 5MHz block of spectrum that T-Mobile is making available for Starlink's current D2D service was valued by the FCC at \$4.8 billion back in 2004. SpaceX

has now agreed to pay \$19B including \$2B of interest to acquire a paired 25MHz block of spectrum from EchoStar for its second generation system. And because of the large size of satellite beams, if a particular spectrum band is used on a satellite system to provide rural coverage, it may no longer be available for use on terrestrial towers to provide capacity in nearby cities.

This has forced Apple and now both AST SpaceMobile and SpaceX to look to existing satellite spectrum to provide sufficient capacity for their needs. However, only a small amount of spectrum is allocated for satellite use, and existing users such as airplanes and ships depend on this spectrum for safety-critical services. All of these constraints mean that D2D can never match the performance of terrestrial networks, in terms of speed, capacity and building penetration.

Satellite and terrestrial

There are a few parts of the country where it will never be economically viable to deploy a terrestrial cell tower and the opportunity to cover these areas with D2D service is why mobile operators are partnering with satellite operators like Starlink and AST. AT&T said at its investor day in December 2024 that "you'll see us plug in [AST's] services on the edge where we don't cover, over the ocean, in the Grand Canyon, in places where, today, it doesn't pay for us to put up wireless cell towers to cover that footprint." Verizon has also stated that the aim of its partnership with AST is "to provide essential connectivity in remote corners of the U.S. where cellular signals are unreachable through traditional land-based infrastructure."

When mobile operators and tower companies decide to build or upgrade a cell tower, they are making that investment because the cell tower would be economically viable: consumers want and need 5G coverage in that area. D2D is not an alternative, it is simply a last resort fall back solution outside of terrestrial coverage. That is valuable in truly remote areas, and it may also be useful in the event of a disaster, such as a hurricane or earthquake, that makes terrestrial infrastructure temporarily unavailable. However, the limitations of D2D service: much lower speeds, limited capacity and poor coverage in obstructed areas like inside buildings, mean that D2D can never be a true substitute for terrestrial cellular service.

The forthcoming WRC-27 holds pivotal significance for the future of satellite D2D services as it will address potential new MSS allocations in Agenda Items 1.12, 1.13 and 1.14, as well as paving ways to accommodate future NTN development and innovations in other frequency bands. Collaboration between satellite operators, MNOs, and regulatory bodies is indispensable to realize the full potential of satellite D2D connectivity and usher in a new era of ubiquitous and seamless communications. By Tim Farrar

AFRICA REPORT

Why vessel traffic downtime remains high at Lagos port?



A vessel goes dark near a sanctioned region. An infrastructure disruption begins cascading across connected systems. A supply chain bottleneck starts affecting production timelines thousands of miles away. Modern operational risk moves fast. For years, organizations invested heavily in visibility tools that improved awareness across maritime operations, logistics networks, defense environments, and critical infrastructure. But visibility alone does not prevent disruption. Today's challenge is reducing the time between signal and response.

In Nigeria, the Lagos port complex is one port that needs Vessel Traffic System services because of its geographical location. It is located at the Apapa area of Lagos, south west Nigeria. Lagos port complex occupies a total land area of over 400 Hectares, a firm, flat terrain, sand filled and concrete paved land area. The geographical location is N6°27'25.1676", E3°22' 14.7252". The port operational area consists of berthing areas, cargo handling areas, stacking areas and storage facilities. The port of Lagos is Nigeria's leading port and one of the largest and busiest port in Africa.

Under the Nigeria Port Authority, the port complex is split into two main sections: Apapa port and Tin Can port. The Apapa port is situated in the main

channel next to Lagos Island and has container and bulk terminals. While the Tin Can port located in Badagry creek which flow into Lagos Harbor from the west is major and RoRo port. The port is connected to other part of the country via roads and a railway.

In 2006, the Federal Government introduced the landlord Port model to improve operational activities and efficiency, culminating in the concession of the terminals to private operators. Presently, the Apapa Port Complex has five private Terminals with expert management and personnel that have both local and international experience in port operation. The Terminal Operators are: AP Moller Terminal Ltd., ENL Consortium Ltd., Apapa Bulk Terminal Ltd., Greenview Development Nigeria Ltd., and Lilypond Inland Container Terminal.

The Tin-Can Island Port was commissioned in 1977 with a total of 13 berths covering a total length of 2185metres. It has the capacity to accommodate up to 13 vessels at once and specializes in the handling of general cargo, container activities as well as dry and liquid bulk. Ro-Ro or simply Roll-on-Roll-off port is the fourth component of the Western port. It was commissioned in 1977 as a part of the modern Tin-can Island Port. The port is basically a Ro-Ro port

as well as containerized cargo, according to the Nigerian Ports Authority report.

Lagos is the most populous city in Nigeria, the second fastest growing city in Africa and the seventh in the world. The population of Lagos urban area, according to Lagos state government is about 18 million. Lagos was reported in 2017 to have a metropolitan population of 21 million, making Lagos the largest metropolitan area in Africa

At any given moment, hundreds of vessels are underway across the oceans. Cargo ships, tankers, fishing fleets, ferries, research vessels, and naval assets crisscross shipping lanes and open water in a constant flow of commerce and activity. A meaningful share of them are not visible to the systems the port rely on to see them. This invisibility is rarely accidental.

Across the world, the Automatic Identification System, or simply AIS, remains the backbone of most vessel tracking. It was never built for security. AIS was designed in the 1990s as a collision avoidance tool, a way for ships to broadcast their identity and position so other ships would not run into them. It works well for that purpose. It works poorly as a surveillance system, and the people who most need to stay hidden understand its

limitations better than anyone.

According to industry expert, an AIS picture of the maritime domain is a picture of the vessels that agreed to be seen. For enforcement agencies, defense planners, insurers, and commercial operators, the vessels that did not agree are usually the ones that matter most.

Despite the geographical location, the Lagos ports complex only have a partial Vessel Traffic Station located at the Bullnose point of Apapa port and one Signal station at East mole to control the flow of vessel traffic. The station reportedly has no IMO license and therefore is not IMO compliance. Perhaps, the lack of adequate equipment and installations hinder the optimal utilization of the Vessel Traffic Station.

Therefore, there is need to access the present equipment and facilities gap at the partial Vessel Traffic Station and provide the station action card that will form recommendation to the Nigeria Port Authority with a view of IMO compliance. With the influx of traffic, the port will need to use Vessel Traffic Station data to control the flow of traffic with the Lagos Harbor in order to improve the safety of navigation. Modern Vessel Traffic Systems also requires sophisticated software to accomplish certain tasks.

Vessel Traffic Systems are made up of equipment such as VHF radio, radar, CCTV, Automatic Identification System, hydrological sensors, weather sensors. Vessel Traffic Systems also incorporates Vessel Traffic Systems data system for effective data recording and such data are made available when need. In recent years, software is needed to drive the Vessel Traffic Systems system for optimal operation more especially as Automatic Identification System is integrated.

At the moment, the Radar, CCTV cameras, VHF radios and GPS receiver are connected to a high-speed switch processing server which is feed into a workstation. The workstation is then connected to a group of display computer, the console from where vessels' traffic is monitored. The meteorological and hydrographic sensors are connected directly to the workstation. In addition, all Automatic Identification Systems are remotely connected to the workstation. The connectivity of these components provides real time particulars of vessel and makes the tracking and monitoring of vessels possible.

AIS versus satellite imagery

The common thread across every use case: fragmented, single-source data produces fragmented understanding. A modern intelligence architecture fuses multiple vantage points into a shared operational picture that supports informed decisions across sea, air, and space. What was once a specialized capability is quickly becoming a security baseline.

Government and commercial operators are not short on data; they are short on integration. Imagery sits in one system, AIS vessel positions in another, RF detections in a third, and terrestrial sensor feeds somewhere else again. Each source was often procured, stored, and analyzed on its own terms.

What that produces is duplication and contradiction rather than clarity. Two systems flag the same event differently, analysts burn hours reconciling feeds instead of acting on them, and genuine signals get buried in the volume. Adding another data subscription rarely helps, and usually just deepens the backlog. The real shift is this: value now comes from integration and interpretation, not acquisition. An operator who fuses ten sources well will outperform one who owns fifty that never speak to each other.

A satellite intelligence platform advances that goal when it integrates local and commercial data into one environment and puts the analytics in the operator's hands. The aim is to make the infrastructure a country already funds far more useful, not to replace it.

Partnerships accelerate this, since no single provider holds every relevant feed and building each capability from zero is slow. Combining regional data providers, specialist maritime intelligence sources such as Lloyd's list intelligence and established defense integrators produces operational capability faster than going it alone. The model applies

across defense planning, maritime enforcement, energy infrastructure monitoring, and supply chain resilience, where the underlying need is the same: convert data a nation already collects into decisions it can stand behind.

AIS transmits a vessel's identity, position, course, and speed over VHF radio. Satellites and coastal receivers pick up those broadcasts, and the resulting picture looks comprehensive. It is not.

The system is cooperative by design. AIS relies on vessels to transmit accurate information, and a captain can physically switch the transponder off. Although many vessels are legally required to operate AIS, the system itself cannot prevent disabling, manipulation, or false reporting.

Vessels can transmit false identities, falsify positions, or clone the identity of a legitimate ship operating elsewhere. Analysts have documented tracks in impossible places, including ships apparently circling in the Utah desert, and a falsified track showing a British warship entering Russian-occupied Crimea days before it actually transited those waters.

Electro-optical satellite imagery shows a vessel's appearance, size, and configuration, as well as whether it is underway or moored alongside another hull. It requires daylight and clear skies. Synthetic aperture radar sees through cloud cover and darkness, detecting radar reflections from vessels regardless of weather or time of day. It reveals presence but not always fine detail.

Radio frequency detection picks up the electromagnetic emissions a vessel produces even when its AIS transponder is off, since radars, communications equipment, and navigation systems all radiate. RF detection can help locate those emissions without requiring the vessel's cooperation. Layer these together, and a vessel that has disabled AIS is still detectable. RF can help locate its emissions, SAR can confirm a vessel at or near those coordinates, and optical imagery characterizes the target on a later pass. What no single sensor can establish, several sensors together can.

VTS operation at the Lagos port complex

In spite of the geographical location of Lagos ports and other factors such as width and depth of the approach channel, the Lagos ports complex only have a partial Vessel Traffic System station located at the Bullnose point of Apapa port and one Signal station at East mole to control the flow of vessel traffic. Vessel Traffic System operation is under the harbor service department of the Nigeria Port Authority. The principal Vessel Traffic System operator under the supervision of the harbor master overseas all signal activities at the Lagos port complex.

Information available at the Nigerian port statistics shows that about twenty-eight vessels pass through the Lagos channel on daily basics. The Ports Statistics reflected that ship traffic at the Lagos ports complex recorded a total of 3,534 ocean going vessels with 92,065,052 gross registered tonnages in 2019 as against 3,645 ocean going vessels with 94,898,545 gross registered tonnages in 2018, but today the figure is steadily improving. Similarly, a total of 8,243 service boats with 3,910,406 gross registered tonnages was recorded in 2019 as against 7,418 service boats with 3,193,402 gross registered

tonnages.

The Nigeria Port Authority uses Vessel Traffic Service to monitor the movement of ships inland out of the Lagos channel leading to Lagos port complex, Lagos pilotage area and the entire Vessel Traffic Service area of about 258km2. This is to ensure the safe and efficient movement of vessels to enhance safe navigation. Lagos port VTS is under the harbor department of Nigeria port Authority, Lagos.

The Lagos Vessel Traffic Service plans the movement of vessels and interact with vessel through VHF radio.

Also, the Vessel Traffic Service provides important navigational information and advice concerning navigation in the Vessel Traffic Service area and record detail of ship movement. Ship with length overall of over 30m must obtained clearance from the Vessel Traffic Service center before entry or leaving the VTS area. Masters or pilots must obtain clearance information before movement. At the anchorage, vessels can only anchor at the position assigned by the VTS center and such position must be continuously relay to the Vessel Traffic Service center via VHF channel 12. Finally, the Lagos Vessel Traffic Service center is opened 24hr a day and seven days a week. In the invent of emergency, the Vessel Traffic Service center is contacted.

Vessels Traffic Service is a maritime traffic management system established in a port or coastal area to monitor the movement of ships in order to improve the safety of navigation and protect marine environment. IMO regulation contained the guideline for establishing a Vessels Traffic Service system and the objectives it must meet.

The Vessels Traffic Service ensures safety and efficiency of navigation and thereby improving safety of life at sea. Vessels Traffic Service helps in avoiding dangerous traffic situation in Vessels Traffic Service area and thereby preventing collision of vessels that will have consequential impact on the marine environment. The Vessels Traffic Service achieves all these objectives through traffic monitoring, provision of information, traffic organization and provision of navigation assistance services.

Vessels entering the Vessels Traffic Service area are tracked and monitored with the aid of AIS. Vessels Traffic Service operators are perhaps the most important element of a Vessels Traffic Service system. As stated above, they are expected to possess the certification and competencies in line with IMO guidelines to perform Vessels Traffic Service functions.

Operators of Vessels Traffic Service expected to undergo regular training to be up to date with IMO standard in order to perform their task satisfactorily. Another important component of the Vessels Traffic Service system is the participating vessels. Though not compulsory, it is mandatory for all vessels that enter in the Vessels Traffic Service area to participate in Vessels Traffic Service. It is important for vessel entry to Vessels Traffic Service area to contact the Vessels Traffic Service center to obtain important information that will help in safe navigation and prevent marine pollution.

In Nigeria, the Lagos port Vessel Traffic System

station is located at the port tower situated at the bullnose point of Apapa port within the Lagos port complex. It is remotely connected to other Vessel Traffic System equipment such as AIS, CCTV, RADAR, and VHF. The configuration of Lagos port Vessel Traffic System is made up of one AIS, four VHF radio, two radio signal station, one radar, one meteorological station, seven CCTV, one RDF, Email and telephone.

The only AIS is strategically deployed around the harbor at port tower, though, the study later shown that three more AIS are needed at Tin Can Port, east mole station etc. The 4 VHF radio are situated at tower, west mole and Tin Can port. While the radar and the meteorological station are situated at port tower.

Masters of vessels or delegates call to Vessel Traffic System station via Radio to convey; Arrival Particulars, vessel's information and SOLAS, emergency information in case of an emergency under GMDSS channel. Master also relates "Information on Security and Safety requirements of the Crew and Vessel departure information and documentation to VTS station".

Lastly, the Nigeria's Ministry of transport need t to assess the current state of Vessel Traffic Service system at the Lagos port complex with a view of upgrading to IMO compliance. The assessment will entail equipment, facilities and staffing. The evaluation to be made according to IMO evaluation criteria of relevance, effectiveness, efficiency, impact, sustainability, coordination and effectiveness.

The Vessel Traffic System area is about 280km2 and has a boundary line of 125.7km. The Lagos anchorage and the pilot boarding point is within the Vessel Traffic System area. It is mandatory for all commercial vessels and vessels over 100 GRT to participate in the Vessel Traffic System or all vessels with an overall length greater than 30m must participate in the Vessel Traffic System when operating within the Vessel Traffic System coverage area.

Finally, for effective VTS operation at Lagos port, more AIS, DF radios, Radars and CCTV cameras with night vision are required to be situated in strategic positions to cover the entire Vessel Traffic System area. There is also need to increase the staff strength with the certification personnel.

At present, the only one Automatic Identification System that is connected to the Vessel Traffic Station is located at the Bullnose point of Apapa port. The Vessel Traffic Station operators requested for more seven CCTV cameras with night vision. According to report, more radars are also needed for optimal functionality of Vessel Traffic Station system at Lagos port complex. For search and rescue purposes, a helicopter is required if an incident of maritime accident occurs. Nigeria, as a maritime country, has not coast guard corps to take responsibility of maritime security.

As at present, the Nigerian Navy handle maritime security in Nigeria waters. The Vessel Traffic Station operators advised the Nigeria government to set up a coast guard. This will assist in maritime safety and security in Nigeria port and waters. The map below shows the position in which some stations' equipment are required to be installed.

Why real time space based intelligence is now more important than ever

Founded in 2014, BlackSky Technology, Inc is a space based intelligence company that delivers real time imagery, analytics and high frequency monitoring of the world's most critical and strategic locations, economic assets and events. BlackSky is trusted by many of the most demanding US and international government agencies and commercial businesses around the world. "We are defining a new category of space based intelligence products and services with real time imagery and automated analytics, delivered through an easy to use interface coupled with our high revisit and low latency satellite constellations both designed to help customers see, understand and anticipate change for a decisive strategic advantage" Brian O'Tool, CEO, BlackSky Technology, Inc. BlackSky can image many of the most strategic locations on earth up to 15 times per day, may traditional earth observation companies image twice per day.

The geospatial company designs, owns and operates the industry's most advanced, purpose built commercial, real time intelligence system that combines the power of the BlackSky Spectra tasking and analytics software platform and our high propriety high resolution, low earth orbit LEO small satellite constellation.

According to the company, BlackSky Spectra is a first of its kind commercial platform that helps customers manage their monitoring activities from space at industry leading speed, frequency, and economics. The BlackSky constellation is the primary sensor and communications architecture that delivers space based data to BlackSky's satellites fly in unconventional, inclined orbits, and with built-in automated systems, the constellation can distinctly deliver time diverse, dawn to dusk, rapid revisit imagery, and analytics with no humans in the loop.

BlackSky recently delivered the first very high-resolution images from the company's third Gen-3 satellite less than 24 hours following the satellite's successful launch. This Gen-3, unit three, very high-resolution image captured over the Port of Jebel Ali in Dubai, United Arab Emirates, shows a diversity of port activities including drayage operations, the movement of intermodal cargo containers from boxships via massive ship-to-shore cranes into stacks and then onto tractor trailers and tugboats actively assisting an oil tanker in docking operations as visible wake trails churn in the deepwater port. The BlackSky image was collected at 10:08 a.m. on November 22, 2025.

"BlackSky's third Gen-3 unit has delivered incredible initial image quality at unprecedented speed less than one day from launch," said Brian O'Toole, BlackSky CEO. "Customers no longer have to wait months typically associated with traditional commissioning timelines. BlackSky's rapid commissioning process places tasking capacity into customers' hands quickly and increases the overall operational life of each satellite as they come online sooner."

With remarkable clarity, the new Gen-3 satellite has delivered imagery detailing vehicles, maritime vessels, and aircraft of various sizes, as well as individual people and their shadows. The new Gen-3 satellite has already demonstrated fully automated tasking to delivery capability. Image quality is expected to increase as calibrations become complete, and the satellite enters its inal operational altitude.

"As BlackSky continues to expand our Gen-3 constellation, this successful mission signiies the value of strategic investments in advancing commercial space-based intelligence capabilities. Our purpose-built software and hardware architecture is uniquely suited to provide secure and iexible commercial services that complement national assets with mission-relevant tactical ISR capability at disruptive speed, scale and economics," said O'Toole.

BlackSky's Gen-3 constellation continues to evolve through a regular interval of launches that expand capacity, reduce latency, add flexibility and increase customer applications for automated real-time and predictive battlefield monitoring. BlackSky is leveraging its full technology stack of vertically integrated satellite manufacturing, software and AI solutions to meet global customer demand for guaranteed access to data, when and where customers need it, through novel delivery models like capacity sharing, Assured subscription access or full sovereign systems. Customers experience the value of BlackSky's capabilities in the On-Demand and Assured service and product offerings. BlaciSky Spectra augments propriety data collected from our constellations with input from third party sensors.

BlackSky generates revenues by selling on-demand and Assured products and services offerings that support a broad range of applications including national security, supply chain intelligence, crisis management, critical infrastructure monitoring, economic intelligence and others. These offerings are comprised of a predefined yet customizable, standard set of imagery and software analytics products accessible via basic subscription plan through our BlackSky Spectra software platform, plus professional and engineering services provided to customers on a project by project basis.

The changing geospatial market

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. In order 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 propriety 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 recently unveiled plans to expand its current high frequency monitoring constellation with multispectral, large-area collection satellites. These new satellites will be designed to support country scale digital mapping,navigation, maritime and 3D digital twin applications at unmatched speed and scale. Initially designated as AROS, the new satellites will augment the high frequency site monitoring capabilities of



Gen-3 to provide customers with dynamic broad area search, change monitoring, and predictable refresh of large area and 3D mapping datasets. BlackSky plans to launch AROS as early as 2027. Artist rendition: BlackSky.

AROS is optimized to collect new multispectral, proprietary, country and region scale datasets and is engineered to power the next wave of Aldriven geospatial and digital twin applications. This constellation will address upcoming gaps in the market as legacy large area collection satellites age out of service over the next few years and are replaced with lower collection capacity satellites. AROS will fill the gap with

increased capabilities at disruptive speed and more favorable economics.

"As legacy satellites approach end-of-life, we see a critical opportunity to address market needs—not just in performance and agility—but also in affordability and AI-readiness. As confirmed through active customer and partner engagement, BlackSky is meeting the modern demands of governments and commercial users who need persistent visibility over very large areas, fast," said Brian O'Toole, BlackSky CEO.

BlackSky's future, integrated constellation will be a first of its kind platform that combines very high-resolution

broad area search with site monitoring to provide dynamic tipping and cueing for advanced maritime and Golden Dome type applications. This advanced platform will be powered by the BlackSky Spectra® AI-enabled real-time tasking and analytics platform, which will offer customers a fully integrated set of solutions.

AROS has been under development for the past two years and was one of the key factors in BlackSky's recent acquisition of LeoStella. Mature, vertically integrated manufacturing and production capabilities are providing BlackSky a strategic advantage in the rapid development and

deployment of advanced space-based intelligence solutions. Leveraging the heritage of proven and reliable Gen-2 and Gen-3 architectures and manufacturing capabilities, the AROS system will incorporate BlackSky's space, software and platform stack with industry-leading, AI-enabled analytics. This announcement comes on the heels of two successful back-to-back Gen-3 launches when BlackSky demonstrated industry-leading speed and performance by achieving first light in under 24 hours and commissioning in under 60 days. These successes demonstrate the maturity of BlackSky's space platform capabilities that will be leveraged for AROS.

Building on BlackSky's Gen-2 and Gen-3 architectures, the new system will operate as an integrated extension of the company's existing fleet, unlocking an entirely new class of scalable, AI capabilities. BlackSly operates a constellation of satellites that is licensed by National Oceanic and Atmospheric Administration NOAA and is optimisd for latency and capacity and delivers high revisit imaging and analytic services without a dependency on any individual satellite. This approach enable the company to strategically deploy capacity to meet customer needs and tailor the capability over time to meet market demand. Under optimal conditions and measured from dawn until dusk, our constellation achieves a peak revisit rate of up to 14 revisits a day.

BlackSky Gen-3 latest deal

Many of the most important and demanding government and commercial organisations in the world, including US defense and intelligence agencies and international ministries of defense, rely on the actionable intelligence we provide. To compete effectively in today's data driven military battlefields and commercial market environments, governments and organisations of all sizes and industries face a growing need for timely and affordable geospatial intelligence and analytics to help shape critical decisions. To meet these customer demands, next generation geospatial intelligence platforms must have the ability to deliver situational awareness, location intelligence, and insights into events and activities as they unfold. BlackSky Technology Inc. recently secured a new eight-igure international contract for accelerated delivery of a Gen-3 sovereign space-based intelligence solution. The agreement combines

the sale of one Gen-3 very-high resolution 35-centimeter satellite with recurring, multi-year on-orbit operations and subscription-based Assured imagery and analytics services, leveraging the company's fully automated end-to-end architecture enabled by the BlackSky Spectra® software platform and its ground network to deliver real-time insights at mission speed and scale.

"With this agreement, our customer will have national on-orbit, best-in-class 35-centimeter imaging and AI-enabled analytics capabilities within months, not years," said Brian O'Toole, BlackSky CEO. "BlackSky is accelerating how our global customer base adopts advanced, space-based intelligence by quickly moving Gen-3 units from our agile production line

through our rapid deployment process, electively enabling long-term mission capabilities in very little time."

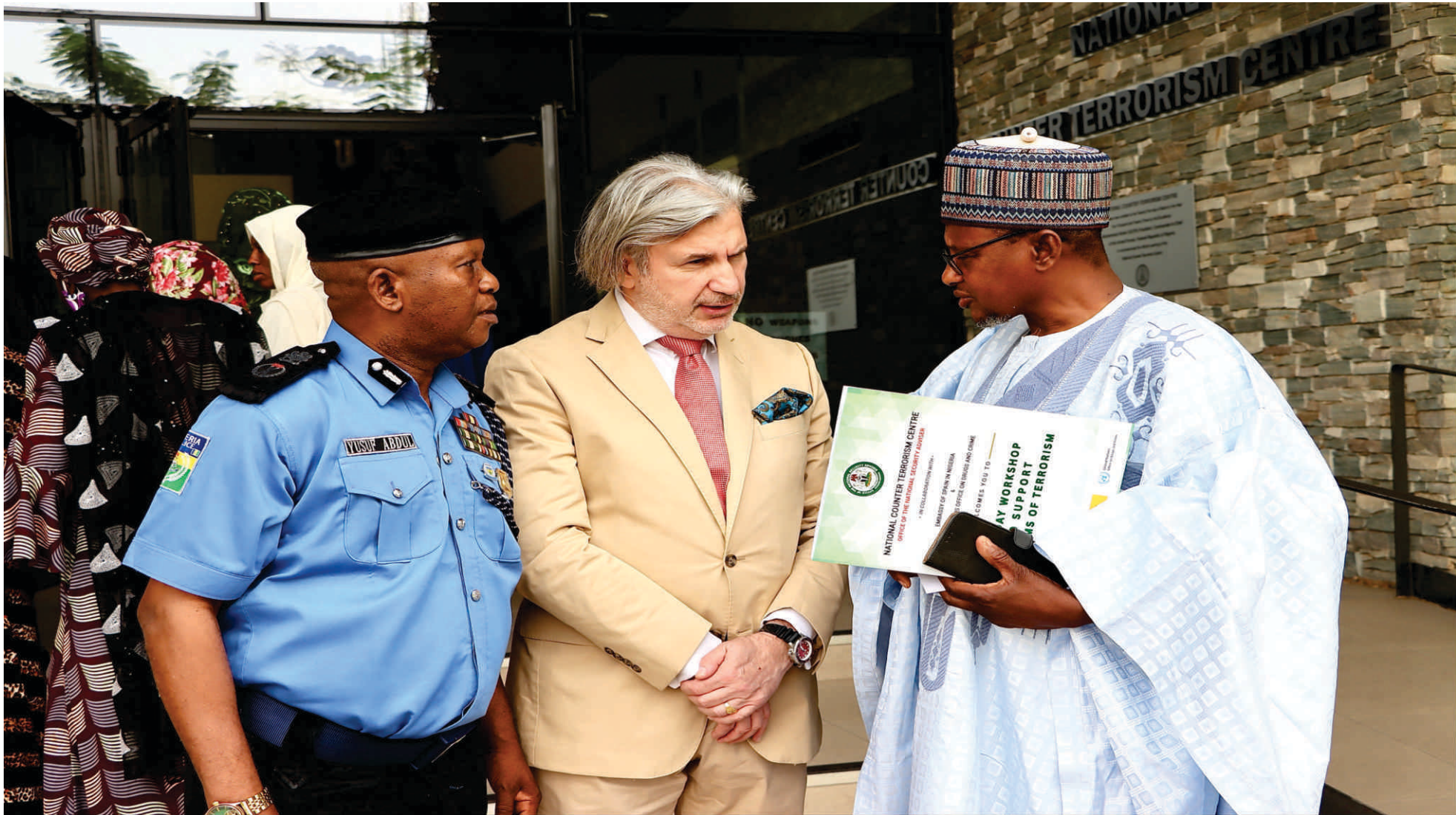
BlackSky sell to multiple US government agencies that span defense, intelligence and federal and civilian agencies. Our intelligence customers include the National Reconnaissance office and National Geospatial Intelligence Agency. In May 2022, BlackSky was awarded its largest imagery contract to date, valued at up to \$1 billion over a ten-year period with the NRO. Through this contract we have delivered thousands of images to the NRO and continues to support this important agency through additional study contracts focused on expanding new technologies. BlackSky provides analytics services to the NGA under an up to five year contract across a range of other governmental customers including Department of Defense such as the Air Force. Assured services provide the customer with immediate guaranteed access and priority tasking capacity through BlackSky's proprietary, dynamic monitoring constellation over their national and regional areas of interest. Once operational, the Gen-3 satellite will work in parallel to BlackSky's constellation to deliver mission-relevant insights at industry-leading speeds. Gen-3's enhanced image clarity expands AI-enabled detection, identification and classification for a wide array of vehicles, aircraft, vessels and other objects of tactical relevance.

BlackSky possesses proprietary in-house satellite design and agile manufacturing, constellation operations and end-to-end advanced software development capabilities. This vertically integrated approach enables the company to quickly develop, produce and deploy reliable space-based intelligence solutions at disruptive speed, scale and economics. To meet global customer demand for guaranteed access to data, when and where customers need it, BlackSky olers On-Demand and Assured subscription access or full sovereign systems. 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. "We can deliver our proprietary, on demand imagery at a lower costs than legacy providers due to our scalable software platform, our capital efficient constellation design, and adaptable pricing models among other things" said, Brian O'Tool, CEO Blacksky.

The need for real time space based intelligence is now more important than ever. Recent global events like the ongoing conflicts in 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.

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 our services for high revisit monitoring of airfields, vehicle depots, troop movements, and other high value locations to detect change in pattern of life. Gen-2 satellites can distinguish landscape features such as roads and buildings, and guage 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.

Harnessing geospatial technologies in Nigeria's counter terrorism operations



At the inception of Bola Ahmed Tinubu administration in 2023, Nigeria was at a defining moment in her history. Acts of terrorism perpetrated by Jama'atu Ahlus Sunna Lidda'wati Wal Jihad, otherwise known as Boko Haram still constituted an existential threat. The group was threatening to seize new local government areas to consolidate its dominance and project its evil ideology.

The administration proceeded to immediately strengthen international partnerships, and initiated a major reorganisation of the Counter-Terrorism and Counter-Insurgency operation, codenamed LAFIYADOLE. The government also

facilitated improved funding, procurement, operations, training, logistics and welfare for the security agencies to ramp up security operations across the nation.

Nigeria, Africa's most populous nation and its largest democracy, has faced some of the gravest challenges of terrorism, banditry, violent extremism, and other transnational threats. Kidnapping, armed banditry and militia activities have become very serious threats to Nigeria's national security, constituting about 40 per cent of incidences of national insecurity in Nigeria. To prevent the incidence of kidnapping, armed banditry and militia activities, the government

have proactively activate systems for early warning and early responses established in the national crisis response mechanisms.

The threat of terrorism and violent extremism has continued to challenge our security forces over the last decade. The splintering of Boko Haram Terrorists into two factions has compounded the complexity of the threat environment. The objective of the factions is to undermine the public trust in government. This is in consonance with the rise in global terrorism as a strategic threat with significant increase of its logistical, financial and operational capabilities. While the activities of terrorists have largely been

degraded by the combined efforts of the Armed Forces of Nigeria and other security agencies as well as the Multi-National Joint Task Force, there are still concerns that these terrorist groups remain a threat. The potential use of disruptive and emerging technologies remains a key concern considering growing advances in this field and the possible attack on Critical National Information Infrastructure.

The Boko Haram Terrorists and ISWAP have continued to carry out intermittent attacks on isolated targets with the ultimate aim of creating an Islamic Caliphate in the North East. The effects of this terror campaign includes mass

displacement and migration, creation of a large number of Internally Displaced Persons, undermining governance, rule of law, national cohesion and economic activities.

However, since its inception, the National Counterterrorism Centre NCTC, has lived up to its mandate of coordinating Nigeria's counterterrorism efforts, providing strategic direction, and serving as the hub for Whole-of-Government and whole-of-Society responses to terrorism and violent extremism.

In 2010, Nigeria was at a defining moment in her history, when the onslaughts of terrorism perpetrated by Jama'atu Ahlus Sunna Lidda'wati Wal Jihad, otherwise known as Boko Haram were at their peak and constituted an existential threat.

The government in 2022, established the National Counter Terrorism Centre NCTC, under the office of the National Security Adviser, out of a hard-won appreciation, earned in the crucible of conflict, that success in the struggle against terrorism requires a fusion of both kinetic and a non-kinetic approaches, linking technical sophistication in intelligence-gathering, inter-agency and multinational cooperation, and community resilience to achieve national goals. The National Counter Terrorism Centre NCTC in its current form now presents Nigeria with the opportunity to take on a regional leadership role in the fight against terrorism and violent extremism.

Since its inception, the Centre has lived up to its mandate of coordinating Nigeria's counterterrorism efforts, providing strategic direction, and serving as the hub for Whole-of-Government and whole-of-Society responses to terrorism and violent extremism. In line with the vision of His Excellency, President Bola Ahmed Tinubu, GCFR, that Nigeria must be secure for all, the National Counter Terrorism Centre NCTC has evolved into a national and regional centre of excellence in counterterrorism coordination. At the National Counter Terrorism Centre, the directorate of Intelligence functions as an all-source intelligence fusion centre comprising analysts from the Nigerian Armed Forces, Intelligence Community and Law Enforcement Agencies which serves as a central intelligence production facility, gathering and analysing information from diverse sources to assess threats to national security. The mission of the Directorate is to leverage technology, data analytics and expertise to fuse and integrate data from multiple sources in order to deliver timely, accurate, and actionable intelligence to the National Coordinator, National Counter Terrorism Centre NCTC, in support of national security efforts. Through collaboration with domestic intelligence agencies and international partners, the Directorate identifies vulnerabilities and opportunities to enable the National Security Adviser take informed decisions in the interest of national security.

In accordance with Terrorism Prevention and Prohibition Act 2022, the Directorate monitors activities of terrorist, violent extremist organisations and secessionist agitation groups as well as other national security issues. The Directorate is also saddled with the responsibility of producing intelligence summaries, contributing to overall security analysis, coordinating intelligence sharing with foreign partners,

maintaining databases of terrorists and persons of interest, setting threat levels and issuing warnings as well as supporting crisis management and engaging in counter-terrorism studies.

The NCTC's role as a Centre of Excellence is to bring experts together from across government, academia, and civil society to ensure that Nigeria's response leverages every tool at the government's disposal in the struggle to restore peace and stability to both the country, and the West African sub-region. The NCTC is intended to become a focal point for engagement with the international community of security professionals, as well as a learning hub for regional partners engaged alongside Nigeria in this struggle. Nigeria has learnt a lot of difficult lessons over the past fifteen years about what works, and what does not, in the fight against terrorism. It is only right that we should share these insights with our friends.

In addition, National Counter Terrorism Centre (NCTC) Directorate of Policy and Strategy is tasked with shaping Nigeria's strategic response to terrorism through robust policy frameworks, stakeholder collaboration and forward - thinking initiative. The Directorate has spearheaded transformative efforts to strengthen Nigeria's counter terrorism architecture, aligning national security objectives with global best practices. This is achieved through leveraging the whole-of-government and whole-of-society approach in ensuring proactive policy direction.

Similarly, the Centre's Directorate of Technical Services is responsible for carrying out the Implement strand of the National Counter Terrorism Strategy NACTEST document. The directorate, in accordance with the Implement string of the document is responsible for the strategic control of IED making materials such as importation, transportation, storage, distribution, usage and disposal of explosives and accessories, dual use chemicals, fertilizers and nuclear materials and CBRNE threat mitigation in Nigeria. The Directorate of Technical Services aims at focusing on attacking the network of illicit sourcing of Improvised Explosives Devices IEDs and Chemical Biological Radiological Nuclear-Weapons of Mass Destruction sensitive materials by emplacing strategic control on their importation, transportation, distribution, storage and usage in Nigeria, defeating the devices and preparing the forces through capacity building and awareness creation through advisory, and it house the 11 integrated forensic laboratory for effective forensic investigation, linking the criminal to the crime.

Geospatial analysis of attacks

Since its inception in 2002, Boko Haram's first major, well-known attack was reported on Christmas Eve, 2003, after coordinating series of attacks on police stations and public buildings in Geidam and Kanamma in northeastern Yobe state, a home state of one of its founder. Again, in 2004, the organization regrouped on the border of Nigeria and Niger, where they recruited and instructed university students and youth, whom were disillusioned by the economic and political situations in the northern states, in Quranic instruction. Since then, the group carried out small arms attacks on police stations in Borno state, which set the pattern of assaults on police,

leading to raids and arrests of group members by the police and security agencies.

For several years, violence attributed to Boko Haram spread into several other northern Nigerian states, escalating the conflicts with police. This pattern of conflict between the police and Boko Haram culminated in the July 2009 riots between members of Boko Haram and police in several northern states. In these riots, the Nigerian police and security forces killed approximately 700 Boko Haram followers, including the group's leader, Mohammed Yusuf, and imprisoned hundreds more. After these riots, the organization was broken up, and members fled in all directions, including to Mali, Niger, Algeria, Libya, Somalia, Afghanistan, and other countries in West and North Africa.

However, the group did not stay silent for long. In 2010, Yusuf's deputy, Abubakar Shekau, who have fled to a hideout in neighboring Cameroon after the 2009 riots, appeared in a video as the new leader of the group in which he vowed vengeance against the Nigerian state and "outposts of Western culture" in Nigeria including Hilton, the Sheraton, and the Nikon Luxury in Abuja. It was at this point, around mid-2010, that Boko Haram returned to Maiduguri in Borno State and began a campaign of assassinations against police and security forces. In September of that year, the group freed hundreds of prisoners from federal prisons in Bauchi state, including about a hundred Boko Haram fighters, using bombs and automatic Weapons. Then, on Christmas Eve 2010, Boko Haram detonated seven improvised explosive devices (IEDs) in Jos, Plateau state, targeting Christian communities and killing about 32 people. In June of 2011, the group launched the first known suicide attack in Nigeria using a vehicle-borne IED, which targeted the Inspector General of the Nigerian Police.

From its very beginning, the geographic mean center of Boko Haram's attacks, essentially their average latitudinal and longitudinal position weighted by number of fatalities, lay slightly west of Nigeria's northeastern region. In this area, the violent incidents typically occurred 220 miles from this mean point. About a third of the 269 incidents in 2012, representing 40 percent of the fatalities for that year, were located outside the three states of emergency.

However, this pattern changed significantly in 2013. Of the 238 violent episodes that occurred in that calendar year, just 37 were located outside the three northeastern states accounting for just 10 percent of 2013's total fatalities. The mean center of attacks in 2013 moved almost 130 miles eastward into central Borno, Nigeria's most northeastern state. The average spread of attacks in 2013 also shrank by a third compared to 2012.

This more spatially concentrated distribution of violence has since held steady. The mean center of the 341 Boko Haram incidents and attacks in 2014 moved slightly eastward, closer to Nigeria's border with Cameroon. Notably, it rests within just a few miles of the town of Chibok, where more than 300 girls were kidnapped by Boko Haram in April 2014. The overall average spread of

incidents in 2014 was roughly the same as in 2013.

But other subtler differences distinguish the geographic patterns of Boko Haram violence in 2013 and 2014. Attacks in 2014 were clustered along the border between Nigeria and Cameroon. About 56 percent of all Boko Haram attacks and fatalities in 2014 occurred within 50 or fewer miles of this border, an increase from 40 percent in 2013. Similarly, in 2013 there were 43 Boko Haram attacks featuring 648 fatalities in Maiduguri, the capital of Borno State located about 100 miles from the border from Cameroon, yet there were just 10 attacks and 164 fatalities in the city in 2014.

The tri-border region where Adamawa and Borno States meet Cameroon experienced especially high levels of violence. Roughly a third of all attacks and all fatalities in 2014 took place within 50 miles of the Borno-Adamawa border with high concentrations near Cameroon. Many of the towns and villages along the border areas experienced repeated attacks throughout 2014, suggesting Boko Haram's hold over some of these border areas is not entirely firm.

Types of targets and engagements also shifted between 2013 and 2014. Whereas the group was as likely to attack civilians in 2013 as it was to engage in battles with Nigerian security forces, in 2014 about 54 percent of all incidents of violence were attacks on civilians while just 39 percent were exchanges with the military and police.

To be clear, these figures reflect only general trends and geographic distributions. There were several large bombings in 2014 that featured dozens or hundreds of deaths in Kano, Jos, and Abuja, far from Nigeria's northeast. But the group appears to be concentrating a relatively larger proportion of its wherewithal and energy on a smaller and more remote border area.

Boko Haram geospatial data

Over 85% of Boko Haram incidents occurred in Nigeria, since the northeastern Nigerian state of Borno is the epicenter of the group's founding and activities, and many of the group's grievances have been centered on the way of life in Nigeria and against the Nigerian government. The second highest number of attacks occurred in Cameroon to the east and south, then Niger to the north, and then Chad to the east with the fewest number. However, since the onset of the campaigns, fewest number of incidents occurred in 2009 and 2010, at 10 and 18, respectively, with steep rises in numbers in 2011 and 2012, and then a drop in 2013. The number of incidents then rose again from 2013 to 2014 and peaked in 2015 at 492, before dropping again in 2016 and staying relatively consistent with some variations from 2016 to 2020.

These patterns reflect the reemergence of Boko Haram in 2009 and 2010, increased activity in 2011 before the government sent out a Joint Task Force of military and police against the group, leading to the reduction in attacks in 2013 after a high in 2012. Then, in 2014 the group was named the deadliest terrorist organization in the world as it spread into surrounding Nigerian states and into Cameroon, Chad, and Niger from 2014 to

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2015, which corresponds to the peak of the number of the group's attacks in 2015.

Clearly, the vast majority of incidents committed by Boko Haram from 2009 to 2020 in the four target countries were committed against Private Citizens and Property, likely to instill fear into the general public to further the group's political and religious extremist ideologies and act upon their grievances discussed in the Background and Objectives section.

The second highest number of incidents against Police targets supports the prior knowledge that Boko Haram has spent much of its existence combating police forces, which the group has viewed as an excessively brutal and abusive arm of the secular governments it wishes to overthrow, throughout Nigeria and the surrounding countries. The third most frequent target type was Religious Figures and Institutions, which Boko Haram aimed to punish Muslims, including members of other religions it believes are guilty of apostasy and blasphemy.

Of the nine attack reported, Boko Haran committed terrorism incidents utilizing eight of those nine attack types, with the number of incidents by attack type greater than the total number of incidents. The report revealed that, of the 2,832 incidents, 1,446 of them were of at least one attack type of the Armed Assault type, with the second highest number being Bombing and Explosion at 884 incidents. Furthermore, of the 13 weapon types reported, Boko Haram committed incidents using nine of those weapon types.

In addition, the patterns of increasing yearly shares of incidents from 2011 to 2020 are also seen for the attack types facility and infrastructure attack, kidnapping, and related attack, respectively, though there were no corresponding decreasing yearly shares of incidents of other attack types.

This means that, over time, Boko Haram did not necessarily shift their mode of attack from some few select attack types to another few, but instead Boko Haram decided, purposefully, to increase the group's share of yearly incidents utilizing facility, infrastructure attacks, kidnappings, and related attack types. Interestingly, this indicates that from 2011 to 2020, Boko Haram carried out a greater share of incidents as kidnapping attacks for instance, the kidnapping of 300 school girls in Chibok in 2014, and attacks on women and girls.

Impacted cities

Of the 78 states across the countries of Cameroon, Chad, Niger, and Nigeria respectively, 33 of them had at least one incident occur within them. However, 25 of those 33 impacted states were in Nigeria, four were in Niger, two were in Cameroon, and two were in Chad. Most of the states are concentrated in the northern and eastern halves of Nigeria, and four of the other impacted states outside of Nigeria border the northeastern Nigerian states.

So far, report shows that each state reported at least a double-digit number of incidents, the

country in which that state is located, and the percentage of total number of incidents that were in each state. However, 11 of these 14 states are in Nigeria, and the other three are one each in Cameroon, Chad, and Niger. So far, Borno state of Nigeria had the greatest number of incidents at 1,564, followed by the Extreme-North region of Cameroon with 288, followed by Yobe state of Nigeria with 247, and so on.

The border with Cameroon is critical. A stronger deployment of security forces in key areas along the frontier zone may lower the incidence of attacks on civilians and lead to more occasions to engage and weaken Boko Haram units. This would require tight security coordination with Nigeria's neighbors to encircle Boko Haram, thereby limiting the group's mobility and the benefits it realizes from operating across borders. It must also balance a population-centric deployment in which military units remain in high-population border areas to defend against attacks on civilians with mobile support units that can respond quickly to intelligence and Boko Haram maneuvers.

Report shows that Boko Haram attacks appear to be concentrated in the state in which the group was originally active, especially in Borno and largely in the surrounding states. However, by incidents per 100,000 people, Borno is in first at 24.9, followed by Diffa in Niger at 15.6, Lac in Chad at 8.2, and then Extreme-North in Cameroon at 7.0. So, on a per capita basis, while Borno in Nigeria is still on top, the three other highest states were actually the states surrounding Borno in the other three countries of interest, showing the low population impacts of these states.

There were 1,047 unique cities, town, or villages in the four target countries in which at least one terrorism incident committed by Boko Haram occurred from 2009 to 2020. This means that for the 2,832 attacks, there were about 1,047 impacted unique cities, which indicates a ratio ranked by attack-to-city ratio, of 2.70 attacks for every one impacted city on average. Nigeria accounted for about 78.5% of the total number of impacted cities, the vast majority, which makes sense because Nigeria accounted for 85.2% of the total number of 2,832 incidents.

However, the share of impacted cities in Nigeria is less than its share of total incidents, and the shares of impacted cities in the other three countries are greater than their share of the incidents. This could mean that incidents were slightly less concentrated by city in the countries of Cameroon, Chad, and Niger compared to in Nigeria. This was confirmed by attack-to-city ratio for each of the four countries, where a greater number means a higher concentration of incidents per city, and vice versa: Nigeria, 2.93; Cameroon, 1.99; Niger, 1.81; and Chad, 1.35. Nigeria's attack-to-city ratio is greater than the other countries and slightly greater than the ratio of all incidents and impacted cities at 2.70, indicating incidents per city were more concentrated in Nigeria compared to all incidents per city overall.

Incident locations and road proximity

The vast majority of impacted cities are located in the northeastern states of Nigeria, namely Borno, and the immediate surrounding states in Nigeria, Cameroon, Chad, and Niger. Many of the cities appear to be located near the center of Borno state, which is also the location of the state's capital Maiduguri. There also appears to be a half-ring or curve-like cluster of impacted cities south of Maiduguri.

Outside of this concentration in the northeast of Nigeria, the number of impacted cities seems to disperse and become sparser as one moves west, south, and a few northwest-ward in the western states of Niger. These 833 mapped cities represent 2,545 mapped incidents, which is 89.9 of the total number of incidents of 2,832.

However, the number and locations of incidents have changed from 2009 to 2020, with the number of incidents represented with proportional symbols, in which a larger the symbol indicates more incidents at that point location. The headquarters and dates active are as follows: July 2009 to March 2015: Gwoza, Borno, Nigeria; April 2015 to September 2015: Marte, Borno, Nigeria; March 2015 to May 2021: the Sambisa Forest, Borno, Nigeria. The mapped incidents in 2009 occurred in two cities, the majority of which in the Borno state capital Maiduguri in the center of the state, and the others in a city to the northeast on the border with Cameroon.

This report shows that the reported headquarters of the group at Gwoza, though, was southeast of Maiduguri on the border with Cameroon. An attack-to-city ratio of 5 in this year reveals that there were five times as many incidents as cities attacked, representing the concentration of incidents relative to the number of cities.

In 2010, a large number of incidents occurred in Maiduguri again, even as the group began to spread almost linearly from Maiduguri southwest-ward to commit incidents in the cities of Jos and the national capital Abuja, about 400 miles from Maiduguri. With an attack-to-city ratio of 4, there were four times as many incidents as cities attacked, representing the concentration of incidents relative to cities, but with less relative concentration compared to in 2009.

In 2011, outside of Maiduguri, which experienced a large number of incidents again, a smaller number of incidents occurred in more cities around Maiduguri and southwest-ward, once again somewhat linearly, with some numbers in Jos and Abuja. In that year, the group reached as far west and south as the Delta State near the Atlantic Ocean, about 630 miles from Maiduguri. With an attack-to-city ratio of 5.55, 2011 is the year in which the incidents were most

concentrated relative to attacked cities, with over five times as many incidents as cities attacked. In 2012, report shows the greatest number of incidents occurred again in Maiduguri and the surrounding towns, with some now popping up near the HQ of the group.

At this point, the next largest number of incidents occurred in just a few cities directly west of Maiduguri, the second largest number of which occurring in the city of Kano near the northcenter of the country. Once again, there was near linearity of incident locations in relation to each other from the northeast to the southwest. In 2020, the group reached as far west as Sokoto in a northwestern state near Niger.

With an attack-to-city ratio of 4.40, where there were 4.40 times as many incidents as cities attacked, representing the high concentration of incidents relative to cities, though less than the previous year. In 2013, report revealed the greatest number of incidents in Maiduguri, with some other large numbers in other cities in the north of the country, like Kano.

However, the vast majority of the incidents are now back in Borno in and around Maiduguri, particularly some concentrations of incidents near the HQ. At this point, the group attacked as far west as Niamey in Niger about 700 miles from Maiduguri, as far south as near the major city of Lagos in the southwestern part of the country near the Atlantic Ocean and Benin about 700 miles from Maiduguri, and as far east as Cameroon's Extreme-North.

This represents the year of one of the largest areal extents of the group's reach, and the first year the group committed incidents outside of Nigeria. This map also highlights the beginning of the free movement between countries that Boko Haram was able to achieve due to the lack of secure borders of Nigeria, Niger, Chad, and Cameroon, largely because of the Sahel in northern Nigeria.

In 2014, report also indicate that a number of incidents occurred in larger cities and smaller towns throughout Nigeria, particularly to the west and some to the south, but the vast majority occurred in Borno, Yobe state to its west, and Adamawa state to its south, with a clustering of incidents along the Cameroon border near the HQ. Once again, at this point the group reached Lagos in the southwest of the country, spanning its entire diagonal length (about 700 miles), and this was the first year the group committed an incident in Chad, at the city of N'Djamena.

With attack to city ratio in the year was 1.94, which is the lowest of all previous years, displaying how incidents were becoming more spread out relative to impacted of cities as time progressed. In 2015, report revealed that the vast majority of incidents occurred in Maiduguri and Borno at large, but this time with a clustering along the Niger and Chad borders to the north and northeast, and along the Cameroon border to the south.

In this year, the group is reported to have several different HQs, including the original at Gwoza, a



brief one at Marte, and the establishment of one in the Sambisa Forest. In this year, many of the incidents appear to be clustered near the two southern HQs at Gwoza and the Sambisa Forest. Also at this time, the half-ring of incidents in south of Maiduguri is starting to form. The near linear patterns of incidents diagonally across the country was also visible, which is why the proximity of incidents to major roads was investigated as well.

In 2016, a fewer incidents occurred in secluded spots throughout Nigeria, but the most significant numbers occurred in Borno, Maiduguri, and near the HQ in the Sambisa Forest, with the half-ring pattern once again visible. 2016 represents the first full year that the Multinational Joint Task Force began fighting back against Boko Haram since its reinstatement in 2015, and the efforts of the Joint Task Force to push the group out of most of Nigeria and back into Borno start to show with these spatial

point incident patterns.

With an attack to city ratio of 1.49, there were about one-and-a-half times as many incidents as there were cities impacted, meaning the concentration of incidents relative to the number of cities is much lower in this year compared to all previous years. This year is the start of the attack to city ratio staying relatively the same throughout the remaining years around 1.30-1.60, which symbolizes how Boko Haram's attacks were in almost as many cities as the number of attacks themselves.

In 2017 a few incidents spread diagonally through the center of Nigeria, extending down to Benin City, but the vast majority are in Borno and Maiduguri, once again with the ring of incidents forming near the HQ at Sambisa. There are also a few incidents located in the adjacent Extreme- North in

Cameroon and Diffa state north of Borno in Niger, though nothing too different from previous years. This is also the last year that the noticeable near linear diagonal pattern of incidents through Nigeria, perhaps due to a road network, is present.

Finally, in 2020, there were a few incidents in northcentral Nigeria, but this time none in the south, and the majority in the northeast of the country and neighboring states in Cameroon, Chad, and Niger. The half-ring cluster of incidents near the Sambisa Forest HQ is once again visible, and the circle of incidents around Borno is somewhat distinguishable. The attack to city ratio in this year is 1.34, which is the lowest of all years, symbolizing the low concentration of incidents relative to the number of cities in this year. Report shows the attack to city ratio over for each year, where one can see that from 2011 to 2015, attack to city ratio dropped quickly until 2016 where it stayed relatively constant through 2020.

This shows that while Boko Haram incidents started out far outnumbering impacted cities, indicating the concentration of incidents at the city level, the number of incidents started to be more equal to the number of cities overtime, indicating decreased concentrations of incidents at the city level. All of these figures together have shown the geographic growth, peak, and decline of Boko Haram in Nigeria, Cameroon, Niger, and Chad from 2009 to 2020. From this analysis of point distances from major roads, it seems clear that Boko Haram heavily utilized major road networks, especially from 2009 to 2013, and particularly when choosing a target type, considering nine target types had minimum distances of 50% of their incidents from major roads at 0.9 miles, below the 1.2 miles of all point incidents, and one at 0.6 miles.

Clearly, those nine target types, such as Government and Religious Figure as well as Institutions targets, accounting for at most 1,227 mapped incidents some target types likely overlapped were most easily accessible

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from the major road networks, and Boko Haram took advantage of this proximity. The same can also be said for when the group chose an attack type, in which assassination, barricade, and bombing attacks were most available and advantageous near a major road, and also of weapon type, in which Explosives, used in Bombings, were most easily deployed on or near these roads.

The National Counter Terrorism Centre

In 2022, the Nigerian Government repealed the Terrorism Prevention Act 2011 (as amended) and enacted the Terrorism Prevention and Prohibition Act. Section 1 (a) of the TPPA clearly states that the purpose of this new legislation is in part to provide an “effective, unified and comprehensive legal, regulatory and institutional framework for the detection, prevention, prohibition, prosecution and punishment of acts of terrorism, terrorism financing, proliferation and financing the proliferation of weapons of

mass destruction in Nigeria.

In keeping with this objective, and with the need for a unified whole-of-government approach to the threat of terrorism set out in the National Counter Terrorism Strategy, NACTEST, Section 6 (1) of the Terrorism Prevention and Prohibition Act formally established the National Counter Terrorism Centre NCTC as: “The coordinating body for counter terrorism and terrorism financing in Nigeria, charged with the coordination of counter terrorism policies, strategies, plans, and support in the performance of the functions of the National Security Adviser.”

The National Counter Terrorism Centre NCTC which is headed by a Coordinator, has pioneered key initiatives since 2012. These include, providing leadership, coordination and strategic guidance to security, law enforcement and intelligence agencies. The Centre's relationships with relevant partners transcend state actors, to include Civil Society Organizations, International Partners, Counter Terrorism platforms like the Global Counter Terrorism Forum, Global Community Engagement and Resilience Fund,

Hedayah, based in Abu Dhabi and the United Nations and its entities.

Situated within the Office of the National Security Adviser under the direct supervision of the National Security Adviser, the NCTC is headed by a National Coordinator, the NCTC is structured into seven directorates and four departments.

Since its establishment, the Centre has already gathered together some of the leading counter terrorism professionals working in Nigeria today, with a considerable degree of firsthand experience seeking to prevent terrorist and violent extremist activity. This expertise will now be directed towards the achievement of these objectives and the development of a range of critical services and outputs designed to augment Nigeria's struggle against terrorist violence, and to share the knowledge and experience gained over the past fifteen years of bloody conflict in the Northeast with allies and partners across West Africa, the Sahel and beyond.

The NCTC's role as a Centre of Excellence is to bring experts together from across government,

academia, and civil society to ensure that Nigeria's response leverages every tool at the government's disposal in the struggle to restore peace and stability to both the country, and the West African sub-region. The NCTC is intended to become a focal point for engagement with the international community of security professionals, as well as a learning hub for regional partners engaged alongside Nigeria in this struggle. Nigeria has learnt a lot of difficult lessons over the past fifteen years about what works, and what does not, in the fight against terrorism. It is only right that we should share these insights with our friends.

As a regional center of excellence, the National Counter Terrorism Centre's activities entails regular terrorism assessments, forecasts, and analytical reports that the Centre prepares for key government customers, counter terrorism partners at the state and federal level, and participating member countries who share information with the Centre. These assessments and reports provide useful insights and timely data on violent extremism and terrorism threats for policy makers, law enforcement organisations, and, on occasion, public and private entities.

NCTC is already well-connected to leading research institutions such as the Hedayah International Centre for Countering Violent Extremism in Abu Dhabi, the Royal United Services Institute in the United Kingdom, and Institute for Security Studies in South Africa, but over the next five years its intention is to develop and elevate homegrown research talent from Nigeria, West Africa and the Sahel, capable of conducting studies on the ground in local languages tailored to address gaps in existing knowledge and understanding of the nature of local challenges.

Highlighting the statutory mandate of the NCTC, General Laka explained that the Centre coordinates and integrates the activities of security, intelligence, and law enforcement agencies, while also serving as the hub for interagency cooperation and international collaboration. “As we review NACTEST, we must align it with this mandate to ensure a more structured and effective counterterrorism approach,” he added.

“The threats we faced in 2016, and those we anticipated then, are quite different from the realities of today's security environment,” he said. “This dynamic nature of the threat landscape necessitates a comprehensive review of NACTEST to ensure its continued effectiveness in countering terrorism in Nigeria.”

In the realization of the fact that no single country can successfully fight terrorism on its own, the NCTC's mission over the next five years is to help create a West African and Sahelian community of counter terrorism professionals that can work effectively together to ensure the peace, security and prosperity of every citizen in the region, says General Laka.

Nigeria's counterterrorism efforts have recorded major successes. This has been seen in the liberation of major towns and villages in the North East, the steady return of internally displaced persons to their communities and the gradual reconstruction of whole communities.

Nigeria has also witnessed the continuous capture and detention of active Boko haram fighters by security forces leading to the need for these fighters to face justice within the rule of law. The need to also seek justice for victims of the heinous crimes perpetrated by the terrorists has remained one of the cardinal objectives of the present administration.

The Centre, according to General Laka has been deepening its collaboration with critical international and regional development partners to expand its frontiers in not only in the fight against terrorism but also in advancement of knowledge.

Multi-Agency kidnap fusion cell to combat ransom crisis

Responding to the growing threat of kidnap-for-ransom across Nigeria, the National Counter Terrorism Centre NCTC, operating within the Office of the National Security Adviser ONSA, announced operationalizing its Multi-Agency Kidnap Fusion Cell. The launch, which took place on December 19, 2024, marks a significant step in the current administration's strategy to enhance national security and protect citizens from criminal exploitation

The establishment of the Fusion Cell is a direct result of the Security and Defence Partnership forged between the National Security Advisers of Nigeria and the United Kingdom in 2022.

This partnership recognizes the shared commitment to democratic governance, human rights, and regional stability, and provides a framework for collaboration on critical security challenges. Over the past two years, the UK's National Crime Agency (NCA) has worked closely with the ONSA and the NCTC to provide vital capacity building support. This includes training, technical assistance, and the development of best practices for intelligence sharing and operational coordination. The Fusion Cell represents a multiagency approach, bringing together expertise and resources from over 15 law enforcement agencies and stakeholders to create a unified front against kidnapping.

However, Major General A.G. Laka, National Coordinator of the NCTC, emphasized the critical role of the Fusion Cell. “This is not just another committee,” he stated. “This is a 24/7 coordination center designed to break down silos, improve information flow, and ensure a swift, effective response to kidnapping incidents. It is a crucial component of our national security architecture.”

Shielding energy infrastructure from terror threats

The electrical power grid is a vast, interconnected network that enables the generation, transmission, and distribution of electricity, a backbone of modern society and critical infrastructure. Reliable electric power underpins economic activity, public safety, and national security, which is why power grids can be a prime target of different kind of hybrid threats that combine cyber-attacks, physical sabotage, and other tactics to disrupt essential services.

The Office of the National Security Adviser ONSA has reaffirmed Nigeria's commitment to safeguarding its energy transition roadmap and securing the country's critical minerals value chain, describing them as central to national development and global competitiveness. This was disclosed at the National Counter Terrorism Centre NCTC, Abuja, during a strategic stakeholders' engagement convened to review key recommendations from the World Bank-supported energy transition framework. In the face of evolving hybrid and non-linear threats, National Counterterrorism Centre, NCTC is integrating diverse sources to generate forward-looking assessments, particularly for small and medium-sized states. Modern intelligence is multifaceted, encompassing a wide range of fields such as Open-Source Intelligence OSINT, Signals Intelligence SIGINT, Geospatial and Imagery Intelligence GEOINT, Measurement and Signature Intelligence MASINT, Cyber Intelligence CYBINT, and Human Intelligence HUMINT. Each of these intelligence areas forms an extensive framework through which information is collected from numerous sources.

Delivering the keynote on behalf of the National Security Adviser, Mallam Nuhu Ribadu, the representative of ONSA welcomed participants and conveyed the NSA's regards, noting that he was unavoidably absent due to pressing national

engagements. He stressed the importance of the forum in ensuring that Nigeria's wealth of natural resources contributes to sustainable economic prosperity rather than becoming a vulnerability exploited by criminal and terrorist networks. “Today's discussions are of strategic significance as we work towards implementing key recommendations from our recent engagement on Nigeria's energy transition roadmap, as proposed by the World Bank,” he said. “Our rich natural resources position us as a key player in this transition, yet we must also remain vigilant against emerging security threats that could undermine our progress.”

The session highlighted several priority measures designed to fortify the sector. Top among them is the intensification of surveillance, with the Department of State Services tasked to strengthen monitoring of mining activities to prevent infiltration by terrorist groups. The Ministry of Solid Minerals Development was urged to tighten vetting and certification processes to ensure only legitimate operators receive licenses, thereby curbing illegal exploitation. In addition, the Economic and Financial Crimes Commission (EFCC) and the Nigerian Financial Intelligence Unit (NFIU) are to step up financial oversight of the sector to detect and deter money laundering and terrorist financing linked to mining operations.

Equally emphasized was the need for stronger institutional collaboration. The Ministry of Solid Minerals Development Mines Marshal and the ONSA Directorate of Energy Security have deepened synergy for a unified approach to sectoral security, while the Federal Ministry of Information and the National Orientation Agency were tasked with protecting Nigeria's national image and promoting positive global perception. “These measures are not just about security; they are about safeguarding Nigeria's future and ensuring that our natural resources drive economic prosperity rather than become tools for criminal networks,” the representative stated.

Nigerian Government Launches CT TECH+ Initiative

With the support of the United Nations Counter Terrorism Centre (UNCCT) of the United Nations Office of Counter Terrorism (UNOCT) and the International Criminal Police Organization (INTERPOL), the National Counter Terrorism Centre (NCTC), Office of the National Security Adviser (ONSA) has launched for the Country, the Counter Terrorism (CT) Technologies + Initiative. The ceremony was held at the NCTC, ONSA in Abuja, 24 April, 2025. Speaking at the CT TECH + Kick-Off meeting, the United Nations Resident Coordinator in Nigeria, Mr. Mohamed Malick Fall commended the Nigerian Government for its unwavering commitment to strengthening national security while upholding the principles of international law.

Mr. Fall observed that we live in a time of rapid technological advancement, where the new and emerging technologies held the potential for development, civic engagement, and promotion of human rights, and he however expressed regrets the technologies were increasingly being exploited by the terrorists to spread fear, recruit, radicalize, finance their operations and conduct their heinous attacks. He added that Artificial Intelligence, the Darknet, encrypted

communication platforms, and virtual assets were now tools for the enemies of humanity whose activities caused threats that were evolving faster posing serious challenges for law enforcement and national security operatives.

He explained that it was in recognition of these challenges that made the United Nations General Assembly, in its seventh review of the Global Counter Terrorism Strategy, called on the international community to strengthen support for member-states in countering threats and leveraging the opportunities provided by new technologies. “The CT TECH + Initiative is a direct response to that call”, he said.

While listing what the CT TECK+ will do within the next 2 years, Mr. Fall noted that Nigeria stood long as a vital partner in regional and global counter terrorism efforts, and that for close to 15 years, the United Nations have been working in tandem with Nigeria in supporting criminal justice reform, DRR programmes, and community resilience initiatives. The NCTC boss reasoned that technology has ushered us into 2 interconnected realms of the physical world and the digital domain, and that as innovation continued to evolve with the emergence of new technologies at space unprecedented, vast opportunities present themselves, but also with complex, dynamic, and ever-changing risks. He says, “To this end, the digital age has opened a gateway for terrorists to exploit emerging technologies from artificial intelligence to autonomous technologies, encrypted communications, and blockchain based financial tools, among others. The access to radical content, recruitment platforms, illicit funding mechanisms, and the anonymity provided by cyberspace have also compounded the threats we face daily”.

General Laka mentioned a disturbing trend where terrorists used commercial weaponized drones for surveillance over military deployments, and delivering explosive payloads, urging the initiative to take a critical look into the areas of grave concerns. He added that the initiative was apt, advocating innovation, adaptation, and strategic foresight in addressing the challenges of terrorism. “At the NCTC, we firmly believe in proactive, collaborative, and tech-enabled responses to the evolving threat landscape. We fully committed to initiatives such as CT TECH+ that align with our mandate not only to counter terrorism, but to prevent and address the root causes of violent

extremism across Nigeria, west Africa, and the wider Sahel region”, he said, pointing out that NCTC aspire to strengthen the response to terrorism in West Africa and the Sahel as a Regional Centre of Excellence.

He reiterated that terrorism has no boundary, and that the only effective response to its threats remained global one anchored in collaboration, technology, and respect for human rights and the rule of law which the CT TECH+ promised, hence “we are all in this together. Overview of the UNOCT/Programme, the CT TECH+ initiative and its support to the Federal Republic of Nigeria by the Head of Cyber and New Technologies Unit, UNOCT/UNCCT, Ms. Akvile Giniotiene; and Senior Coordinator of INTERPOL, Ms. Nadia Larsson, and INTERPOL Criminal Intelligence Analyst, Mr. Oskara Blazeivicius. The discussion on behalf of the Nigerian authorities was lead by the National Coordinator of the National Cybersecurity Coordination Centre (NCCC), Sa'ad Abubakar.

APPOINTMENTS

SANSA Welcomes Appointment of Interim Board

SANSA has welcomed the appointment of an Interim Board for the South African National Space Agency, effective 21 August 2026. The appointment was announced by the Minister of Science, Technology and Innovation, Professor Blade Nzimande, in terms of Section 13A(3) of the SANSA Act, 2008, and will remain in place for a six-month period until January 2027 or until a new Board is constituted.

The Interim Board brings together a wealth of expertise in research, finance, and astrophysics. Mr Andrew Khutso Msiza, Senior Vice President of Research & Technology at SASOL Ltd, will serve as Chairperson, bringing strong governance and innovation experience. He is joined by Mr Shawn Basson current Head of Finance and Supply Chain Management at SARAO), Prof Thulani Phillip Jili of the University of Zululand, Dr Sinenhlanhla Precious Sikhosana, similarly from the University of KwaZulu-Natal, and Dr Adriana Marais at the Foundation for Space Development Africa. The Agency looks forward to benefiting from the Board's expertise and governance during this period of their term.

Jenna Rhodes-Tiwana Joins Open Cosmos as Chief of Staff

Open Cosmos has welcomed Jenna Rhodes-Tiwana as its new Chief of Staff. Jenna brings a wealth of experience from the frontier of space exploration, most recently at ispace, inc., where she contributed to the company's lunar exploration efforts.

In her new role, Jenna will work closely with the leadership team to help scale Open Cosmos's operations and accelerate delivery on its mission: connecting the world through space and putting satellite data to work on the challenges that matter most to our planet.

Open Cosmos is on a mission to solve Earth's critical challenges with actionable data and connectivity from space. The company simplifies access to orbit by delivering a complete, end-to-end service for satellite missions - from design and manufacturing to launch and operations. A cornerstone of this mission is the Open Constellation, a mutualised satellite infrastructure that redefines how organisations access vital information. This collaborative approach makes space simple, affordable and scalable, enabling partners to share data and assets for broader global coverage and more frequent insights.

By equipping clients to drive innovation in Earth observation, IoT connectivity and

secure communications, Open Cosmos is not just launching satellites, it's building a better future powered by space technology to understand and connect the world.\

Côte d'Ivoire names Tidiane Ouattara first Director General of national space agency

The government of Côte d'Ivoire has appointed H.E. Dr Tidiane Ouattara as the inaugural Director General of the Space Agency of Côte d'Ivoire (ASCI), placing an experienced African space policy and Earth observation expert at the helm of the country's newly established national space institution.

Dr Ouattara becomes the first person to lead ASCI, which was established by a decree of the Council of Ministers on June 4, 2025, and operates under the supervision of the Ministry of Higher Education and Scientific Research.

ASCI was created as a public administrative institution with a scientific and technological mandate to oversee the peaceful use and exploitation of outer space for the benefit of Côte d'Ivoire. Its responsibilities include coordinating national space science and technology initiatives, advancing space-based technologies for sustainable development, promoting domestic expertise and supporting scientific research.

The agency's programme areas include Earth observation, space meteorology, astronomy, space exploration, satellite navigation and satellite communications. It is expected to serve as the central coordinating institution for Côte d'Ivoire's ambitions in the sector date back to at least 2015, when President Alassane Ouattara commissioned a feasibility study for a national satellite programme. The 2025 decree subsequently formalised that ambition through the establishment of the agency.

The establishment of ASCI followed years of discussions on the need for a dedicated national space institution. Côte d'Ivoire's ambitions in the sector date back to at least 2015, when President Alassane Ouattara commissioned a feasibility study for a national satellite programme. The 2025 decree subsequently formalised that ambition through the establishment of the agency.

Dr Ouattara brings more than three decades of experience in the space sector, beginning in academia before moving into the Canadian government and later continental African space governance.

He holds a Master's degree in Physical Geography from the Université de Cocody-Abidjan, now the Université Félix-Houphouët-Boigny, as well as a Master's degree and a PhD in Remote Sensing and Geographic Information Systems from the Université de Sherbrooke in Québec, Canada. He completed his Master's degree in 1996 and doctorate in 2001.

Following his doctorate, Dr Ouattara joined the University of Sherbrooke as a lecturer before moving into space applications and management roles within the Canadian government, where his work covered Earth observation, policy, strategy and international relations.

In 2016, he joined the African Union Commission as GMES and Africa Programme Coordinator, serving as the Commission's focal point for the joint African Union-European Union Earth observation initiative and overseeing its implementation across several funding cycles. Under his tenure, GMES and Africa secured EUR 54.65 million in European Union investment, comprising EUR 30 million for its first phase from January 2017 to December 2021 and EUR 24.65 million for the second phase from January 2022 to December 2025

In January 2024, the African Union appointed Dr Ouattara Head of the Science, Technology and Space Division at the Department of Education, Science, Technology and Innovation. In that role, he coordinated the development and implementation of the African Outer Space Programme and the African Space Policy and Strategy.

He also played a central role in the establishment of the African Space Agency, headquartered in Cairo, Egypt, and served as the AU's principal negotiator for the European Union's EUR 100 million investment in African space programmes beginning in 2025. In February 2024, the African Union Executive Council appointed Dr Ouattara as the inaugural President of the African Space Council, the governing body of the African Space Agency. He was formally sworn into the position at the African Union Commission headquarters in Addis Ababa in July 2024. His term runs for four years and is renewable once.

Dr Ouattara has also served on the Board of Digital Earth Africa, a continental initiative focused on open satellite data infrastructure for sustainable development.

His appointment in Côte d'Ivoire gives ASCI a leader with extensive experience spanning space applications, Earth observation, continental space policy and international cooperation as the country moves to operationalise its national space agenda.

Dr Ouattara has repeatedly highlighted the economic potential of Africa's space sector, describing the continent as "the El Dorado for global space business."

Chris Hartley appointed as EUMETSAT's next Director of Technical and Scientific Support

Europe's operational satellite agency for weather and climate, EUMETSAT, has appointed Chris Hartley as its new Director of the Technical and Scientific Support Department.

Chris Hartley will join the department on 1 November 2026 and work alongside the current

Director to ensure a smooth transition before formally assuming the role at the end of February 2027.

As Director of Technical and Scientific Support, he will oversee the delivery of technical and scientific support to the development and operations of EUMETSAT satellite systems, as well as ICT and management support services to the whole organisation.

Chris Hartley brings extensive experience in satellite systems, programme management, procurement and organisational transformation. After beginning his career in aircraft systems, he moved into the space sector, working on satellite command and control software projects at the European Space Agency's European Space Operations Centre in Darmstadt and to systems development for Argentina's space agency.

Chris Hartley first joined EUMETSAT in 2000 and spent more than 20 years working across the EUMETSAT Polar System and Meteosat Third Generation programmes. In 2021, he moved to CERN as Head of Industry, Procurement and Knowledge Transfer, where he oversaw procurement, knowledge transfer and EU relations and contributed to strategic initiatives including CERN's focus on socio-economic return to its Member States.

Frank D. “Trey” Whitworth, Former Director of the NGA, Appointed as President of Satellogic

Satellogic, Inc., the infrastructure company for Persistent Global Intelligence, announced that Vice Admiral (Ret.) Frank D. "Trey" Whitworth has been named President of the company, effective immediately. In this role, Whitworth will lead Satellogic's internal operations, integrating mission with sales and marketing efforts, while also shaping strategy for the Company's defense and intelligence product suite. Whitworth will report directly to Emiliano Kargieman, CEO and Co-Founder of Satellogic.

The appointment comes as Satellogic scales increasingly complex, mission-critical sovereign satellite programs for governments and defense partners around the world.

"We've had the benefit of Trey's insights as an advisor for the past several months, and he will bring exactly the leadership and operational execution we need at this stage," said Emiliano Kargieman, CEO and Co-Founder of Satellogic. "His vision for where this industry is going, combined with his deep understanding of defense and intelligence requirements and the problems our customers are trying to solve, makes him uniquely suited to help us scale."

Whitworth steps into the President role directly from his strategic advisory position, which began in March 2026, and his most recent role as Chief Executive Officer of r4 Federal, where he led artificial intelligence-driven decision

advantage initiatives for defense and intelligence partners.

Whitworth brings more than 36 years of leadership in the U.S. Navy and the American intelligence community. From June 2022 to November 2025, he served as the eighth Director of the National Geospatial-Intelligence Agency (NGA), where he led a 16,000-person Combat Support Agency and expanded the Pentagon's Project Maven artificial intelligence program across every military service and combatant command.

Earlier in his career, he served as Intelligence Director for The Joint Staff, advising the Chairman of the Joint Chiefs of Staff; as Intelligence Director for U.S. Africa Command; as Deputy Director for Computer Network Operations at the National Security Agency; and as Intelligence Director for Joint Special Operations Command (JSOC). Whitworth is a graduate of Duke University and holds a master's degree in national security studies from Georgetown University. He is a Life Member of the Council on Foreign Relations.

General (Ret.) John E. Hyten Joins Astranis Space Technologies as Chairman of New Strategic Advisory Board

Astranis Space Technologies Corp., announced that General (Ret.) John E. Hyten has been appointed to serve as chairman of a new strategic advisory board created by the company, effective immediately.

As Chairman, General Hyten will advise the Astranis leadership team across all aspects of strategy, business, and technology as the company builds resilient space architectures for both commercial and government customers. "General Hyten's extensive experience driving national security space strategy and operations over decades of military service gives Astranis a decisive edge as we enter our next phase of growth," said John Gedmark, CEO and Co-founder of Astranis. "He brings a passion for innovative, fast-moving approaches and a deep conviction for building a robust American space industrial base. We are honored and excited to have him advise Astranis as we rapidly scale the business across both commercial and government markets."

"Astranis is uniquely positioned to drive a strategic shift to smaller, proliferated space systems in higher orbits," said General John Hyten. "Their progress over the past several years is impressive and the company's technology represents innovative and resilient capabilities that I see playing a large role in advancing U.S. strategic interests. I look forward to working with John and his team."



General Hyten's appointment reflects the expansion of Astranis' role as a strategic partner to the U.S. government and defense community.

Kinéis appoints Thomas Hiriart as General Manager

Against this backdrop of strong growth, Kinéis announces the appointment of Thomas Hiriart as General Manager. With experience in high-value-added industrial and technology sectors, he will be responsible for accelerating international commercial deployment, structuring the company's offerings and services, strengthening strategic partnerships with major European customers, and preparing the next IoT/AIS constellation planned for 2030. A graduate of ISAE-Supaero and the Georgia Institute of Technology, and holder of an INSEAD MBA, Thomas Hiriart has built his career across space agencies, industrial players in the sector and strategy consulting at BCG. He subsequently led the development of ION-X, supporting the deeptech from its early stages through its first technological, industrial and commercial successes.

"With 25 satellites launched in 2025 and a fully operational constellation since last summer, Kinéis is Europe's first operator of its kind, offering global and fully sovereign connectivity. I am honoured to join the

company and put my energy and experience at the service of this outstanding project, whose applications in civil protection, energy, logistics, the environment and defence are of paramount importance."

AiDASH Appoints Garrett Little Chief Financial Officer to Lead Next Phase of Growth

AiDASH, the company leading the PreventionFirst™ movement for electric utilities and transforming grid resilience through its pioneering platform that unifies vegetation, asset, storm, and wildfire intelligence, announced the appointment of Garrett Little as Chief Financial Officer.

Little brings nearly two decades of financial leadership across infrastructure, energy and technology sectors. As CFO, Little leads AiDASH's global finance organization, including FP&A, treasury, accounting, strategic development, and capital markets. In this role, Little will help lead AiDASH's next phase of growth.

Prior to AiDASH, Little held senior finance and CFO roles within the energy and infrastructure space at Shell, Volta Charging, and Commercial Energy, scaling

finance organizations, supporting organic growth and capital markets strategy, including IPOs and M&A. At Volta Charging, he co-led the integration into EV charging networks in the United States. Most recently, he served as CFO of Commercial Energy, a retail energy and distributed generation platform. He began his career in M&A advisory at KPMG and PWC.

"AiDASH has entered a new phase of growth, and that demanded a CFO with deep experience at the intersection of energy, infrastructure, and finance — and the operational scale to match," said Abhishek Singh, Co-founder and CEO of AiDASH. "Very few finance leaders bring that combination. We are thrilled to welcome him to the team."

"AiDASH is solving one of the most consequential societal problems — protecting the grid and the communities it serves," said Little. "I am excited to partner with Abhishek and the team to build the financial foundation for what comes next."

Vantor Appoints Will Cocos to Lead U.S. Government Business

Vantor, the leader in unified spatial intelligence, announced that Will Cocos

has been appointed Executive Vice President and General Manager of its U.S. Government business. Cocos will lead Vantor's work across the U.S. defense, intelligence and civil government communities, with a focus on accelerating the delivery of mission-ready capabilities to warfighters and other operators.

Cocos has served as Vantor's Chief Transformation Officer since 2023, helping shape the company's strategy and expand its spatial intelligence capabilities. Over the past year, he has helped drive growth in Vantor's international business, including supporting the company's partners in conflict zones. That work has given him firsthand insight into how rapidly evolving battlefields are changing customer needs and what it takes to move technology into operational use quickly.

Cocos brings that perspective to Vantor's U.S. Government business as missions grow more complex and decision timelines shrink. Warfighters, commanders, analysts and civil government users need more than just data; they need trusted intelligence delivered fast enough to act. They also require technology that works where the mission happens from contested tactical environments to disaster response and humanitarian operations.



MIDDLE EAST

Saudi Arabia: Between indigenous capacity building and foreign outsourcing



Rising smart city development, satellite technology advancement, and government-led infrastructure modernization are driving geospatial analytics adoption in Saudi Arabia, supported by Vision 2030 initiatives, expanding e-commerce logistics, and growing demand for location-based intelligence across urban planning, natural resource management, and disaster response applications. According to latest data, the Saudi Arabia geospatial analytics market size was valued at USD 3.6 Million in 2024. Looking forward, IMARC Group estimates the market to reach USD 7.7 Million by 2033, exhibiting a CAGR of 8.15% from 2025-2033. Geospatial analytics now represents a cornerstone technology for Saudi Arabia's digital transformation, powering everything from mega-project planning and smart city operations to oil exploration and

environmental monitoring. The market benefits from substantial government investments in National Spatial Data Infrastructure, growing availability of high-resolution satellite imagery, and expanding applications across diverse sectors. Technological innovations in satellite and remote sensing capabilities are revolutionizing Saudi Arabia's geospatial analytics landscape through enhanced data accuracy and real-time monitoring capabilities. The UAE's Etihad-SAT radar Earth Observation satellite launched in March 2025 provides high-resolution, all-weather, day-and-night imaging supporting GIS, urban planning, environmental monitoring, and smart city systems across the region. Neo Space Group, Saudi Arabia's leading

commercial space services provider backed by the Public Investment Fund, partnered with SuperMap Software in March 2025 to enhance Geographic Information System services and bolster the Kingdom's Vision 2030 initiatives. Abundant Earth-observation data unlocks real-time monitoring use cases while hyperscale data-center rollouts lower total cost of ownership. These technologies enable applications ranging from environmental monitoring to disaster management and defense, with government agencies and businesses acquiring improved capabilities to monitor and analyze vast geographies at unprecedented precision levels. The rapid expansion of Saudi Arabia's e-commerce industry is creating substantial

demand for geospatial analytics solutions optimizing supply chains and last-mile delivery operations. The e-commerce sector is projected to reach SAR 50 Billion, reflecting strong compound annual growth driven by 90% smartphone penetration facilitating access to geospatial applications. Companies increasingly rely on geospatial data to streamline operations, monitor shipments, and enhance delivery effectiveness through GIS tools analyzing spatial patterns, reviewing traffic situations, and identifying optimal routes. The IMARC Group predicts the Saudi Arabia e-commerce market will reach USD 708.7 Billion by 2033, with retail and location-based services projected to lead growth at 12.52% as malls, quick-service restaurants, and e-commerce firms

harness footfall analytics for site selection. Enhanced delivery tracking and route optimization become essential for meeting consumer expectations in this expanding digital marketplace.

Artificial intelligence integration is transforming Saudi geospatial analytics through enhanced pattern recognition, automated feature extraction, and predictive modeling capabilities. In January 2025, Kidana, a leading Saudi real estate developer, partnered with iSolution and Google Cloud at the Hajj and Umrah Conference & Exhibition, becoming one of the region's first organizations adopting Cloud on Google Cloud. This innovation opens powerful capabilities for processing complex geospatial data and high-performance computing, supporting Saudi Arabia's vision for cloud-first and digital innovation. AI-powered mapping solutions enable automated change detection, environmental monitoring, and urban growth prediction with unprecedented accuracy. Organizations leverage machine learning algorithms to process vast satellite imagery datasets, identify patterns invisible to human analysis, and generate actionable insights for planning decisions. As geospatial AI advances, the Kingdom positions itself at the forefront of intelligent spatial analytics applications.

Saudi Arabia is investing in sophisticated geospatial analytics enhancing disaster management capabilities and climate adaptation strategies. Natural disasters including floods, earthquakes, and sandstorms drive necessity for improved preparedness through real-time monitoring, risk assessment, and emergency response planning facilitated by geospatial technologies.

Government agencies utilize geo-analysis determining vulnerability zones, mapping evacuation routes, and undertaking effective resource allocation during distress situations. Advanced GIS simulations pinpoint vulnerable areas guiding smarter planning and enabling rapid response measures. The growing prevalence of climate-related incidents combined with satellite technology advancement drives demand for converged geospatial analytics solutions supporting disaster management. Applications extend to environmental monitoring, water resource management in arid regions, and alignment with FAO-backed efficiency pilots for agriculture programs using remote sensing to optimize irrigation in water-scarce zones throughout the Kingdom.

Saudi Arabia's growing space economy

Saudi Arabia entered the arena of space exploration in a big way. As the kingdom witnessed an income boom from the late 1960s, it became a founding member of the Arab Satellite Communications Organization ArabSat, the main provider of satellite services in the Arab region formed by members of the Arab League in 1976, and

committed the highest amount among member states towards the organisation's paid capital.

In the 1980s, Saudi Arabia became not only the first Middle Eastern country to send an astronaut into space but also the first Arab country to launch a satellite. By the year 2018, the kingdom was home to ArabSat, the largest satellite operator and service provider in the Arab world, as well as to various institutions that participate in space research and the commercialisation of space technologies.

The rise in Saudi Arabia's space efforts came about as the kingdom sought to lay a more systemic foundation for, and upscale, its space economy. This shift corresponded with Saudi Arabia's national transformation drive starting in 2016 under the new leadership. With Vision 2030 as its guideline, this grand scheme aims to build a knowledge-based economy and bring about openness and vitality to Saudi society, in addition to forging a new identity for the Saudi nation. The space programme of Saudi Arabia is now driven by a variety of factors. Besides the aforementioned domestic need for economic diversification and identity building, geopolitics is another consideration.

Between the 1980s and 2010s, Saudi Arabia's main focus in developing its space economy was in satellite manufacture and provision of satellite communications services. During this period, ArabSat and King Abdulaziz City for Science and Technology (KACST), served as the two main actors. As a commercial corporation, ArabSat operates satellites to provide Direct-to-Home DTH television broadcasting, broadband and telephony backbone connectivity, and satellite internet.4 The manufacture and assembly of ArabSat's 17 satellites was mainly entrusted to Western companies, including Thales Alenia Space, Lockheed-Martin and Boeing.

The main features of ArabSat's commercial model are direct purchases of Western satellites and subsequent reliance on overseas launch missions, while the corporation focuses on downstream services in the space sector.

In contrast, KACST adopted a different pattern regarding satellite development and operation. The City, formerly known as Saudi Arabia National Center for Science and Technology, took on its current name in 1985, and since then has served as a hub of scientific research in the kingdom, with direct support from the royal family. During the period under discussion, the City, with the affiliated Space Research Institute (SRI), served as the kingdom's semi-official space centre.

In 2002, the Saudi government launched a National Science, Technology, and Innovation Plan (NSTIP), with KACST tasked with designing the plan and its implementation.5 In this plan, space and aeronautics technology was listed among the

12 programmes for developing "the strategic technologies that are most important to the Kingdom", signalling the national security implications of the selected programme fields.

Between 2000 and 2019, KACST produced 17 Saudi satellites, with the majority designed and manufactured locally by Space Research Institute. Currently capable of manufacturing mini satellites weighing between 100 kg and 500 kg, the City's manufacturing capacity has steadily risen. It is worth noting that KACST also participated in the manufacture and operation of ArabSat satellites and paid special attention to obtaining technological transfer from foreign partners.

The Space Programme

Saudi Arabia's space programme began to take shape only after 2016, under the leadership of King Salman and his son, Prince Mohammed bin Salman. However, during the reign of the late King Abdullah, the Saudi government was in fact aware of the significance of expanding KACST's role in the value chain of the state's space economy. The government hence designated TAQANIA Space, a subsidiary of the Saudi Technology Development and Investment Company, TAQANIA, as the authority responsible for "commercializing KACST technologies and operating national Saudi Satellite Assets".

During the recent Saudi Arabia-US Investment Forum in Riyadh, **Elon Musk announced that Saudi Arabia has officially approved the use of Starlink for aviation and maritime applications.** The expansion of SpaceX's satellite internet service marks a key advancement in the Kingdom's connectivity and aligns with the technology agreements signed during President Trump's visit.

Saudi Arabia therefore joins **other Middle Eastern countries such as Jordan, Oman, Qatar and Yemen**, where Starlink has already begun successful operations. The Saudi permit strengthens the service's presence in a strategic region due to both its air traffic density and international maritime routes.

This approval is also in line with the **national technology strategy of the kingdom**, which seeks to modernize its transportation, defense and telecommunications systems as part of the **Vision 2030**, the country's ambitious economic transformation plan.

Rayyanah Barnawi, Saudi Arabia's first female astronaut, has emerged as a transformative figure in the Kingdom's space narrative, reshaping public perception and inspiring a new generation towards science and exploration. A biomedical scientist by training, Barnawi flew aboard a SpaceX Dragon 2 to the International Space Station in May 2023, where she conducted advanced experiments in stem cell biology, neurophysiology, and microgravity effects, returning with 92 scientific samples. Her mission, aligned with the Saudi Space Agency's objectives, not only advanced Saudi research capabilities in orbit but also symbolized a broader national commitment to inclusive innovation, education outreach, and space sector development.

Saudi fund launches new group to boost space industry

NEO Space Group, Saudi Arabia's national space champion that is leading efforts to develop the space industry in the Kingdom, has announced international telecoms industry veteran Martijn Blanken as its new group Chief Executive Officer.

NSG is seeking to unlock the potential of space, from Saudi Arabia to the world by delivering advanced satellite communication services through different orbits. Furthermore, it will invest in innovative new start-ups and entrepreneurs, partner with world-class space companies, and localize key activities to the Kingdom. NSG aims to become a global leader in space, driving innovation worldwide for a better future while transforming and inspiring society.

The fund recently launched the Neo Space Group to work on the kingdom's nascent satellite and space industry, its first investment in the sector. One of the world's largest sovereign wealth funds, the PIF has already invested heavily in sports, gaming and so-called Saudi mega-projects including Neom, a \$500-billion futuristic megacity under construction in the desert.

The Neo Space Group or NSG is the "PIF's first investment focused on the space industry", the sovereign wealth fund said in a statement. It "aims to develop and enhance commercial space operations in Saudi Arabia, providing innovative satellite and space solutions locally and globally", the PIF said. It will also "invest in localisation, technology, startups, and knowledge in the space and satellite sector in Saudi Arabia" in the latest bid to boost economic diversification. Under Crown Prince Mohammed bin Salman, the de facto ruler, Saudi Arabia has sought both to open up and diversify its oil-reliant economy.

So far, the bulk of the kingdom's space budget remains reserved for satellite-related operations, where the main need lies. In 2019, expenditure related to satellite communication and Earth observations took up 63% and 22% of Saudi Arabia's space budget, respectively. By introducing an institutional framework for its space programme, Saudi Arabia seeks to integrate domestic techno-scientific capacity and extend the space sector value chain to incorporate more private sector actors. In this regard, the first "KSA Space Market Investment Opportunities Report", unveiled by CST in November 2023, explicitly depicts the projected roadmap for the state's space economy.

While shoring up domestic capacity by improving indigenous techno-scientific infrastructure and expanding local markets for its space products, the Saudi space programme also has what can be called an overseas dimension, which relies heavily on purchases of foreign services for high-end space activities. The overseas dimension has been given renewed attention in Saudi Arabia's space programme. Branding itself as the first Arab country to have sent a man into space, the new leadership seeks to revitalise this piece of memory and consolidate its leading position in manned flights.



INDUSTRY REPORT

Is Mega-constellations the future of satcom industry?

Satellite services offering critical global connectivity have become indispensable in the modern world. Whether supporting mobility in the form of Internet access and real-time telemetry from airplanes or ships on oceanic routes, or distribution of high-quality entertainment video to dispersed areas in emerging markets without significant infrastructure, or emergency communications in adverse conditions or in remote areas, or military theater applications with unmanned aerial vehicles, satellites fill a void that cannot be met by other forms of communication mechanisms, including fiber optic links.

As technology advances costs has become cheaper, more companies and associations began to build satellites to meet the needs of different states, firms, navigation companies, and other organizations with large needs of communications traffic. Nowadays, there are many Service Providers and manufacturers that ease the usage of satellite communications as an alternative and affordable option. The ubiquity and security provided by satellite services have resulted in a substantial increase in interest in satellite communication.

The advent of high-speed, low-latency internet access in remote and underserved areas worldwide promises a step toward bridging the digital divide in an increasingly connected and technology-dependent society.

The rise of megaconstellations has set a new precedent in orbital congestion, simply as a result of the increased number of satellites involved. According to the United Nations Office for Outer Space Affairs, since the launch of Sputnik 1, 17,263 objects have been launched into space, of which 11,330 individual satellites were orbiting the Earth at the end of June 2023, representing a 37.94% increase since January 2022.

LEO constellations require hundreds to tens of thousands of satellites, the many launches needed to deploy the full constellation are no longer untenably expensive. According to Elon Musk, the initial cost estimate for Starlink of \$10 billion, later revised to \$30 billion. Telesat estimates \$5 billion for their Lightspeed constellation.

Compared to a single satellite, a constellation can provide permanent or near-global coverage, in a way that at least one satellite is visible at any time, everywhere on Earth. In recent years, LEO Constellations have gained much attention among researchers both in industry and academia due to reasons like having low latency, high capacity, and reusability among many others compared to the GEO and MEO systems. Morgan Stanley predicts satellite internet will grow to over 40 percent of the space economy, \$412 billion,

by 2040. There have been several space industry market reports done by investment banks like Morgan Stanley, Goldman Sachs, and Bank of America that size the 2040 space economy at over \$1 trillion.

LEO market analysis

"The low earth orbit LEO satellites market is witnessing rapid expansion, driven by technological advancements and increasing applications across various sectors. This overview explores the current market size, key drivers, regional developments, and future growth prospects that are shaping this dynamic industry. The market for low earth orbit satellites has experienced significant growth in recent years. It is projected to rise from \$7.11 billion in 2025 to \$8.14 billion at the end of 2026, exhibiting a compound annual growth rate (CAGR) of 14.5%. This increase has been fueled by the widespread deployment of small and mini satellites used for communication and earth observation purposes.

Additionally, innovations in lightweight satellite components have facilitated mass production. The expanding applications of LEO satellites in military reconnaissance and imaging, along with the growth of commercial satellite imaging and data services, have further boosted the market. The availability of more affordable launch services has also played a crucial role in enabling the deployment of large LEO satellite constellations.

Looking ahead, the low earth orbit satellites market is expected to grow rapidly, reaching \$13.49 billion by 2030 with a CAGR of 13.5%. This anticipated growth is largely due to the increasing demand for high-speed, low-latency global connectivity through LEO constellations. Commercial operators are expanding mega-constellation programs, while advancements in satellite propulsion and on-orbit maneuvering technologies are enhancing satellite capabilities.

The integration of AI-driven imaging and analytics into LEO satellite missions is becoming more prevalent. Moreover, government and defense sectors are investing heavily in resilient LEO based communication and surveillance systems. Key trends shaping the market include the rising deployment of small satellite constellations, a greater need for real-time earth observation data, enhanced military reconnaissance missions, growth in low-cost launch services, and continued miniaturization of satellite components.

A low earth orbit satellite is defined as an object orbiting the Earth at altitudes between approximately 160 km and 1,000 km, which is lower than geosynchronous satellites. These satellites are commonly utilized for communication, military reconnaissance, spying, and various imaging applications. Their proximity to Earth allows for faster

data transmission and more detailed observation capabilities compared to satellites in higher orbits.

The increasing adoption of LEO satellites across multiple industries is a key driver of growth in the aerospace sector during the forecast period. These satellites are vital for protecting the planet by enabling earth observation on a global scale, which is critical in fields such as agriculture. LEO satellites provide valuable data used to monitor biological, chemical, and physical aspects of the environment.

For instance, as of October 2025, OneWeb has successfully deployed around 650 LEO satellites operating in 12 synchronized orbital planes at an altitude near 1,200 km. OneWeb partners with Arianespace for satellite launches from various spaceports. The company's latest expansion aims to deliver fast, low-latency internet services worldwide, covering land, sea, and air. In 2025, North America held the largest share of the low earth orbit satellites market and is also predicted to exhibit the fastest growth during the forecast period.

The dilemma of LEO systems

As the performance of a satellite network depends on the orbit the satellite is deployed in, the distance from the Earth affects the capabilities of the satellite. Although satellite networks in LEO orbit require the most satellites to build up a constellation and the area covered by a single satellite is relatively small, the system as a whole provides a very low latency above 50 m/s compared to satellites in GEO over 700 m/s or MEO above 150 m/s as well as offering coverage of the polar areas, where the GEO satellites may have limited or no line of sight.

The distance to orbit is also a determining factor of the most important variables of commercial satellites: the cost of launch. In case of GEO satellites, the launch cost comprises more than one third of the total cost of the satellite, while LEO satellites are smaller, lighter, and the cost of launch per satellite is lower.

On second glance, however, it becomes clear that this may not be the case for the whole constellation, which may comprise hundreds or even thousands of satellites to allow it to provide uninterrupted service. When compared with a GEO satellite with an active service life of 20 years, the cost to deploy a LEO satellite system is significantly higher, almost tenfold. As LEO satellites have a shorter operational lifespan, typically from three to five years, they therefore need more frequent replacement, and also require more complex tracking and control

systems, thus, from this perspective these constellations might seem less attractive.

As for the frequency bands, most LEO systems use Ka 12–18 GHz, Ka band 18–26.5 GHz and Ku bands 26.5–40 GHz, as these bands are the most advanced in technology. Very low latency is a unique characteristic of LEO constellations, which supports real time communications, not just in voice and data services, but also broadband internet access in remote or rural areas, offering global coverage.

In this wise data collection is the main focus of the Earth observation applications, which also operate in low Earth orbit. The high-resolution images and extensive data provided by these satellites are invaluable for weather prediction and for studying climate change as well as disaster response to recovery efforts. These capabilities of LEO satellites are an invaluable asset for surveillance and reconnaissance, together with satellite navigation and positioning, as well as for agriculture and forestry.

State sovereignty and economic considerations of operators

The continuous development of space technologies made the emergence of space communications possible, and by the late 1980s the first private satellite operators, including PanAmSat and SES, were already competing with established market players operating in the form of inter-governmental organisations. The liberalisation of the communications market by the late 1990s led to the privatisation of most intergovernmental satellite organisations and marked the beginning of the commercial use of outer space.

However, this did not mean that the state's role in the use of space ceased, but rather that the centre of gravity shifted: while previously the state actors determined the direction and methods of space research and use, from the 1990s, certain areas of space research and some, in particular, non-civilian uses remained in the hands of the states while commercial use became free under strong state control in a large proportion of the world, which led to the emergence of global service providers.

The consequences of the state's involvement in the background can be very serious for the state's sovereignty. On the one hand, the technological knowledge acquired puts each company or group of companies in a monopoly position, and thus defence investments become completely vulnerable to these companies. The advance of artificial intelligence shows that technology-

developing companies with strong capital are already determining the evolution of the market, with no state having any influence on the price and distribution of their products and developments, which puts state customers in a vulnerable position.

On the other hand, the basic interest of companies is profit maximisation, not loyalty, so it can easily happen that opponents have the same military equipment at their disposal. The third and last consequence to be mentioned is that multinational companies dominate the global market. Their size and influence are greater than the capabilities of a small or medium-sized country, and they are also able to represent their interests more effectively. Currently, multinational companies prefer to enforce their interests through individual countries, but it is expected that these companies will realise the potential of their political influence related to their financial capabilities, and many consider that it is only a question of time before they act openly to assert their interests.

The situation is more nuanced by the fact that multinational companies, applying the practice of "forum shopping", settle in the territories of states in which entering the market is subject to predictable conditions, the risk of their investment is not too high, and the regulations of the given state do not demand too much of their income. In the satellite sector, following the communications liberalisation of the 1990s, this process only accelerated. As noted earlier, this trend is supported by the ITU's processes for frequency filings, where the flag of convenience is becoming easier to access via the procedures of national administrations.

Based on all of this, the market role of multinational companies raises serious questions of sovereignty and security policy, especially if the company's products involve key military technology or the multinational company provides a service that is vital for the protection of the state's security. Although multinational companies are not completely global and cannot be understood without considering the country where their headquarters are located, they can nevertheless represent a significant force within the given country.

The obligations of multinational companies are determined by the internal legal framework of the state where their headquarters are located, but due to their size and activity, a rapid change of circumstances, including a change of the state of their headquarters, is not possible in practice. Due to their size alone, multinational companies



have a clear financial, economic and even political influence on the states in which their headquarters or even their subsidiaries and branches operate. This assumes that the multinational company's settlement in the given state was preceded by the consent of the home state, and that the multinational company recognises the sovereignty of the given state over itself. However, this does not entail absolute control over the entire activity of the multinational company, as it is possible to control only certain activities related to the given state.

Regulatory challenge

Mindel De La Torre, Chief Regulatory and International Strategy Officer, Omnispace said: LEO is actually a subset of an NGSO. So LEO stands for the low earth orbit, and NGSO is a nongeostationary orbit. So there's different kinds of non-geostationary satellites. There's the LEOs which are in low earth orbit. There's some that are in MEO orbit (mid-earth orbit). And then there's also highly elliptical systems that actually they go,

basically if you think about it, they go from sort of the North Pole to the South Pole. And so they're used a lot by military and by weather and etc. So there's different kinds of NGSO satellites and LEO happens to be one of them. They're the one that you read about the most right now because everybody's putting them up.

Kevin Bryan, Associate Professor, University of Toronto also said that private space business is booming at the moment. There's tons of money going into it, partly because of regulatory changes that have just made this possible. So it wasn't feasible for especially small organizations to be involved in putting things into orbit until recently. So the legal change has been important, but the bigger change has been the cost. So if I drop the cost of something 10x, which is essentially what happened with satellite launch and dropping even further every year. So, once the next SpaceX version arrives in a year or

two, you could see another 10x reduction in the per-pound launch costs of satellites. And it's really amazing to give you an idea of what the numbers look like. As of 2010, I don't think we'd ever had at any point a thousand active satellites in orbit. And now, every year we put more than that number of satellites into space. There's something like 10,000 satellites in space at the moment. And, you know, this year, if we if we had 200 launches and another 2,000 satellites go into space, I don't think anyone in the space world would be surprised, he said.

However, the global market for satellite communications cannot be managed within the framework of current international trade cooperation which was defined in the early 1990s. The general principles of competition regulation and the special principles regarding electronic communications, as well as the basic principles for the reasonable, efficient and economical use of frequency and satellite orbit appearing in the ITU system determine the



frameworks that must also be followed in the regulation of space communications, although, this is not possible without the existence of an international organisation with appropriate powers.

Satellite communication operates in an international market that aims to provide end users with a low-cost, unified communication option capable of covering a region or the entire Earth. Unlike terrestrial networks, satellites can provide service almost everywhere: in both urban and rural, congested or sparsely populated areas alike.

Many functions that guarantee and protect the interests of the licencing state or the customers are difficult or impossible to implement in the case of a global service provider. Although the licensing state must request territorial consent from the relevant state for purposes of frequency coordination, it does not mean that the satellite will actually provide any service in the consenting state. The provision of electronic communication services in the territory of the EU is subject to notification, and many consumer protection and data protection rules are connected to this.

Whitney Lohmeyer, Assistant Professor of Engineering, Olin College said: "The LEO landscape is somewhat challenging to define because we often resort to FCC filings to understand current systems. But the way that we authorize satellites for U.S. market access is through something called a processing round. And once you file to the FCC an application, it's actually kind of challenging to modify that application. And if you do modify it, you have to show that your interference environment is not increased. So what actually happens is that operators over-file for their systems".

So you'll see applications of tens of thousands of satellites. Right now, as of December 2022, we had about 4,000 broadband satellites in orbit, in low-earth orbit, mainly from OneWeb and StarLink. Kepler has also launched a few satellites, but we anticipate based off the market access applications that there could be upwards of 70,000 satellites. Now, I personally don't believe that's going to happen. I think that was, like I said, the product of our market access application system, these processing rounds. But currently the landscape is

that SpaceX has 3,000 plus satellites in orbit, OneWeb approaching a thousand. And they're our two main players.

Whitney Lohmeyer, Assistant Professor of Engineering, Olin College believe that the FCC is the governing body in the United States through which all of these networks have to receive authorization. They are the body that effectively permits entities to transmit over certain radio frequencies. As a result of launching a satellite, you generally want to communicate to it. You want to send commands up to it. You want to send your requests to post your picture to Facebook, your email, and then you want to receive data from it. So you want to transmit information back to the ground. And the FCC authorizes one's ability to utilize radio spectrum. So given frequencies for these LEO systems, it's generally Ku-band, Ka-band. So 10 gigahertz, 27 gigahertz, upwards to V band, which is more like 47/50 gigahertz.

In addition, Julie Zoller, Head of Global Regulatory Affairs, Project Kuiper at Amazon argues that Next generation satellites are revolutionizing the communications landscape and the United States

is leading in that regard. We're innovating and investing in satellite and customer terminals and antenna technology here at Amazon. The growth of the LEO broadband industry played a part in FCC's recent announcement of the Space Bureau and the focus on improving the efficiency and effectiveness of the Commission's processes.

It is universally acknowledged that the satellite industry is one of the most dynamically developing sectors in today's economies, providing innovative technology and new services. However, market access is dependent upon an understanding of the regulatory landscape. As states have the authority to establish their own national rules for the use of the frequency spectrum, they are obliged to manage the spectrum in a way that is rational, economical and fair, 18 while taking a vast number of measures to serve their national interests.

We're in an emerging industry here. We have one player in the United States, SpaceX and its service, StarLink, which have at the moment a first mover advantage. They are the company that has launched the greatest number of satellites says Harold Feld,

Senior Vice President, Public Knowledge. They're vertically integrated, so they have both launch vehicles and satellites and they're actually offering commercial service both to residential customers, to local and state governments, and internationally. We have a number of other providers who have either started service but have a smaller number of satellites up in orbit and need to catch up to reach that capacity, and we have a couple of players who are not yet entering, have not yet entered the market, but have plans to enter the market and expect to enter the market within the next one to three years.

Julie Zoller, Head of Global Regulatory Affairs, Project Kuiper at Amazon said: The FCC licenses satellite systems and to do that for LEOs, the FCC initiates a processing round, establishes a cutoff date for applications in that processing round for the specific spectrum that's at play. The FCC puts these applications on public notice, grants the applications that meet their standards, and regulates those NGSO systems with rules such as power limits for ensuring compatibility with other services, coordination requirements, and they also include space safety requirements, such as filing an orbital debris mitigation plan for commission approval.

The existing licencing processes are designed for traditional satellite services, and may not be suitable for the deployment of more innovative services within shorter timeframes. As mentioned earlier, the spectrum allocation processes are not globally harmonised, which means that deploying a new globally reachable satellite system is complicated by the different regional regulations involved. Efficiently managing spectrum usage while avoiding interference is also crucial, not just between satellite networks, but also between satellite and terrestrial networks, as in lower frequencies the usage may overlap.

On the strong issues of policy makers and competition policy in the space industry, Kevin Bryan, Associate Professor, University of Toronto said: "There's one company, SpaceX, whose costs of getting to orbit are just much better than everyone else. And their technical lead is only growing. So from a competition policy standpoint, on the one hand, should I worry about a company that's essentially single-handedly responsible for a huge drop in the cost of assets in space?

Probably not. You know, on the other end, you worry a little bit about the incentive to invest in other technologies that might be useful for space when you have such a big dog in this area. So to give you an example, solar panels have decreased in cost also, you know, an order of magnitude in the past ten years. This seems like it would be good. It's not necessarily good for innovation in the sense that investment into solar innovation has fallen a lot as well. Just because the panels are so cheap, it's not worth the R&D cost.

And so if I were on the competition side, the only thing I would worry about is anti-competitive actions by a company like SpaceX, which reduces the incentive to innovate in other areas of the space ecosystem. I haven't seen anything that worries me at this point. I think actually the decrease in launch costs have been spurring complementary innovation. So we've seen actually a lot more, say, venture money going into small space companies than we did ten years ago, which generally I would take as a sign that competition policy is not a major worry at this point".

Establishing competition from the get-go is very important. One of the things that's important to understand is that while space is big, given the positions that these satellites have to be in and the number of satellites that you have to have in the air in order to offer a service that we think of as modern broadband, it's actually

crowded and getting more crowded says Harold Feld, Senior Vice President, Public Knowledge. The concern on competition is that if you have a free for all, it just becomes a race. One provider gets as many satellites up in the air as they possibly can, and then they are able to screen out all other potential competitors. So we need to be thinking about competition early. We need to think about how to foster an environment where, on the one hand, the service is economically sustainable and, on the other hand, though, where consumers enjoy the benefits of multiple providers, providing multiple differentiated services at different price points.

However, the merger of satellite operators is a complex process that involves various legal, regulatory, financial and operational considerations. Mergers in the communication industry often, particularly in the satellite sector, require regulatory approval from relevant authorities, to ensure that the consolidation does not result in anti-competitive behaviour, and that it complies with national and international regulations. Regulatory bodies may assess the impact of the merger on market competition, pricing and overall industry dynamics, while also scrutinising satellite operator mergers from a national security perspective. If the satellite services are critical for national infrastructure or defence, the regulatory authorities may assess the potential impact of a merger on national security before granting approval.

Consolidations and mergers often involve streamlining operations, eliminating redundancies, and improving the overall efficiency of a company, which can lead to a more agile and cost-effective organisation capable of responding to market dynamics more effectively. Moreover, merged companies may have extra resources available to invest in research and development, fostering innovation and the integration of advanced technologies, and resulting in the development of more capable and competitive satellite systems.

Another benefit of mergers in the satellite sector is that merged satellite operators may be able to optimise their use of spectrum and orbital slots, potentially leading to more efficient utilisation of resources. This optimization can be important in addressing the growing demand for satellite services and mitigating concerns about orbital debris.

Whitney Lohmeyer - Assistant Professor of Engineering, Olin College observed that there are policymakers at the FCC. The FCC is, I believe, doing an incredible job of sitting with a system that was developed in the early 2000s. So that was that processing round that actually came out of the results of efforts to do exactly what we're doing now with satellite broadband in the nineties.

And so they created this processing round system, and realistically, I would argue that when they did, they weren't expecting more than one or two systems to come to fruition. They certainly weren't expecting more than 20 distinct operators to file for over 70,000 satellites, which we've seen in the past like eight years since 2016. And so currently the FCC is starting to think about how

these NGSO or LEO systems are going to coexist and share spectrum.

They're starting to think about competition in the form of spectrum being a shared but limited resource. And so one of the questions, too, in thinking about how they're going to exist in competition, the FCC started to propose rulemaking of how are we going to share beam pointing information? How do we ensure that these systems are working together? And already as a result, we've seen SpaceX and OneWeb come out saying that they've reached coordination as well as Kuiper and Telesat reaching coordination agreement. And that's publicly saying we can coexist and we're working together to ensure that interference won't occur.

Emerging trends

Emerging technologies and trends define the future of global communication, especially in the satellite sector. As 5G technologies reshaped communication, the seamless integration between ground and space networks became a reality. Integrated hybrid systems have the advantages of both high capacity and low latency, similarly to terrestrial systems, while offering the global coverage of satellite systems. This technological breakthrough is transforming the face of terrestrial communication networks today.

A powerful synergy of complex communication systems is provided by "multi-orbit" satellites and terrestrial networks, that can satisfy the changing consumer habits, which with the increasing demands of consumers for continuous "online" presence and services "on-demand" lead in the direction of the convergence of the sectors of the telecommunications industry.

Multi-orbit satellite systems are changing the global satellite market, as GEO satellite operators combine with MEO or LEO operators to diversify their services. The use of multiple orbits enables operators to optimise their performance across different networks.

With GEO satellites offering high capacity, MEO and LEO satellites providing low latency and global coverage, the demands of end users for reliable service, cost effectiveness and high speed are best served. The mergers and collaborations taking place on the global market show that established operators are opting to deploy multi-layer satellite systems, either by building their own constellations such as Telesat or SES, or by merging their capacities like Eutelsat-OneWeb or Viasat-Inmarsat.

Apart from the mergers and collaborations of the satellite operators, the traditional telco companies 23 are also reaching out to complementing satellite networks, since the fibre technology is widely available at densely populated areas, whereas satellites services do not have the capacity to provide that level of service, and fibre is not an option for most rural or strongly segmented areas.

Although these rapid technological developments have facilitated a reduction in satellite operational costs and made satellite communication more widely available, reaching profitability in the short term remains a challenge, since launching and operating a satellite network is an extremely capital-intensive investment.

For this, the market demands for high-bandwidth, low-latency networks to satisfy customer needs may best be met via multiple solutions provided by multilayer networks. The most rapidly technologically developing companies are mostly small and thus lacking funds, while established operators are searching for new methods and new markets to maintain profitability. All these circumstances strongly suggest that the consolidation of the satellite communication sector is inevitable.

Apart from the market consolidation of the satellite operators, the advancement of technologies contributes to the changes of production and usage of equipment. Advancing technologies for user terminals contribute to decreases in cost, while miniaturisation has led to smaller, more efficient terminals with higher performance. As developers aim to create more user-friendly, customer-oriented solutions, self-installing equipment and terminals are taking over, further reducing costs by eliminating the need for professional installation and maintenance. However, this scenario will influence the existing regulatory framework and its implementation, as this increase in the amount of equipment and terminals leads to the expansion of spectrum demands, causing further congestion in the limited frequency bands and increasing the possibility of interference.

As equipment and terminals for satellite communication are not in all cases exempted from licencing in the state where they are used, the sheer number of these devices can lead to lingering licencing processes, which also implicates that regulators will have to reshape their licencing procedures.

The more congested the orbital planes around the Earth become, the more forward-thinking regulation will be necessary to ensure seamless, uninterrupted service. With the accessibility of myriads of LEO satellites and the technological innovation they represent, the regulatory landscape goes beyond technological aspects and encompasses new issues such as safety, security, privacy and regional harmonisation.

This complex regulatory challenge cannot be faced by the regulators alone. Synergies need to be created and maintained between stakeholders at all levels, since space is a global common. Developing and harmonising regulations across different countries and regions is a challenge that needs to be overcome to ensure the responsible use of space resources, balancing the interests of various stakeholders, ensuring equitable access and avoiding harmful interference.



DEFENSE REPORT

Why Space sustainability isn't just about space debris?

From a state-owned enterprise to a startup, CEO André Wall has set his sights on nothing less than this transformation, in the future RUAG International with solely focus on space. The vision is clear: RUAG International is to evolve into a company that advances humankind and enables the exploration of the world and beyond.

André Wall explains the mission as follows: "We want to develop integrated satellite and launch system capabilities with strong partners in Europe. In doing this, we will guarantee our customers 100% mission success. We will be the first startup to combine agility, speed and innovation with decades of experience and proven quality."

RUAG has been proven many times to be at the forefront of delivering innovation to push boundaries. RUAG supplied the payload fairing for the Ariane-1's maiden flight in 1979. For more than 40 years, European missions such as Galileo, SolarOrbiter, MetOp and Copernicus have been equipped with RUAG computers, insulation, and mechanisms. Large US space programs such as James Webb Space telescope, IceSat or, most recently, the NASA Mars mission Perseverance also had technology from RUAG in use.

André Wall, CEO of RUAG International, says: "We have an ideal launch window ahead of us: the space market is booming. Analysts forecast a \$1 trillion market by 2040 with annual growth rates of over 16 percent.

André Wall sums up the transformation: "Change does not happen overnight. Inspired by the future ahead of us, however, we have already initiated numerous measures to create our present. Our promise to our customers is clear: as a leading-edge technology company with the highest reliability and the mentality of a startup, we make a significant contribution to their sustainable success and aim to advance to be an incubator for innovation."

Over the past few decades, the application of space has changed substantially, moving from a nation-state-dominated field Old Space to one where private organisations are increasingly playing a key role New Space.

Satellite technology and space-based services have rapidly advanced thanks to an extraordinary fill of money, inventiveness, and insight brought by the emerging commercial space industry. These businesses have shown an unequalled capacity to create, launch, and run satellites efficiently, upending established business

practices and posing a threat to major participants in the space industry. As they move ahead with audacious ambitions and groundbreaking technology, commercial space businesses are previewed to enhance nationstate space capabilities, including their military endeavours. The literature review seeks to delve into this progressive trend.

The year 2021 was a turning point for the private spaceflight industry often referred to as NewSpace. Among the commercial firsts in the space sector, two companies Blue Origin and Virgin Galactic began to offer space tourists tickets for suborbital spaceflights. SpaceX achieved a record number of launches including the first allcivilian spaceflight and NASA awarded contracts for new private space station concepts.

In November 2021, the Director General of the European Space Agency ESA stated his aim for "European footprints" on the Moon by 2030, which would "become a new economic space, and a new continent" of human activity. Such imagery leads to questions of how particular European value constellations shape space future visions and, in turn, how European outer space infrastructures and space policy are co-constitutive of these shared images in advancing processes of political disintegration.

Spaceflight is obviously at a turning point, entering maybe a new era with an expected large increase in launches per year due to plans to increase the number of satellites and constellations in orbits largely.

Rocket and emissions

Space-based technologies can be valuable assets for environmental protection and for supporting Sustainable Development Goals SDGs on Earth. However, these technologies have had their own share of environmental impacts. Recently, advancements in space policy have been focused on the in-space pollution that satellites and rocket bodies produce in the orbital environment. While orbital debris may well be viewed as the most consequential threat from space activities today, the appropriate scope to understand the full environmental cost of the expanding space industry also encompasses ground and atmospheric consequences.

In 2022, scientific understanding of the environmental impact of atmospheric

emissions from space launches is very scarce. This situation is essentially the consequence of a historical assumption that because so few launches occur every year, this impact could be disregarded. The strategic nature of space activities in the context of the second half of the 20th century also ensured a low political willingness to investigate. Finally, progress in understanding higher-atmosphere chemistry and climate modeling are recently removing some of the technical blockers to a better understanding of rocket emissions.

On the other hand, the Space Launch System, NASA's super heavy-lift expendable launch vehicle, stands at 111 m with a combined propellant mass of over 2,500 t and can inject up to 45 t of payload including crewed capsule Orion, to lunar vicinity in its most powerful configuration. When comparing the atmospheric impact of launchers, there is a necessity to account for the mass of payload sent to orbit along with the targeted orbital regime, to perform a meaningful analysis.

The trajectory of a launch vehicle through the atmosphere is linked to the orbit in which the payload is delivered. Depending on their target orbit, launch vehicles emit through nearly all layers of the atmosphere, troposphere, up to 10-15 km, stratosphere, 10-15 to 45-55 km, mesosphere, 45-55 to 80-90 km, thermosphere, 80-90 to 500 km and exosphere, above 500 km.

However, rocket propulsion, the fundamental mechanism riding space launches, releases various emissions and pollutants into the environment, according to a report.. "These emissions, including carbon dioxide, soot, water vapor, and other compounds, make contributions to atmospheric pollutants", the report said. The ignition and ascent phases of a launch generate big warmth, sonic booms, and chemical exhaust, altering atmospheric conditions and potentially impacting local air first-rate.

Furthermore, the trajectory of a rocket release and its next stages can result in the dispersion of pollution throughout exclusive atmospheric layers, potentially contributing to ozone layer depletion or altering atmospheric chemistry. These atmospheric disturbances would possibly have implications for climate styles, atmospheric stability, and the worldwide weather device, although the exact quantity and importance

of those impacts are topics of ongoing studies and difficulty.

The most common rocket fuels that are used today come in a solid form. However, the solid rocket fuels that are used have been considered as extremely dangerous to the environment and atmosphere. The most common solid fuel that is used today is Ammonium Perchlorate. This fuel has been used since the early stages of the rocket industry due to its relatively easy ability to store, high propellant density, high thrust, and relative ease of engineering an engine around it.

However, the launch effects that it has are extremely averse to the environment and atmosphere. The most harmful emissions that come from Ammonium Perchlorate are chlorine and alumina⁶. Chlorine is an element that can disrupt the ozone cycle completely and alumina will act as a catalyst to exacerbate the destruction of the ozone layer. The alumina can increase the destruction process by nearly 22%.

Launch vehicle design

Until today, and for the foreseeable future, the only way to reach orbit and beyond is through rockets powered by chemical propulsion. Any strategy to ensure a more sustainable future for the space launch involves the development of rocket engines with improved environmental performance.

However, the design of launch vehicles has been consistently driven by mission performance, cost and reliability so far. Initial guidance, although evident, is that environmental impact and sustainability will have to become key considerations in rocket design and manufacturing. The diversity in rockets' environmental impacts resulting from their diversity in designs demonstrates that there exists a trade space on that matter, especially regarding propellant choices.

Rocket vehicles' harmful emissions of chlorine and alumina particles are associated with ozone depletion, radiative forcing, and local ground impacts through acid rains for instance. These effects should lead to a reduced role of these boosters in the architecture

of future launchers, although they will still be used in the future by SLS, Ariane 6, Vulcan Centaur, or Long March 11.

In addition, liquid Oxygen and Kerosene engines, because of their emission of soot particles and their radiative forcing effect, should also be carefully considered. They are currently among the most popular rocket fuels in the US, Russia, and China. Hypergolic rocket fuels based on nitrous oxide and unsymmetrical dimethylhydrazine are extremely toxic for local ecosystems, and for human beings.

Similarly, launch vehicle manufacturers in America and Europe have already moved away from it, Russia a long-time user seems to be transitioning as well, but China still relies on hypergolic propellants heavily so far. Liquid Oxygen and Hydrogen rocket engines are so far the cleanest technology to have flown to orbit.

This is the propulsion technology to be used soon on Ariane 6, SLS, and Vulcan Centaur. A growing number of launch vehicle manufacturers have started including sustainability considerations in the design of their launchers. In Europe, ArianeGroup has investigated the environmental impact of their Ariane 5 and future Ariane 6 launchers, and included it as a requirement in the development of the Prometheus engine.

Startups like Skyrora and Orbex are demonstrating efforts to reduce the environmental impact of their propellants, in particular from their manufacturing. Finally, the recent development of Liquid Oxygen and Methane rocket engines for the next generation of launch vehicles Starship, Rocket Lab's Neutron, New Glenn,

Regulatory challenges

Rocket emissions fall into a category of environmental impact that may be particularly difficult to regulate for at least three reasons. First, there are many gaps in the scientific understanding of rocket launch and reentry emissions and a lack of appropriate metrics to characterize



their exact environmental impact. Second, despite the fact that rocket launches do produce compounds that are known to affect the atmosphere in complex ways, they lack an immediate, visible, and salient threat in the public consciousness.

Effective regulation and mitigation of any harmful effects of spacecraft launch and reentry emissions will ultimately require a baseline understanding of the existing issue and the potential impacts that may result from increased number and frequency of rocket launches. Whether binding legislation or voluntary norms are enacted, specific metrics will need to be developed that identify atmospheric and climate variables relevant to spacecraft launch and reentry and allow different spacecraft designs to be quantitatively evaluated and compared.

The space economy is expected to continue growing at a fast pace over the next two decades, likely reaching the trillion-dollar mark around 2035. The launch industry would then quadruple in volume of annual launches and its environmental impact most probably soar if no strategy is implemented to mitigate it.

Atmospheric emissions from space launches are highly dependent on the design choices made on the launch vehicle, at the forefront of which are the rocket engine and propellant mix.

Although literature in this area is still relatively scarce and magnitudes of the impacts remain to be precise, specific combustion products have been identified as consequential on higher atmosphere chemistry. Black carbon, alumina particles, chlorine, and nitrogen oxides are the most prominent of these, propellants associated

with these emissions, such as solid fuels, hypergolic rocket fuels, and Liquid Oxygen and Kerosene engines should be used with restraint.

Liquid Oxygen and Hydrogen is in comparison relatively harmless, but Liquid Oxygen and Methane emissions still need to be thoroughly studied, especially on life cycle aspects. International treaties do not presently address rocket emissions.

Only general environmental regulations, mainly at the national and local levels, exist. This is mainly due to the perception of this impact as being minor, to the traditionally strategic nature of the space industry, and to the typical difficulties of addressing 'Commons' problems.

Results of the comparative analysis of societal responses to various negative environmental externalities suggest that the

current response is very low, especially in terms of policymaking activity.

The recent peak in media coverage and research activity take-off could be precursors of future regulations, but go with significant inertia as in all industries investigated.

In order to avoid future impacts harmful to societal well-being, sustainability will have to become a key consideration in rocket design and manufacturing. This is a critical time for implementing these solutions, as the number of new rocket designs being developed has never been higher, and as technological choices made today will define the impact of the future fleet of launch vehicles.

Market-based incentivization of launch vehicle manufacturers towards sustainable designs could prove very effective, therefore future work should focus on methodologies and metrics development to better assess the environmental impact of launch vehicles.

MIDDLE EAST REPORT

Shipping industry worried over unprecedented distress alerts across Eastern Mediterranean sea



Shipping is more than flashy luxury role only from 1950 onwards. passenger liners, floating hotels or fast ferries. The real workhorses of the industry are the untiring freighters, be they tramp ships or liner vessels. In the old days, trampers used to be humble ships certainly not over-engined and with modest cargo gear. They would seek and load cargo wherever offered, hopefully at rates that made ends meet. To this day ballast positioning voyages are part of the game as are, if less frequently, idle times. And then there are specialized ships far and few between in the twenties but quite numerous in this day and age.

World War I, terminated in 1918, left the world fleet decimated but had not impaired the role of the irreplaceable ocean-going steamer. The advent of steamers gave birth to regular and reliable liner services around the globe and on many a local or regional route.

Then, trade expanded in tune with rapid industrialization during the second half of the nineteenth century and shipping duly followed suit. Initially liner and semi-liner services would be the almost exclusive domain of steamers. In the year 1880 the merchant navies of all European nations totalled 127,170 sailships and no more than 13,858 steamers. 1860 is acknowledged as the absolute peak of European sailships which outnumbered steamers at the rate of 92,270 to 2,974. That ratio steadily declined ever since and steamers increasingly catered for bulk cargoes, a virtual monopoly occupied by sailships well into the first decade of this century.

Large barks and full-rigged ships went through a short illusory boom during a few years following 1919 when ships were scarce, but many different types of sailships held their own much longer in the coastal trades and in fishery. Steel had replaced brittle iron

and as early as 1901, a full 95 % of vessel newbuildings worldwide were made of steel. The first motorships already traded in 1920 but marine engines were yet to commence their real development and assumed a leading Shipping is more than flashy luxury role only from 1950 onwards.

Seafaring in those days meant hard manual work. Accommodation on board was anything but luxurious. Officers had narrow and sparingly furnished outer cabins accessible from hot alleyways leading to the engine room. Ratings, stokers and coal trimmers were put up under the forecandle head, the most obvious place in vintage steamers. Newbuildings from the thirties onwards had accommodation amidships or aft, but older vessels would of course not be converted solely for the purpose of improving crew accommodation. Nautical crew and the cook had the privilege of the starboard

compartments, stokers had theirs on the port side.

There normally were two crew compartments, one each for eight men, into which the bunks would be squeezed with maximum space utilization in mind, as opposed to comfort. One locker per person, and a narrow one at that, offered just enough room for personal effects normally carried on board in a duffle bag. As Jochen Brennecke aptly described it in his book 'Geschichte der Seefahrt': "there was a bare mess table in the centre of the room which all had to share. Electric lighting was late to come.

The pungent stench of oil lanterns combined with smells and odours of all sorts to form what is commonly known as fug. Showers and baths were quite unknown, except those provided by breaking seas in rough weather. However, good owners saw to good food, realising that good crews could prevent

costly disasters."

Looking back it is often forgotten that those ashore, be they factory workers, artisans or office staff did not live in paradise either. The vast majority of people led a hard life full of privation and what little time off they had would have to be spent in various ways maintaining their modest belongings or improving their income or the quality of their food. Hard work and deprivation aside, seafaring was a sought-after manner of earning one's keep. Nautical and technical seafarers with a sense of duty earned a reasonable income. They progressed in life even without taking university degrees and above all they could see foreign countries which most landlubbers could not.

The coming of GMDSS

Despite new technologies and changes to regulations, seafarers continue to encounter unsafe conditions on board ships. "I still see ships with out-of-date firefighting equipment and blocked escape routes," said Pradeep, a second engineer from India. Fatigue remains a critical concern, with ships operating minimal crew and seafarers being asked to sign last-minute contract extensions. "Our pay is better but on my last voyage, I worked over four months with barely any rest between shifts or shore-leave," reported Nikolaos, a Greek deck officer. Pradeep also cited onboard living and working conditions as a concern, "I miss food from my country but am still adding weight. It is difficult to exercise on my ship", he said.

This echoes the findings of the 2024 global health study by Marine Benefits, which reported that almost 70% of seafarers believed themselves to be overweight or obese .Despite efforts to improve connectivity, isolation continues to affect mental well-being. "I do not speak to my family for days," said Joseph, a Kenyan AB. "Ship internet is expensive and often doesn't work. The separation from life is very hard for me."

Feelings of fatigue and isolation are compounded by a sense of vulnerability. All three seafarers agreed that more training is required to address new hazards, in particular the use of new fuels such as LNG and ammonia. Yet they reported feeling unprepared. "I had a short briefing on ammonia. What happens if there's an accident?", Pradeep asked rhetorically.

Effective and relevant training contributes to risk management, yet Joesph recounted that he "used instructions written many years ago." In a similar vein, Nikolaos noted: "We hear about safety but are then expected to work long duties, which means we cannot rest well or practice proper drills."

But it's not just a matter of shipping companies addressing onboard conditions. Geopolitical instability is also pushing some to reconsider their seagoing careers. "After sailing through the Red Sea, I started looking for other work," Joseph admitted. "My family worry and the stress is too much", he added. Pradeep had a different but no less impactful experience. "I have been lucky to avoid the war," he explained "but that means weeks longer at sea, which adds to my tiredness." There are no easy solutions for shipping, but without further reform it seems likely that the industry will continue to struggle with recruitment, adding yet more pressure on working seafarers. Yeoman Burn and Yeoman Brook were the first EO

ships to be equipped with the GMDSS Global Maritime Distress and Safety System. Its purpose is further to improve maritime safety with safety at sea being the main object for broadcasting and receiving topical information, locating vessels in distress, search and rescue operations. The system rests on several pillars, including but not limited to the reallocation of radio frequencies, sophisticated equipment on board and ashore, manning of ships and training and certification of seafarers.

"Every day, seafarers and ships keep global trade moving and maritime safety is fundamental. Over the decades, innovations like satellite-based maritime communications, have played a vital role in ensuring the safety of life at sea. Today, these systems are more important than ever, supporting navigation and the digital transformation of the industry.

As the transition toward decarbonized shipping, new low and near-zero fuels bring potential safety risks that require updated regulations, specialized crew training, and robust emergency systems. At the same time, digitalization and automation introduce cyber risks and operational challenges, highlighting the growing need for resilient satellite technologies and real-time connectivity.

Therefore, international regulations require deck officers including masters to obtain certificates of proficiency at operating GMDSS equipment. The various national shipping administrations have meanwhile published their own regulations dealing with the subject. To cite one example, Liberia, as stipulated in the 'Minimum Safe Manning Certificate', requires no fewer than two deck officers on board Liberian ships to hold a Liberian certificate called 'General Operator GMDSS'.

The said licences are being issued separately and cannot be obtained by having, the Licence of Competence endorsed. Filipino nationals must obtain their national 'General Operator's Certificate GMDSS' prior to applying for the Liberian version. German, Indian and Russian deck officers are required to hold a valid unrestricted general radiotelephony certificate.

Lucy Oldendorff and Elisabeth Oldendorff, two new buildings which followed a little later duly received GMDSS equipment, and long before the 1995 deadline by which time all new buildings had to be GMDSS fitted, the complete EO fleet had been so equipped. Vessels completed before 1995 have to meet GMDSS standards by 1999.

Inmarsat is the world leader in mobile satellite communications, operating a global system of 14 geostationary satellites and associated ground infrastructure that offers a wide range of communications solutions to customers on land, in the air, and at sea. Inmarsat has an unrivalled track record of operating the world's most reliable global mobile satellite telecommunications networks, sustaining

business and mission critical safety and operational applications for more than 40 years.

Since its creation in 1979, Inmarsat has been operating pioneering global mobile satellite communication systems. The company came into being as an intergovernmental organization to provide global safety and other communications for the maritime community. Starting with a customer base of 900 ships in the early 1980s, it grew rapidly to offer similar services to other users on land and in the air. It now supports links for phone, fax and data communications to more than 287 000 ships, vehicles, aircraft and other mobile users in every part of the World except the polar regions.

Distress calls by Nature

According to Allianz's Safety and Shipping Review 2025, 27 vessels over 100 GT were lost in 2024, the lowest annual total on record, foundering was the main cause, claiming 12 vessels. This continues the trend that has seen a near 75% decline from the 105 losses reported in 2015 and improves on the previous lowest annual total of 35 set in 2023.

The headline reduction in total losses is an impressive indicator of improved vessel safety and is to be welcomed. However, the situation is more nuanced when viewed through the prism of onboard safety, shipping casualties or incidents increased by approximately 10% during 2024 as 3,310 compared to 2,963 in 2023, with the highest number being reported in the congested waters around the British Isles 799 incidents.

Open conflicts, ratcheting geopolitical tension, unpredictable climatic events and rapid technological evolution combined to test its resilience once again. The ripple effects on international shipping operations were profound. Flashpoints in the Strait of Hormuz, Red Sea, Black Sea and South China Sea endangered ship safety, stress tested stakeholder adaptability, stretched mechanisms of international collaboration and, in the case of the South China Sea, raised the risk of miscalculation and confrontation. Seafarers once again unwittingly found themselves on the frontline of these disputes, facing increased psychological and physical risks as a result.

'Shadow' fleet operations, false flagging, and piracy and armed robbery incidents also contributed to shipping's higher-risk profile, while the industry simultaneously had to contend with the growing cybersecurity threat. Multiple ransomware and malware attacks disrupted port operations, navigational systems, and supply chain continuity in 2024, with over 1,800 vessels reportedly targeted in the first six months of the year alone. These incidents exposed vulnerabilities and reinforced the need for robust cyber-resilience strategies across fleets and shore-based operations.

Climate change exerted a parallel and intensifying influence on maritime safety in 2024. Severe weather events, such as increasingly destructive cyclones, flooding, extended heatwaves and persistent droughts, caused extensive disruption to maritime routes and port operations.

Notably, low water levels in the Panama Canal curtailed cargo volumes, forcing operators to adopt alternative and less efficient transport options. And the retreat of Arctic ice continued to spark debate about the viability and risks of the Northern Sea Route, while highlighting concerns about search and rescue preparedness, environmental spill response, and the fragility of polar ecosystems.

Of the global total, Allianz calculated that machinery damage or failure was the root cause of 56% of reported incidents, followed by collisions and fire and explosion, an increase of 20% year-on-year and the highest number in a decade.

A report published by DNV told a similar story. While casualties from collisions, groundings, and similar incidents declined over the last decade, the number of marine incidents rose by 22% between 2022 and 2024, and fire and explosion incidents increased by 42% compared to 2021 data. The report also suggested that the number of maritime safety incidents increased by 42% between 2018 and 2024, far outstripping the 10% growth of the global fleet over the same period.

Of the 801 distress calls registered in 2024, 718 did not include the nature of the incident. While the sample size is therefore small, and the nomenclature of the incident types is more expansive, GMDSS distress data highlights similar issues to those reported by Allianz and DNV. Tracking these statistics over time, can help to build a more detailed safety picture that the steady decline in total losses may otherwise mask. Of the 83 distress calls that included the nature of the incident, 31 also included vessel-type information.

A report published in 2020 analysed evidence of occupational injuries and fatalities on board merchant vessels over 500 gross tonnage trading internationally. It concluded that "slipping, stumbling and falling of a person" was the top immediate causal factor of occupational injuries and fatalities onboard merchant ships.

The highest number of occupational accidents were reported in the "Ship" zone, which includes all the open decks and stairs, followed by accommodation, engine room, and cargo and tank spaces. Within the "Ship" zone, the highest number of occupational accidents occurred on the freeboard deck.

The analysis indicated that passenger and ro-ro cargo vessels experienced the highest frequency of onboard occupational injuries, but that 60.6% of occupational fatalities occurred on board solid cargo vessels, including bulk carriers, container ships and general cargo vessels.

SPECIAL REPORT

Maritime security over Kharg Island, SAR images detect four vessels, all are dark



The future of maritime security, in one observation, over Kharg Island Four vessels, all are dark. That is what the CogniSAT-6 satellite, built by Open Cosmos and flying Ubotica's onboard AI, saw in a single pass over Kharg Island, Iran's main crude oil terminal.

The four vessels detected in open water, located, measured and classified by size, including three at very large container vessels scale. The detections reached the ground in minutes.

The full observation followed much later, as conventional Earth Observations always do. On the ground, Open Cosmos AI agents fused those detections with AIS, the signal every compliant vessel broadcasts to announce its identity, position and course. All four were dark: visible from orbit, silent on AIS. To be clear about what this is not. We do not publish live vessel positions in a conflict zone and we are not naming ships.

Going dark is not, in itself, evidence of wrongdoing. But a crude terminal where four vessels are dark is exactly the kind of pattern that merits a deeper look. Most nations are responsible for a maritime zone many times larger than their land.

Beneath those waters run the cables and pipelines that carry the energy and data our economies depend on. No one can watch everywhere, all the time. And the threats do not sit still. Earth Observation should be the answer.

Today, AI on the ground predicts where risk is rising and prioritises where to look. It then orchestrates the right sensor for the right observation: if a vessel needs watching at night, darkness will not stop a radar satellite, so it cues SAR first, then follows up with optical when the skies are clear and if additional observations are needed.

AI in orbit processes onboard and returns structured intelligence in minutes. AI agents on the ground fuse those detections with AIS, history and other sources to establish what each vessel is doing. Orbital AI learns. Every observation improves the next one.

Since the war, 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, but there is no indication yet that this increase is linked to suspicious behaviour including covert ship-to-ship activity.

A vessel's automatic identification system AIS have been playing important role in commercial shipping, transmitting information about a vessel including its location to help avoid collisions.

Away from the mainland, Kharg Island is not just a small island in the northern Gulf. It is one of the most critical nodes in Iran's energy infrastructure and, by extension, a pillar of the country's economic and political stability. Iran is a major oil exporter, and a significant share of its crude exports flows through Kharg Island. The revenues generated there form the backbone of the Iranian economy and sustain the functioning of the state itself.

For that reason, any attack on Kharg Island would not be seen merely as a regional military strike. It would be understood as a direct assault on Iran's economic sovereignty and national stability.

The island of Kharg, situated in the northeastern quadrant of the Persian Gulf approximately twenty-five kilometers off the Iranian coast, represents the most critical node in the Islamic Republic's national security architecture. While Iran possesses

various ports and smaller terminals, Kharg Island is the undisputed heart of its petroleum industry.

Historical data and current 2026 intelligence confirm that the terminal handles upwards of 90 percent of Iran's total crude oil exports. This geographic concentration of wealth makes the island a unique economic gravity well. The island is not merely a piece of industrial infrastructure but the primary life-support system for the Iranian state and its military apparatus.

The strategic importance of Kharg is rooted in its deep-water capabilities. Unlike many other locations along the shallow Persian Gulf coastline, Kharg possesses natural deep-water berths capable of hosting Very Large Crude Carriers and Ultra Large Crude Carriers.

Furthermore, the island serves as a psychological fortress. For decades, the Iranian leadership has projected the invulnerability of Kharg as a symbol of national resilience, dating back to the Iran-Iraq War where the terminal survived repeated Iraqi air strikes. In 2026, the rhetoric from Tehran suggests that Kharg is the "red line" of all red lines.

The economic gravity of the island extends beyond Iranian borders, as its output is a vital component of the "shadow fleet" trade that bypasses international sanctions. Major global players, particularly in the Asian markets, rely on the consistency of the Kharg output. Consequently, the island is the epicenter of a complex web of global energy security, regional power projection, and revolutionary financing. Controlling Kharg does not just "turn off the tap" for Iran; it fundamentally reorders the geopolitical energy map of the Middle East.

Since 2025, the shipping industry has been affected on multiple fronts, with the loss of life and vessels in the Strait of Hormuz, disruption to trade between Middle East and Europe, and the growing burden of sanctions. 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.

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. Kpler uses a wide range of AIS data sources, reducing the likelihood of falsely indicating a vessel has gone "dark" due to poor coverage.

Around 2,000 seafarers were thought to be stuck on vessels in the Persian Gulf following the outbreak of the US attacks on Iran. However, trapped crews face the constant threat of attack, with little access to food or medical supplies. Tragically, a number of crew have already been killed in attacks.

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 while the tanker sector faces huge restrictions and

disruption, as do bulk and general cargo operators shipping LNG and crude oil."

"Seafarers 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 Russian and Ukrainian seafarers may be unable to return home or rejoin ships," says Captain Rahul Khanna, Global Head of Marine Risk Consulting at AGCS.

What is passing through the Strait?

As of March 20, Iran-linked tankers were the main vessels carrying crude oil through the strait, with other traffic slowed to a trickle. Data from Kpler shows that between March 5 as risks to shipping began to increase and March 20, at least twenty-eight oil tankers linked to Iran transited Hormuz in both directions empty and laden, at least eight of them in the past week. These include tankers with a history of sailing to the East Outer Port Limits off Malaysia near the Singapore Strait, a ship-to-ship hub where vessels transfer their oil cargoes for transport to China.

Among them is the *Nora*, which is believed to have loaded around 2 million barrels at Kharg Island on March 7, keeping its Automatic Identification System switched off like oil tankers often do when loading in Iran. The *Nora* then transited the strait on March 15 with its AIS on and was observed sailing very close to the Iranian coastline until it reached Chabahar before sailing out into the Arabian Sea.

It is unclear whether the ship's unusual navigational behavior was related to concerns about being targeted or seized. In any case, data from MarineTraffic shows the *Nora* signaling China as its destination, indicating that Tehran's oil sales to its top customer have not been disrupted by the war. In addition, at least eight oil tankers not linked to Iran six laden, two empty passed through the strait between March 5 and March 20. These include the Pakistani-flagged *Karachi*, which crossed on March 15 with crude loaded at Das Island, United Arab Emirates, and bound for Pakistan.

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. Insurers may also face claims under marine war policies from vessels and cargo blocked or trapped in ports and coastal waters by the U.S 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 the ports and the Strait of Hormuz. There are potential issues around safe navigation, crew, maintenance and salvage for these ships if

they are unable to leave."

Shipping trapped or blocked in the Strait 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 due to security worries.

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.

Again, given the legal and reputational risks, many companies including insurers have pulled back from trade within the Middle East. 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.

In addition, 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 instance, 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.

In general, Automatic Identification System AIS promotes a higher level of safety at sea by allowing maritime authorities to locate and track seafaring vessels.

AIS technology was developed and implemented with the goals of automating and improving navigation safety at sea, preventing collisions through a ship-to-ship operative mode, providing key information about a ship and its cargo to other ships and parties within littoral zones, and functioning as a traffic management tool for vessel traffic services.

AIS has quickly become an operational tool exploited by a large number of actors, providing precious information, not only to crews but also to terrestrial regulatory authorities, not forgetting individuals and

research scientists. Among the tracking tools that exist for maritime traffic, AIS supplies information but does not reinforce ships' safety. On the contrary, it sometimes even appears that it is used by the very pirates themselves. In fact, the cause of the system's greatest defect comes from one of its main assets: the data are originally free of charge, free to use and thus difficult to monitor.

However, today, satellite Automatic Identification System (AIS) technology has fundamentally changed the landscape for monitoring the maritime domain. Improving upon existing AIS technology already deployed aboard all large vessels and many smaller vessels around the globe, satellite AIS is truly revolutionary in providing a complete and global picture of the world's maritime shipping environment.

According to maritime experts, the data capabilities of AIS mean that it, "has the capacity to improve situational awareness via the production of information that allows a clearer picture to emerge of which ships are in the vicinity, where they are heading, and what they are doing at any given moment . This is obviously important for both shoreside authorities and ships' officers.

Imagery automation and classification

While the role of AI in space-based surveillance is growing, with Capella Space, a U.S. space technology company, has brought to bear in the ongoing conflict, a fully automated marine vessel classification system. According to report by SAE Media Group, the system utilises AI to assess satellite images to detect ships and run historical analysis against the company's archives to identify them.

With the eyes of military analysts across the globe fixed firmly upon key maritime choke points including the Strait of Hormuz, the practical applications for the technology are focused on the Kharg Island.

The system essentially reduces the latency between generation of satellite imagery and identification of any vessels that have been captured in the images which is critical when time is of the essence, as is generally the case for military surveillance.

Dan Getman, VP of Product at Capella Space, said: "When it comes to intelligence, speed and accuracy is of the essence. Capella's platform effectively minimizes the latency from tasking to intelligence extraction."

The announcement from Capella Space came one day prior to an announcement by the U.S. National Geospatial-Intelligence Agency (NGA) of its first commercial solutions opening.

The Intelligence Agency expressed a need for commercial technology to aid in tracking maritime threats across the globe.

With Capella Space already having developed a strong partnership with the NGA, it is likely that we will see the technology used to improve NGA's maritime domain awareness.

The US Intelligence Agency also recognises the value of AI technologies such as machine learning and computer vision outside of maritime surveillance, using them alongside traditional surveillance techniques to inform military leaders across all operations, from the battlefield to geopolitical analysis. According to Vice Adm. Frank Whitworth, Director of the National Geospatial-Intelligence Agency, the agency are "very excited about the trajectory of AI applications".

However, aircraft and patrol boats are not suitable for persistent monitoring of vast maritime areas due to their limited range and coverage capabilities. Additionally, shore-based surveillance systems are often unavailable in remote regions, making satellite platforms essential for effective monitoring. Given the large expanse of these areas and the large volume of data generated, the use of AI is important for processing and analysing the data efficiently and accurately. In order to overcome the environmental challenges of these regions, the primary data sources utilised are Synthetic Aperture Radar SAR, Radio Frequency data, and Automatic Identification Systems AIS, which together provide comprehensive coverage and valuable insights into ship activity.

Chinese factor

By 2026, China has solidified its position as the primary consumer of Iranian crude, often facilitated through a "dark fleet" of tankers and non-dollar denominated transactions. For Beijing, the Iranian energy supply is not merely a matter of economic convenience but a critical component of its "Malacca Dilemma" mitigation strategy. If the United States "turns off the tap" at Kharg, it effectively grants Washington a veto over a significant portion of China's industrial energy input, a move that Beijing views as a provocative act of containment.

Analysts suggest that while China may avoid a direct ship-on-ship confrontation with the U.S. Navy, it could provide Iran with real-time satellite intelligence, advanced electronic warfare suites, or "volunteers" to operate air defense systems on the mainland, thereby turning the Persian Gulf into a high-tech proxy battlefield.

Meanwhile, 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 throughout the past week 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.

“NewSpace” phenomenon and the emerging cyber threat in space systems



Commercial space companies 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 2021, there are more than 7,389 satellites in orbit, with 4,084 operational and 3,305 inactive.

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. Global space industry revenues topped USD 323 billion in 2015, with 76 per cent comprised of commercial space products and services, and

commercial infrastructure. The space industry has also grown by almost 10 per cent between 1998 and 2015, much more than global GDP growth over the same period of time. In this context, the satellite industry has proven to be the dominant driver of growth, accounting for more than 62 per cent of space industry revenues in 2015, the majority of which was generated by satellite services such as telecommunications, Earth-observation, science and national security applications. In the years 2009 to 2015 satellite applications were dominated by technology, 47 per cent, whereas projected trends show that as from 2016, Earth-observation will take the lead with 73 per cent of the applications market.

The average number of satellites launched globally per year increased by 36 per cent in the years 2011 – 2015 over the previous five years, with a number of total operating satellites reaching 1,381 in 2015 as compared to 986 in 2011. This report draws attention to the rise of the new wave of companies, characterised by different and innovative business models.

The paradigm of traditional satellite companies - large, less cost-effective, backed by huge government investment is declining, leaving room to small-medium size companies, often spun-off from universities to grow and prosper. This phenomenon widely termed “NewSpace”.

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.

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, that is, by 2050.

The Space Foundation reported that the global space economy reached revenues of US\$570 billion in 2023, reflecting a 7.4% increase over the previous year in line with a five-year CAGR of 7.3%, and nearly double the total from a decade ago. As of July 2024, commercial revenues account for almost 80% of industry activity.

According to a recent report from PwC, the space industry is at a turning point. Commercialisation is massively ramping up, with future growth projects set to hit \$2 trillion.

But booming prosperity also means ballooning demand, and manufacturers are racing to catch up. The expected jump in demand for components and materials for satellites, missiles, and re-entry vehicles is eye-watering, more than 650% satellites are expected to be built over the next five years.

Future projections suggest that the global space economy may grow to as much as \$2 trillion by 2040. While government spending in the sector continues to grow, private companies are expected to take the lead, driving innovation through increased investment and strategic collaboration between commercial and government entities.

Before 2012, annual space launches never exceeded 170 objects. But since 2019, each year has set a record. In 2023, 2,664 objects were launched into space, 2,166 of them from US soil.

The services feeding into the global space economy are consumer television, consumer broadband, mobile satellite services, remote-sensing services, ground equipment, satellite manufacturing, and space-launch services. In time, other services, such as on-orbit satellite servicing and lunar and asteroid mining, may increase the above numbers. The overall growth of small-satellite services will increase over the coming decade.

However, there will be a shift in the applications of these spacecraft and the types of services provided.

In the year 2000s, satellites are getting smaller, as a number of technological advancements made it possible to put more capable payloads onto smaller satellites. Among the key technical advances there are improvements in microprocessors, solar cells, batteries, and microelectromechanical systems that give smallsats capabilities previously possible only with larger spacecraft. Another relevant innovation that has helped small satellite development has been the Internet, allowing for improved collaboration on development efforts and even easier control of spacecraft through Internet-connected ground stations.

Perhaps the major innovation that has supported the growth of the smallsat field has rather been the CubeSat program. Developed by California Polytechnic State University and Stanford University, it set a new satellite standard as a CubeSat is 10 centimeters on a side and weighs about 1 kilogram. CubeSats initially found interest among universities in part as a means to give students engineering experience with spacecraft for a tiny fraction of the cost of a larger spacecraft, particularly when coupled with secondary, or rideshare, payload launch opportunities.

This renaissance has been made possible by a set of technology drivers that have thrust the satellite industry for the last 25 years. The advent of microelectronics saw the development of microprocessors, making gigabytes stored on a fingernail. “Moore's Law” was proven to be successful as transistor density has been doubling every 2-2.5 years since 40 years ago and it is said it may last for more 10 years, making it possible to produce high-performance smart sensors and distributed processors systems. Inexpensive and multi-mega pixels imagery is now affordable, addressing Earth imagery purposes.

The development of Micro-Electro-Mechanical Systems also boosted nanosatellites' technology, as rate gyros, accelerometers and microbolometers can now be set together. Solar cells reached higher efficiency levels, as today's solar cells are significantly more efficient than those available 25 years ago: fewer cells are required per unit power.

In addition, cell voltages have increased so that a single cell can drive spacecraft circuits. Moreover, The CubeSat standard adoption led to a containerized delivery of satellites, with orbital deployers providing physical containment of secondary satellites and less risk for primary, heavy satellites. The CubeSat paradigm has then improved small satellite access to space: initial cost was around \$40K for a 1 unit CubeSat, a cost universities could afford. Many international launch options now exist, and that way small satellite missions are getting more diverse and launch rates are rising up: small satellites are deployed for space biology experiments, tracking ships, monitoring stellar magnitudes, inspecting other vehicles, space weather measurements, etc. It's also interesting to notice that more nanosatellites are being launched than microsatellites.

As a positive disruptor, small satellites allow the government to field numerous capabilities, such as communications and remote sensing, at significantly reduced costs. The average

production and launch costs for small satellites are up to 90 percent lower than those of larger satellites. Because production and per-unit launch costs for small satellites are significantly lower than for larger satellites, on-orbit systems can be replaced as more advanced technology becomes available. This technology refresh rate as quick as twenty-four months, compared to ten years for more traditional satellites allows increased capabilities to be fielded at minimal cost and risk.

However, one negative disruption that presents challenges for the NewSpace industry is the widespread cybersecurity vulnerabilities. Space and other mission systems are usually complex, requiring “serious attention to be paid to their people, organizational processes, and technologies, the three interdependent elements.”

Cybersecurity on space systems has introduced a large challenge for the commercial and national security planners. The use of tens of thousands of small satellites connected to global communications and data has exponentially increased the cyberattack surface area. Space systems are becoming an increasingly large sector and global economy and global cyber infrastructure. This increasing attack surface area now presents two specific challenges: to secure use of commercial capabilities for national security, and to protect commercial satellite systems as an element of US critical infrastructure.

However, the first cyberattacks on space systems took place in the 1980s with a first hijacking attack on an HBO satellite television broadcast conducted by an individual in 1986, an eavesdropping attack carried out by the Indonesian government on a U.S. EO satellite in 1986, as well as a first attack on a ground systems conducted by teenagers on a NASA satellites through a trojan horse in 1987.

According to Brandon Bailey, the cybersecurity of space systems has long focused solely on electronic attacks such as jamming and spoofing as well as on the ground segment and not on the space segment because satellites were not perceived as hackable devices.

Satellites are now frequently equipped with software components and are connected to the internet. In addition, most processes in the design, manufacturing, testing, launch, and operations of satellites rely on digital technologies. For example, recently the first Bluetooth connection to a satellite over 600 km away was established. Satellites can therefore be regarded as expensive computers flying in orbit, which can be hacked like any other connected device. This has led to an extension of the attack surface, which refers to all the entry points that can be exploited by an attacker to disrupt, damage, disable, or take control of a satellite.

However, satellites are increasingly digitized, interconnected, linked to the Internet or an intranet network, their distance from the earth does not make them less vulnerable and the encryption keys can be decrypted. According to the Secure World Foundation, many Nations-States are developing cyber offensive capabilities that could be used against space systems and many non-state actors are actively trying to find cyber vulnerabilities on satellites that are similar in nature to those found on traditional computers on Earth.

Even as at today, experts recount the increasing number of cyberattacks, in particular during armed conflicts as well as the rising complexity of attacks

and threat vectors linked to the growing number of cyber operations carried out by State actors.

First, small-satellite communications architectures are complex, offering numerous opportunities for malicious attacks. The communications link between a ground station and a satellite consists of a wireless link between the satellite and ground station. The link must be encrypted and command authentication in place to prevent hostile takeover of the satellite.

The ground station is connected to a control center, which might be a local link or a link traversing the Internet. The control center itself will likely consist of industry-standard commercially available servers, and those will be connected to each other via a switch. Their entry point to the Internet is a router with a firewall. The firewall itself may be based on dedicated hardware, or it can be a commercial off-the-shelf (COTS) server with special-purpose software for routing and firewall functions. While the switches are not very vulnerable to attacks, the COTS computer infrastructure is. Attacks against industry-standard servers have proven successful, both against the server and its operating system, and against its baseboard management controller.

Therefore, attacks against the baseboard management controller can be used to permanently alter the firmware of the server, thereby making the attack persistent and nearly undetectable. In either case, it is possible to take control of the server, and, by doing that, it is possible to issue malicious commands to the satellite. If the link between the ground station and the control center is not secured via a virtual private network, then attacks could be as simple as monitoring the traffic and injecting commands. That is easily done via a switch with port-replication features. Oftentimes, the control center allows for remote-control centers to connect and, as such, the remote-control centers and their links must be protected as well.

Satellites and their supporting infrastructure are no longer immune to cyber threats. As digital systems evolve, so does the threat landscape, exposing satellites and their control networks to potential exploitation. These vulnerabilities can result in wide-reaching disruptions from interrupted communications to compromised national security. The emergence of satellite mega-constellations further increases complexity and expands the attack surface, complicating efforts to maintain secure operations across globally distributed systems. This reinforces the need for robust cyber defenses that protect the availability, integrity, and continuity of space-based services.

According to UNIDIR Researcher Laetitia Zarkan, a cyberattack against a commercial satellite can be potentially more dangerous than a cyberattack against a military satellite since military systems are generally more secure and military satellite operators are used to being attacked and even expect to be. As a result, there is a better chance that they know how to react to an attack, which is not always the case in the commercial sector. However, governments are



increasingly using commercial solutions. For instance, 80% of the needs in bandwidth come from commercial telecommunication satellites. As a result, cyberattacks against commercial satellites can have consequences on military operations.

According to Jacob Oakley, with the emergence of NewSpace, there are many instances in which one organisation owns and operate the satellite bus and another organisation owns and operate the payload on board of the satellite. As a result, one organisation, one organisation's ground station may track and send commands to the satellite bus and another organisation's ground station may send commands to the payload. This situation raises cybersecurity risks as the two organisations may implement different cybersecurity protocols and standards, and a cyberattack on the payload may affect the bus and vice versa.

This risk usually arises from a lack of containers and logical separation between the satellite bus and the payload software and network environments, which would prevent cyberattacks on the bus to spread to the payload. This situation raises policy questions regarding the legal responsibility of each stakeholder in case of an attack. Overall, New Space bring new and additional cyber

risks on the space segment. Regarding satellite constellations, new cyber risks arise as software and hardware are usually identical for all the satellites of the constellation, which increases the surface of attack and put the entire constellation at risk. Should an attacker discover one vulnerability on one satellite, it may enable the attacker to target all the satellites of the constellation.

Among the segments of space infrastructure typically classified as Space, Launch, Link, Ground, and User the Ground Segment is particularly significant. It frequently supports multiple missions at once, handling all control and mission data. Unlike the space segment, ground infrastructure is physically accessible, which increases its attractiveness to adversaries.

One of the challenges, which was identified by a number of stakeholders, was the large amount of legacy technology in ground infrastructure within the space sector. These technology components have not been designed with modern cyber security principles and present persistent vulnerabilities. This is partially due to the relatively long lifetime of both satellite operations and other physical components such as

antennas, compared to standard IT technology lifetimes. Many of these legacy systems have been built and operated with an "if it ain't broke, don't fix it" mindset, which has led to outdated security practices.

According to Michael Krepon, president of the Stimson Center, cyberattacks on the ground segment are more likely than those aimed directly at the space segment. The ground segment enables command, control, and management of satellites, their position, the position of their solar panels and instruments, sending and receiving data. As long as these systems are connected, they can be targeted by cyberattacks. Both the uplink and downlink may be targeted by cyberattack as well as the link between the ground station and the control centre.

Moreover, ground stations are increasingly digitalized and generally use common software and operating systems such as Linux or Unix, which can be victims of traditional cyberattacks that are not specifically programmed to target a particular space system, thereby increasing the likelihood of an attack. According to a report, compromising a ground station is the easiest way to take control of a satellite.

Space cyber architecture

Space is quickly becoming an extension of the internet, with some satellites now being directly reachable from the internet. This opens the door to cyber threats like unauthorized access, rogue ground stations, and ransomware attacks on space assets. "Attackers could start scanning for internet-connected satellites or even set up rogue ground stations to exploit vulnerabilities," Wallén explains.

In the last few decades, space systems have gone from analogue to digital systems, thereby increasing the surface of attack, lowering the barrier of entry for attackers, and making satellites and satellite services new cyber targets. Indeed, satellites are increasingly equipped with reprogrammable software, on-board computers, and connected through TCP/IP protocols. They can simply be defined as computers in space, which are controlled by other computers on Earth. This trend is rising with inter-satellite links, on-board data processing software, cloud ground stations and other space-based data services. As any connected object, this makes them increasingly vulnerable to cyberattacks.

The rise of mega constellations made up of large fleets of interconnected satellites raises new cybersecurity challenges. These networks require standardized communication protocols, but traditional trust models based on physical location do not apply. "In space, trust cannot be established the same way we do with terrestrial systems," Wallén explains. "We need new frameworks to ensure security across diverse, interoperable satellite networks."

Historically, commercial satellite developers have not prioritized cybersecurity considerations when creating space systems, similar to the challenges at the inception of the Internet. However, as the space domain's attack surface expands with the increase of satellites in orbit, experts are concerned with cybersecurity threats posed to commercial satellites, whether privately owned or used by the government.

The use of COTS software and hardware components presents unprecedented challenges for commercial satellites, as the presence of these assets in space has diversified from government control to CubeSats deployed by many businesses. COTS components allow companies and organizations to launch satellites at a low cost, but they also have the potential for vulnerable components due to fast production and little security consideration. The use of COTS components allows attackers to easily access the code to explore for vulnerabilities, which was previously more difficult when satellites used proprietary software.

Cloudification of space, where startups are offering rentable satellite payloads or even planning on deploying datacenters in space, means customers can upload and run their own code on satellites, or run some of their computations on their data on servers in space much like cloud computing. "This is an exciting development, but it also means we need strict security measures to prevent malicious code from being executed in space," Wallén continues.

Although cyberspace seems only virtual, the physical layer is rather tangible. This physical layer, also called the material or infrastructure layer, are the equipment, infrastructure, and hardware such as computers, submarine-cables, smartphones; and satellites that

enable data to flow through cyberspace. It includes servers, USB keys, and datacentres where data are stored. This infrastructure can be geographically located and physically destroyed. The logical layer, also called software layer, consists of the lines of codes in various programming languages and binary information that the machine will transform into readable information for the end user.

According to report, strategic stability in space used to be partly enabled by a limited number of actors and a limited access to space and cyber technologies; a relatively easy attribution of kinetic attacks by all actors, which rendered plausible deniability and stealth impossible; and the potential creation of debris in case of a kinetic attack on a satellite, which would affect all spacefaring nations, including the attacker.

However, today, the widespread and relatively cheap accessibility to cyber offensive technologies lowers the barrier of entry and enables all actors, including non-space and non-state actors, to conduct cyberattacks on satellites. In addition, cyberattacks are difficult to detect and attribute. Unlike kinetic attacks where radars of any country can monitor the space environment and attribute ASAT attacks, cyberattacks are difficult to attribute, increasing plausible deniability and decreasing deterrence. It is about finding evidence of the attack and its origin through detecting IP addresses, digital signatures, logins, or even the attack patterns, programming languages, alphabet.

When it is possible, it is even more difficult to demonstrate who the attackers are working for, when nation-states are sub-contracting these activities to hacker groups, including in third countries. Finally, cyberattacks on space systems do not necessarily create debris and can be reversible, which do not deter attackers and contribute to instability in space as there is no longer an 'environmental interdependence'.

Australia is developing launch sites in Abbot Point, North Queensland, Nhulunbuy, Northern Territory, and at Whalers Way Orbital Launch Complex Eyre Peninsula. Australia does not have mature launcher capabilities and mostly launches foreign rockets from its soil.

Australia signs a contract with a new U.S. launcher company to launch a Japanese satellite. In this context, the Australian spaceport in the Eyre Peninsula welcomes staff from both the American and Japanese companies for the launch. The foreign staff is staying in a hotel near the launch site. As the launch is being delayed because of the weather, which is common, the foreign staff work remotely from the hotel and use the hotel's Wi-Fi.

However, an unnamed group possibly knows that foreign staff which come to the launch site always stay at the same hotel. As a result, they target the hotel's Wi-Fi to launch a sophisticated attack. The attackers send a malicious email to the hotel's reception, which appears to be a reservation from a well-known hotel booking website. The receptionist clicks on the emails, which downloads a backdoor and installs it. The attackers are then able to access the Wi-Fi network of the hotel and can launch attacks on computers and smartphones connected to the hotel's Wi-Fi network. They use the open-source Responder tool to listen for MBT-NS broadcasts from devices that are attempting to connect to the Wi-Fi

network and collect credentials login and passwords.

The attackers gain access to the laptops of both an employee from the U.S. launcher company and an employee from the Japanese satellite operator. When the launch is about to take place, the two employees travel to the launch site with their laptops and connect to the Wi-Fi of the Launch Control Centre without any prior cybersecurity check on their computers.

As a result, the attackers gain access to the Control Centre's Wi-Fi network and capture all the traffic on the network, including launch tests procedures, revealing some information about the components and systems of the rocket. The attack is detected by the Control Centre, which leads to the interruption of all activities on site, launch delays, additional costs as well as an investigation by the U.S. Department of Justice for potentially violating U.S. export control laws on missile technology. The company is therefore accused of missile proliferation, which affects its reputation and financial stability due to legal costs.

Unique challenges in the space supply chain

The space industry is seeing increased commercialization, with private companies taking on roles traditionally held by government agencies. This includes commercial cargo and crew transportation to the International Space Station, as well as commercial Earth observation and communication satellite constellations. Start-ups are making extensive use of Commercial Off-the-Shelf COTS components, especially electronics proven in other industries like mobile devices. This allows companies to leverage high-volume, low-cost parts while accepting some level of failure risk. Even NASA is exploring greater use of COTS parts to reduce costs.

Similarly, India heavily relies on imported components like semiconductors, carbon fiber and propulsion systems, creating vulnerabilities to geopolitical risks and disruptions. However, during the COVID-19 pandemic, the delay in importing critical parts hindered the progress of satellite launches. India's Production Linked Incentive schemes in electronics and semiconductors are designed to boost local manufacturing, attract global players and reduce reliance on imports, showcasing the country's commitment to building a resilient and self-reliant supply chain.

The time required to procure critical components, often exceeding 12-16 months, significantly delays project timelines. In 2021, delays in importing high performance solar cells impacted the readiness of a communications satellite in India. This incident underscores the challenges faced by Indian space technology start-ups due to global supply chain disruptions, including increased lead times for critical components like chips and sensors. In addition, there is a long gestation period, as manufacturing often starts only after the purchase order is issued.

The absence of an Indian Space Quality

Standard leads to inconsistencies and reduced trust in domestically produced components. ISRO has encountered challenges in marketing domestically produced satellite components internationally, primarily due to the absence of globally recognized certifications. This lack of certification hampers the competitiveness of Indian components in the global market, as international customers often require adherence to stringent quality and reliability standards. Addressing this issue is crucial for India to enhance its position in the global space industry.

The lack of specialized training programmes and inadequate infrastructure impedes India's ability to meet the demand for space-grade manufacturing. For instance, start-ups often need to send prototypes abroad for testing due to the absence of advanced facilities in India.

In Australia for instance, the space ecosystem is comprised of organisations ranging from small start-ups to large multinational companies, it is clear that a 'one size fits all' approach to cybersecurity will not prove effective due to the difference in terms of company maturity, risk profile, and available resources to respond to cyber compliance tasks.' In addition, the space environment is 'a tightly coupled ecosystem, where local developers are bound to a limited number of local suppliers and a much wider number of options from overseas suppliers. This introduces a level of sovereign risk to the growth of the local industry, if the supply chain is compromised by cybersecurity issues both domestically and abroad'.

The growing maturity of the LEO ecosystem is also reflected in the evolving supplier landscape. High-profile operators are increasingly relying on long-term collaborations with trusted component manufacturers to co-develop high-frequency solutions across multiple bands. These relationships demand not only technical excellence but also the ability to meet ambitious delivery schedules and scale production without compromising on performance.

The space economy supply chain involves a diverse range of stakeholders, each playing a vital role in the development, deployment, and utilization of space technologies and services. From component manufacturers to end users, this interconnected network drives innovation and progress in the space industry. As the industry continues to evolve, collaboration, adaptability, and innovation will be key factors in shaping the future of the space economy supply chain.

What was once a world of low-volume, bespoke geostationary GEO build is now giving way to high-throughput

manufacturing for vast constellations. Leading the way are companies like SpaceX and OneWeb, which operates more than 600 LEO satellites. In fact, Starlink has already launched over 7,000, and Eutelsat recently reported double-digit growth in its government services arm, showing rising interest in secure, homegrown connectivity across Europe and beyond.

For companies entering the LEO market, whether as satellite OEMs, payload developers or ground station providers, this shift requires a change in mindset. The heritage-driven model of GEO, where suppliers are selected based on long histories of proven success in similar environments, does not scale well when thousands of LEO satellites are needed, many of which will operate in low-redundancy architectures and face much shorter mission lifespans. Instead, cost-effective, volume-ready designs are paramount, says says Dr Peter Krier, director of programmes at Filtronic.

One of the most noticeable shifts in LEO supply chains is the growing acceptance of commercial off-the-shelf COTS components. Traditionally avoided in space systems due to their limited flight heritage, COTS parts are now gaining traction, provided that they are properly qualified and integrated within robust manufacturing and testing regimes.

The appeal is clear. With LEO satellites often launched in batches of dozens or more, the economics of traditional "space-qualified" components, which are produced in small numbers at high cost, are no longer viable.

That said, LEO doesn't offer a free pass on quality. Satellites still need to survive harsh radiation, extreme temperature fluctuations and mechanical vibrations during launch. The difference is that operators now balance these challenges against the realities of volume manufacturing. The result is a growing preference for suppliers that can demonstrate experience in producing high-reliability components at scale, especially those with roots in adjacent industries like telecoms and defence..

Recently, an Australian academic institution is developing a nanosatellite for Scientific, Technology, and Education demonstration, relying on COTS components for software, firmware, and hardware. The university orders COTS for the On-Board Computer and decide to use a 220 MHz Strong ARM processor manufactured by Intel, which had its own supply chain compromised. In this compromised supply chain, a software engineer has access privileges within the software development environment and inserts hidden malicious code in the processor during the testing process to prevent any detection. Intel was not able to detect the malicious code. As the nanosatellite is being developed by a university, the university did not have the technical and financial means to further test the processor to detect the malicious code either. While the malicious code does not prevent the basic operations of the nanosatellite, the On-Board Computer provides automatic control of the spacecraft, which are disabled by the malicious code.

In the space supply chain, risk is usually discussed in terms of propulsion failures, launch delays, component defects, or financial exposure. However, there is another category of risk that can quietly undermine a company long before a technical failure ever occurs. That risk is brand uncertainty.

For suppliers in the space industry, market position is not simply a matter of marketing visibility. It is a signal of reliability, maturity, and mission readiness. Procurement officers, program managers, and prime contractors operate in environments where failure can carry enormous financial and reputational consequences. As a result, they often evaluate suppliers through a lens of risk reduction rather than pure innovation.

This means that the question buyers often ask themselves is not simply, "Is this company capable?" Instead, the real question becomes, "Is this company safe to bet a mission on?"

Space programs have repeatedly demonstrated how fragile supply chains can affect mission timelines and costs. For instance, delays in the development of the Space Launch System were partially driven by supplier production issues and component readiness challenges across its complex contractor network supporting the National Aeronautics and Space Administration. Similarly, during early production of the Falcon 9, the company faced launch delays after supplier-provided components required redesign or replacement, illustrating how even highly integrated programs can be vulnerable to supply chain disruptions..

In the space sector, cyberattacks on the supply chain have evolved with the emergence of New Space. Space systems used to be unique systems built for one specific client, which would define most of the design, software, and system requirements. Now that space is accessible to more actors, an increasing number of established space companies and start-ups use COTS, which may contain vulnerabilities and may be subject to the insertion of backdoors, may be sabotaged, destroyed, or replaced with counterfeit components by malicious actors throughout the supply chain. Industry experts believe that the vulnerabilities of LEO satellites stem from the supply chain such as COTS components, the use of old proprietary IT software, the failure or incapacity to conduct software updates to patch vulnerabilities.

According to Scott Millwood, cyberattacks in the telecommunication industry almost always happen in the supply chain. For instance, in 2019, Airbus suffered a series of cyberattacks which allowed attackers to access

confidential data, including on military systems, by exploiting vulnerabilities in the networks of subcontractors, which were connected to Airbus' VPN network. Similarly, according to Harrison Caudill, president of the company Orbital Security Alliance, cyberattacks on the supply chain can also target the intellectual property of space companies. Space companies computers, including their suppliers and their subcontractors, could represent an interest for an adversary.

In 2020, an Australian company is relying on COTS components for some pieces of hardware. The company orders a CAN micro-controller to include in the power system to measure solar array temperatures and voltages from a trusted and known supplier. Due to supply chain delays following the COVID-19 pandemic and the shortage in semi-conductors, the company decides to change its supplier for another to keep its project on track. However, the satellite company is not aware that this supplier has a less protected supply chain. As a result, a legitimate hardware was replaced by a malicious component in the supply chain by an adversary, who had access to the plant in charge of the welding and therefore had access to the microcontroller.

The malicious hardware added to the micro-controller is an additional battery charge regulator, which is supposed to implement maximum-power point tracking, but instead contains a malicious software, which tells the system that it is constantly overcharged when it is not. This leads the battery charge regulator, which has a temperature compensated end-of-charge voltage trigger, to be into a constant trickle-charging mode. As a result, the satellite runs out of electric power and becomes inoperable, eventually ending up in an uncontrolled re-entry on a Brazilian city.

Cyberattacks can also target launch sites as well as launch vehicles. Most cybersecurity risks on the launch vehicles stem from vulnerabilities in COTS components, which are widely used in launchers. Cyberattacks on launchers during launch can be critical and lead to a launch failure, which may create physical damage on inhabited areas as well as impact the surrounding natural environment. Cyberattacks can also lead to physical damage on launchers, satellites in the nose cone, and the spaceport infrastructure, leading to additional costs, reputation risks, and physical risks for employees

. Additionally, cyber risks on launch sites and launch vehicles can be very specific as launchers use the same technology as missiles, which entails that launch site operators are subject to missile technology laws and non-proliferation regulations. As a result, launch site operators must

protect the intellectual property of launcher companies and protect their launch and mission control centres against cyberattacks, in particular data breaches. Moreover, spaceports are usually operated jointly by a space agency and a launcher company, which may create conflicts in case of cyberattacks depending on the priorities, duties, and responsibilities of each actor.

For instance, in August 2019, Iran failed to launch a satellite into orbit after its rocket exploded on the launch pad. Donald Trump then reacted on Twitter by posting a satellite image, probably from a military satellite, showing the launch site, accompanied by a message denying any involvement of the United States in this explosion.

According to Daniel Porras, researcher at UNIDIR, cyberattacks, possibly coming from the United States, affected many tankers in the Gulf shortly before the launch. According to him, it is therefore not entirely unimaginable that the United States may have caused this explosion. Several months earlier, the New York Times published an article about a potential American program that would aim to sabotage Iranian rockets by compromising the supply chain through cyberattacks. Similarly, in 2019, the United Arab Emirates failed to launch a spy satellite.

Software Defined Satellite

The satellite industry has undergone massive transformations in the past decade. Among the many technological developments that have occurred as a result of new innovations and evolution in the NewSpace sector, the software segment remains one of the key drivers of transformation. This process has further enhanced technological advancements in the satellite manufacturing industry, leading to the inception of the Software Defined Satellite concept.

Such systems are emerging in several different areas and with a variety of setups. In general, software defined satellites are not coming to market as fully fledged, self-contained alternative platforms as a result of the greater adoption of software development in the industry. Instead there is a gradual transition towards software-defined technologies to meet both customer demand and to the need to integrate greater flexibility into satellite operations. While several factors have led to these changes, in many ways the more common use of Software Defined Radio (SDR) technologies in satellites can be considered to be the beginning of the era of Software Defined Satellites.

Furthermore, with the digitalisation of satellites, software defined radios have replaced hardware equipment such as

modulators, demodulators, and antennas. Software defined radios are reprogrammable and reconfigurable software, which enable digital signal processing to adjust frequencies, coverage, and bandwidth. Software defined radios are computer systems, and therefore are vulnerable to cyberattacks.

Changing the configuration of a satellite in-orbit was once the distant dream of many operators, but the development of software defined satellites has enabled companies to remotely reconfigure payloads using ground commands. This is bringing new capabilities, commercial applications, and risk mitigation strategies to today's missions, in line with the evolving requirements in the downstream sector.

For instance, satellite data customers can sometimes alter their demands and requirements, particularly if their businesses are undergoing a large-scale expansion or other changes. With traditional satellites, reconfiguring the payloads as per the customer demands was a barrier, but this has been overcome by the Software Defined Satellites.

AI-driven autonomous cyber defense is emerging as a critical security measure. Satellites in orbital mesh networks can now share data and dynamically adjust their defenses on the fly. "We are seeing a shift towards self-healing constellations, where satellites can detect and neutralize threats autonomously and also share these to neighboring satellites that they trust. This could be a game-changer in mitigating cyberattacks in space and is the only way to respond fast enough to cyberattacks" Wallén notes.

One of the most significant advancements is the development of optical inter-satellite links and space-to-ground links to optical ground stations, which will enable seamless, always-on communication between ground and space vehicles with very high data throughput capabilities. This constant connectivity enhances operational efficiency but also increases the attack surface. "With satellites continuously connected, we must rethink how we secure data transmission, and protect against cyber threats in real time," Wallén explains.

A satellite is a complex nexus of many interconnected subsystems, but it could operate as a single plug-and-play solution. ReOrbit currently provides three different platform solutions with software-defined architecture: Plug-and-play solutions simplify setup and testing, and can also make procurement and regulatory compliance more efficient. They also give more autonomy to satellite operators.

Software Defined Networks are gradually gaining momentum in the satellite industry. From the software

domain, the ability to deploy advanced Software Defined Satellites is a promising development that network designers and operators are keeping a close eye on in the industry. The alignment of the upstream and downstream markets, in terms of software defined capabilities, standards, and conventions, can help accelerate this growth.

For example, one of the key features of Software Defined Satellite technology is remote operating capacity, which opens up new capabilities and efficiency levels for ground network operators. It will also further contribute to the virtualization of ground stations and the control of satellite configurations in the earth's orbit. Ultimately this can lead to more timely, useful, and valuable data acquired with fewer resources. But to better understand these opportunities, let's take a closer look at the areas where Software Defined Satellites can have the greatest impact.

Cyber Security Threats and the Future of GNSS

According to a 2023 European Union Aviation Safety Agency report, attacks on satellites that provide positioning, navigation, and timing services, also known as Global Navigation Satellite Systems, GNSS have been rising sharply in intensity and sophistication, especially in and above the Black Sea, Middle East, Baltic Sea and the Arctic. Several of these incidents represent attacks designed to disable GNSS usage in specific geographic areas rather than unintentional disruptions caused by internal technical issues.

This surge in GNSS disruptions is alarming. Attacks on GNSS often have enormous economic, security and environmental consequences, not just for navigation but also for power grids, data centers, communication networks, as well as train and financial systems which all use GNSS for timing and synchronization. Monetarily, this impact is measurable: an outage of the GNSS in the UK during seven days would cost around £7 664m and the outage of the GPS system would cause an economic loss of \$1B per day to the US.

The implications of attacks on GNSS are far-reaching. They are the symptoms of a wider trend: the evolution of the Earth's orbit as a geostrategic and increasingly militarized space.

Three common threats are jamming, spoofing and anti-satellite weapons, all of which make up a large amount of the cyber-attacks today and future risks to GNSS. The first two constitute cyber-related attacks targeting the signal, while the latter is a physical attack directly targeting the satellite.

One of the most common and challenging cyber threats to GNSS is jamming. GNSS jammers use the same frequency or very close frequencies as GNSS devices to annihilate the signal sent by the GNSS to



the receiver. Criminals typically use jamming to prevent electronic surveillance and conceal drug trafficking activities, cargo thefts to block the tracking signals, and airplane interference. In the context of warfare, jamming is meant to disrupt airforces, drones, and guided weapons used by belligerents.

Another common risk is spoofing, a practice where a malicious actor transmits a seemingly legitimate signal to a receiver antenna, while, in reality, the data is intentionally incorrect. In the absence of robust cybersecurity measures, users are particularly vulnerable to being misled about their position, velocity, or time. This can result in serious consequences: aircrafts or ships may deviate from safe routes, autonomous vehicles could veer off course, and financial systems relying on precise timing could experience synchronization

errors.

Spoofing has increased, particularly, as the cost of those attacks has fallen, devices costing as low as 300 US dollars - and this technology is now used by both state and non-state actors. One example of spoofing occurred in the Middle East, where Israel used spoofing to mislead satellites about its citizens' location.

According to Israel, this measure was intended to disrupt drone and missile attacks. However, the spoofing attacks have also had civilian consequences such as food orders arriving at inaccurate locations, Uber drivers making mistakes about clients' actual location, and dating apps showing users in neighbouring countries instead of Israeli user profiles.

The increasing dependency on space systems and the growing number of satellites contribute to the importance of cyber situational awareness in the future of the space industry. By enhancing the ability to sense and detect

cyberthreats in near real time, these vital assets can be better protected from malicious actors. Through regulation, standardization, incentivization, enforcement, and collaboration, there can be a more resilient space ecosystem that provides continued benefits of space-based technologies for society.

In order to improve the state of space cybersecurity, it is essential to ensure information sharing regarding cyber threats on space systems, sending alerts regarding current threats, conducting cyber intelligence, and gathering news about cyber events as well as resources to support response and mitigation.

The future of the space economy, and by extension the modern way of life often relies on the availability and reliance of the cyber domain that space systems operate in and through. Yet, it's hard to protect what can't be seen.

Therefore, cyber space situational awareness of the space ecosystem is critical. The UK Space Agency recently released a Space Cybersecurity Toolkit for the Space Industry, which provides general information regarding potential cyber threats to space systems, how to conduct impact assessment as well as which general cybersecurity standards to adopt. More importantly, the Toolkit outlines relevant authorities and their mandate for reporting different types of cyber incident as well as an overview of some processes in case of an attack.

This toolkit is a short document that does not outline detailed procedures but provides a clear outlook on how to report cyberattacks and to which organisations, which was considered as a main area of confusion by consulted stakeholders. This type of informative documentation can be used by start-ups, established industries, universities, and government stakeholders to increase their awareness, adopt good practices and responsible behaviours.

SPECIAL REPORT

How satellite connectivity is enabling new level of digitalisation



The oil and gas industry is under increasing pressure to reduce expenditure as profits are squeezed and the world attempts to shift energy use from hydrocarbons to sustainable alternatives. As the industry looks for long term solutions, a clear route to significant cost saving opportunities lies within the development of digital technology, enabled by satellite communications.

Since the 1950's, a group of oil and gas producing companies positioned themselves strongly in the industry and have until today secured their strong position. Lifting on the economic recovery and boost within the United States of America and Western-Europe that made the demand for oil and gas boom, in combination with the technological revolution that made these companies able to drill for gas and oil in more and more situations.

Thus, rising supply, made these companies grow into a group of companies that today can be placed among the largest companies in the world. Taking a small look at these companies it can be noted that the size and the strength of these have gained over time. Still in competition with Apple of being the most

valuable listed firm in the world, Exxon Mobil is with a market capitalization of \$417 billion a true giant. Another big player in the market is Royal Dutch Shell which is the most valuable company listed on the London Stock Exchange. The firm Chevron is employing around 62,000 people worldwide and is operating in over 130 nations. The last example that indicates the strength of these companies is illustrated by BP.

This company has been facing major problem over the last years with the deep-water horizon Disaster where due to explosion during deep-water horizon oilrig working in the Gulf of Mexico in April 2010 resulted in a great economic and environmental disaster. In order to compensate the disaster and the economic and environmental consequences, BP paid \$90 billion in fines and compensations. The strength and size of a company such as this one is illustrated by its ability to pay such a sizeable amount in fines and compensations and still being able to operate after. In the last decades, there has been a change within the industry resulting into great consequences for the firms and shifts within the industry.

First, the demand for oil and gas increased over the last decades. It has been seen that around 60% of the oil demand is used for transportation which obviously remained to increase due to globalization and development of countries such as the USA and Western-Europe. The amount of cars on the American and European roads has increased, along with the amount of sea- and air transportation movements.

Another beneficial fact for the oil producing companies was that the supply of oil and gas has been in the lift. Over time, new oil wells have been found, enabling the oil producing companies to produce more of their product. In addition, technology and expertise that is needed to drill for oil increased and therefore the oil producing companies were able to drill as well to oil- and gas-wells at locations with complex geographical circumstances

Despite these factors that normally would complement the success for these companies, one important factor is threatening the existence of the previous mentioned firms. The leading oil companies within the industry are losing ground. In the last

decades, countries that possessed oil and gas sources within their national territory started to operate the production activities themselves by founding National Oil Companies NOCs.

Today, these NOC's possess 90% of the worldwide oil- and gas reserves around the world. As a result, the capital generation out of oil- and gas producing activities have now been streaming towards national governments that own the NOCs instead of to the big oil and gas producing companies. In addition, the rate of available natural resources such as oil and gas has been diminishing over the years due to oil and gas extraction at large scale as a consequence of rising global demand.

Therefore, the giant firms in the industry have been exploiting their added value in terms of knowledge and expertise repeatedly since sources got more scarce. The firms focused on specializing into three activities/company characteristics that required comprehensive expertise and skills.

It is for the abovementioned reasons that the major oil companies in the industry have been spending more and more over the last decades to increase the level of expertise and skills available within the firms to be able to drill for oil in the abovementioned circumstances. Therefore, with the percentage of oil wells diminishing and the rising costs for operating the residual percentage, the future does not look so promising for the major oil companies.

The IOCs have over time internationalized all over the world, starting new drilling projects in the world's backwaters. Due to exploiting of the sources, the international activities per location are not ever lasting and thus new projects are founded elsewhere. This continues internationalization is perceived as a vital element for the strategy of these companies over time and it could potentially be the key to future success. The major oil- and gas-producing firms within the industry are thus facing problems. These companies are now focusing on a small percentage of oil wells that can be characterized by (a combination of) factors such as complex chemical structure, complex geographical and/or metrological location or political unstable territory. The last two characteristics will be used to see what strategies the major firms opt in terms of internationalization, to remain successful within the industry.

Future outlook

The result of all of this change on the oil and gas industry is that the short to medium-term outlook is more challenging than ever for producers, particularly high-cost producers, small operators and those with high levels of debt.

Already, the larger oil and gas companies are cutting both capital and operational expenditure which will have a knock-on effect on the wider industry, affecting suppliers and oilfield service providers. As businesses throughout the industry shape near-term strategies, they will be focused on retaining and retraining skilled workers, guaranteeing the safety of their employees, ensuring their assets operate as efficiently as possible with minimal downtime and diversifying into renewables.

Given the importance of reducing costs and improving efficiency, oil and gas companies are

increasingly focused on strategically applying new technology and how to use digitalisation. One of the key areas of focus for new technology is to reduce costs through production efficiency and increased uptime of equipment, using online remote monitoring and diagnostics tools and services. This allows timely delivery of critical information, negating the requirement for employees to make frequent and costly onsite visits, and providing the ability to diagnose problems online before any production time is lost and costly breakdowns occur.

Access to some remote sites has been severely hindered by the pandemic, making remote monitoring even more urgent. Oil and gas companies have long had motivations to drive future profitability in an increasingly expenditure intensive industry, whilst also meeting environmental demands for the oil and gas industry to minimize its environmental footprint. Satellite communications can support all of these goals.

Satellite connectivity is enabling a new level of digitalisation for the industry, offering affordable and secure solutions to some of the industry's biggest challenges. From efficiency and safety monitoring of assets using machine to machine (M2M) solutions, to predictive maintenance, safety alerts and communications for remote employees, Inmarsat's reliable, and global satellite connectivity is helping the extractive industries adapt and succeed.

Digitalisation for operational improvements and cost savings

Using satellite communications to provide connectivity on remote sites allows for the collection, analysis, and utilisation of huge amounts of data. These can bring substantial operational improvements to the field through the use of sensors, analytics, robotics and sophisticated equipment and control systems. The positive impact of digitalisation and connectivity runs across multiple areas, from better usage of labour, to keeping overheads low, minimising waste and making sure throughput targets are met to ensure equipment is fit for purpose and runs at full capacity.

According to a report by McKinsey & Company in November 2020, it is estimated that "advanced connectivity to optimise drilling and production throughput and improve maintenance and field operations could add up to \$250 billion of value to the industry's upstream operations by 2030". The report goes on to say that between \$160 and \$180 billion of that value could be realised with existing infrastructure, while an additional \$70 billion could be unlocked with satellites and next-generation 5G technologies. There's no doubt that satellite communications hold impressive cost saving opportunities for the sector.

Maximising operational efficiency with satcom

With the oil and gas industry's unshakeable focus on maximising operational efficiency, reducing well and pipeline downtime has always been a priority. Connectivity can play a significant role in achieving this goal. Whether it's voice and data connectivity for remote workers, tracking of high value assets or machine to machine (M2M) solutions for monitoring, controlling, automation and optimisation of important assets, Inmarsat offers reliable, affordable and secure solutions.

Connectivity technologies are nothing new in the oil and gas sector, with radio and cellular networks used for decades. These networks can be problematic, however, as large areas of these networks contain coverage deficiencies and can be prone to congestion, failing to provide the resilience required from a communications solution that needs to be reliable and secure. That's where Inmarsat's global and reliable satellite network comes in. Satellite connectivity not only eliminates coverage and congestion issues, but it can do so in a cost-effective manner, providing 'always-on' connectivity at affordable prices with guaranteed service-level agreements.

As Inmarsat owns and operates global networks that deliver award-winning L-band services, such as Broadband Global Area Network BGAN, we enable oil and gas companies to standardize their communications and equipment across their entire production and distribution operations regardless of location. This level of global reach is not available via cellular networks which often need contract renegotiation established in each country of operation. Addressing the industry's need to keep a close eye on efficiency, digitalization can provide tangible results when operated with satellite based technology for oil and gas companies and service providers.

Choosing the right satellite connectivity partner

Satellite connectivity is not a new concept in the management of oil and gas production, but the level of sophistication of services has dramatically improved. It is important to underscore the fact that not all satellite services are the same. Due to the unique nature of the requirements of the oil and gas industry, understanding the differences and limitations of different satellite services is crucial.

In particular, the adoption of VSAT satellite systems occurred in the sector in the recent past, but there are notable limitations to this approach. VSAT systems rely on a high-power draw which means they can cease working in the event of a power outage, with solar power often not an option. Furthermore, VSAT is prone to rain-fade, a phenomenon that hampers performance in certain conditions. VSAT also requires more specific placement to connect with satellites, meaning they often lose connection if wind or other environmental factors move the terminal.

This not only impacts the continuity of service, but also means trained technicians often need to be redeployed to re-align terminal, which adds significant costs to an operation.

Finally, VSAT works with bulky terminals, which look like typical satellite dishes, making them an obvious target for theft or vandalism, which can also add to costs. So, while the VSAT service may

appear to be less expensive in terms of ongoing airtime cost, their suitability causes issues often making the overall Total Cost of Ownership (TCO) high.

In contrast, Inmarsat's BGAN M2M service is providing oil and gas companies with the reliable and proven satellite connectivity needed to remotely monitor and control important assets across the world. The BGAN M2M service operates on Inmarsat's L-band network, which was created for mission-critical military and safety-of-life applications and is ultra-reliable, secure and available on demand. L-band is the ideal satellite network for enabling centralised artificial lift, wellhead and pipeline monitoring and control in particular, as it provides up to 99.9% uptime even in the most extreme weather conditions where other satellite services may fail.

The BGAN M2M service features robust and compact terminals, such as the Hughes BGAN 9502. This terminal is about the size of a small laptop/tablet, is easy to install, and can withstand hostile environmental conditions with a lifespan up to ten years or greater. With low monthly data pricing and long lifespan of the hardware, the Cost of Ownership for the service is low compared to the cost of dispatching technicians to resolve issues and achieves a higher continuity of service.

Wellhead monitoring

Wellhead monitoring also connects multiple safety systems so that several points can be constantly observed, ensuring any alerts or shutdowns are picked up immediately and the issue can be isolated. This means problems can be prioritised and addressed according to their urgency which can prevent damages, extended shut in times, loss of production and escalating costs. The BGAN M2M connection makes it possible to monitor numerous devices on location, gathering data and making requests to any of those devices. Another important process that can be required of wellhead operators is to provide information on hydrocarbon production that is required by national governments in the form of custody transfer reports.

Traditionally, this information was captured manually by an employee who needed to travel to the wellhead site to pull the data and enter it into the system. With connected terminals, these reports can be retrieved over BGAN M2M and sent to relevant regulatory bodies, saving costly and sometimes hazardous travel.

How inmarsat BGAN M2M improves efficiency, provides critical information and reduces costs

Many of our customers have installed BGAN M2M terminals to their artificial lift equipment in remote locations. These terminals are designed to be energy efficient and managed remotely, they are also set up to detect anomalies.

This means that if the terminal ever loses connectivity, it automatically re-establishes connectivity with the network to continue providing service to the customer. The BGAN M2M terminals are manageable remotely, making it easy and secure to do configuration changes, upgrade firmware for added functionality as well as check the terminal status and GPS positioning.

This data assures operators that the asset is fully operational and producing efficiently, whilst reporting on the safety systems and monitoring the asset for any issues. If any problems are detected that present a safety or environmental risk, the operators have the ability to shut down the production remotely.

As part of this assessment of operational status of the asset, customers can also compare actual performance to trend data, allowing them to adjust operations further and ensure optimal performance over the life of the well. Finally, this insight allows for the use of predictive analytics, which provides insight into upcoming maintenance requirements.

Pipeline monitoring

Monitoring and controlling the flow of product through an oil or gas pipeline is just as vital as monitoring well production. Strict communication requirements can apply to oil and gas pipelines, so multiple valve stations are installed along the pipeline along with numerous sensors and flow metres that are connected via BGAN M2M. These communication points allow operators to monitor and control the status of the product in the pipeline.

If a reduced flow rate is picked up by flow metres, operators can identify at which point the flow rate changes and pinpoint the area where the problem is occurring. The flow metres and sensors also pick up on any changes in pressure, sending an alert so that the cause can be investigated and mitigated.

The sensors and flow metres are connected to a central point, which is configured to send an alert when certain factors occur within the information that is being automatically pulled from the pipeline. Once an alert is triggered at this central data gathering point, it uses BGAN M2M to push this data through to the operator at a central office.

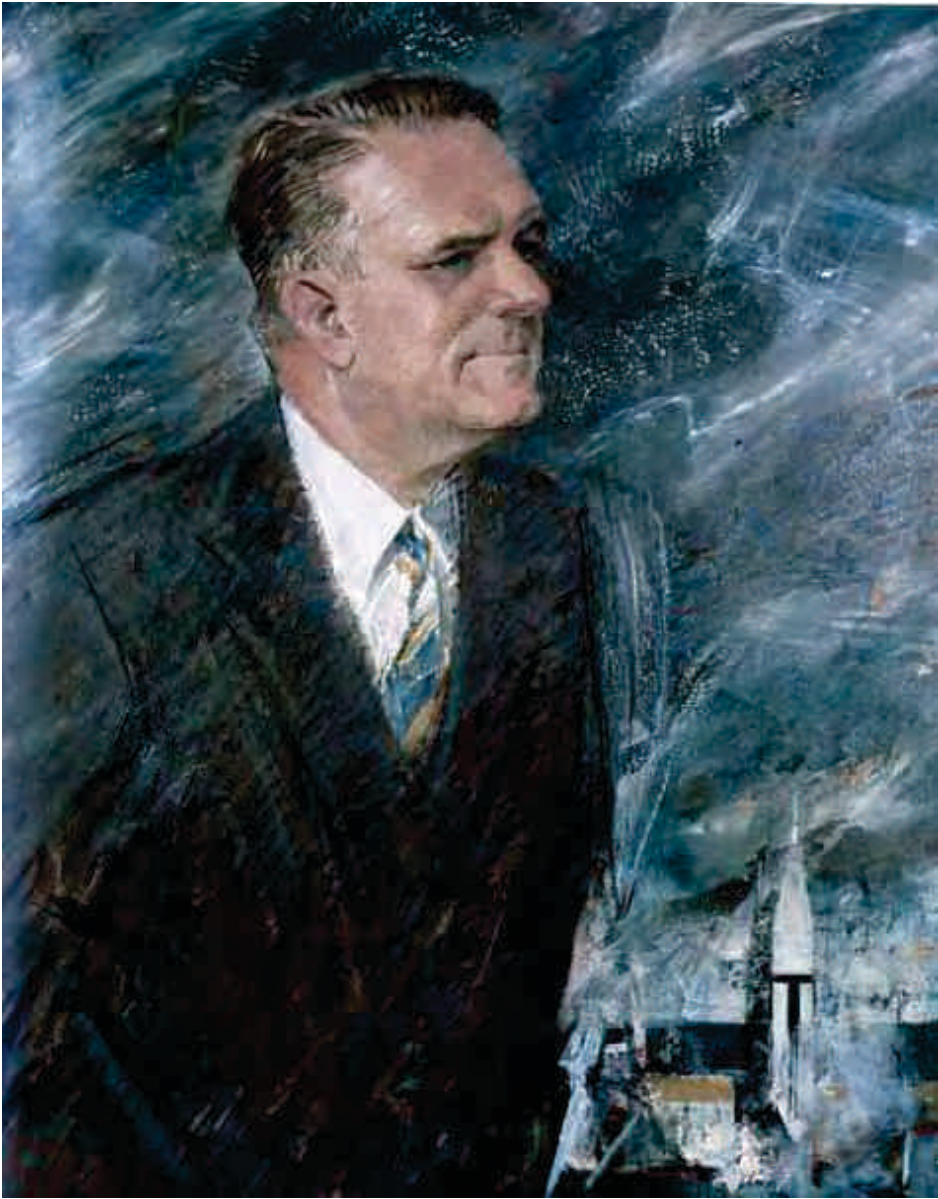
The oil and gas industry remains one of the world's most vital industries as it plays a strategic role in every economy around the globe. Energy consultant Enerdata indicates that oil accounted for 31% of the world's total production of power sources. This is more than any other power source, and, despite the increasing pressure to replace hydrocarbon use with renewable energy sources, the transition needs to be managed carefully.

With increasingly volatile pricing and pressure to reduce production in the long-term, the industry's focus on cutting CAPEX and OPEX is unlikely to shift. Digitalisation provides clear direction for improving operational efficiency, providing instant and enhanced data gathering, improving retention of employees who can gain new skills and therefore job security, as well as improving safety across the sector.



SPECIAL REPORT

10 men that fulfil NASA's dream of sailing “this new ocean” of space



The central task of the men who served as NASA Administrator since 1958 has been strategic leadership, by which is meant the setting of priority goals for the Agency for the periods in which they held office.

How well the Administrator performed his task depended on his capacity to match the goals he set with the forces in his environment. James Webb, NASA's Administrator in the 1960s, described leadership as "fusing at many levels a large number of forces, some countervailing, into a cohesive but essentially unstable whole and keeping it in motion in a desired direction." He called this process the creation of a "dynamic

equilibrium." It entailed setting and implementing policy. The various Administrators used rhetorical and coalitional skills to achieve their purposes, building internal and external support, while seeking to neutralize opponents. Their role was daunting. Sometimes an Administrator succeeded and at other times failed; but unless an Administrator prevailed to some degree, the forces in his environment determined NASA's fate rather than the Administrator.

In every instance, real administrative influence depended on a match among the Administrator's gifts, organizational capacity, and political times. Even when a particular leader was unable, for one

reason or another, to make a significant personal mark on history, he could still be important as part of a "relay" leadership, initiating or steering particular programs he inherited forward. Given the brief tenure of most Administrators vis-à-vis the large-scale, long-term programs with which they dealt, that is itself important in NASA's fate.

In drafting the Space Act for NASA in 1958, the White House and Congress clearly wanted NASA to have a leader with significant authority. The leader was given prerogative over budget and personnel, subject to the President and Congress. It is notable that the Administrator is a single figure. The Space Act gave NASA a range of tasks in space and aeronautics, but those were relatively broad and vague, leaving it to the Administrator to use his or her discretion in their interpretation. Congress at the time of NASA's creation organized itself into two authorizing and two appropriations committees dealing with space. This pattern simplified reporting assignments for the Administrator. The mood of Congress, triggered by Sputnik and Cold War competition with the USSR, favored action; but it was up to the initial incumbents in the office to give substance to the words and mood of the time.

T. Keith Glennan, August 1958–January 1961

NASA's first Administrator, T. Keith Glennan, was an engineer and university president with experience in industry. He came to NASA from the presidency of Case Institute of Technology in Cleveland, Ohio. He was 53 years in age at the time he took official charge of the new agency on 1 October 1958. Glennan served under a President who wanted to restrain NASA from engaging in any "race" with the Soviet Union. President Eisenhower intended "leadership" in space to be established through sound scientific and technological principles. Congress, led by Democrats, was much more "bullish" on space and wished to charge faster ahead. Glennan steered NASA between these two stances.

His goal was to get NASA started quickly, but in a competent way, building on the National Advisory Committee for Aeronautics base of 8,000 scientists, engineers, and support personnel he inherited. He consolidated entities that were transferred from DOD, including the von Braun rocket-engineer team, which became the nucleus of Marshall Space Flight Center in Huntsville, Alabama; the space-science group of Naval Research Laboratory, which became GSFC in Greenbelt, Maryland; and JPL, run for NASA by the California Institute of Technology in Pasadena, California. Glennan organized the basic divisions of NASA manned spaceflight, space science, Earth-oriented applications, and

aeronautics. He began the first human spaceflight program, Project Mercury. Finally, he determined that NASA would get most of its work done by industrial and academic contractors, keeping its government base relatively limited

Glennan's goals were clear, but limited, and he achieved much that he set out to do. However, NASA was still a relatively weak and much-criticized agency when he left office in 1961, and the Soviet Union was well ahead of the United States in space achievements. The Department of Defense remained a formidable bureaucratic rival for supremacy as the nation's premier space agency.

James Webb, February 1961–October 1968

The new President, John Kennedy, appointed James Webb his Administrator. Webb, 54 in age at the time, was neither a scientist nor an engineer, but a professional manager and lawyer. He had extensive government experience, having worked for Congress as a young man and later as Truman's Director of the United States Budget and Undersecretary of State. He also had considerable executive experience in industry.

He considered himself a government manager, but what most observers saw was a remarkably savvy bureaucratic politician, one capable of dealing one-on-one with Presidents and senior legislators in ways that made him persuasive in advocating NASA's cause. To help him in his inside role of managing a technical agency, he developed a "triad" concept that had a physicist as his Deputy Administrator and an engineer as his Associate Administrator and de facto general manager. Better than any Administrator in NASA's history, Webb understood power in Washington, DC, and how it worked. He sought to enhance NASA's bureaucratic power and his own as its leader.

Thanks to Kennedy's Apollo decision of 1961, Webb succeeded in building NASA quickly and substantially in budget and personnel and transforming it into a special organization capable of taking America to the Moon. In doing so, he placed NASA clearly in charge of the space enterprise, neutralizing DOD, the White House science adviser, and internal rivals.

Webb understood he had a two-year "honeymoon," given the nation's frustration with being behind in space and especially with having a Russian, Yuri Gagarin, be the first man in space. He used the President's directive to win

the race to the Moon to NASA's advantage, taking his organization's estimate of costs to achieve a lunar landing and doubling the figure while also extending the deadline in Kennedy's speech from the original 1967 to "within the decade." Kennedy made the decision to go to the Moon, but Webb shaped it with an eye to implementation. He also extracted from Vice President Johnson promises of help in maintaining support over the long haul.

As NASA's budget doubled and doubled again and its personnel grew apace from 1961 to 1963, he made virtually all key decisions required about facilities and contractors to get to the Moon. He could justify these decisions on technical grounds but usually made them also with an aim at long-term coalition building. For instance, the location of the new Manned Spacecraft Center was in the district of the lawmaker with the most control over NASA's budget.

Similarly, Webb's managers wanted Gemini, an interim program between Mercury and Apollo, as a stepping stone for technical learning. Webb saw Gemini in "political rhetoric" or public relations terms, a way to keep NASA before the public eye in the mid-1960s. He knew the early honeymoon would not last, and it didn't. But he maintained Apollo in the mid-1960s, as Kennedy, assassinated in late 1963, gave way to Lyndon Johnson. It is notable that Webb's goals were broader than Kennedy's or Johnson's.

Thomas Paine, Acting Administrator, October 1968–March 1969; Administrator, March 1969–September 1970

Tom Paine, age 46, was an engineer and technical manager who came to NASA from a high executive position at General Electric. He was a solid, risk-taking manager who made the final decisions that got NASA to the Moon. He was also a visionary, a space enthusiast, who wanted to build on Apollo with a bold program of space exploration. His prime goal as Administrator was to sell a comprehensive post-Apollo space program that would enlarge NASA's budget and allow it to go to Mars and build a Moon base, a large space station, and a space shuttle to go to and from the space station. Unfortunately, Paine's political skills were such that he misread the nation's mood and the interest of President Nixon in a bold space program.

A program that had at its mid-1960s height spent close to 4.4 percent of the federal budget fell to approximately 1 percent in the Nixon

era. Paine had little access to Nixon, who was one of the most inaccessible Presidents in history. Paine's expansionary rhetoric was out of sync with what the President or his aides wanted to hear. Paine, to his credit, pushed forward with many of the existing programs he inherited and kept his Mars vision alive through his backing the unpiloted Viking program.

However, he could not build a coalition for new large human spaceflight programs that would stop the retrenchment of the Agency. He reluctantly ended the Apollo Moon landings and Apollo-Saturn system. For NASA, political support began with the President, and Paine had no influence on Nixon. He resigned early in disappointment and frustration, with NASA's post-Apollo future still undetermined.

James Fletcher, April 1971–May 1977

James Fletcher, age 51, came to NASA from the presidency of the University of Utah. A Ph.D. physicist who had achieved wealth in industry, Fletcher fit the mold of the Administrator Nixon wanted. He was conservative politically and economically. Not a space cadet like Paine, he was willing to compromise. He did not seek to promote goals that had no hope of acceptance by Nixon. He was not a combative bureaucrat like Webb. His primary interest was clear: stop the decline of NASA by obtaining a significant goal in human spaceflight that was large enough to maintain the Agency. The only goal with a chance to be adopted, given the national mood of the early 1970s, was the minimal goal of the Space Shuttle. Selling that goal became his primary aim.

Paine had believed the NASA Administrator should be a "swashbuckler," a term he used. Fletcher was instead quiet, persistent, and compared to Webb and Paine dull to most observers of NASA. While an able inside manager, especially with the help of the legendary NASA veteran, George Low, as his deputy, Fletcher was not experienced in the ways of Washington, DC. In selling the Space Shuttle, he acquiesced to the pressures of the Office of Management and Budget, a more powerful organization vis-à-vis NASA under Nixon than it had been under Kennedy or Johnson. This meant the Shuttle had to be justified in the language of Office of Management and Budget, in cost-benefit or economic terms. The Office of Management and Budget pushed Fletcher hard, ratcheting down the price of the Shuttle. The Columbia Accident Investigation Board would later state that the economic pressures of the early years led to technical compromises and overpromising that contributed to subsequent troubles affecting the Shuttle.

But Fletcher may have had little choice but to bend. Without the Shuttle, NASA would likely have continued its downward spiral. Also, in building support for the Shuttle, he entered into alliance with DOD and adopted designs to suit DOD needs. The Shuttle was sold not as a NASA system but as a "national" system. In 1972, Fletcher finally got the President to say "yes." The budgetary decline ended. NASA stabilized. Ironically, Nixon appears to have made his decision not on economic grounds, but primarily on a combination of electoral and geopolitical calculations. He wanted California votes and international prestige. Roger Launius has written the primary published



assessment of Fletcher. He points out that Fletcher's Mormon background was important in several non-Shuttle decisions. For example, Fletcher believed in life beyond Earth, a factor in his making Viking a high priority not only for space science, but for NASA generally. He also backed other unpiloted space probes, such as Voyager to Saturn and Jupiter, and the Hubble Space Telescope. Moreover, Launius writes, the Mormon tradition of "stewardship" for Earth had impacts for Fletcher's goals as Administrator.

Robert Frosch, June 1977–January 1981

Robert Frosch, age 49, was, like Fletcher, a Ph.D.

physicist. He had risen to high positions in industry and government. Appointed by President Jimmy Carter, he found that his most important goal had to be sustaining the Shuttle development program he inherited. Shuttle cost overruns and schedule slippages became painfully obvious in the Carter years. Carter was not particularly interested in NASA, but he did have a military space priority. He wished to launch intelligence satellites to monitor weapons development, proliferation, and arms control agreements. The Department of Defense connection helped save the Shuttle from a Carter termination decision. Like Fletcher, Frosch promoted the Shuttle as the nation's prime vehicle for scientific, military, and commercial access to space. Carter endorsed a "Shuttle-only" policy for major launches.

SPECIAL REPORT



James Beggs, July 1981–December 1985

Aged 55, James Beggs was a U.S. Naval Academy graduate with a Harvard M.B.A. He had served in the Navy and held a middle-management position with NASA in the late 1960s. He was the second-ranking administrator at DOT in the 1970s. He was a chief executive officer in industry before becoming President Reagan's appointee as NASA's leader in 1981.

Beggs was an astute, seasoned, and persistent Administrator. Quiet, but effective, he knew what his prime goals were when he came to NASA. They were to complete the development and testing of the Shuttle and move it to "operational" status. Then, he intended for NASA to take "the next logical step" to develop a space station. The comprehensive package of programs that Paine had unsuccessfully tried to promote had been broken up by political reality. Successive Administrators were moving incrementally, one major piloted development program at a time. For Beggs, selling the space station would be his legacy. Like his predecessors, he believed that for starting big programs, coalition building in government began with the President.

In the early 1980s, the Shuttle finished its tests and NASA declared it "operational," rhetoric that legitimated the transition of NASA, an R&D agency, to a new development program. Beggs faced many forces that wanted to thwart the station's initiation, including Office of Management and Budget, the White House science adviser, and the Secretary of Defense. Beggs proved to be an able bureaucratic politician. He had piqued Reagan's interest in space by inviting him to initial Shuttle launches. He made an end-run around his opposition, getting to Reagan via an interagency committee and making a presentation that appealed to Reagan's desire to use space to project national power, especially vis-à-vis the Soviets.

In 1984, Reagan, in a State of the Union address, gave the go-ahead for the space station. Beggs began building a coalition for the station that was both domestic and international. Sustaining various space science programs

he inherited, providing essential additional funding to the Hubble Space Telescope, Beggs's most important other legacy was arguably his support for NASA to move more seriously into the global environmental field.

He backed a gradual, growing involvement in global environmental problems, building on Fletcher's policies. NASA's emerging role reached high visibility in the mid-1980s when NASA provided scientific leadership in determining the causes of ozone depletion in the Antarctic.

What had been an "applications" program entailing weather and communication satellites in the 1960s was transformed by successive Administrators into what would eventually be called a "Mission to Planet Earth." In late 1985, however, Beggs took leave from NASA to fight a false charge of wrongdoing while in industry, prior to becoming Administrator. In January 1986, NASA was devastated when the Challenger Shuttle exploded, killing the first teacher in space. NASA needed a strong Administrator at the helm and did not have one, and the Agency suffered accordingly.

James Fletcher, May 1986–April 1989

President Reagan called Fletcher back to service in 1986. Fletcher's goal was to heal a wounded Agency battered by Challenger's avalanche of criticism and lead its recovery. He guided NASA's return to flight, which took place in September 1988, and authorized many technical and organizational changes in NASA, including pulling power back to Headquarters for Shuttle management, a reversal of his earlier approach. He helped persuade Reagan to add a replacement for Challenger, maintaining the Shuttle fleet at four. He also adapted the space station, a project requiring modification in the face of technical and fiscal reality.

Much of Fletcher's decision-making involved choices about priorities in what would launch and when, owing to the Shuttle's absence from service for 32 months. The "Shuttle only" policy he had pushed ended with Challenger. The Department of Defense and commercial flights would use expendable rockets. Fletcher still wanted as many NASA flights to go up on the Shuttle as possible. He believed deeply in the Shuttle and its promise.

Fletcher also wanted NASA to begin moving toward a mission beyond the space station and Earth orbit. He had Sally Ride, the first female astronaut, provide him with a menu of options for NASA's future. It included various missions, three of which focused on exploration, including a piloted flight to Mars. Fletcher established a new Office of Exploration. He apparently tried to get Reagan interested in exploration; he got some verbal support but little else. However, he did preside over NASA's return to flight and bolstered the morale of an agency profoundly in need of nurturing after Challenger.

Richard Truly, May 1989–March 1992

The man who served as Fletcher's Associate Administrator for returning the Shuttle to flight was Richard Truly. Truly was President George H. W. Bush's choice of NASA Administrator. Aged 52, Truly

was a naval aviator with an aeronautical engineering degree. He was a former NASA astronaut with considerable experience in space. His prime goals as NASA Administrator were to get a fifth Shuttle orbiter and to further develop the space station. The latter was behind schedule, growing in cost, and fast losing congressional support. Indeed, money was being spent, but little or no hardware was being built owing to continuing design changes. President Bush gave him an additional goal, involving the Moon and Mars, one with which he did not appear to the White House to be fully comfortable.

Bush had restored the National Space Council, a White House interagency body created when NASA came into existence and abolished by Nixon. It was headed by Vice President Dan Quayle, and its role was to set space policy for his administration. While there had been some human spaceflight planning at NASA for a return to the Moon and a Mars program, the stronger impetus for this new Moon-Mars mission came from the National Space Council. In 1989, the 20th anniversary of the first Apollo landing, Bush proclaimed his Space Exploration Initiative (SEI), a return to the Moon, followed by piloted missions to Mars. The announcement seemed to come out of the blue, and there had been minimal political spadework with Congress, which was controlled by the Democrats.

Congress was underwhelmed by the decision, as were the media and general public. The mood of the nation was to deal with a substantial budget deficit, not start a big new space program. The Cold War was ending; the nation looked to new priorities, but not any involving space. When NASA came up with the estimated cost for the program, perhaps half a trillion dollars, Congress called it "dead on arrival." Bush could not get the program funded. Truly sought to start the SEI, raising the Office of Exploration to Associate Administrator level and appointing Mike Griffin its director. Griffin could plan, but not implement. Support further eroded in 1990 when the Hubble Space Telescope went up. It provided blurred images and caused NASA ridicule by late-night television comics. An independent panel headed by Norman Augustine called attention to NASA's many infirmities and called for substantial raises for an agency seeking to do more than it could afford. These large raises did not come.

Daniel Goldin, April 1992–November 2001

Daniel Goldin was the longest serving and most controversial Administrator in NASA's history. He was 51 at the time of his appointment. He had begun his career at NASA shortly after college and then joined TRW, a large, California based aerospace firm, where he had risen to vice president for space activities. Most of his work was in classified national security programs. He was an "outsider" to NASA and most space watchers when his name as Administrator was announced. An engineer and technical manager, he was closest to Paine in his sheer passion for space. But whereas Paine could not adjust his

bold visions to a shrinking budget, Goldin almost found the constrained budget he encountered helpful. It enhanced his own power.

Whereas Webb sought power to enlarge NASA and its role on the national stage, Goldin sought power to move the Agency in another direction. Webb, secure with bureaucracy, made NASA his ally. Goldin, distrustful of NASA managers, seemed at times at war with the agency he led. If Truly was uncomfortable with multiple goals, Goldin sought as many goals as he could establish. A self-described change agent, he made organizational chaos his handmaiden and revolution his byword.

"Faster, better, cheaper" became his mantra. It fit the times, and his willingness to embrace this philosophy helped keep him NASA Administrator from Bush through two Clinton terms and briefly into the term of the second Bush. Goldin took the NASA job because he wanted to lead NASA back to Mars.

He learned quickly that the SEI was not in the cards. Nevertheless, there was much else he wanted to do, and he lasted long enough to see both successes and failures in his attempts at innovation. He also held to his piloted Mars goal, and he sought to move NASA in that direction, but indirectly and, in some ways, covertly.

Mars was his love, but the space station was his necessary priority. It was NASA's flagship, whether he liked it or not; and it was in deep trouble when he arrived. In 1993, it almost died in Congress, surviving by one vote in the House. Goldin was not especially politically astute at first, but he learned quickly that he needed the President as an ally. He brought Clinton aboard the space station by linking it with Clinton's foreign policy need to help post-Cold War Russia turn to the United States. The space station became the ISS, with Russia the most significant of several international partners. Throughout the 1990s, Goldin struggled to make the U.S.-Russia partnership work and build a U.S.-Russian Space Station core. When he left in 2001, such a nucleus was in space and inhabited by U.S. and Russian astronauts. Getting the Space Station up was his major achievement.

His second major achievement concerned Mars. In 1993, the \$1 billion Mars Observer, the first Martian flight since Viking in 1976, died on its way to the Red Planet. Goldin used the failure as an opportunity, remaking the Mars program into the symbol of his faster, better, cheaper robotic program. Similarly, in the mid-1990s, he used claims of fossil bacteria in a Mars meteorite to rekindle NASA's search for life beyond Earth. This came at a time when new planets were being discovered around extrasolar stars. What was called "exobiology" in the 1970s became "astrobiology" under change-agent Goldin.

Sean O'Keefe, December 2001–February 2005

It is not unusual for a President to select an

Administrator who embodies characteristics he perceives missing in a NASA predecessor. Goldin, with his creative passion and vision, was seen as different from Truly. But Goldin was subsequently seen to be a bad manager by President George W. Bush, as witnessed by a \$4.8 billion cost overrun on the Space Station the new President inherited in 2001. Bush wanted a "competent manager" and chose the Deputy Director of Office of Management and Budget, Sean O'Keefe.

O'Keefe was 45 in age and had a career that made him one of the most government experienced Administrators in NASA history. He had worked on the Hill and been the comptroller of DOD and Secretary of the Navy. He had a master's degree in public administration and had taught the subject at his alma mater, the Maxwell School of Syracuse University. O'Keefe had good inside-the-beltway political skills, possibly the best since Webb. He was not a stirring speaker and certainly not a space cadet.

In his first major address, he appalled many space enthusiasts when he said he wanted NASA to be "science-driven," rather than "destination-driven." His primary goal at the outset was to strengthen the Space Station program financially. What came to be his second goal was to address the Shuttle-successor problem, not through Goldin's technologically revolutionary X-33, but through an interim system called the Orbital Space Plane. The Orbital Space Plane would complement the Shuttle and extend its life several years.

However, in February 2003, the Columbia Shuttle disintegrated, killing all aboard. Whatever goals O'Keefe had in 2002 were now on hold and subject to change. Columbia came to define his tenure at NASA. He got NASA through the disaster and the investigation that followed with relatively modest organizational damage. However, the report of the Columbia Accident Investigation Board forced him and everyone else to face a reality that the Shuttle was old, flawed, and high-risk. O'Keefe, because of Columbia, had a window of opportunity for major policy change. The Columbia Accident Investigation Board helped him think big by stating that NASA needed a significant goal worthy of risking human life beyond the Space Station.

Michael Griffin, April 2005–January 2009

Michael Griffin is the Administrator who most recently completed his tenure at the time of writing this profile. Hence, this assessment is somewhat premature, his legacy being dependent on what President Barack Obama decides to do about NASA. However, certain observations are possible for the Bush period. Griffin, aged 55, came to NASA with a long and deep experience in the space field,

indeed a lifetime of interest and work. A man with a Ph.D. in aeronautical engineering and many other degrees, Griffin began his career with NASA via JPL. He served as Associate Administrator for Exploration under Truly and Goldin before the senior Bush's Moon-Mars program was killed at the outset of Clinton's administration. He was head of space research and development for APL of the Johns Hopkins University when he was appointed to head NASA.

He was coauthor of a book, Space Vehicle Design. Like Paine and Goldin, he had a passion for space, but he displayed that passion more quietly than they. It is hard to imagine anyone who could have been better equipped technically or, probably, managerially to implement the Moon-Mars decision. Indeed, Griffin's prime mandate as NASA Administrator was clear: carry out the Vision for Space Exploration, as it was then called. But many an implementer has to worry about politics.

Policy decisions do not leave political and bureaucratic conflict at the adoption door. Typically, the struggle goes on. Griffin wished to move the President's decision down the hardware path so solidly that when he left, his successor would seamlessly take the program the next step toward fruition. Like other Administrators, he had to continually sell the lead program and build a support system for it while fending off opponents of his goals.

O'Keefe got the Moon-Mars decision during the window of opportunity created briefly by Columbia and the Columbia Accident Investigation Board. Griffin faced a closing window for implementing this initiative. The Bush administration was weaker in 2005 than in 2004 because of an unpopular war, high deficits, and a declining economy. Hurricane Katrina also occurred at a most inopportune time for Griffin, just as he was trying to ramp up Moon-Mars funding in the fall of 2005. His political/budgetary situation grew subsequently worse.

When Griffin became NASA Administrator, he set three major goals: to return the Shuttle to flight, to finish the Space Station, and to implement the Moon-Mars decision. Griffin said at his confirmation hearings he would try to bring the Shuttle successor into service sooner than 2014. He also said he would revisit the Hubble Space Telescope decision. He took office in April 2005. Griffin moved as quickly as he could on all fronts once in office. He succeeded in returning the Shuttle to flight and made good progress in finishing the ISS. He reversed O'Keefe's Hubble Space Telescope decision.

He came up with a design for the Shuttle successor and return-to-the-Moon system, called Orion-Ares. It was Shuttle-derived and looked much like Apollo. The capsule was Orion and the rocket, Ares I. There would be a large Ares V rocket for cargo shipments to the Moon, as well as a lunar lander. The whole system was called Constellation. First came Orion-Ares. Griffin called Orion-Ares "Apollo-on-steroids." The



tentative cost for a Moon return was \$104 billion.

He hit a roadblock to his personal goal of accelerating implementation in narrowing the Shuttle/Orion-Ares gap in the fall of 2005. He discovered that the Shuttle budget projections he inherited were unrealistic. The Shuttle costs were not going to go down appreciably prior to 2010. Where would money come from to make up the difference? In announcing the design decision (Orion-Ares), he had said he would not take "one thin dime" from space science to pay for the return-to-the-Moon system. But when he found he needed additional money, OMB refused to revisit the budget projections set in 2004. It proposed that Griffin kill the Shuttle early to get the money, a non-option for Griffin.

All the various NASA Administrators have been significant in one way or another in the history of the space agency. Each has brought a particular background, training, and set of skills to the Administrator role. All have been important, particularly as "relay leaders." Administrators invariably serve briefer terms than it takes to adopt and fully implement the programs they run. The ISS, for example, began under Beggs and was still unfinished when Griffin completed his tenure with President George W. Bush. They make their mark primarily as they affect the course

of these large-scale, long-term programs. Some are initiators; most are implementers; some are saviors. It is also notable that a few stand out as especially influential.

Webb, in particular, is larger than life. He shaped and carried out a program, Apollo, in such a way that it stands as an icon for effective government. He made the most of a rare opportunity on an historic stage and exemplifies what is possible when there is a strong match among man, organization, and time. Fletcher, Beggs, and O'Keefe got presidential decisions for flagship programs; and Frosch and Goldin got presidential decisions that saved two of these programs. Griffin is critical as a relay leader, implementing a program that may (if sustained by successors) at last get NASA out of Earth orbit and back to where it was in the 1960s. Glennan got the Agency and a range of new programs, including the beginning human spaceflight effort, underway.

Whatever their strengths and weaknesses and all the NASA leaders had both they, as a group, did their best and have kept the Agency sailing "this new ocean" of space, often under extremely adverse conditions. NASA and the nation have been fortunate to have had such an able and dedicated set of leaders.

‘Satellite technology would be the solution to many problems'

In 2023, space enthusiasts from across Columbia's campus filled the Altschul Auditorium for a once-in-a-lifetime opportunity to video call the International Space Station ISS. Led by the Columbia Space Initiative, the 90-minute event featured a Q-and-A with NASA astronaut Warren Woody Hoburg who recently made his first expedition into space. Hoburg is currently on the ISS as part of NASA's Crew-6 mission.

The space race that began more than 60 years ago in the world, in Colombia it seems that it continues to be a plan. However, since 2017 the Colombian Space Agency (AEC), led by its founder Pilar Zamora, has begun working on projects that highlight the nation's need to acquire this technology, and the uses that, in practice, could contribute to solving or controlling various problems.

"Talking to students who are excited about space is possibly one of the coolest things I could do," said Hoburg, who has expressed interest in visiting Columbia Engineering in person when he touches down on Earth. Students spent time asking Hoburg questions about his experience on the ISS, ranging from mealtime in space to conducting research and working with other fellow astronauts.

"I've been making all sorts of different taco creations, using cranberries on tacos and coming up with interesting concoctions for variety," he said with a laugh.

On a more serious note, when asked about working with others on the ISS, Hoburg said, "Something that is so apparent when you're up here is that you can't do human space flight on your own. You have to be part of the team ... And beyond that, looking back at Earth—that beautiful marble sitting in that black vacuum of space—you realize that we are kind of one team on Earth, as

well, and we really need to come together in order to solve the challenges we have on our beautiful home." Mike Massimino, professor of professional practice in the Department of Mechanical Engineering, also shared moments from his own exciting career in space. From 1996 to 2014, Massimino served as a NASA astronaut, flying in space twice and walking in space four times for the final two Hubble Space Telescope servicing missions.

Mike Massimino, Columbia Engineering faculty and former NASA astronaut, makes introductory remarks at the recent Columbia Space Initiative ISS call with Astronaut Woody. Credit: Minju O'Rourke"

This doesn't happen very often," said Massimino to the packed auditorium. "Astronaut time is really valuable on orbit so devoting time to do this [event] is important. NASA likes to spread the word to encourage students and education, but there are so many schools that would love to have this opportunity; we are really very fortunate.

What a Blast!

The Columbia Space Initiative Rocketry team designed, built, and launched a hybrid rocket in one year for the first time in Columbia history! The 20 members of the CSI rockets team travelled to New Mexico, representing Columbia at Spaceport America Cup, the world's largest intercollegiate rocket competition. On the final launch day, they successfully launched the rocket and won 3rd place in their category. They also received recognition for the avionics subteam's firing control user interface and the President's Choice award

At a remote site in the Mojave Desert, Columbia's student rocketry team achieved an exciting milestone. On June 2, 2025, the Columbia Space Initiative Rockets team successfully launched a hybrid rocket powered by liquid oxygen, a first for a student-led group, according to organizers of the FAR-OUT student rocketry competition.



"We had to make a lot of tough engineering decisions and develop our program to move from nitrous to liquid oxygen," said Michael Sheehan, co-lead of Columbia Space Initiative Rockets and a 2025 mechanical engineering major with a minor in aerospace engineering. "We pushed ourselves to do it because industry is increasingly focused on liquid oxygen-fueled rockets."

Blast off! Columbia Space Initiative Rockets team successfully launch its hybrid rocket using liquid oxygen. Credit: Courtesy of Columbia Space Initiative.

The successful launch capped off a yearslong effort by nearly 60 undergraduates to design, build, and test the rocket. The project came to fruition at the FAR-OUT 2024-2025 competition, where the rocket reached its target altitude for the first time in team history and achieved full recovery. The team shared video clips of the launch with Columbia Engineering faculty and supporters.

"This is an incredible achievement," said Hod Lipson, James and Sally Scapa Professor of Innovation and chair of the Department of Mechanical Engineering. "It shows how our engineering education has accelerated from textbooks and lectures to record-breaking experiential learning. This is literally the next generation of rocket scientists."

"It made my day to see our student team launch this newly designed rocket," said Shih-Fu Chang, Dean of Columbia Engineering.

Now in its third consecutive year of successful launches, CSI Rockets has become a proving ground for student-led aerospace work. With this milestone behind them, the team is already planning its next move.

Colombian Space Agency finally takes off

A group of researchers, academics, and entrepreneurs created the Colombian Space Agency, an initiative that seeks to boost the aerospace industry in the country.

With the purpose of generating and promoting an industry around aerospace activity, companies, universities and representatives of the national and French governments created the Colombian Space Agency. This institution, whose CEO and co-founder is Pilar Zamora, a renowned Colombian lawyer with extensive experience in this type of aerospace development and initiatives, held its first Board meeting just a few days ago in Bogota. But even though the Agency is just getting started, there are already two

initiatives to be finalized this year.

The first of these seeks to improve connectivity to bring educational content to the most remote places in the country; the other task of this Agency will be to advance engineering competitions in universities for the development of satellites in Colombia. Similarly, work is underway on a Conpes document that will define a medium- and long-term policy. Colombia is one of the few countries in the region and the world that lacks a productive infrastructure for developing the satellite industry. The most paradoxical aspect is that the country's geographic location is almost ideal for boosting this sector. The applications and uses are nearly limitless. For example, it can optimize weather forecasting for farmers, improve national defense systems, and bring more communications to remote areas. But that's not all. Satellite technology can optimize a significant portion of production processes across all sectors of the economy, thanks to its easy accessibility and widespread availability. Companies such as Airbus Thales and Eutelsat will be among the members.

Getting to the Launchpad

The Columbia Space Initiative Rockets team is composed entirely of undergraduate students, drawing from a wide range of disciplines and schools across Columbia University. While the group is rooted in engineering, it includes students from Columbia College, Columbia Engineering, and Barnard. While most teams at FAR-OUT work on the same rocket for two or three years, the Columbia team builds a new rocket each year.

"We do something different with the rocket every year," said CSI Rockets co-lead Valentina Fichera, who graduated in 2025 with a degree in mechanical engineering. "Everyone was on board with transitioning to liquid oxygen, it forced us to push ourselves."

This year's team included about 60 members, with 19 traveling to the desert for the launch. Those undergraduate students were spread across specialized teams focused on propulsion, electronics, airframe, payload, and the combustion chamber.

Inside the Rocket

Columbia Space Initiative Rockets had previously relied on nitrous oxide hybrid systems. But this year, the team switched to a liquid oxygen hybrid, which is a far more technically demanding system typically used in larger-scale commercial rockets. Few student teams even attempt liquid oxygen hybrids. "We all wanted that experience," Fichera said.

"Liquid oxygen exists in a cryogenic state," explained Sheehan. "So everything from storage to pressurization becomes more complex. We had to overhaul our entire propulsion system." The team

used gaseous nitrogen to pressurize the liquid oxygen and built new components to manage the system safely and effectively.

"We designed for a target apogee of 6,500 feet and reached nearly 5,700. It was our most accurate launch yet," Fichera said. The launch itself came on the second-to-last window on the final day of the event, after multiple early-morning attempts.

Fichera and Sheehan, who have interned at leading aerospace companies like Firefly and SpaceX, are pursuing engineering positions in industry. "We spent a lot of time working on the rocket this year," Fichera said with a laugh.

Columbia University's First Student-Organized Satellite

In 2023, Columbia University satellite team took off, thanks to funding from NASA. At the end of March, Columbia University's satellite development team was chosen as one of the eight universities, including Harvard College and Saint Louis University, for nanosatellite flight opportunities by NASA CubeSat Launch Initiative. This is the first time Columbia University has been selected for the program.

"It gives the mission and the team just a lot of potential and a lot of opportunities that I feel like we definitely would not have if it weren't the fact we got selected," said Bruno Rergis, a Columbia Engineering student who will graduate this year. Rergis is also the former co-president of the Columbia Space Initiative, which founded the CubeSat team in collaboration with Columbia Robotics, another club.

Columbia is one of eight sites, including Harvard College and the University of Texas at Austin, selected by the NASA CubeSat Launch Initiative, which provides flight opportunities for educational and nonprofit organizations. CubeSats are miniature satellites that are both easier and cheaper to launch but can play instrumental roles in space research and exploration.

Along with NASA funding, the team has also been chosen by the inaugural University Nanosatellite Program Mission Concepts-1 Program, a collaboration between NASA, the U.S. Air Force, and the U.S. Space Force that provides \$60,000 of funding, internships, and training to build the device. The Columbia CubeSat, named Cubesat-1, will photograph light emitted from gas atoms,



which can indicate how gas behaves in neighboring galaxies and the spaces between them. Essentially, (CU)besat-1 is a small telescope able to track galaxies through space and time. Advising the project is David Schiminovich, professor of astronomy and co-director of the Columbia astrophysics laboratory, along with Mike Massimino, professor of mechanical engineering and former NASA astronaut.

When Matthew Werneken, a junior engineering student and co-president of Columbia Space Initiative learned the news, he "started screaming and messaging frantically on Slack." The nanosatellite, CubeSat, developed by students with a mini camera, will photograph light emitted from gas atoms in space to further the study of the movements of gasses and galaxies. And the learning will be shared with middle school students to address the team's mission "to provide accessible and engaging astrophysics education for middle school students in underserved New York City public schools." David Schiminovich, co-director of Columbia astrophysics laboratory and a Professor of Astronomy, is an advisor for the CubeSat team and believes that CubeSat provides valuable

opportunities to learn almost everything needed to fly a big satellite, which is difficult in New York due to the limitation of facilities.

In addition, the team has been awarded \$60,000 for summer traveling internships, sending four interns to Kennedy Space Center and Albuquerque, New Mexico to develop skills to build CubeSat by the University Nanosatellite Program Mission Concept-1 Program.

Despite achieving success, the team was established in the fall of 2022. It took a lot of effort. In September, both Columbia Space Initiative and Columbia Robotics attended the school's club fair and prepared booths for students to learn about the clubs and sign up for their newsletters. It was at one of the first meetings of CSI and Columbia Robotics, students were introduced to the launch of the CubeSat program.

Soon, members worked on the CubeSat proposal for NASA CubeSat Launch Initiative. Later, club members also submitted it to the University Nanosatellite Program Mission Concept-1 Program.

"The cool part is this whole proposal is really driven by what people wanted to research about this topic, and then we just worked from there," Werneken said.

The proposal ballooned to 50 pages, which was written by club members with the help of other professionals in the field for review, including, Schiminovich, Michael Massimino, professor of professional practice at Columbia and former NASA astronaut, and Keenan Albee, a NASA jet propulsion laboratory robotics technologist. "It was very daunting to start the proposal because we were struck with how much we didn't know about what we had to do," Khouider said. "But, it was very rewarding because it was very much starting from a place we didn't know much about and getting to a place where all of the sudden, all these subsystems and connections start to make sense to us. And I really really like to work with the team here because everyone here is so nice and had a lot of fun."

Khouider especially loved the collaborative environment. Khouider is also one of the participants who will participate in the University Nanosatellite Program Mission Concept-1



SPACE REPORT

Program internship.

"I'm very excited to be able to spend time this summer learning all the little pieces needed in order to make this project a reality," she said. "Our goal is to come out of this summer with a clear plan and model for satellites, knowing what we have and what we need."

Manuella Kwawu, an engineering student, said she is particularly eager to learn beyond the opportunities that CubeSat can provide. "I'm also excited to work with the outreach mission that will give high school students the opportunity to experience engineering up close, and beyond what they would ordinarily have access to in their classroom," Kwawu said. It is the mission of the team to create a legacy and opportunities for space education that lasts. To achieve the goal, members are continuously looking for funding opportunities and sponsorships because of the raw materials and the costs of the development.

"Small satellites, such as CubeSats, play a valuable role in the agency's educational, science, and technology investigations, including planetary exploration, Earth observation, and fundamental Earth and space science," said Bradley Smith, NASA's Launch Services Office director. "They are a cornerstone in the development of cutting-edge NASA technologies such as laser communications, satellite-to-satellite communications, and autonomous movement."

Launch opportunities for the selectees are provided through the Educational Launch of Nanosatellites (ELaNa) missions facilitated by NASA's Launch Services Program. Selected CubeSats are launched aboard planned spaceflight missions led by NASA, other U.S. government agencies, or commercial organizations with coordination from LSP. After launch, the CubeSats will deploy into orbit from either the rocket or the International Space Station.

Colombia's own satellite in space

After the idea of launching a Colombian satellite into space was shelved due to high costs, risks, and a lack of expertise in the country, Dinero learned of a Public-Private Partnership PPP proposal presented by the French multinational Eutelsat, which aims to make the country the first hub or operations center of this type in Latin America.

The proposal which has already been submitted to the Ministry of Information Technologies and Communications (MinTIC) and is in the study phase could be given the green light next month, when the national government, led by MinTIC, National Planning and the National Spectrum Agency (ANE), is expected to endorse the project and order the proponent to prepare more detailed

technical studies.

What does Eutelsat offer? The company, listed in Paris and with a fleet of 39 satellites is offering the Colombian government exclusive access, for the 15-year duration of the contract, to 18 transponders, or communication channels, on the Eutelsat 115 West B satellite.

According to Pilar Zamora, legal director of Visión de Valores SA, the firm that structured the proposal, the construction of a satellite control center, valued at US\$10 million, is also planned for the Bogotá Savannah. "The idea is to plant the seed in Colombia to develop a satellite industry. That's why the proposal includes the training of Colombian personnel and the transfer of advanced technology," explains the lawyer. A group of international experts will arrive in the country during the first week of February to begin a technical study to determine the best location for this center. Bogotá or nearby municipalities such as Tocancipá are being considered initially.

The first public-private partnership PPP in the technology sector in Colombia also envisions the installation of 25,000 communication antennas across the country. The Ministry of Information Technologies and Communications MinTIC will be responsible for determining the types of entities or locations where this equipment and these services will be installed. However, Martha Suárez, director of the National Spectrum Agency ANE, explains that if the initiative is approved, it could benefit approximately 42,000 schools and nearly 1,800 health centers and hospitals, most of which are located in areas far removed from major urban centers.

Another advantage of this type of technology is that the country's emergency services will have an efficient communication system in case of a natural disaster or a sudden and widespread failure in conventional or terrestrial communication systems. "Another positive aspect is that the different entities and ministries that use and contract satellite information for communications will have a single operator, which reduces costs and improves the efficiency of the State," says Zamora.

The planned investments in this PPP amount to US\$1.095 billion, of which approximately US\$268 million would have to be allocated by the Colombian government over a 15-year period, averaging about US\$18 million per year.

According to Zamora, this amount is significantly lower than what public entities currently pay for these types of services. "We estimate that the Colombian government will generate savings of around US\$200 million by improving economies of scale and eliminating intermediaries or integrators from the system," he adds.

It is necessary to clarify that this type of geostationary satellite offered by the French multinational is not suitable for taking images for the defense sector or the Ideam and does not work for positioning navigation or GPS. This Eutelsat satellite can indeed be used to expand digital public television coverage, for example in San Andrés; or for the communications services of the Military Forces, for navigation on the Magdalena River, to improve air operations at airports like El Dorado, and even for mass transit systems like Transmilenio.

The contract also includes the permanent allocation of two orbital slots to Colombia. These rights are known as Orbital Spectrum Resources (ORER), which can be auctioned on international markets or commercially exploited by governments and private companies. What's missing?

Once the multinational receives approval from the Ministry of Information Technologies and Communications (MinTIC) regarding the feasibility study, it must begin a negotiation process concerning the terms, guarantees, and investments. Since this is a public-private partnership (PPP) requiring public investment, a bidding process will be necessary, which is scheduled for the second half of this year. If another similar company submits a more attractive financial proposal than the one submitted by Eutelsat, the French company will have the option to match it.

If there are no setbacks and negotiations and bidding processes proceed smoothly, construction of the control center and installation of the 25,000 antennas could begin in 2017.

Securing the financing is relatively straightforward, given the company's strong financial position and the fact that the satellite is already in orbit and operational since last October. The satellite's lifespan is 15 years, the same period as the proposed Public-Private Partnership (PPP). The potential benefits of this contract are still being evaluated by both parties. However, Eutelsat states that the PPP guarantees connectivity for approximately 10 million Colombians and improves communication across some 640,000 square kilometers of Colombian territory.

Live From The International Space Station: A Conversation With Astronaut Don Pettit

On October 25, 2024, the Columbia Space Initiative (CSI) hosted a live downlink in the Davis Auditorium with astronaut Don Pettit. More than 400 people gathered for the live conversation, including high school students from Carey High School in Long Island. Currently aboard the International Space Station (ISS) in Low Earth orbit, Pettit is an American astronaut and chemical engineer on Expedition 72. As the oldest astronaut on an active mission in space, he

will turn 70 next spring, Pettit brings a passion for both his scientific pursuits and astrophotography.

The event began with a detailed introduction by Columbia Mechanical Engineering Professor, CSI faculty advisor and former astronaut Michael Massimino. After earning his Bachelor's degree in Industrial Engineering from Columbia and his PhD from MIT, he was selected to fly on both Columbia and Atlantis missions to serve the Hubble Telescope. Massimino began by describing his relationship with Pettit, a fellow member of his 1996 NASA (National Aeronautics and Space Administration) graduating class. The two started an educational video series called ISS *Science Garage* and generally spent a lot of their time together. "He looks at the world with just childlike curiosity," said Massimino, highlighting Pettit's inquisitive nature.

Massimino then spoke about NASA's opinion on private space initiatives and enterprises looking to commercialize space discovery. Contrary to the belief of many, he claimed that NASA has a very favorable view of these companies. In the 80s and 90s, while he was studying to become an astronaut, NASA was actually converting spaceship manuals so that commercial airline pilots could fly them. This and other commercialization programs were shut down, but this ambition has rekindled recently. A NASA crew recently landed a SpaceX vehicle back on earth after a mission, and they are also looking at commercial crew programs with cargo in addition to astronauts.

If NASA's current economic goals are to increase efficiency through partial privatization, their scientific goals over the next ten to fifteen years should focus on greater research of the Moon and Mars. "With our current technology," said Massimino, "the propulsion isn't there to go much farther than Mars." This narrows NASA's focus to completing an orbital flight of the Moon. Achieving a moon landing is also a significant objective, as this has not been accomplished in around 50 years. Achieving both of these goals would allow NASA to shift focus to Mars and collaborate with other nations to achieve the necessary technology.

Transitioning into Massimino's personal experience as an astronaut, a high school student asked him about his first mission. He described going into space for the first time as an inspiring experience as he was surrounded by a crew of people all equally dedicated to one objective: accomplishing the mission. Seeing the Earth from space felt like looking "at absolute paradise," and the thinness of the atmosphere reminded him of the fragility of life. While he felt like a New Yorker at Columbia and an American at NASA, being in space completely shifted his perspective, and he felt like the "whole Earth" was his home.

After Massimino's introduction, CSI connected with NASA's control center in Houston and with Don Pettit in the ISS. The view behind the astronaut was picturesque, with seven window panes arranged into a hemisphere above his head. We were witnessing him on a daytime pass over Earth, the planet rotating as he spoke. To his left, another spacecraft passed by, intercepting the circular solar panel visible at the top of the screen.

Pettit is no stranger to a picturesque view of outer space. As an avid astrophotographer, he is fascinated by the beauty of capturing moments in still images. According to Massimino, Pettit invented the technology to make sequential stills and long-exposure photographs of space. When asked about balancing this passion with his scientific pursuits, Pettit responded that the two go hand in hand. Photography serves as both a creative outlet and a useful measure for documenting his investigations.

Another question focused on Pettit's current investigations and scientific projects. Pettit responded that working on science experiments under Space Station principal investigators has somewhat resembled "graduate students under the wing of a major professor." Since he lives in an orbiting laboratory, he can do smaller educational demonstrations as part of his Saturday Morning Science Project Series in his off-duty time. Pettit showed the audience a photo of one of these projects which focused on the freezing front of ice. As he has access to -95 °C freezers in the space station, he can produce highly complex crystals under polarized light.

Pettit then shifted the conversation to his broader experience on the International Space Station and his thoughts about its future. He expressed that his favorite part of being in the station is experiencing the feeling of zero gravity, a feeling he so enjoys that he even patented a zero-gravity coffee mug.

Although the ISS is facing decommissioning at the end of the decade, Pettit feels optimistic about the future of space exploration and the prospect of private startups commercializing the sector. Pettit hopes that we as a nation "continue to support and maintain" these space endeavors.

A small Cubesat, one giant leap for Columbia students

Lions are land mammals, but on July 2, 2026, a 2D resin-printed Roaree figurine Columbia University's lion mascot was deployed into space and snapped for a photo in the successful finale of Columbia Space Initiative's LionCub CubeSat prohect CibeSat project .

Roaree's low-Earth orbit portrait represents the culmination of a multiyear project by the students in the Columbia Space Initiative, the largest engineering club at Columbia, comprising students from across the UniversityColumbia Space Initiative boasts more than 250 active members, all dedicated to the pursuit of knowledge in near-space, space, and beyond.



A year after the LIONESS mission's approval, the LionCub mission was born. Before launching LIONESS, the club wanted to get some hands-on CubeSat learning. The goal was to get more experience with not just the tangible elements of building a satellite but the operational, logistical, and administrative processes that are critical to putting it in space.

LionCub was the result. CubeSat team members joined a CubeSat launch project spearheaded by California State Polytechnic University, Pomona, and worked as part of the collaborative group with clubs from Northeastern University, UC Santa Cruz, and Texas State University. CSI workshopped and made valuable connections with other students in the field. They also created LionCub, a functional nanosatellite that would serve as a trial run for LIONESS.

Launching LionCub into space was a critical way to "give CSI some heritage," as Mata said. As an organization made up of almost exclusively undergraduates (and a handful of grad students), means CSI as a whole and the CubeSat teams in particular have new people coming in and older, more experienced team members graduating out every year over the course of the multiyear mission. Building institutional knowledge and hands-on satellite experience is essential to maintain continuity and keep the larger mission on track.

LionCub, his ride to space, is a nanosatellite, a 10cm modular cube designed to hitch a ride on a larger rocket.

Its successful launch is a massive first step for one of the club's most ambitious projects: the 2027 launch of LIONESS, the first satellite designed by Columbia undergraduates that will collect data from beyond the atmosphere and support both important research goals as well as bring science education from space directly to New York City middle schools.

The voyage LionCub undertook started when it was launched into space on a SpaceX rocket on April 11, with two team members on hand at the Florida launch site and many more watching the livestream together back at Columbia. (Originally scheduled for an April 1 launch, space enthusiasts will appreciate the reason it was pushed back: Its slot was given to NASA's Artemis II mission.

The LionCub CubeSat was docked with the rocket at the International Space Station (ISS) until July, when it was deployed. "That was our trial run," said graduate team lead Moises Mata '26CC. "This is the first satellite launch from the university to space." It's a major milestone.

"I am so proud of our CSI LionCub team. Preparing a satellite for launching into space is a huge

undertaking, and is an example of the great things that Columbia students can achieve. Godspeed LionCub!" said CSI faculty adviser Nike Massimino , professor of professional practice in the Department of Mechanical Engineering at Columbia and former NASA astronaut.

Mission for science education

Launching a CubeSat into space has been a Columbia Space Initiative mission for years. In 2023, a Columbia Space Initiative proposal led by former Columbia Space Initiative Co-Presidents Matthew Wemeken BS'24 and Bruno Rergis BS'23 was accepted by NASA's CubeSat Launch Initiative, which provides flight opportunities for educational and nonprofit organizations.

That project, LIONESS, will photograph light emitted from gas atoms, with the data gathered helping support a current research initiative led by David Schiminovich, professor of astronomy and co-director of the Columbia astrophysics laboratory.

The mission and its learnings will also be used to create curriculum and help support CSI and Columbia Engineering Outreach's longtime partnership with the Sophie Gerson Healthy Youth nonprofit to bring extracurricular science education to more than 500 students in underserved New York City middle schools.

Defining addressable IoT markets



The Internet has become an essential global communication network among people, supporting communication between various devices. During past few years, Internet has extended its reach to connect things, such as heart beat monitors, temperature meters among many others to improve quality of life for people. It is safe to say that the long term goal of the Internet is to integrate human, things, data and different processes to create a powerful network and to do so, the Internet of Things (IoT) has been introduced to expand Internet connectivity to things

During past 40 years, the Internet has been used mainly to connect people to each other through email, forums and most recently by social networking sites. However, today, the Internet is servomg as a link between devices, machines and other things through wired and wireless networks using an open standard Internet protocol. The new movement in this era of computing is estimated to be outside the world of desktop. A new paradigm called

Internet of Things has grown fast during past few years.

The World Economic Forum's report states that 84% of IoT deployments are addressing, or have the potential to address, the UN's Sustainable Development Goals. These SDGs include combating climate change, sustainable production patterns and ensuring availability of clean water.

But as the report points out, "No services are possible without the infrastructure in place. Particularly in the case of IoT, at some point in the future revenues may come from the services associated with data, but without addressing the infrastructure solutions first, that day is still far away."However, traditional IoT works well where cellular networks exist. But significant gaps remain oil and gas pipelines, energy transmission lines, remote agricultural areas, maritime shipping routes, mining operations, and emergency response zones. Geographic gaps in coverage limit what's possible. For

instance, asset tracking stops at the cell tower's edge. Environmental monitoring skips the places that need it most. Emergency services lose connectivity in rural areas.

Cellular networks are inherently designed for where people live, yet 85% of the earth surface lacks terrestrial connectivity. For applications that need truly global connectivity, hybrid solutions that combine satellite with terrestrial connectivity can drastically expand the opportunity. Beyond the enhanced opportunities in expanded coverage, device vendors desire to ship globally without the potential limitations of network coverage. This simplifies and optimizes their supply chains to maximize the impact for their customers.

Satellites and high-altitude platforms serve as "flying base stations" enabling a single satellite to extend coverage across hundreds or even thousands of kilometres. Unlike terrestrial infrastructure, satellites are unaffected by terrain. Whether trekking in the Himalayas, sailing across the Pacific, or conducting research in the Sahara, satellites overhead can

automatically function as your mobile base station. Beyond LEO low Earth orbit constellations such as Starlink and OneWeb, NTN also encompasses geostationary orbit GEO satellites, medium earth orbit MEO satellites, low- altitude platforms, and high-altitude platform systems.

According to GSMA.Intelligence, as of September 2025, 110 operator groups representing 67% of global mobile connections have established active partnerships with satellite companies. This year marks a pivotal commercialisation milestone with operators such as AT&T and T-Mobile have launched services in Europe and North America, with rapid expansion underway in the Middle East and Latin America.

Similarly, over 70% of global mobile operators including China Mobile, Verizon, and Vodafone have signed agreements with satellite providers. In Japan, more than one million KDDI users have used satellite messaging while hiking or at sea. In New Zealand, One New

Zealand customers have collectively sent over one million satellite-enabled text messages

A GSMA survey of 12,390 respondents across 12 countries found that 60% are willing to pay 5–8% more on their monthly bill for ubiquitous coverage and nearly half would switch operators for such a service. Indian consumers are willing to pay a 9% premium significantly higher than the 5– 8% seen in the United States reflecting stronger demand for reliable connectivity in regions with frequent service disruptions.

In 2022, Saudi Arabian Oil and Gas company Zamil Offshore recently conferred with Inmarsat to use Inmarsat's Fleet Connect and Fleet Data IoT solution to provide video-based performance management to more than sixty of its vessels. Accordingly, Inmarsat's IoT solutions offer satellite connectivity and data analytics to Zamil operators in tough-to-reach regions, which is crucial to monitoring activities and optimizing workflows.

In addition, the partnership between manufacturer Terex and IoT solution provider ORBCOMM sees the latter utilizing an E2E telematics solution that facilitates the tracking and monitoring of the performance of crushers. When cellular connectivity is unavailable, the IoT solution utilizes satellite communications. ORCOMM's SatCom offering allows Terex's fleet managers to access dynamic dashboards, filters, and custom reports for data-driven insight, even in cellular dead zones.

"Satellite communications services have seen a new wave of enthusiasm and convergence with terrestrial networks looking to extend past their coverage zones and bridge the digital divide. We are witnessing a growing trend of operators leveraging software-defined satellites and multi-orbit solutions to meet the connectivity demands of the future," *Andrew Cavalier, ABI Research Industry Analyst.*

While satellite IoT is not a new concept, the idea of leveraging satellite connectivity for IoT applications is gaining traction across industries. Enterprises expect satellite IoT solutions to augment traditional monitoring applications) that use terrestrial infrastructure. This added value will come in the form of more accurate and granular operational data, especially for job sites in remote areas lacking proper network support.

Fleet management and monitoring services account for the lion's share of the satellite IoT revenue opportunity. Maritime vessels, airplanes, and heavy equipment vehicles in remote areas are often in cellular dead zones, which satellite services could remedy. In turn, enterprises can track their fleets location, equipment failure, in real-time without any interruptions. For monitoring applications, satellites are essential in providing connectivity to IoT sensors located outside the range of networks. Agriculture, mining, drone, and video surveillance applications are significant beneficiaries, given they are often in remote and rural settings.

As various players race to the top of the market, partnerships have become a common strategy to fill the voids that exist in their solutions. Industry collaboration enables companies to leverage the differentiated capabilities of their partners, which helps improve the end product.

So far, Geostationary Earth Orbit GEO and Low Earth Orbit LEO constellations are the most common deployments for satellite IoT. Regarding satellite IoT use cases, GEO constellations are best matched for

high IoT device density use cases where near real-time data updates are a priority. LEO constellations, on the other hand, are better apt for use cases where IoT devices are widely dispersed, and real-time data updates are not essential. Another key difference between GEO and LEO constellations is that the latter typically does not require an additional gateway to aggregate sensor data; instead, the data can be sent straight to the LEO satellite.

NTN mobile market players

According to an analysis conducted by Lynk, roughly 3 billion mobile users worldwide experience extended periods of cellular connectivity every year. NTN mobile satellite is seen as a prime technological candidate for filling in the gaps as it provides ubiquitous coverage despite environmental and topographic conditions.

TGI Connect, a pioneer in the IoT sphere, is driving significant innovations in the transportation industry in partnership with Globalstar's robust satellite network. With a strong focus on creating sensors for trailers, collecting valuable data, and offering efficient automation for actionable business decisions, TGI Connect is reshaping how transportation companies operate.

Business gets done every day and everywhere – not just downtown, but also beyond line of sight and outside the range of cellular coverage. From oil wells and snow-covered mountains to ranches spanning thousands of acres, businesses run on information. Their data may be as basic as where an asset is located. It may be confirmation that a remote machine is doing its job. That's why remote asset tracking and monitoring by cellular, LoRa and satellite have become a growth industry. The need is met by companies with expertise in industries from energy and utilities to agriculture and leisure. But they have a few things in common. Faced with a jumble of cellular carriers and data plans, they struggle to make things simple for their customers. They are also under constant pressure to provide the data their customers need at a price that makes sense.

Lonestar Tracking is a Texas-based company founded in 2016 to deliver IoT services to the oil and gas industry. Its founders had worked in the business and knew its needs: to track costly, complex equipment going to remote regions anywhere in the world, collect data from it and send that data in real time to Houston or another energy capital for processing. They also knew their former colleagues didn't want or need to understand the technology; they wanted to pick devices, receive and activate them and have them work right out of the box.

To provide the IoT connectivity the energy business needed, Lonestar chose the ST100 satcom module from Globalstar. "We absolutely love that board," says cofounder and CTO Thomas Remmert. The self-contained transmitter and modem add low-cost satellite connectivity to any OEM product. The ST100 features an ultra-light, compact design that includes GPS, an accelerometer, Nordic processor and Bluetooth connectivity. Without external antenna, it connects to the Globalstar low-Earth orbit satellite network and, through more than 20 ground stations, to Globalstar's processing system, which prepares the data and forwards it to Lonestar in real time.

TGI Connect's trailblazing innovation lies in its cutting-edge sensors for trailers. These sensors are equipped with state-of-the-art technology, enabling frequent data collection from trailers while in transit. By employing a robust sensor network, businesses gain critical insights into their trailer performance. A few of the business challenges TGI focuses on are location, temperature, door open, cargo and other crucial parameters. The accuracy and precision of these sensors ensure that

companies can monitor their assets more effectively and reduce potential risks during freight transit.

Founded in 2014, Mongolia-based Value Added Reseller Spotter has developed highly innovative solutions to satisfy the region's unrelenting demand for capable, reliable and far-reaching technology solutions that can monitor the location of millions of horses. The company created an animal-tracking collar based on Globalstar technology. Each Spotter collar is fitted with Globalstar's SmartOne C satellite IoT transmitter, so the solution helps herd owners keep tabs on their valued equines wherever they travel in this desolate region, even when well beyond the reach of GSM mobile signals. With SmartOne C's small size, versatility, and low price, Spotter is seeing rapid uptake of its lightweight, rugged, and economical tracking collars.

The horses typically roam in herds of around 30-50, with one lead stallion keeping the animals together and providing protection. As a result, the group can be effectively monitored with just one collar. Thanks to Spotter, and the enabling power of Globalstar's Low Earth Orbit satellite network, over a million animals are now being reliably tracked.

There's a growing understanding among the horse owning community of the value and reliability of the satellite IoT technology solution, according to Spotter Co-Founder Tsogbadrakh Surenjargal. "People are becoming aware that terrestrial telecoms infrastructure like mobile networks are simply unable to provide the ubiquitous and always-on tracking capability of satellite."

Spotter has seen sales of its satellite IoT-enabled horse tracking collar more than double in 24 months. Spotter has reached a milestone of over 31,000 animal collars deployed, enabling the reliable monitoring of free-roaming horses across Mongolia and Kazakhstan. Describing sales uptick of nearly 160% since October 2022, Spotter Co-Founder Tsogbadrakh Surenjargal says "the growth has been phenomenal."

The Spotter system's reliability and robustness have particularly demonstrated their worth during the extraordinarily harsh winter. Extreme weather and inaccessibility did not impede Spotter's capability to keep concerned herd owners updated on the animals' whereabouts, which can be monitored on users' smartphones. The principals of Spotter often hear from the herd owners themselves about how much they value the system's accurate tracking, particularly when climatic conditions have been extreme.

This Facebook post from one Mongolian herd owner was typical of many others: "My horses usually graze in the Southern Gobi, but because of the extreme snow, they migrated over 1,000km eastward to find grazing. The inaccessible location and frequent storms meant I wasn't able to check on them until Spring, but I trusted Spotter Horse Tracker to monitor my herd. Just yesterday I travelled to the horses' location, indicated by the system, and I'm so overjoyed to say that all my horses are well and healthy. I greatly appreciate Spotter Horse Tracker and its excellent support."

Why was Globalstar technology the right choice for Lonestar Tracking? "Performance for price," says Thomas Remmert. "We didn't need a continuous stream of data. We didn't need two-way communications or coverage at the poles. When we stripped away those requirements, Globalstar was the most cost-effective solution, without sacrificing anything we did need. The technology and service worked the way it was supposed to, and they opened up a host of opportunities we couldn't get from the other players in the market."

IoT connectivity has been on a downward cost curve for a decade, Remmert adds. "A lot of today's new satellite IoT technologies sound promising but when you're talking real value, it's about IoT connectivity from a device that works in the back of a metal FedEx truck. That's Globalstar."



SPACE STARTUP PROFILE

International Space Summit: Paris seeks to shape a new global dialogue on space



The first International Space Summit has ended in Paris, after bringing together heads of state and government, scientists, astronauts and industry representatives.

Initiated by French President Emmanuel Macron and co-organized by France and Germany, the two-day summit attracted around 2,000 participants. At the summit, discussions focused on science and space exploration, including exploration of Mars, ocean observation and space research; the global space economy, including access to space, connectivity, industrialization and European competitiveness; and space security and governance.

Space, a rapidly changing field. The space sector has been transformed over the past 20 years as a result of technological breakthroughs and changes to its economic model. Space and space applications are now everywhere. An increasing number of state and private actors are emerging and pursuing spectacular ambitions enabled by technological progress.

Space is already a part of our daily lives: satellites orbiting the Earth allow us to know our position on the planet, observe it and communicate. They are also essential for the use of smart devices, autonomous vehicles,

telehealth and remote surgery, shipping and defense.

It is up to us, as inhabitants of Earth, to take our future into our own hands, because the matter is urgent. While new prospects are skyrocketing, so are the risks, and we must collectively set out a strong pathway for the sector's development to ensure that the use of space is sustainable and benefits all.

This summit aims to promote frank and direct dialogue, as well as outlooks and avenues for work and action through high-level talks, announcements and workshops. Strategic

reflection on the future of space must be a global endeavor, which will be reflected by statements by States, international organizations and private stakeholders.

A day before the event, French President Emmanuel Macron announced that more than 50 projects are expected to be signed over the course of the two-day event, stressing the need to "strengthen the European and space research", but also to deepen partnerships with other countries around the world.

Alongside Greek Prime Minister Kyriakos Mitsotakis, he also welcomed the European Space Agency's (ESA) next private astronaut mission, PAM-6, to the International Space

Station ISS, scheduled for 2027 which will mark the first ever journey to space by a Greek astronaut, Adrianos Golemis.

Taking to X, he also hailed a major deal signed between Amazon Leo and Arianespace, stating that "Amazon Leo is renewing its trust in Arianespace with 6 additional launches, 24 in total."

Ahead of the summit, several US companies reportedly withdrew from the event, due to pressure from Washington over support for "EU policy positions."

The event began with the dialogue on the convergence of agendas, in areas including the growing use of low orbits, structuring the space economy, major scientific fields, Moon exploration and skill development. These topics are too often addressed separately, when they are in fact closely linked and should be approached jointly and clearly, as parts of the same system.

Despite this, the summit comes at a strategic crossroads for the European space industry, described by President Emmanuel Macron as an opportunity to "bring Europeans together around a common ambition" and develop a "shared vision of Europe's place on the map of global space powers by 2035" when he announced the event in October 2025.

According to the Elysée, the summit focused on international space cooperation and strengthening space security. In recent years, Europe has increasingly sought to challenge US dominance of the global space market: developing its own homegrown rockets and increasing funding for space at both a state and bloc-wide level.

Europe has historically invested 0.07% of GDP into space programmes, compared with 0.24% by the US. But 2025 marked a turning point, as the European Space Agency ESA approved a record-breaking €22.3 billion budget for its three-year funding cycle 2026–2028 in November, with €35 billion for space for security and defence.

Lunar mining has also emerged as a potential avenue for securing clean-energy resources and critical raw materials, as Europe works to move away from Chinese and Russian dependencies.

Divergence between France and Germany

Nearly a year after Macron announced the summit, it encountered some bumps in the road before the event had even begun. Germany's Chancellor Friedrich Merz confirmed on Friday that he would not attend the summit due to domestic commitments, with defence minister Boris Pistorius and space minister Dorothee Bär set to go in his place.

Behind the scenes, France and Germany have faced a number of disagreements over space and defence projects, ditching the Future Combat Air System FCAS project in June 2026, after years of disagreements.

Macron has consistently stressed the importance of building up Europe's strategic autonomy, backing programs like Ariane 6, rather than relying on US providers such as Elon Musk's SpaceX.

Meanwhile, Germany has expressed a greater willingness to rely on lower-cost US alternatives, such as SpaceX. Last month, German startup Isar Aerospace launched the first commercial rocket to reach orbit from mainland Europe, marking a major

turning point in Europe's quest to secure independent access to space. Merz described the launch as "the beginning of a new era."

US companies withdraw from event

A number of US companies also withdrew from the event, after a White House official reportedly warned them that their attendance "could look like tacit support for EU policy positions," Politico reported.

A spokesperson for France's Ministry of Higher Education and Research, which oversees national space policy, told the AFP news agency that SpaceX, Blue Origin, Stoke Space, and Starcloud had withdrawn from the event, stating "it's hard not to link it to the rumours of pressure in the press."

Hermann Ludwig Moeller, Director of the European Space Policy Institute described France as a "driving force" in Europe's space sector, providing "strong political support" to the industry, stressing that the "relevance of space is only increasing."

"It is increasingly becoming a war fighting domain, while at the same time it has become evident also to the general public that conflict has become hybrid in nature, for instance through attacks on critical infrastructures in transport, energy, digital. This is where space can provide increased resilience."

Moeller stressed the role that space technologies such as satellite navigation have in terms of both civilian and military usage.

"While they are essential to everyday life, the war in Ukraine has also highlighted their strategic importance in modern warfare", he said.

Kyiv's reliance on Musk's Starlink following Russia's full-scale invasion of Ukraine has underlined the strategic importance of space services during wartime — that the satellite network provides resilient internet connectivity even when infrastructure is damaged or destroyed.

This reality also pushed Europe to develop its own independent satellite networks, notably the secure internet constellation known as IRIS².

The choice of Paris also reflects France's ambition to place Europe at the centre of discussions over a sector where geopolitical and commercial competition is intensifying. "Space is an obvious illustration of the links between research, innovation and sovereignty," said Philippe Baptiste, France's Minister for Higher Education, Research and Space.

The summit will focus on four broad priorities: security, the space economy, regulation and space as a common good, as well as research, exploration and youth engagement. The agenda reflects a fundamental transformation. The rapid growth of private operators, satellite constellations and low-Earth-orbit infrastructure has created new economic opportunities while raising new regulatory and security challenges.

Astronaut Thomas Pesquet was named Special Envoy of the President of the Republic for the International Space Summit that began on 9 and ended on 10 September 2026.

Thomas Pesquet began his career as a satellite dynamics engineer at Thales Alenia Space, then GMV in Spain, followed by the French space agency, CNES, before becoming an airline pilot with Air France in 2006. In 2009, he was selected by the European Space Agency ESA to join its astronaut corps following an intensive training programme.

In 2016, he became the 10th French astronaut in space when he embarked on the Proxima mission, during which he spent 197 days on board the International Space Station (ISS), performed two extravehicular activities and took part in over 50 scientific experiments.

In 2021, he returned to space on a second mission, Alpha, on board SpaceX's Crew Dragon spacecraft, and became the first French commander of the ISS.

He holds the European record for time spent in space 396 days as well as for extravehicular activities for six, for a total of 39 hours. In addition to his work as an astronaut at the ESA, Thomas Pesquet is currently a test pilot at Airbus, a pilot with the French Air and Space Force and CEO of Novespace.

Within the framework of the agreement concluded between the American company Vast and the French Government, announced by President Macron on 1 June 2026, Thomas Pesquet has been selected to fly on board the commercial mission PAM-6, a short-duration mission to the International Space Station and the sixth private space mission to the ISS.

For Thomas Pesquet, Special Envoy of the French President for the summit, the response cannot be an unregulated race.

"Space is not the Wild West. It is important to understand this," he said in an interview published by the French Ministry for Higher Education, Research and Space. Space, he argues, "concerns everyone" and must be used "in a coherent and coordinated way."

Cooperation will therefore be a central issue. Navigation, meteorology, Earth observation and telecommunications already depend heavily on cross-border infrastructure and data. "There is no area of space that cannot benefit from cooperation," Pesquet said, referring both to exploration and Earth observation.

Sovereignty versus cooperation

The paradox of today's space landscape is clear: governments want to preserve strategic autonomy while simultaneously needing international cooperation to finance and develop increasingly ambitious infrastructure.

France is seeking to defend this approach at European level. Paris is working with its partners to strengthen Europe's autonomous access to space and its satellite capabilities. A joint Franco-Italian declaration published on 25 June expressed the ambition to make Europe "a major space power", supported by an industry that is "robust, renowned, competitive, high-performing and sovereign."

Security is another major concern. Satellites have become essential to communications,

intelligence, navigation and military operations. At the same time, the rapid expansion of private operators is forcing governments to reconsider how the sector should be regulated.

Philippe Baptiste argues that regulation should not prevent innovation, but should allow countries and companies to share an orbital environment subject to increasingly significant constraints, including frequencies and navigation.

Pesquet believes governments must retain a central role while the private sector brings "innovation and efficiency". The objective, he says, is to find "**something harmonious**" between public authorities and companies.

A changing space order

The summit is also taking place as the global space map is changing. The United States, China, Russia, Europe and Japan remain major players, but a growing number of countries are accelerating their own programmes. Emmanuel Macron has said that India will have "a prominent role" at the Paris summit.

For Pesquet, this evolution should lead to a broader negotiating table. "I think we will increasingly have these countries around the table, and all the better for it. It must also be our role to include them," he said.

This opening matters because the civilian uses of space are expanding rapidly. Earth observation now supports climate monitoring, natural-resource management, agriculture and disaster response. French authorities emphasise that space data has become essential to a growing range of activities on Earth.

Macron has also defended a vision of space that combines scientific ambition with collective interests. "That is the viable space model," the French president said, arguing for continued investment in exploration and in the ability to better understand Earth and the universe.

This summit also matters for Africa. After years of limited participation in major international space discussions, African countries are developing their own satellite programmes and technological capabilities. Pesquet explicitly recognises this trend: "I am certain that space in Africa, for example, will develop." He points to Earth observation for climate action, agriculture and disaster response, while calling for greater inclusion of African countries in international discussions.

The Paris summit will therefore not only be about the next phase of space exploration. It will also test whether the international community can build a governance framework that is not limited to established space powers and whether emerging players, including Africa, can secure a meaningful place in shaping the future of the space economy.

For several decades, France has pursued an ambition for space founded on European and international cooperation, as well as scientific and industrial excellence. France's national space strategy particularly aims to preserve the ability of both France and Europe to maintain autonomous access to space. By hosting the International Space Summit, France aims to help foster a collective dialogue on the future of space and the cooperation needed to address the challenges ahead.

INTERNATIONAL REPORT

How markets, technology, and power are reshaping the second space age



The night sky has served as a canvas for myth, navigation, and wonder, a domain whose scale defies ordinary understanding. And yet, much of our modern economy depends on the orbital infrastructure operating hundreds of miles above Earth. From global logistics and modern defense architectures to AI, strategically important industries all rest in part on technologies that circle the planet every 90 minutes.

In the last few decades, the economics of reaching space have fundamentally shifted, reusable launch systems, smaller satellites, advances in computing, and modern manufacturing techniques have reduced the cost of sending payloads into orbit. In turn, private-sector companies now build the infrastructure

once exclusive to government programs, and capital markets provide the critical funding for space exploration and commercialization.

Americans often present the image of Project Apollo and the other great accomplishments of the early years of spaceflight as prime examples of the achievements that a properly run government can produce. “If we can send a man to the Moon,” one journalist observed in a commonly heard refrain, “why can’t we clean up Chesapeake Bay?” When Al Gore challenged Americans “to commit to producing 100 percent of our electricity from renewable energy and truly carbon-free sources within 10 years,” he invoked the memory of Project Apollo. In a work of dramatic fiction, the actor portraying Gene Kranz in the movie Apollo 13 repudiates the pessimism of fellow flight

controllers with the announcement that “this is gonna be our finest hour.”

Although government-led spending and innovation defined this era, it gave rise to many of the commercial space-based technologies and services that have revolutionized life on Earth for the past several decades. Today, these innovations support diverse sectors spanning telecommunications, logistics, agriculture, defense, and finance. Space is becoming a new pillar of the industrial economy, one that is increasingly important to life on Earth. As the economic frontier of space extends, so will competition for orbital access, launch capacity, and space-based services. As with other industrial systems, the space economy

will develop supply chains, infrastructure nodes, and points of concentration where economic power accumulates.

Similarly, the space economy will face the same technology, financial, and regulatory bottlenecks that impact traditional industrial supply chains. The firms and countries that control launch capacity, manufacturing capability, orbital infrastructure, and space-derived data will shape how value is created in the emerging space sector.

Global demographic changes expected over the next decade are creating a large market for small-satellite services, including mobile and broadband communications, entertainment, and

remote sensing. According to the European Commission, by 2030: The global middle class is expected to reach 5.3 billion people.

This means an additional 2 billion people with more purchasing power than the earth contains today. Most of this growth will be in Asia. By 2030, China and India together will represent 66% of the global middle-class population and 59% of middle-class consumption. With the rise of the global middle class, Morgan Stanley expects demands for space-based and associated services to increase significantly.

As space becomes more economically central, it also becomes more strategically important to national security. And with corporates preparing to build and operate much of this critical space infrastructure, the line between public- and private-sector interests is blurred.

These converging forces are fueling a new space age defined not only by exploration but also by economic competition, a domain where capital markets, industrial capacity, and national strategy collide. Control of infrastructure, access to scarce resources, and mastery of emerging technologies will shape the orbital ecosystem.

Beyond the original scientific exploration, telecommunications and spy satellites, space is used today for everything from positioning, navigation and timing, to weather forecasting and monitoring climate change, crops and oceans, to managing electricity grids, sewage systems, maritime traffic and financial transactions, as well as broadcasting and video conferencing. Western economies are far more dependent on space for everyday transactions, communications and public services than most citizens imagine. “Our daily life really depends on satellites,” said Josef Aschbacher, Director General of ESA. The number of objects in orbit has dramatically risen with the emergence of a fast-growing commercial sector, often collectively known as ‘New Space’, which has far outstripped the number of government players in space. This has raised growing issues of congestion, pollution and traffic management that lack an up-to-date international regulatory framework.

Highlighting the extraordinary pace of change, Aschbacher said as many satellites were placed in orbit between 2020 and 2021 as in the entire period from the first Sputnik launch in 1957 until the end of 2019. The growth rate is set to accelerate further as constellations of thousands of satellites are proliferated in low earth orbit (LEO), between 400km and 2,000km above earth, to provide connectivity and broadband internet access to users in every corner of the globe.

Of the roughly 4,500 active satellites currently in all orbits, a single company Starlink, a unit of Elon Musk’s privately owned SpaceX already operates more than 2,000; the internet satellite constellation has regulatory permission to launch 10,000 more this decade and applied to launch another 30,000. Musk’s arch-rival and Founder of Amazon, Jeff Bezos, has licences to launch a constellation of more than 3,000 LEO satellites as part of his Project Kuiper to compete in the broadband internet market.

UK-based OneWeb, rescued from bankruptcy by

the British government and Indian investors in 2020, is the only European competitor in spacebased broadband internet so far with nearly 400 satellites in space as part of a planned broadband constellation. China also has plans for a 13,000-satellite mega-constellation run by private companies and overseen by a state owned enterprise.

Starlink is subject only to US regulation. Its first mover advantage in ‘occupying’ space real estate, with the approval of US government agencies, is not constrained by any international limits or supervision. ESA’s Aschbacher says this is effectively a land-grab that could shut out European competitors seeking frequencies in LEO. “You have one person owning half of the active satellites in the world. That’s quite amazing. De facto, he is making the rules. The rest of the world including Europe is just not responding quick enough,” he said]

Evolution of the modern space economy

The modern space economy is structured into upstream and downstream. The upstream segment encompasses the manufacturing and deployment of space assets, including satellite production, launch services, and ground infrastructure. Conversely, the downstream segment focuses on the operational utility of these assets, delivering space-enabled services that support a vast range of terrestrial activities. These capabilities spanning Earth observation, global communications, object tracking, and precision PNT serve a diverse array of end users from nearly every global industry. Since the early 2000s, the modern space economy has been revolutionized by three interconnected innovations: the advent of reusable rockets, the phenomenon known as the ‘SmallSat revolution,’ and the growing use of LEO.

Because of the limited number of launch service providers globally, launch acts as the upstream chokepoint for every aspect of the space economy and defines the cost structure for all other segments of the industry. In 1981, getting a kilogram of mass into LEO cost \$65,400/kg16 on the US Space Shuttle. Today, SpaceX Falcon Heavy has brought costs down to \$1,500/ kg. This massive decline in costs has been enabled by the advent of partially reusable rocket boosters, an innovation that transformed the massive fixed costs of building rockets into an asset that can be recycled for multiple launches. As a growing number of companies seek to replicate and improve upon this innovation, launch costs could continue to decline, democratizing space access even further.

At the same time, technical innovations and cheaper manufacturing techniques have led to a decline in the size and manufacturing cost of most functional satellites, creating new form factors and dramatically decreasing the complexity of reaching orbit with SmallSats. Until the mid-2000s, the industry had been dominated by large, school-bus-sized satellites in geostationary equatorial orbit GEO 35,786 km above

Earth’s equator that cost \$100 million to \$200 million to build, with launch costs on the order of \$50 million. These custom-built satellites were designed to remain in orbit for decades, making them prohibitively expensive for most actors except governments and telecommunications giants.

Concurrently, more satellites began to move into LEO ~550 km from Earth from higher orbits, taking advantage of lower latency and cheaper costs.

While the LEO constellations of the 1990s made up of Iridium, Globalstar, and Teledesic failed spectacularly, by the 2010s a new class of space startups were launching commercially viable, large-scale LEO constellations. Operating closer to Earth offered several advantages. First, lower radiation makes it viable to use commercial-grade electronics. Second, LEO satellites require less intense receiving infrastructure and user terminals on Earth, enabling devices as small as a satellite phone to communicate with a satellite and further reducing infrastructure costs. Finally, with reduced latency, the LEO revolution expanded the types of activities that could be conducted, such as video calls and online gaming. LEO infrastructure is one of the clearest commercial beachheads of the modern space economy, extending, supplementing, and even competing with terrestrial networks

In the four years since launch, Starlink, SpaceX’s fully operational global broadband LEO constellation that provides high-speed low-latency internet, has served more than 10 million customers, generating more than \$11 billion in revenue in 2025. The Starlink network currently has almost 10,000 satellites in LEO, with thousands more approved23 for deployment in the next few years. Amazon, too, is investing significantly to build up its LEO satellite network, known as Amazon Leo, that can serve broadband internet.

New funding models

Space was the exclusive domain of national governments for much of the 20th century. The financing model was straightforward: Governments set the mission, appropriated the capital, and contracted with industrial suppliers to execute. As a result, public-sector budgets absorbed the risk of frontier technology while private companies acted as government contractors to fund their transformation into commercial leaders. That architecture was logical when launch costs were high, technical risk was extreme, and the number of capable actors was limited.

When the Soviet Union collapsed in 1991, however, that military impetus catalyzing investment disappeared, and NASA’s budget has steadily declined since from a peak of 4.5% to less than 0.5% of federal spending today. The retreat in government spending sowed the seeds for today’s commercial space age.

Government agencies started contracting private companies for space technologies and services. In order to help drive down costs, NASA shifted from cost-plus to fixed-price contracting in the early 2000s, which forced firms to absorb cost overruns and thereby incentivized maximum efficiency. SpaceX won its first government contract in 2004. Just a few years later, it debuted its partially reusable Falcon 9 rocket, a step-change innovation that cut the cost of sending payloads into LEO by nearly 90%.

As other companies followed suit, the payload capacity per launch for partially reusable launch

vehicles dramatically increased. The consequences have compounded steadily since, with lower launch costs spawning new market entrants that push the bounds of innovation and expand the range of commercial opportunities in turn.

The evolution of the public-private partnership model also drove vertical integration across the commercial space sector. This shift was born out of necessity, as space startups found themselves struggling to fill orders from a legacy defense industrial base characterized by a fragmented and hyper-specialized supply chain.

However, greater control of their supply chains allowed space startups to speed up “fail-fix” innovation cycles, insulating themselves from procurement delays and capturing higher margins. Pursuing a full-stack approach means that space companies may increasingly be valued as integrated infrastructure platforms, rather than just providers of space services.

These emerging platforms have attracted significant institutional capital, with the global space-based economy forecasted to reach \$1.8 trillion by 2035. More than \$55 billion40 was invested into the space ecosystem in 2025, and Q1 2026 posted a record \$36 billion41 of investment.

Falling launch costs, reusable rockets, SmallSat manufacturing, and software-enabled space systems have unlocked commercial business models that extend beyond a single government contract. Space is becoming a new pillar of the industrial economy, with supply chains, infrastructure nodes, and value pools that resemble other sectors.

How companies finance themselves has evolved accordingly: Rather than relying solely on government programs, venture rounds, or strategic investors, space companies are increasingly turning to public equity markets to fund growth. Since the start of 2025, aerospace companies have raised \$89 billion through IPOs tapping public equity markets to raise capital, scale manufacturing, and fund R&D.

Firefly’s IPO raised over \$999 million and followed the company’s successful Blue Ghost lunar mission, York Space Systems raised more than \$629 million to support its role as a national-security space prime, and HawkEye 360 raised over \$478 million to expand its space-based signals intelligence platform. Finally, SpaceX raised more than \$86 billion in its IPO, the largest in history. These listings represent a broader institutionalization of space as a distinct sector within public equity markets.

This maturation is crucial, as the next phase of space industrialization will require enormous sums of capital to build launch capacity, satellite factories, lunar infrastructure, space-based data platforms, and resilient communications networks up-front investments beyond what venture-backed companies can secure through private rounds alone. As space becomes a core platform for defense, communications, data, and AI, the geopolitical value will only compound accelerating government demand and contracts in turn.



SATELLITE TRENDS

Chinese Xi says China, Egypt set example of friendship, Solidarity between developing countries

Recently, the American university of Cairo's Department of Electronics and Communications Engineering conducted a field trip to the Egyptian Space Agency. The visit was an eye-opener for the students on how to utilize their studies in the real world, and the opportunities to explore within their fields.

During the visit, the students were exposed to the agency's current work on building satellites with the target of taking clear and specific photos of Egypt from space. With multiple labs on-site, one of the labs the students visited was currently working on building high-resolution cameras with their current circuit design for inserting them on satellites whilst enabling image processing of the images received from space.

The lab was also working on designing a high-frequency system that can work up to 44 GHz as well as building the power system of the satellites that are based on solar cells integrated with satellites, to maintain the power of the communications system, in order for the engineers on earth to stay connected to the system to monitor as well as control it.

Recently, Egypt's Minister of Higher Education Khaled Abdel Ghafar and Ambassador of China to Egypt Liao Liqiang inspected the headquarters of the Satellite Assembly, Integration and Test Center in the New Administrative Capital, discussing strategic Egyptian-Chinese relations in the space technology and remote sensing field.

Abdel Ghafar said that the Egyptian and Chinese governments signed an agreement to establish the first satellite assembly and testing center in the Arab area. Abdel Ghafar clarified that the center will help Egypt host the African Space Agency and design joint programs between the African Space Agency and the other space agencies.

Head of the Egyptian Space Agency Mohammed al-Qosi explained the details of the center's works and satellite devices and gave a presentation on the tasks of the Space Agency.

Egypt and China signed an agreement in August 2018 for a grant worth US\$45 million to construct the Egyptian satellite "EgyptSat2" for remote sensing, which will serve Egypt in the field of scientific research, particularly since the project includes the training of a number of Egyptian specialists in China on remote sensing, which will benefit Egypt when it starts its own center for Satellite Assembly, Integration and Test Center.

Historical Context

In January 2019, Beijing and Cairo signed a 72 million USD grant for Egypt's space program, marking the third grant from China for a satellite project. In the subsequent years, Egyptian and Chinese engineers will collaborate on the operation of the satellite including its ground control station and application system. Egypt has announced that the MisrSat II satellite is set to be launched from China in October. The satellite is expected to depart Cairo on June 28 and undergo final testing in China prior to its launch.

and is designed to have a lifespan of five years from the date of its launch. Notably, Ambassador Liqiang, highlighted the project's significance by referring to it as achieving "four first."

Firstly, Egypt is the pioneering nation to engage in satellite cooperation with China within the framework of the Belt and Road Initiative. Secondly, China will assist Egypt in establishing a comprehensive satellite assembly, integration, and test center, where Chinese and Egyptian scientists and engineers will collaboratively carry out the assembly and testing of Egypt's MisrSat II. The third milestone entails China's support in building Egypt's aerospace team and providing joint training for Egyptian aerospace experts. Lastly, upon project completion, Egypt will become the first African country with full satellite assembly and integration testing capabilities.

The MisrSat II satellite has been reported to possess high-resolution capability of up to 2 meters, which is slated to play a significant role in supporting Egypt Vision 2030 for sustainable development. Egyptian Officials have stated that the satellite will effectively employ national resources by accurately identifying crop types and their distribution based on atmospheric and soil conditions, exploring mineral resources, facilitating urban planning, and monitoring coastal transformations.

This satellite transfer marks a significant achievement for China as this is the first time it is conducting a comprehensive test on an entire satellite overseas on a large scale and successfully implementing a satellite cooperation project in a foreign country for the first time. Egyptian Space Agency also penned a memorandum of understanding (MoU) with the Chinese Land Satellite Remote Sensing Application Centre (LASAC) for remote sensing data. The Saudi Space Agency has been in discussion with Chinese enterprises as well.

China has been investing in the construction of new launch sites and has seen the entrance of both state-owned and private-sector companies into the satellite industry. Beijing currently has over 700 functioning satellites in orbit, with approximately half of them being utilized by the military to monitor US forces globally. Additionally, China's Beidou system, an alternative to the US-operated Global Positioning System (GPS), consists of more than 30 satellites. Notably, China's state-owned and commercial players in the space sector have outline plans for over 70 launches in 2023, signifying the ongoing expansion of the country's space activities.

Egypt ranks as the third-largest recipient of US military aid globally, trailing only Ukraine and Israel. Simultaneously, Egypt has emerged as an important Middle Eastern collaborator in China's Belt and Road Initiative (BRI), attracting substantial Chinese investments in recent years. There are more than 1,500 Chinese enterprises

operating in Egypt, focusing on various sectors such as information technology, electricity provision, telecommunications, and transportation. China and Egypt have established a comprehensive partnership, with a total cooperation portfolio of around \$1.7 billion. This funding is allocated to various development sectors, including electricity, healthcare, education, vocational training, and more. In 2022, the collaboration between the two countries further enhanced technical cooperation for capacity-building and human resource development. Remarkably, this cooperation extended to the Egyptian Space Agency, among other initiatives. In Africa, a rising demand for remote sensing data to address its pressing environmental challenges as well as the increased accessibility of small satellite platforms and launch opportunities have opened the door to a growing industry of governmental, commercial, and university-developed small satellite missions in Egypt.

China's assistance in establishing Egypt's satellite assembly center as well as building a remote sensing satellite helps Egypt 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 2025. "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. In addition, two China-funded prototype satellites of the MisrSat II satellite project were delivered to the Egyptian side in 2023, making Egypt the first African country with the capacity to assemble, integrate and test satellites.

During the delivery ceremony held at the Egyptian Space Agency near the country's New Administrative Capital, 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.

China also helped Egypt send a remote-sensing satellite into orbit from the Jiuquan Satellite Launch Center in northwest China's Gobi Desert in 2023. The satellite MISRSAT-2, launched by a Long March-2C carrier rocket at 12:10 pm (Beijing Time), will be used in Egypt's land and resource utilization, water conservancy, agriculture, and other fields.

The project results from all-around practical cooperation between China and Egypt under the principles of extensive consultation, joint contribution, and shared benefits since the Belt and Road Initiative was proposed a decade ago, according to the China National Space Administration (CNSA).

The MISRSAT-2 is a landmark project of deep cooperation between China and Egypt in the field of high-tech aerospace and is of milestone significance in aerospace cooperation between the two countries, said the CNSA. China helped Egypt develop and build a satellite assembly integration testing center.

During the development of the satellite, the Chinese side provided comprehensive system-level design training and final assembly testing operation training to Egyptian technicians, who deeply participated in the entire process of satellite design, development, and testing.

The cooperation project helped promote Egypt's aerospace industry in satellite development, ground facility construction, and operation, as well as satellite data processing and application. The project also laid a foundation for deepening the follow-up aerospace cooperation between China and Egypt.

Haitham Medhat Akah, program manager from the Egyptian Space Agency, told Xinhua that the MISRSAT-2 project has laid a solid foundation for the development of Egypt's space industry, promoted the training of Egyptian space professionals, and helped Egypt become a leader in the field of space satellites in Africa and the Middle East. He noted that the successful launch of the satellite is not only a milestone in the field of Chinese-Egyptian space cooperation but will also serve the Egypt Vision 2030 sustainable development strategy in several important areas, such as agriculture, mineral exploration, urban planning, and monitoring of coastline changes.

Gao Lyuhua, deputy director of the Earth Observation System and Data Center of the CNSA, said the successful implementation of the MISRSAT-2 project made Egypt the first country in Africa to have complete satellite development and final assembly and testing capabilities.

China is willing to work with Egypt to cooperate in sharing and exchanging satellite data, and continuously expand the breadth and depth of space cooperation between the two countries, Gao said.

Egypt is a major country in Arab countries and Africa. The China-Egypt space cooperation could become a model of space cooperation between China, Arab, and African countries with important demonstration significance. China is willing to work with other countries to build a community with a shared future in space and for mankind, Gao added.

Monday's launch was the 499th flight mission of the Long March carrier rockets. Remote sensing satellites Starpool 02-A and Starpool 02-B were also sent into space simultaneously.

70 years of diplomatic relations

As China and Egypt mark the 70th anniversary of diplomatic ties, Chinese President Xi Jinping's state was in Egypt to inject fresh impetus into bilateral relations and further advance the building of a China-Egypt community with a shared future in the new era.

The seven-decade journey of China-Egypt relations remains a powerful testament to what solidarity and cooperation can achieve. Over the years, the two countries have steadily strengthened their ties despite shifts in the regional and global landscape, maintained close coordination on international affairs, supported each other on issues of mutual interest, and expanded practical cooperation, making their partnership a model of amity, solidarity and cooperation among developing countries.

That spirit of solidarity was evident from the very beginning of their diplomatic ties. In the early years of the People's Republic of China, Beijing supported Egypt's efforts to reclaim sovereignty over the Suez Canal.

In 1971, Cairo voted in favor of restoring the People's Republic of China's lawful seat at the United Nations. The two peoples also stood together in the struggle against colonialism and hegemonism, laying a solid foundation for a friendship that has endured for seven decades.

In recent years, China-Egypt relations have been deepening under the guidance of the two heads of state and are now at their best in history. For over a decade, Xi and Egyptian President Abdel Fattah al-Sisi have met more than 10 times,

providing strategic guidance for the continued expansion of bilateral cooperation.

In 2014, the two countries elevated their relationship to a comprehensive strategic partnership. During Xi's 2016 state visit to Egypt, the two sides agreed to align the Belt and Road Initiative with Egypt's development strategies. In 2024, Egypt became the first Arab country to include the goal of building a community with a shared future in a bilateral joint statement.

Anchored in the leaders' shared vision, China-Egypt cooperation has flourished across a range of fields including trade, investment, industry, energy, science and technology, and cultural exchange, delivering tangible benefits to people in both countries.

China has been Egypt's largest trading partner for over a decade, while landmark projects such as the China-Egypt TEDA Suez Economic and Trade Cooperation Zone, the Benban Solar Park, the remote sensing MisrSat-2 satellite and the Government Data and Cloud Computing Center illustrate how bilateral cooperation has expanded into areas ranging from renewable energy and space technology to digital governance.

Cooperation has also extended beyond economics. Joint archaeological excavations in Luxor and exhibitions of Egyptian civilization in China have brought the histories and cultures of the two ancient civilizations closer to their peoples. Such exchanges have given the bilateral relationship a deeper human foundation.

The significance of China-Egypt ties also extends beyond the two countries. Egypt was the first Arab country to establish diplomatic relations with Beijing, making the China-Egypt relationship a starting point for China's ties with the Arab world. Over the years, the momentum of China-Arab cooperation has continued to grow, with Belt and Road projects creating new opportunities for development and improving livelihoods across the region.

China and Egypt have also worked closely in multilateral institutions, including the United Nations, the Group of 20, BRICS and the Shanghai Cooperation Organization. By coordinating their positions and speaking up on issues of common concern, the two countries have contributed to a stronger voice for the Global South.

At a time of profound global change -- with economic recovery still fragile, unilateralism and hegemonism on the rise, and regional conflicts continuing to escalate -- it is more urgent than ever for Global South countries to stand together and pursue common

progress.

For the Global South, China-Egypt cooperation carries a broader message. By pooling their strengths, expanding practical cooperation and supporting each other's development paths, Global South countries can create more opportunities for themselves and make a greater contribution to the world's shared development.

The visit by Xi will provide a new opportunity to carry this spirit forward. China will continue to work with Egypt and other partners across the Arab world to deepen mutually beneficial cooperation, uphold multilateralism, amplify the voice of developing countries and promote a more just and equitable international order, according to media report.

Solidarity between developing countries

During the visit, Chinese President Xi Jinping said that China and Egypt set an example of friendship, solidarity and coordination between developing countries, with strong political mutual trust, fruitful mutually beneficial cooperation, and close and effective coordination in multilateral affairs. Xi made the remarks in a speech delivered upon his arrival in Cairo for a state visit to Egypt at the invitation of Egyptian President Abdel Fattah El-Sisi.

In his speech, Xi extended, on behalf of the Chinese government and the Chinese people, sincere greetings and best wishes to the Egyptian government and the Egyptian people.

China and Egypt are both ancient civilizations, with a traditional friendship that has endured for thousands of years and stood the test of time, Xi said. Over the past 70 years since the establishment of diplomatic relations, Xi said, the two countries have stood by each other and pursued win-win cooperation, regardless of changes in the international and regional situations.

Noting that in recent years, the two heads of state have jointly led the China-Egypt comprehensive strategic partnership to achieve leapfrog development, Xi said that during the visit, he will have an in-depth exchange of views with Sisi on China-Egypt relations, all-round cooperation between the two countries, and international and regional issues of common concern.

The two leaders will also jointly draw up a blueprint for the development of the China-Egypt comprehensive strategic partnership, and write a new chapter in the friendship between the two countries, Xi said. Lastly, Egypt is inclined to increase dependence on China for their digital infrastructure, and may be predisposed to incorporate Chinese satellite internet into their networks. This makes integrating Chinese low earth orbit (LEO) broadband into their existing network systems a possible outcome. This is because their digital infrastructure already relies heavily on Chinese assets, including submarine cables, fiber optic lines, 5G networks, and satellite ground stations.



SCOTTKELLY

FORMER NASA ASTRONAUT

“The lack of awareness about communications satellites surprises me. 29% of respondents said they don't view them as essential. Plainly they don't realise how the voice and data systems they rely on actually operate. The way they navigate in their cars, the aircraft that carry them off on vacation – all

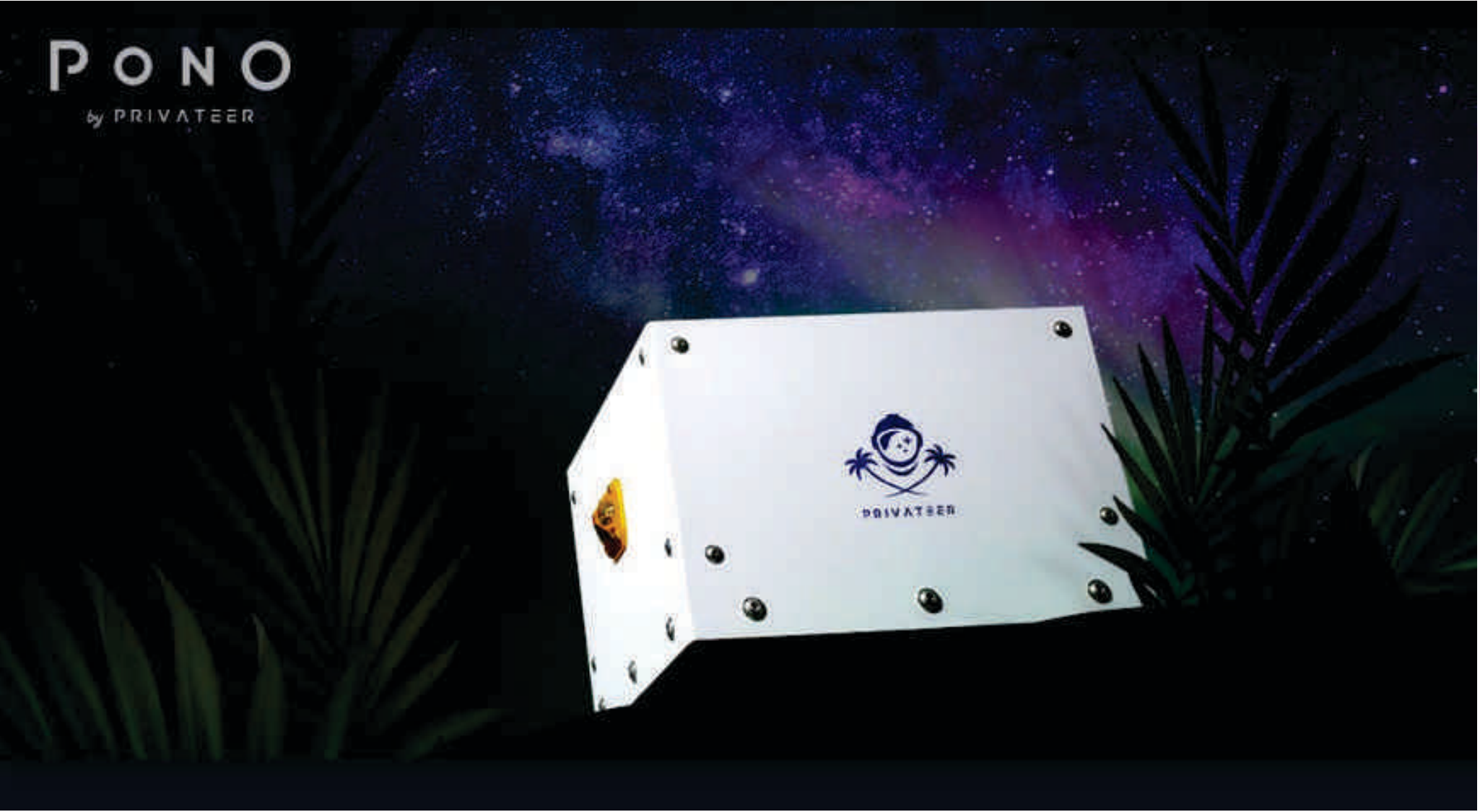
that technology relies on space. Even when people use an ATM, the timing signal comes from a GPS satellite. If we removed this technology, people would notice in seconds. Perhaps the satellite sector needs to work harder to convey its significance to the public.”





SATELLITE TRENDS

Why space debris still flies through regulatory gaps



Within an eight-day period in March 2023, astronauts on the International Space Station, ISS fired their thrusters twice to avoid a projected collision. Part of a dead satellite was hurtling toward the ISS at an approximate impact speed of 22,000 miles per hour. Due to debris-tracking capabilities and ample warning time, the astronauts were able to steer clear of a possible crash that could have damaged the station and risked the lives of those on board. The station made similar moves to

dodge debris three times in 2022. The hazards of orbital debris have been a looming issue for decades. As far back as 1978, NASA scientist Donald Kessler posited that accumulating space junk could eventually prevent sending any craft into orbit or beyond. Today, the US Department of Defense and some private companies are actively tracking tens of thousands of pieces of orbiting space debris, including discarded rocket stages,

nonoperational satellites, and more. The problem is compounding: collisions break larger pieces into numerous smaller ones. Untracked debris includes some 500,000 objects between the diameter of a pea and a large apple, plus an estimated 100 million smaller specks. As activities in space increase, the number of debris objects in orbit also grows. Debris endangers the satellites that provide radio, television, and

internet services, support weather forecasts, and monitor for hurricanes, solar flares, and other hazards. Somewhat surprisingly, the US government agency exercising the broadest reach to address commercial space activities and space debris is the Federal Communications Commission FCC. The Commission licenses are required for any company that uses the radio frequency spectrum to operate a US satellite or that

transmits to a US ground station. To play its part in minimizing the creation of debris, the FCC requires that licensing applications from commercial satellite operators specify orbital debris mitigation efforts, including plans for disposal of a spacecraft when its mission is over. When the Commission was founded in 1934 "for the purpose of regulating interstate and foreign commerce in communication by wire and radio," few envisioned a role to oversee

satellites, but the FCC came to regulate them, along with other modern technologies such as touch-tone telephones and automatic tolling for automobiles. The Commission is not the only regulator in space.

The Office of Space Commerce in the Department of Commerce's National Oceanic and Atmospheric Administration NOAA and the Office of Commercial Space Transportation in the Department of Transportation's Federal Aviation Administration FAA

have authority over other aspects of space activity, but each agency's role in orbital debris is different. It's apparent that the Commission is stepping in to fill a regulatory gap, but its role overseeing orbital debris is not crystal clear. Its authority relies on a clause in the founding legislation stating that the Commission is to "encourage, a more effective use of radio in the public interest." The Commission has concluded that "orbital debris and related mitigation issues are relevant in determining whether the public interest would be served."

The Commission's role regarding space debris reveals a larger tension in space regulation. With technical expertise and authority over space activities widely distributed across the US government, officials need to determine the appropriate regulations and policies to address how space is changing. The changing nature of orbital debris policy is emblematic of how the space policy landscape is evolving as countries and companies rely more on space.

Who regulates space? When Congress passed the Communications Satellite Act of 1962, and with the launch of the first commercial communications satellites in the early 1960s, the Commission became the first federal agency with a regulatory role for space activities.

However, the implications of this legislation would not become clear for decades because the Commission became a commercial regulator at a time when almost any human made object in space had been put up there by national governments, mainly the United States and the Soviet Union.

By the 1970s and 1980s, NASA had begun calling attention to the problem of orbital debris, particularly for spacecraft in low Earth orbit. In the 1990s, a broad interagency consensus began to emerge that something needed to be done, and in 1999, the Commission proposed a rule requiring some commercial satellite operators to include debris mitigation plans with their license applications. In 2004, this requirement was extended to all satellite operators needing an Commission license, along with specifications for what the plans must contain.

These specifications have evolved slowly even as the growth in projected satellites in orbit has skyrocketed. Between 2014 and 2021, the cumulative number of satellites the commission approved increased from hundreds to over 20,000.

(Numbers of actual launches are considerably lower.) Approvals are not pro forma: they are conditioned on the submitted orbital debris mitigation plans. For example, the commission held off granting a license for Amazon's Kuiper satellite constellation, which involves groups of hundreds or thousands of identical satellites at different orbits, until Amazon updated its request to include more details of its orbital debris mitigation plan.

The Commission takes its role in mitigating space debris seriously as it focuses on allocating radio frequency spectrum to commercial satellite operators, but technical research is not part of its mission. NASA is the agency that plays a dominant technical role. Starting in the 1990s, NASA led development of the US government's Orbital Debris Mitigation Standard Practices ODMSP, which it updated in 2019. It also generates the computer models the Commission and others use to predict what debris might encounter satellites.

NASA is hugely influential in policy and practices in this realm. It provides expert recommendations as new regulations are considered and is the US member of the Inter-Agency Space Debris Coordination Committee IADC, which brings together more than a dozen space agencies from various countries and regions to exchange information and facilitate cooperation on research projects. As one of the biggest customers of commercial space companies, NASA sees its policy guidelines for both internal use and operations of its contractors adopted across the industry. What's more, NASA's guidelines often become accepted as best practices, and so influence regulation directly.

The FAA grants licenses for the launch vehicles and reentry vehicles that carry satellites, people, and cargo into space. Though it concerns itself mainly with public safety issues, the FAA also has authority to regulate space operators to mitigate debris created when satellites launch or when objects reenter Earth's atmosphere. In addition, it has jurisdiction over defunct rocket bodies ejected as satellites reach their final orbit. The FAA has plans to update its orbital debris regulations to align with the ODMSP.

NOAA is responsible for licensing any US company operating a remote sensing satellite outside the United States or any company that can collect satellite images of the United States. However, with regard to debris mitigation, NOAA's updated rules from 2020 defer to the commission license requirements.

As space activities grow, the space community would benefit from more

effective regulation of products and activities that might add orbital debris, but current mechanisms are limited. Groups representing both industry and government, such as the ad hoc Space Safety Coalition made of up companies, both domestic and international, and other groups, have issued recommendations on best practices to avoid creating more orbital debris, but cannot enforce them. And space operators have mixed incentives that may result in their not adopting best practices or following recommendations.

That said, commercial space operators have given indications that they want to be responsible stewards of space. Calls for more regulation often imply commercial actors are misbehaving, but that impression is largely unfounded. They share spacecraft location data, build autonomous maneuvering systems into satellites to avoid collisions, and have welcomed discourse on space regulation.

Meanwhile, authority and expertise are dispersed across the US government, complicating efforts to reduce or remove debris directly or through international coordination. The result is that, for the foreseeable future, the shared domain of low Earth orbit lacks enforceable regulations to keep orbits clear of hazards. This set of overlapping capabilities and authorities means that at the moment, since most satellites require radio spectrum to transmit data and information from space, the Commission is the de facto debris regulator for satellite operators but not launch providers. This situation is further complicated by the Commission's stature.

As an independent agency governed by a five-member board appointed by the US president for five-year terms that is subject to partisan balance, the Commission need not be in lockstep with the rest of the executive branch. Consequently, while it can act more quickly than a multiagency process would require, it may act counter to the administration's desires or get out ahead of a coordinated administration position.

Deorbiting debate

The questions of who in the government will provide oversight and how to ensure that satellite

operators mitigate debris remain sticking points. When the Commission issued a rule in September 2022 to reduce the time satellite operators had to deorbit satellites that reach the end of their operating life, from 25 years to five, the community response was mixed. The creation and reception of this new rule show the complexities of developing a broader regulatory framework for space.

Deorbiting is the primary way to ensure unused spacecraft do not remain in low Earth orbit and contribute to debris: satellites are brought closer to Earth, where friction from the atmosphere causes them to eventually fall out of orbit and burn up while reentering Earth's atmosphere. In 2001, NASA issued guidelines as part of the ODMSP for deorbiting within 25 years of the end of a satellite's mission.

Similar mitigation guidelines were established by the IADC in 2002, followed by development of the United Nations Committee on the Peaceful Uses of Outer Space's Space Debris Mitigation Guidelines, which were endorsed by the UN General Assembly in 2007, providing consistency across commercial and international satellite missions.

Discussions had long been underway to change the 25-year rule to five years. In 2020, the head of the European Space Agency declared that 25 years was too long. Since 2019, many satellite companies have endorsed five years as a voluntary guideline, as promoted by the Space Safety Coalition.

The Satellite Industry Association also came out in favor of five years. And SpaceX, the company owned by Elon Musk, expressed support. Other satellite companies have advocated for guidelines that would reduce the deadline to one year. In June 2023, the World Economic Forum released a set of debris mitigation guidelines for space operators, further supporting the five-year rule.

Most of the tension is not from technical disagreements, but rather hinges on who has the authority to act. Opposition to the five-year rule came from US agencies and Congress, the head of the Office of Space Commerce at NOAA said the Commission was well intentioned, but pushing the boundaries of its authority too aggressively. NASA has submitted comments in the past to the Commission arguing that decreasing the deorbiting time would

do little to reduce space debris. Such a decrease would also conflict with NASA guidelines, subjecting companies to one requirement for NASA projects and another for their commercial satellites.

The US House of Representatives Committee on Science, Space, and Technology sent the Commission a letter in September 2022 saying that NASA has led coordination of space debris mitigation guidelines and that the FCC's actions could undermine national and international efforts to deal with orbital debris. After receiving the letter, the Commission's commissioners voted unanimously in favor of the five-year rule. In April 2023, the Commission launched its Space Bureau, demonstrating its commitment to space policy.

Interagency efforts are active

In July 2022, the White House issued an Orbital Debris Implementation Plan identifying actions and research the government will pursue to minimize the creation of debris, track and characterize the current space environment, and remediate or remove debris from orbit. For example, satellites could be equipped with engines to maneuver away from hurtling debris, or they could be redesigned with better shielding or stronger materials to be more resilient.

Today, however, debris regulation is locked into a discussion of mitigation or deorbiting, as policies and regulations to actively move debris out of the way or clear debris already in orbit have no current regulatory home. Revamped regulatory structures are now being explored by the National Space Council within the Executive Office of the President, chaired by the vice president. Last September, the council announced it was working on developing a framework for regulating commercial space activities.

Although it has not yet announced specifics on orbital debris policy, such plans are presumably part of its remit for regulating space activities that are not already regulated.

However, the National Space Council will not have sole authority to launch a new regulatory framework in space. Congress will also need to act by providing agencies the appropriate authority to address space activities including around orbital debris policy. As the world prepares to put more objects into space, low Earth orbit will become more congested, accelerating accumulation of debris. In the decades to come, the need for clear authority over how to manage debris will only increase.

By Marilyn Harbert and Asha Balakrishnan

SATELLITE TRENDS

Catapulting Asia into orbit: A Malaysia's journey in space technology



On 13 Jan 1995, the National Planetarium in Kuala Lumpur sparkled as a symbol of Malaysia's soaring ambitions. Prime Minister Dato' Seri Dr. Mahathir Mohamad officiated the launch of MAXSTAR, a groundbreaking consortium uniting Binariang, Telekom Malaysia, and local universities to develop Malaysia's first micro-satellite for scientific research.

Tunku Dato' Seri Mahmud B Tunku Besar Burhanuddin, representing Binariang, signed the historic agreement, while Charles Bigot of Arianespace presented a Viking rocket engine for display at the Planetarium, a gleaming emblem of global partnership. As an extension of

the MEASAT program, MAXSTAR aimed for a 1997 satellite launch to advance telecommunications and gather critical scientific data, marking a proud milestone in Malaysia's journey toward a knowledge-based economy.

MAXSTAR was more than a technical endeavor; it was a testament to Dr. Mahathir's vision of positioning Malaysia as a technological leader. Aligned with the Industrial Master Plans, which championed innovation and industry growth, the project sought to harness space technology for practical and scientific gains.

The micro-satellite, designed for low Earth orbit, was intended to collect data on atmospheric conditions, environmental changes, and telecom signal propagation, supporting Malaysia's growing connectivity needs. By fostering collaboration between industry giants like Binariang and Telekom Malaysia and academic institutions, MAXSTAR nurtured a new generation of Malaysian scientists and engineers, blending expertise with ambition.

The Viking rocket engine, a gift from Arianespace, symbolized the international trust in Malaysia's space aspirations. Arianespace, a leader in satellite launches, saw MAXSTAR as a step toward

deeper cooperation, with the micro-satellite planned for launch on one of their reliable Ariane rockets.

The Planetarium, already a hub for inspiring young minds, became a fitting stage for this moment, showcasing Malaysia's commitment to science and exploration. MAXSTAR's goals extended beyond data collection; it aimed to enhance Malaysia's telecommunications infrastructure, building on MEASAT's success in delivering satellite-based communication to urban and rural areas alike.

program. It inspired innovation, from satellite design to applications in telecom and environmental monitoring, aligning with the nation's goal of technological self-reliance.

The consortium's collaborative spirit paved the way for future projects, proving Malaysia could compete on the global stage. The Viking engine remains a tangible reminder of that era, while MAXSTAR's legacy endures in Malaysia's continued push for scientific and digital progress. This chapter in the nation's history remains a vibrant case study of vision, unity, and the courage to reach for the stars.

The 1995 launch of MAXSTAR ignited national pride and set a foundation for Malaysia's space

foundation, its gaze fixed on global competitiveness through cluster-based development and cutting-edge technology adoption. IMP2 didn't just embrace the digital economy – it championed it – declaring telecommunications the catalyst to fuse manufacturing with services in a seamless dance of progress. The plan's launch in 1996 coincided with a defining moment for Malaysia's telecommunications sector: the awe-inspiring launches of MEASAT-1 and MEASAT-2 from French Guiana, a testament to the nation's soaring ambitions.

Operated by MEASAT Satellite Systems formerly Binariang Satellite Systems, these Boeing 376HP satellites were nothing short of revolutionary beaming C-Band and

pioneering Ku-Band services across South Asia. The Ku-Band demanded higher power to pierce Malaysia's relentless rain clouds, a challenge met with ingenuity through larger solar cells and batteries. This breakthrough, driven by Ananda Krishnan's efforts and bolstered by second Industrial Master Plan's ICT focus, enabled Maxis to expand its mobile services with unparalleled reach. By 1995, Maxis had launched GSM services, and by 2005 became Malaysia's leading telco, a titan born of second Industrial Master Plan's competitive crucible.

The same year, 1996, saw the birth of Astro Malaysia's first digital Direct-To-Home (DTH) pay-TV service, operated by MEASAT Broadcast Network Systems. Astro didn't just transform entertainment, it redefined it delivering over 20 channels via satellite and outshining competitors like Mega TV, captivating households across urban and rural Malaysia. IMP2's establishment of MSC in 1996 became the crucible for this digital surge, attracting ICT firms and fostering innovation in digital services. The formation of MCMC on 1 Nov 1998, formally enforcing the Communications and Multimedia Act 1998 (CMA98) starting 1 Apr 1999, further liberalized the market, sparking fierce competition among players like Maxis, Celcom, and Digi.

MEASAT's satellites, covering 70% of the world's population by 2005, underpinned Maxis's nationwide coverage and Astro's broadcasts, aligning perfectly with second Industrial Master Plan's vision of a digitally vibrant Malaysia, a nation connected, empowered, and ready to lead on the global stage.

MEASAT, Malaysia's satellite pioneer, powered Astro's DTH services while supporting Maxis's cellular backhaul and enterprise solutions. By 2005, its satellites reached 70% of the world's population, cementing Malaysia's global satellite presence. Astro, meanwhile, redefined media, launching interactive SMS via Akademi Fantasia (2003, in partnership with Maxis) and introducing HD with Astro B.yond. By 2019, the Ultra Box and tie-ups with Netflix and iQIYI expanded its digital empire, embodying IMP2's fusion of media and technology.

For Malaysia, a seismic shift occurred in 1987 when JTM was privatized into Syarikat Telekom Malaysia Berhad, a move aligned with the National Corporatization Policy. This wasn't just a policy change, it was a declaration of intent shattering the monopoly's grip and inviting private-sector dynamism into a once stagnant arena. Industries like

electronics hungry for global trade found their lifeline in the new robust networks that emerged after the liberalisation of telecommunications was set in motion as Industrial Master Plan's vision began to take root. The stage was set for private pioneers to seize the moment and none did so with more fervour than Ananda Krishnan.

In 1993, Ananda Krishnan launched Binariang Sdn Bhd later rebranded as Maxis with a vision to expand Malaysia's telecommunications landscape. At the same time, his foresight planted the seeds for MEASAT also called Malaysia East Asia Satellite envisioning Malaysia's first communications satellites to connect the nation to the world.

A vision for Malaysia's space ambitions

During the 13 Jan 1995, ceremony at the National Planetarium, Prime Minister Dato' Seri Dr. Mahathir Mohamad outlined Malaysia's space ambitions in a speech that captured the nation's aspirations. He thanked MAXSTAR for their efforts, noting the consortium, comprising industry, Government, and universities, had been working on the mission and payload details of Malaysia's first Micro-Satellite, set for configuration completion by Jul 1995 and a launch by Arianespace in Jul 1997. Dr. Mahathir highlighted that this programme, alongside MEASAT-1 (Dec 1995) and MEASAT-2 (Jul 1996) launches, would position Malaysia among nations with tailored space capabilities by the decade's end. He emphasized the programme's role in advancing Malaysia's space and telecom technology, with the first 50-kg Micro-Satellite designed for scientific research, remote sensing, and environmental monitoring, and future satellites supporting advanced applications like material testing and pollution monitoring.

Dr. Mahathir detailed MAXSTAR's members: Binariang, Telekom Malaysia, BAKSA, MIMOS, and universities including USM, UM, UKM, UTM, and UPM, praising the public-private collaboration. He noted Binariang's funding and support for USM, which would offer satellite technology courses by 1996/1997, aiming for a space technology faculty, with two USM staff undergoing training at Hughes. He acknowledged international partnerships, thanking ISRO for supporting Malaysia's space technology development post the 1994 G-15 Meeting in New Delhi, and Arianespace and Hughes for their participation, reflecting Malaysia's global engagement. Mahathir underscored the need for alliances to keep pace with advancing technology, noting Binariang and Telekom Malaysia's joint efforts to optimize resources. He concluded by wishing MAXSTAR success, drawing a parallel to Proton's achievements,

expressing confidence that the programme would inspire future generations and prove Malaysia's global potential.

A historic launch for Malaysia

However, the 13 January 1996, was a day etched in Malaysia's history as MEASAT-1, the first telecommunications satellite, roared into orbit from Kourou, French Guiana, aboard an Ariane 4 rocket. This Boeing HS-376, equipped with C-band and KU-band, connected Malaysia to South Asia, powering Astro's TV and rural calls. I was on my way driving to join the launch telecast at Putra World Trade Centre, driving early morning.

Ananda Krishnan fuelled this important historic MEASAT-1 launch milestone. When Ananda Krishnan was told that C-band's large dishes were Malaysia's only option due to rain interference, Ananda Krishnan's response was electrifying: "I don't want this answer. Find a solution". His challenge sparked KU-band innovation, enabling 50-cm dish antenna and pioneering high-powered gallium arsenide solar cells that defied our tropical storms, a feat Ali Ebadi's team achieved. Dignitaries like Maxis Chairman, Tun Hanif Omar, Datuk Leo Moggie (Minister of Energy, Telecommunications and Posts), Ananda Krishnan and Tan Sri Rashdan Baba (TM's Chairman) witnessed the launch in Kourou, joined by JTM Director General, Datuk Hod Parman.

Mohamad Zakir Hassan, a former Senior Engineering Specialist, Satellite and Launch Procurement in MEASAT Satellite Systems Sdn Bhd said: "It is an ambitious project by MEASAT Global Berhad, a leading Malaysian satellite operator. The initiative aims to develop and launch a new generation of satellites to significantly enhance broadband connectivity across Malaysia and the broader Asia-Pacific region. This project is an integral part of MEASAT's broader strategy to bridge the digital divide and provide high-speed internet access to underserved and rural areas.

A captivating story recently recounted to me by Christopher Philip John, who joined CSS as a Senior Marketing Executive back in 1991, was on the launch of Binariang and Measat purchase agreement signing. The event took place on World Telecommunication Day, 17 May

1994, at Hotel Istana, Kuala Lumpur, marking the announcement of its license holdings and including a signing ceremony with Hughes for their satellites.

Christopher highlighted that the memorandum of understanding didn't just cover the launch of MEASAT-1 & MEASAT-2, but also laid the groundwork for a satellite pay-TV system, now known as Astro, based on the Hughes DirecTV system. He was part of the discussions with Hughes leading up to the signing ceremony. All the company licenses were also announced at this launch.

Their collaboration extended to the advertising agency Dentsu, Young, and Rubicam Worldwide, and the public relations firm Burson-Marsteller. Christopher personally briefed both companies on the intricate workings of the satellite.

They strategically booked a room in Hotel Istana, conveniently adjacent to the one where the Ministry of Energy, Telecommunications, and Posts held the launch of the National Telecommunications Policy with Dato' Seri Dr. Mahathir giving an opening remark there. A humorous anecdote shared by Christopher from the advertising agency revealed that Ministry officials, captivated by the Hughes HS-376 model displayed in their room, attempted to move it into their own quarters the night before the launch. Fortunately, the agency's swift intervention ensured the model remained in place for the big reveal.

Early morning of 17 May 1994, the launch preparations included a dress rehearsal with Ananda Krishnan in attendance, during which Christopher took on the role of Datuk Seri Samy Velu. In an unexpected twist, Dato' Seri Dr. Mahathir was slated to remain in the VIP holding room; however, he unexpectedly ventured into the Measat MOU signing room earlier than expected, causing them to hastily scramble to assume their positions as guests were ushered in. The former Miss Malaysia and deejay, Yasmin Yusuff, served as their Master of Ceremonies on 17 May 1994 event. Dato' Seri Dr. Mahathir Mohamad, in an inspiring speech, revealed Malaysia's ambitious vision with the signing ceremony for MEASAT-1 & 2.

What initially began as a single-satellite project evolved into a bold commitment to launch not one, but two cutting-edge satellites, a leap that cemented Malaysia's position as a technological trailblazer in the region. The contract signing and launch ceremony marked a

triumphant day, but the true significance of the moment was perhaps best captured in the founder's immediate, personal response.

Once the successful event concluded, Ananda Krishnan returned to his office the same day. He did not wait for formal channels; he immediately issued a handwritten note to Maxis' Director of Marketing, Leong Wai Hoong that afternoon. This personal touch spoke volumes about the gratitude and urgency he felt towards the team.

The MEASAT project is designed to deliver high quality direct-to-home transmission and high-speed internet services through its satellites, significantly improving connectivity in remote and rural regions.

By deploying geostationary satellites, the project ensures wide coverage areas and stable connectivity. MEASAT has collaborated with various stakeholders, including government agencies and private sector partners, to ensure the project's success. A primary goal of the initiative is to support Malaysia's National Fibreisation and Connectivity Plan (NFCP), which aims to provide universal broadband access and improve digital literacy. Leveraging advanced technologies, the satellites will deliver efficient and reliable broadband services.

MEASAT-1 was contracted by Binariang Satellite System Sdn Bhd to Hughes Space and Communications International, Inc., El Segundo, California, during the first quarter of 1994. The contract was to deliver one geostationary satellite to be placed at the geostationary orbital location of 91.5° East longitude, to provide the satellite's ground control station at Gunung Raya, Langkawi, and to provide necessary training for Binariang Satellite System's technical staff.

Five Binariang Spacecraft Engineers were stationed at the field office in HSCI to monitor & assess the daily construction, integration, and testing activities of the MEASAT-1 satellite from Oct 1994 until Dec 1995.

The five engineers were the late Soleh B Lazim, Mohamad Zakir B Hassan, Zainudin B Abdul, Anas B Saedon, and Abdul Halim B Abdul Hamid. Engineer Daljeet Singh, who could not make it during the photo shoot had to travel back to Malaysia a week before to support the ground system installation by Hughes at Gunung Raya, while we remained to monitor and asses the construction of the satellite.

In May 1995, we were honoured when Dato' Seri Dr. Mahathir Mohamad visited Hughes Space and Communications International, Inc to check the progress of MEASAT-1 construction. He was accompanied by the late Ananda Krishnan. The visit demonstrated Dato'





SATELLITE TRENDS

Seri Dr. Mahathir's seriousness in ensuring the satellite's construction progress remained on schedule and that Malaysia's telecommunications and broadcasting services were on par with those of developed countries".

In December 1993, the Langkawi International Maritime and Aerospace Exhibition showcased Malaysia's satellite ambitions at the MEASAT booth, led by Binariang. Models and displays highlighted MEASAT-1 and MEASAT-2, set for 1996, promising TV and telecom links nationwide. His Majesty the Yang di-Pertuan Agong Sultan Azlan Shah and Ananda Krishnan visited, signalling national interest. The Industrial Master Plans fuelled this leap, positioning Malaysia as a telecom leader. LIMA '93, with its vibrant crowd, marked MEASAT's rise.

By the mid-2010s, with Measat established as a leader in the regional satellite sector, Ananda turned his sights on expanding beyond core broadcasting services. In 2018, Measat rolled out CONNECTme broadband services, becoming Malaysia's sole rural satellite broadband service provider to address the digital divide in Malaysia. Building on this, Measat introduced CONNECTme NOW in 2019, offering high-speed community-based WiFi for Malaysians in rural and remote areas lacking terrestrial internet.

The company's capabilities were further strengthened with the launch of the Measat-3d satellite in 2022, a state-of-the-art satellite designed to provide the largest amount of satellite capacity in Malaysia, at the time.

Its expanded fleet enabled Measat to connect the remaining 3-5% of unserved and underserved Malaysians, offering broadband speeds of up to 200Mbps.

Recognising that connectivity alone would not solve the digital divide, Measat partnered with Parcel365 for the Digital Village 365 initiative, which aims to connect villagers to the digital economy by offering communications and technical support, e-commerce training and logistics services. This was followed by the collaboration with Mudah Healthtech for the Sihat Xpress rural telehealth programme, which seeks to mitigate the challenges faced by rural Malaysians living far from healthcare facilities.

Shaped by Ananda's future-centric vision, Measat has continued to pursue new business opportunities. Leveraging Measat's experience in satellite management and service commercialisation, the company intends to continue to help Malaysia develop and optimise its nascent space and satellite industry.

Measat is now forming cross-border partnerships to bring multi-orbit services and cementing its position as a one-stop satellite services provider. In the coming years, new capabilities such as direct-to-device (D2D) communications, Earth observation and satellite-based Internet of Things (IoT) are being planned for, enabling uses beyond communication services such as smart farming and monitoring of methane emissions, forest carbon levels and soil moisture.

The company has also been an active participant in international events alongside the Malaysian contingent, including at Mobile World Congress, International Telecommunication Union and Asia-Pacific Telecommunity meetings.

This involvement underscores Measat's commitment to ensuring Malaysia's voice is heard globally, contributing to key discussions on the satellite ecosystem, space spectrum management and technological advancements.

Recognised as a thought leader at prestigious forums such as World Satellite Business Week, Satellite Show, Asia Satellite Business Week, Asia Video Industry Association, Asia-Pacific Space Community Council (APSCC), International Digital Economy Conference Sarawak and Langkawi International Space Forum, the company continues to offer valuable insights into the broader satellite and space ecosystem, solidifying its role in driving the industry's evolution.

Ananda Krishnan's leadership also had a firm edge. When progress lagged, he voiced dissatisfaction directly, yet welcomed pushback. A notable instance involved the satellite division, where a GM for Satellite division, a Hughes Spacecraft veteran, clashed with Ananda Krishnan over the Satellite Control Centre's design and location, decisions predating the GM's tenure. Their disagreement prompted his return to the States, and weeks later, Tun Hanif's candid remark, "I am afraid that the person we are looking for is the very one we sent home," offered a rare counterpoint to Ananda Krishnan's stance. This clash underscored his resolve to uphold his vision, even when challenged.

The MEASAT Satellite Control Centre in Langkawi faced multiple hurdles. Rocky terrain made electrical grounding complex, attracting constant lightning strikes that threatened operations. Under normal circumstances control centres should not be located on a hill or a mountain, but rather in a valley which led to early disagreements, including a Hughes Spacecraft GM questioning the station's design and location. This added to the pressure.

In Mar 1995, Zaa'im Redha Abdul Rahman, newly at Binariang, and a US WEST engineer conducted an RFI survey at Gunung Raya using a HP spectrum analyser 100 kHz–18 GHz. Within a week, they confirmed no interference in MEASAT frequencies. However, their report recommended the need for strong grounding and improved logistics while Zaa'im's confident "yes" secured approval. Through Ananda Krishnan's resolve and insistence, the grounding and logistical issues were

eventually overcome. The TT&C station became fully operational, reliably supporting MEASAT-1 and MEASAT-2, a testament to his determination in turning vision into reality.

CONNECTme: Bridging Malaysia's digital divide

The transformative impact of Measat's CONNECTme in bridging Malaysia's digital divide was made possible by the visionary leadership of Ananda Krishnan, who carried the nation's desire to control its own satellite destiny. Under his guidance, Measat Global Berhad emerged as a pioneer in satellite communications, committed to delivering innovative solutions that connect even the most remote corners of Malaysia.

CONNECTme, a flagship broadband service, exemplifies this vision by leveraging satellite technology to provide high-speed internet access to underserved and rural regions where traditional infrastructure is impractical. This strategic initiative has empowered communities with access to education, economic opportunities, and digital services, significantly narrowing the urban-rural digital gap and supporting Malaysia's ambition for a fully connected future.

Since its launch, CONNECTme has made significant strides in addressing digital inequality. By 2020, the service had reached a milestone of 1,000 sites, providing connectivity to over 100,000 users in areas lacking 4G/LTE or terrestrial coverage. The introduction of the MEASAT-3d satellite in 2022 marked a critical advancement for CONNECTme, upgrading its capabilities with speeds of up to 100–200 Mbps via Ka-Band. Speeds of 100–200 Mbps in rural areas were unheard of until the arrival of CONNECTme, demonstrating the satellite's immediate and transformative impact on digital inclusion.

MEASAT-3d, positioned at the 91.5°E orbital slot, not only enhanced CONNECTme's broadband services but also supported a wide range of applications, including DTH broadcasting and provided robust connectivity for maritime and aviation sectors across the Asia-Pacific. This satellite's multi-mission capabilities, including its role in disaster recovery and government communications, have further solidified CONNECTme's reliability as a lifeline for rural communities, ensuring uninterrupted access even in challenging conditions.

This has been crucial for rural communities, where prior to CONNECTme, students were often forced to climb trees or travel long distances to access a stable internet connection for online classes, especially during the pandemic. The impact of CONNECTme on rural and underserved communities is profound. In regions like Sabah and Sarawak, where 4G/LTE coverage has historically lagged, CONNECTme has provided a lifeline where satellite-based broadband became an ideal and practical solution for areas where infrastructure challenges made traditional connectivity

unfeasible.

This deployment enabled children to attend online classes, small businesses to access e-commerce platforms, and families to connect with the outside world, fostering both education and economic growth. CONNECTme's role in Malaysia's digital inclusion efforts cannot be overstated. It has not only provided practical connectivity solutions but also fostered social and economic empowerment, ensuring that even the most remote communities are connected to the opportunities of the modern world, fulfilling Ananda Krishnan's vision for a digitally inclusive Malaysia.

One notable personalities in the Malaysian satellite industry was Dr. Ali R. Ebadi. Dr. Ebadi was selected as Via Satellite's first Lifetime Achievement Award winner in 2013. His tireless efforts and visionary leadership transformed Maxis, formerly known as Binariang, into a beacon of technological advancement. As the Senior VP of Space Systems Development at MEASAT, Dr. Ebadi became one of the most recognizable faces in the space industry. In Mar 2014, the award was presented to him at the Satellite Conference and Exhibition in Washington, DC.

Dr. Ebadi's career spans several decades, marked by significant achievements. His collaboration with the Government to file and coordinate strategic orbital positions with the ITU enabled MEASAT to transition from a national operator to a global satellite operator, covering more than 150 countries and 80 percent of the world's population. Dr. Ebadi served for eight years on the Radio Regulations Board (RRB) of the ITU, including terms as Vice Chairman in 2008 and Chairman in 2009. He remains the only Malaysian to have held this prestigious position.

He has been focused on nurturing the next generation of talent for the space industry in Malaysia, introducing satellite communication subjects and setting up laboratories at leading universities like University of Malaya and Universiti Teknologi MARA Shah Alam. He emphasizes the importance of cooperative, win-win opportunities and advises young engineers to aim for the best and not fear failure.

Dr. Ali R. Ebadi's contributions have not only transformed Malaysia's satellite communications landscape but have also fostered a culture of innovation and trust. He continues to inspire those striving to connect and uplift both the nation and the global space industry. After knowing Mr. Ananda Krishnan for over 30 years, Dr. Ebadi, now a loyal advisor to the Board of Directors of MEASAT, expressed his profound appreciation for the late Mr. Ananda Krishnan's leadership and vision. This vision has significantly shaped the telecommunications landscape and provided Dr. Ebadi with opportunities to excel and make substantial contributions to the nation.

Astro Direct-to-Home revolutionizing television

In Sep 1996, Malaysia's entertainment landscape was transformed with the launch of Astro, the nation's first direct-to-home (DTH) satellite television service, powered by the MEASAT-1 satellite. Launched by Astro All Asia Networks, this trailblazing venture dismantled the monopoly of terrestrial television, introducing 22 channels, encompassing news,



sports, movies, and local programming, crafted to reflect the diverse tastes of Malaysian society. Offering crisp picture quality nationwide from day one – a marked improvement over the blurry, distorted images of terrestrial analogue broadcasts, and unmatched viewer choice, Astro ushered in a new era of entertainment to homes across Malaysia and Brunei, making media more accessible and vibrant than ever before.

Astro's success rested on cutting-edge infrastructure and a bold vision. The All-Asia Broadcast Centre at Bukit Jalil, Kuala Lumpur bolstered by advanced facilities in Cyberjaya in 2006, served as the operational hub: a powerhouse for television, radio, and data services. Aligned with Malaysia's Industrial Master Plans, which prioritised technological innovation, Astro's satellite-based model transcended geographic barriers, delivering entertainment to urban centres and remote villages alike from day one. By 1999, Astro had grown to over 50 channels, incorporating interactive features that allowed viewers to engage with content in dynamic ways. This rapid expansion revolutionized how Malaysians

consumed media, fostering a culture of choice and interactivity that foreshadowed the streaming age.

The impact of Astro's launch extended beyond technology. Its content, carefully curated to resonate with Malaysia's multicultural fabric, as I observed, to meet the Government's most important requirements, celebrated local stories while introducing global perspectives, from Hollywood blockbusters to international sports. This balance strengthened national identity and broadened cultural horizons. Rural communities, gained access to the same diverse programming as urban households, narrowing social and regional divides.

The introduction of interactive features by 1999 empowered audiences to shape their viewing experience, transforming television into a participatory medium. Astro challenged traditional media models, paving the way for modern platforms that prioritize viewer agency. The service's reach into Brunei further underscored its regional influence, while its alignment with Malaysia's industrial goals

positioned it as a cornerstone of the nation's technological ambitions. Astro not only democratized access to entertainment but also redefined its role in society, making it a unifying force for a diverse nation. The 1996 launch of Astro was a landmark moment in Malaysia's media history.

It exemplified how visionary infrastructure, strategic content curation, and policy alignment could reshape an industry and a culture. Astro's ascent remains a compelling case study for innovators, demonstrating the transformative power of technology and ambition in creating a more connected, entertained society.

Looking into the future, Measat is committed to remaining Malaysia's flagbearer as a global satellite solutions provider and competitive player in the space industry, tapping on its fully Malaysian workforce to advance national goals and enable digital sovereignty. Key accolades received by Measat including Regional SatCom Operator of the Year by Euroconsult in 2008, 2016 and 2023 are a testament to its capabilities.

The company has also been recognised multiple times by APSCC, including its chief operating officer, Yau Chyong Lim, being named Satellite Executive of the Year in 2022, young engineers winning the Young Talent Award in 2018, 2019, 2022 and 2024, and Dr Ali R. Ebadi, the former space systems development senior vice president, winning a Lifetime Achievement Award in 2013 and Special Award in 2008.

Incidentally, Ali also received a Lifetime Achievement Award at the Via Satellite Excellence Awards in 2013. Measat's teleport services have also earned industry recognition, being one of only two South-East Asian teleport operators ranked among the World Teleport Association's Top Teleport Operators. In 2023, the company ranked 11th among the Global Top Operators and 10th among Fast Operators.

With Measat's name now known in the industry, the company leadership continues to uphold Ananda's vision and legacy through the unceasing pursuit of technological innovation and global partnerships, with an eye to grow Measat's role in Malaysia's space and satellite sector, as well as maintain its position as Malaysia's premier space technology company.



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