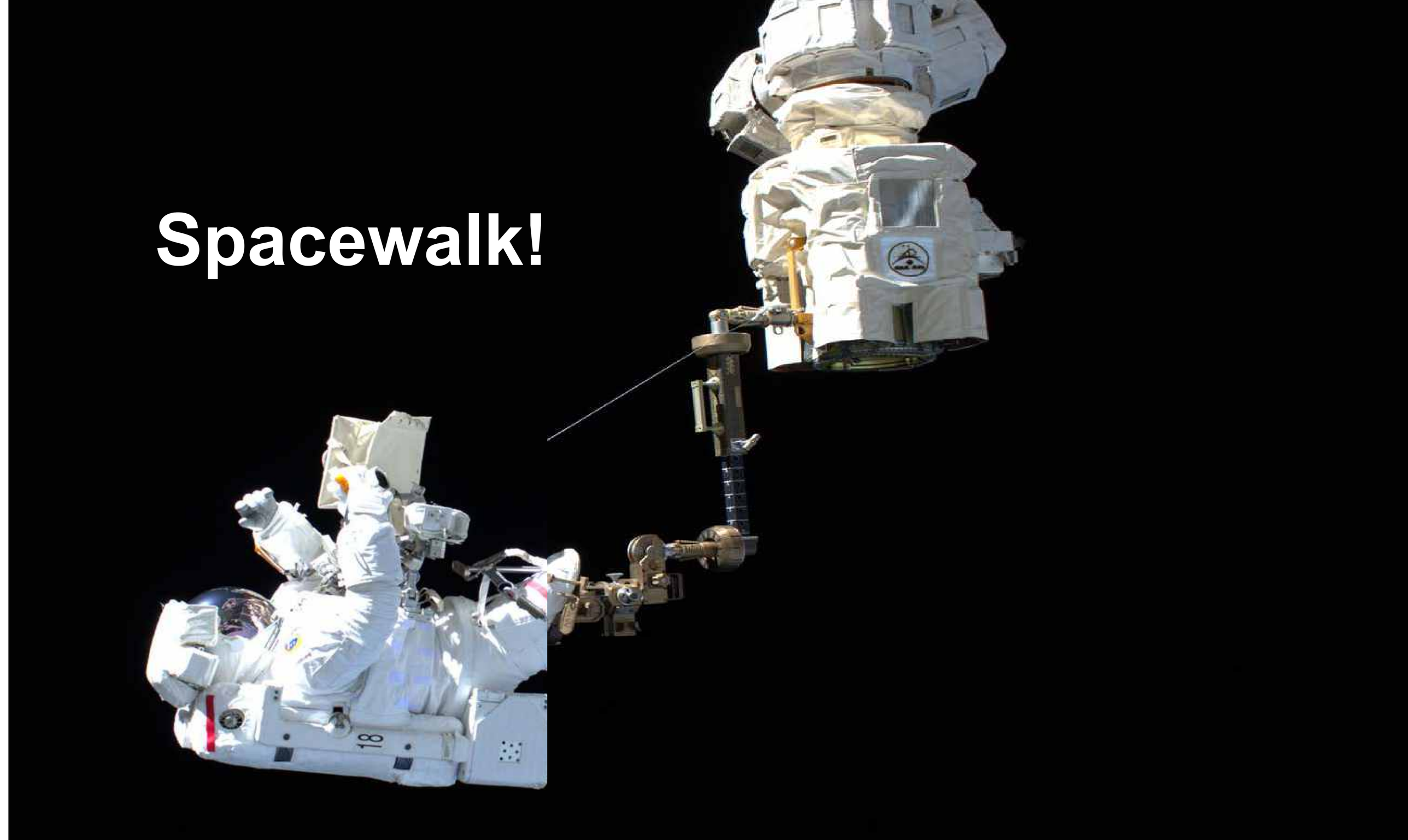
SPACEWATCH AFRICA

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SPECIAL REPORT

Why smallholder farmers are struggling with precision technologies

Spacewalk!



SPACE SYSTEM REPORT

Exploring 'New Space' Low Earth Orbit satellites for positioning, navigation and timing



Humans have always been motivated by the desire to accurately determine their position. This intrinsic need, deeply rooted in our evolution, has led generations of scientists to develop and Perfect instruments capable of ensuring our correct orientation, whether at sea, in the air, or on land.

The ability to accurately determine one's location is important: not only is it essential for Navigation and reaching specific destinations, but it also plays a key role in territorial knowledge and mapping, infrastructure construction, and traffic management.

In its earliest basic form, celestial navigation gives direction. The Sun rises in the east and sets in the west. At noon, the Sun is at its highest point and always points towards the equator. This is why moss growing on trees typically indicates north in the northern hemisphere, south in the southern as this side is always in shade. However, direction on its own isn't enough, to specify location we first need a coordinate system.
So, a reference grid of parallels of latitude and meridians of longitude allow us to uniquely specify a point on Earth. Latitude indicates north-south and longitude eastwest. These reference lines have been placed on maps since at least the 3rd century BCE. Latitude has a natural zero, the Earth's equator. Since ancient times it has been observed that the Sun, Moon, and planets all pass directly overhead at the equator.

However, latitude can be determined using observations of the Sun or stars. The angle between Polaris, the North Star and the horizon is very nearly latitude. The midday Sun can also be used. At local noon, the Sun is at its maximum elevation and can be used in conjunction with lookup tables to compute latitude. These tables correct for the tilt of the Earth and its relationship with respect to the Sun throughout the year. This method, and measurement instruments like the Jacob Staff, have been known to astronomers since at least 400 BCE and used by mariners since the 16th century.
Subsequently, improved instruments such as the astrolabe and later the octant and sextant were developed for better accuracy, allowing north-south to be determined to 2 miles (3.2 km) at sea. Longitude is not as easily determined and was an unsolved problem until nearly the 19th century.

The Earth turns eastward at a nearly constant rate, completing one revolution in 24 hours, or 15 degrees per hour. This fact, along with knowledge of local ship time and the time at the port of origin, allows for the determination of longitude. Consequently, the problem of longitude was a problem in precise timekeeping at sea.
In 1763, the Royal Observatory published a solution to timekeeping based on celestial observation. This became known as the lunar distance method where observations between specified stars and the Moon could be used with lookup tables to establish absolute time with respect to the observatory in Greenwich, still the location of the prime meridian today. Though ingenious, the observations required proved difficult on a ship and the calculations were initially complex and laborious.

Satellite Navigation

In October 1957, the world wakes up to the launch of Sputnik-1, the first artificial satellite launched from the Baikonur Cosmodrome in modern-day Kazakhstan by the former Soviet Union. Sputnik-1 was equipped with a simple radio transmitter and was placed in a low Earth elliptical orbit.

Soon after launch, Guier and Weiffenbach of the Johns Hopkins Applied Physics Lab, observed the predictable Doppler shift of Sputnik-1 as it passed overhead. This information was rich; with one pass, enabling them to determine the orbit of the satellite. These were soon recognized for navigation. If the satellite knew its orbit, observing the Doppler curve as it passed above could allow for location to be determined on the ground, according to the researchers. This idea gained momentum and funding from all over the world.

The coming of LEOs

With the advent of smartphones, there are now over 4 billion devices which make use of the Global Navigation Satellite System. By 2019, it is estimated that there will be over 7 billion, providing not just the blue dot representing location on our phones, but also support the critical infrastructure that humanity rely upon.
According to US report, all 16 sectors of its critical infrastructure, including financial transactions, telecommunications, and the power grid; precise positioning for agriculture and surveying; and safety-critical services like landing aircraft depend on GPS.

Similarly, with about 6500 million receivers around the world and a global market of devices, applications and services valued at about 150 billion euros, Global Navigation Satellite Systems (GNSS) represent probably the biggest space technology-transfer success story. Most of today's GNSSs involve constellations of about thirty medium orbit (MEO) satellites at a height of about 25,000 Km to give global coverage, backed up by a few satellites in geosynchronous orbit (a height of 36,000 Km) to provide additional services at regional level.

The ITU will ultimately make the decisions of which frequency bands LEO PNT Signals will use. Out of the dozens of reserved radionavigation frequency bands, two primary options are emerging for dedicated LEO PNT systems: the L-band and the C-band. Receiver manufacturers must carefully evaluate which band their products will support, as resources are required to design, implement, and validate a radio front-end optimised for performance within the chosen band.

The L-band, which is the selected band for Xona Space, Geely, Centispace, SatNet LEO and ESA's FutureNAV LEO-PNT IoD, resides in the frequency band near the familiar GNSS MEO satellite signals. This option may appeal to receiver manufacturers with existing product lines to avoid new radio front-end development. Customers might even be able to use the same antennas, potentially reducing the cost of adoption and minimising changes to the overall system for both the receiver manufacturer and the consumer.

As LEOs positioning systems becomes a reality, receiver manufacturers should evaluate the risks of reusing a GNSS L-band radio front-end for applications where jamming is a concern. LEO positioning signals that are sufficiently close in frequency to traditional GNSS signals may be subject to a higher in-band jamming to signal power ratio.

However, the C-band, which is the selected band for TrustPoint, ESA's FutureNAV LEO-PNT IoD, and JAXA constellations, has historically experienced less jamming compared to the L-band, making it an attractive option for receiver manufacturers to consider in environments where the probability of a jamming event occurring is high. C-band phased array antennas can be made more compact than L-band phased arrays and offer much greater directionality, hence providing enhanced protection against jamming.

LEO navigation system is emerging as a transformative force in the global satellite navigation industry. With advancements in technology and reductions in launch costs, LEO constellations are being developed to complement or augment traditional Global Navigation Satellite Systems (GNSS). These innovations aim to address critical challenges of GNSS such as signal vulnerability, urban canyon coverage, slow convergence times and more.

All known LEO PNT initiatives and emerging service providers are profiled including Iridium® STL, Xona Space, and TrustPoint based in USA; JAXA and ArkEdge Space in Japan, Centispace, Geely, and SatNet LEO in China; and ESA's FutureNAV LEO-PNT In-orbit demonstration, as well as two emerging systems, namely Fergani Space in Turkey and GNSSaS based in UAE.

Iridium NEXT constellation has a hosted positioning, navigation and timing payload from Satelles, which provides a commercial Satellite Time and Location (STL) service in L-band, fully independent of GNSS. In 2024 Satelles was acquired by Iridium and the service was rebranded as Iridium® STL.
Globalstar has partnered up with the US-based hardware and software manufacturer Echo Ridge to collaborate on an assured positioning, navigation and timing service in S-band to the low number of satellites in orbit (48), the service is not intended for high accuracy applications. In 2021, Echo Ridge was acquired by Parsons Corporation.
China SatNet is developing the Guowang mega-constellation, which will consist of nearly 13,000 satellites, with the first launch in December 2024. In addition, China SatNet is working on the SatNet LEO PNT constellation.
Similarly, GeeSpace, which is a subsidiary of Zhejiang Geely Holding Group, is building a broadband mega-constellation called GEESATCOM, consisting of 5,676 satellites. It is also planning to have a dedicated positioning, navigation and timing constellation of 240 satellites.
Skykraft, an Australian startup deploying a LEO constellation for air traffic management, is looking develop a collaborative, open-source positioning, navigation and timing architecture in the S-band, to be adopted by different satellite constellations in LEO to provide positioning, navigation and timing services. The advantages of this approach include cross-provider compatibility, shared development costs, broader adoption and wider end-user accessibility.
ArkEdge, a Japanese start-up is developing a VHS Data Exchange System for maritime use, which is mainly a communications system, but will also have a dedicated ranging component, which can be used to position ships at sea independently from Global Navigation Satellite System.
Eutelsat OneWeb is actively developing its Gen II satellites, expected to include some positioning, navigation and timing features. While specific details remain unavailable, the satellites are being designed to align with the objectives of the EU's IRIS² program.

LEO is twenty times closer to Earth, substantially reducing path loss and leading to signals up to one thousand times (30 dB) stronger on Earth. Their downside is coverage: it takes seven LEOs to match the footprint of one MEO, requiring hundreds to achieve the coverage of GPS. These numbers are found in the LEO constellations of OneWeb, SpaceX, Boeing, and others which promise hundreds and even thousands of satellites.
LEO constellations offer better geometry than GNSS core-constellations, allowing other factors to relax and for the use of commercial-off the-shelf components to obtain comparable performance. So far, a global geometry analysis established that even the smallest constellation is three fold better than core-constellations today.

One of the largest constellation today is Iridium consisting of 66 low Earth orbiting polar satellites. Even though Iridium has twice as many satellites as GPS, at the equator users can only see 1 satellite whereas they can see 10 from GPS. This coverage comes down to satellite footprint. It takes seven LEO satellites to match the footprint of one MEO, hence requiring many more satellites to cover the Earth.

This was one of the fundamental trades considered in the design of the GPS Constellation, as the higher altitude, brings in higher each launch cost. The lower, the more satellites had to be built to provide coverage. To put this in perspective, global coverage for one satellite in view at all times requires less than 10 satellites in MEO but requires closer to 100 in LEO.

The unprecedented number of satellites of these LEO constellations gives rise to better geometry than any of the GNSS core-constellations in MEO by at least threefold. This strength in numbers is key as it allows for relaxation of the signal-in-space user range error, while still matching the position accuracy of GPS. This, coupled with the more benign radiation environment in LEO compared to MEO, enables a hosted payload designed using commercial-offthe-shelf components.

The addition of navigation satellites in LEO provides a number of benefits to the user. LEO spacecraft travel overhead more quickly, passing in minutes instead of hours in MEO. This gives rise to more multi-path rejection, as reflections are no longer static over short averaging times [89]. This faster motion also gives rise to benefits in the initialization time required for carrier-phase differential GPS.

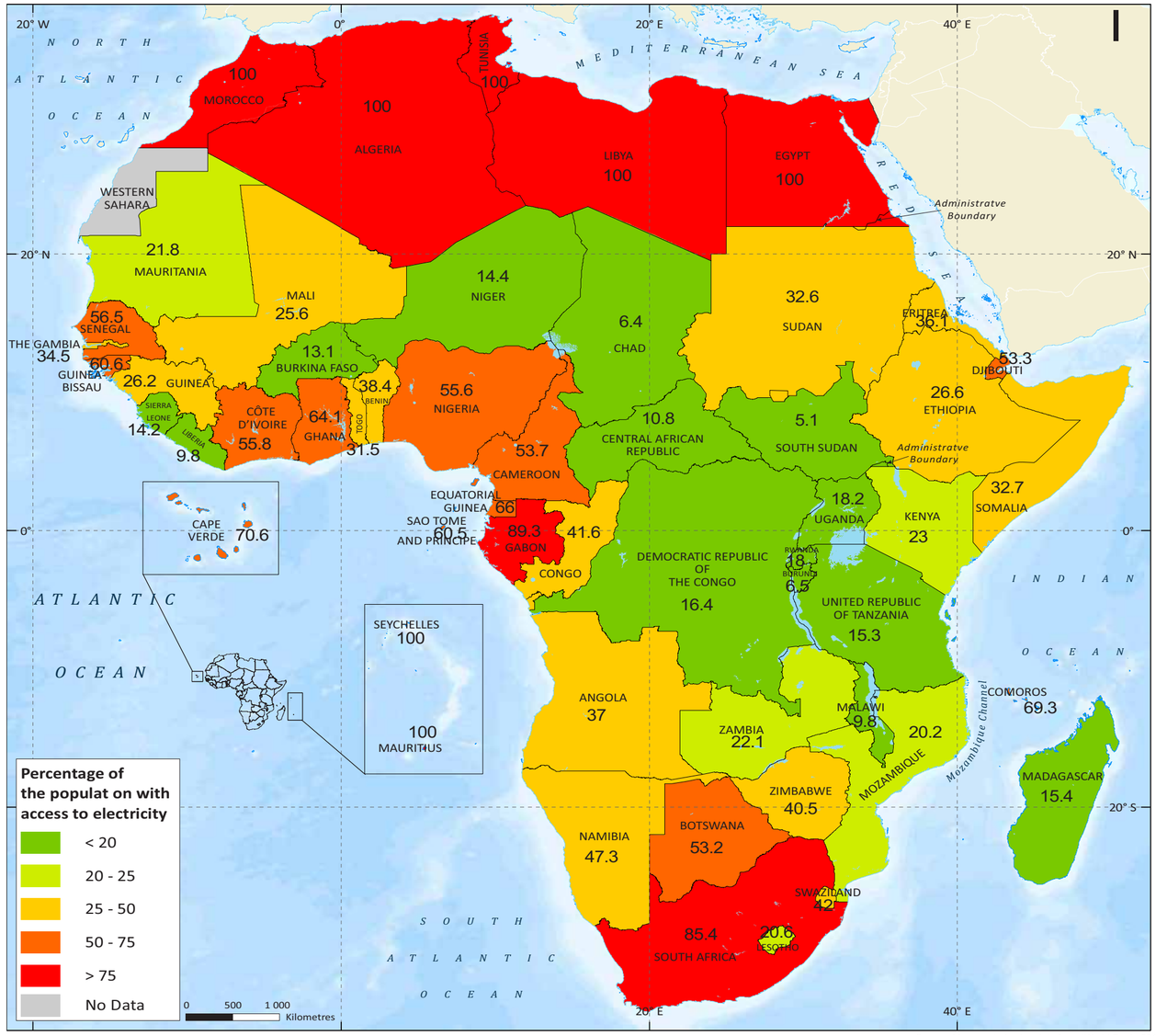
Perhaps most importantly, LEO has the advantage of being closer to the Earth than core constellations in MEO, experiencing less path loss and delivering signals one thousand times (30 dB) stronger. This makes them more resilient to jamming and more capable in deep attenuation environments such as in urban canyons and indoors.

New business dynamics are being investigated in this emerging space. Besides relationships between receiver companies and service providers, simulator companies are playing a vital role. Safran, for example, has announced collaborations with Xona Space and TrustPoint to provide simulated signals for their respective constellations. Spirent and Syntony have also announced support for Xona's PULSAR signal.

Governments have allocated budgets to support both LEO Positioning, navigation and timing service providers and receiver companies, including research and development to leverage communication satellites that were not designed for PNT, and launching new constellations dedicated to navigation system.

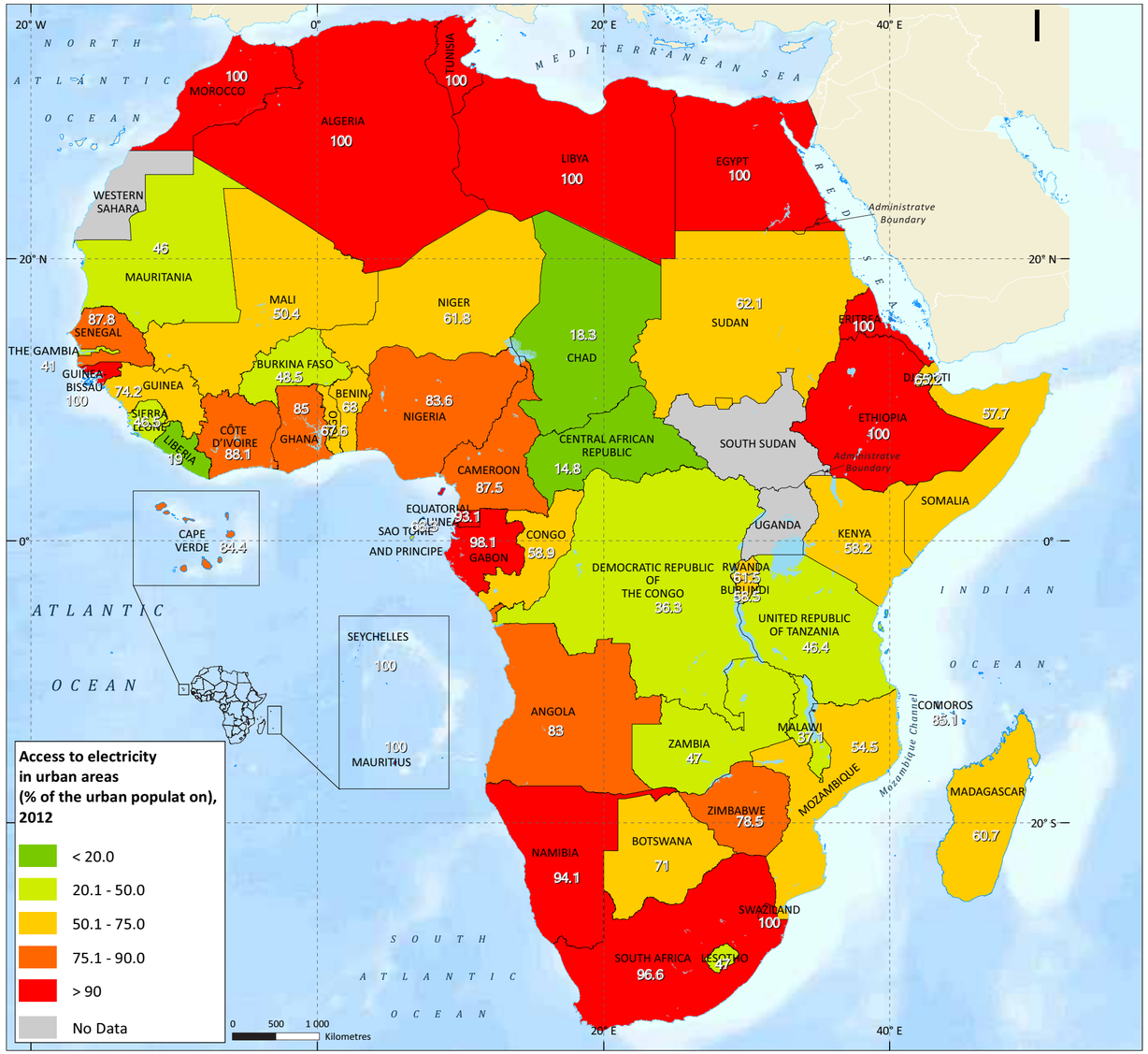
TrustPoint has enlisted the support of six product partners to develop C-band capable receivers able to receiver and process TrustPoint's services. Public disclosure of the product partners is expected in late 2025.
SpaceX is positioning itself to dominate the LEO satellite market because of their plans to adapt Starlink for military applications in the future, aided by what will likely be increased U.S. funding for space startups. It is anticipated that SpaceX would develop their own receivers for this purpose. These advancements reflect a dynamic and competitive global race in the development and implementation of LEO navigation systems.

Access to electricity (percentage of population), in Africa



Source: Map created using data from (World Bank, 2016c)

Figure 6: Access to electricity in urban areas (percentage of the urban population), 2012



Source: Map created using data from (World Bank, 2016c)

Percentage of population with access to electricity

The percentage of the population with access to electricity is measured by the availability of a connection to a source of electricity or the use of electricity as the primary source of lighting. Electri#cation data are collected from industry, national surveys and international sources (World Bank, 2016a). The percentage of the population with access to electricity in Africa is presented in Figure 4. Figures 5 and 6 show the percentage by rural and urban areas, respectively.

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Dam in South Africa

Percentage of population with primary reliance on clean fuels and technology

The following 12 products are used to assess clean technology penetration and use:

1. solar photovoltaic (PV) cells;
2. light emitting diodes (LEDs);
3. small hydro turbines (capacities below 1 megawatt [MW] and 1–10 MW);
4. wind turbines;
5. biodiesel fuels;
6. insulation materials;
7. %uorescent lamps;
8. heat pumps;
9. reversible heat pumps for air conditioning;
10. electric vehicles;
11. portable electric lamps; and
12. parts of portable electric lamps.

Africa derives nine per cent of its energy and 21 per cent of its electricity from these modern renewables, putting it ahead of Asia in this category.

Digital farming, the final frontier?



Located in southern Africa, bordering South Africa, Namibia, Zambia, and Zimbabwe, the Republic of Botswana is a landlocked country that lies about 1,000 m above sea level and covers an area of about 582,000 km2.
AAbout 2.3 million people live in Botswana, a tenth of them in the capital Gaborone alone, in the southeast of the country. Botswana has one of the highest urbanization rates in Africa. At the same time, Botswana is considered one of the most sparsely populated countries in the world, with an average of only about 4 people per km2.
Not least because of the often inadequate quality of arable land for agriculture, about 70% of the land is used for livestock, which is thus the predominant agricultural activity in Botswana. Livestock farming is mainly used for the production of beef, which is the most important agricultural export product.

The successful realisation of the African Union's Agenda 2063 has been touted as key to the continent's economic development, social prosperity, political stability, environmental protection, and regional integration in future. Agenda 2063 encapsulates not only Africa's aspirations for the future but also identifies five priority areas, including Light up and power Africa, Feed Africa, Industrialize Africa, Integrate Africa, Improve the quality of life for the people of Africa.

These five critical priorities in Agenda 2063 are central to the Ten Year Implementation Plan as well as intrinsically linked to the UN Sustainable Development Goals SDG designed to mitigate and adapt to the changing climate, and build capacity in Africa for a resilient continent.

Much of Botswana is part of the vast Kalahari Desert, where chronic water shortages pose a major challenge. While water is essential for plant growth, it is scarce in many parts of Botswana. Resourceful and controlled application of crop irrigation is therefore imperative for African farmers.
In Botswana, Digital agriculture helps farmers do more, with less. In the next 40 years, the world population is expected to explode from 7 billion to more than 9 billion people and already hundreds of millions of people worldwide go hungry every day. In fact, the United Nations is calling for a 70 percent increase in food production by 2050.

Digital agriculture seeks to use new technologies to increase crop yields and profitability while lowering the levels of traditional inputs needed to grow crops such as land, water, fertilizer, herbicides and insecticides.
In order to address this challenge, the government proposed the Southern Okavango Integrated Development Plan designed to retain and store Okavango's precious water supplies by dredging the delta and building a series of dams.

Few people around Maun gave the plan much credence until the heavy equipment began to arrive. This had long been a remote area where nature ruled and where government was defined more by its absence than its presence. “Suddenly, it was all systems go,” Masamba notes.

“People opened their eyes and saw the bulldozers and earth-moving machines.” The reaction was neither accepting nor passive. “There was a local uproar and an international furor,” says Masamba. The plan, in fact, was halted, partly through the action of the Kalahari Conservation Society, which emphasized the need to gather more scientific information about the effects of impeding water flow in the delta.

The society then marshalled support from other organizations that held similar views. In the early 1990s, the government bowed to the concerns and offered an alternative plan that emphasized the need for additional and ongoing study.

The new plan called for the construction of a Maun Field Station. The station, which was not completed until five years later, consisted of a laboratory, two small dormitories, a storeroom and a small ablutions block. There was no furniture, equipment or staff, except for a single caretaker. Not surprisingly, this half-hearted measure did not assuage the critics. The facility, Masamba observes, was ultimately deemed “below the minimum threshold required for effective operation.” Events continued to proceed slowly. In 1987, a small expansion took place, but funding for operations remained stagnant. Finally, in 1991, a report funded by the British High Commission recommended the establishment of a full-fledged Okavango Research Centre, to be operated by UB, for the “conservation and advancement of scientific knowledge of the Okavango delta and ecosystem.”

Electricity access

In rural areas, only about 30% of the population has access to electricity. Botswana's annual electricity consumption is 3.64 billion kWh and averages 1500 kWh per capita. However, national electricity generation is not sufficient to cover the country's electricity consumption. As a result, a large part of the annual electricity consumption is covered by imports, mainly from South Africa.
A fundamental prerequisite for digital development is access to electricity. Since electricity can be used to supply energy to countless other technologies and consumers, it forms the cornerstone for digital development. However, access to electricity is particularly difficult in rural areas of Botswana, where many smallholders live and work. On the one hand, existing infrastructures can be expanded, and on the other, new, decentralized energy plants can be installed, where they are needed.

The solar energy has the potential to offer rural communities annual photovoltaic potential averages about 1850 kWh/kWp. In summer, the daylight duration is almost 10 hours, and in winter still just over 8 hours. In total, about 3200 hours of sunshine per year can be expected in Botswana. This makes Botswana an attractive and highly profitable location for the use of photovoltaics.
In order to convert the sun's energy into usable electrical energy, essentially only solar modules and corresponding inverters are required. The solar module is used to generate electrical energy from the incident sunlight. This electrical energy is then available as direct current. However, since electrical consumers usually require alternating current, the current must be converted from direct current to alternating current. This task is performed by the inverter.

Internet access

In addition to access to electricity, internet connectivity represents another key technological need, or critical infrastructure, for data-driven advancement. A stable internet connection enables access to countless pieces of information that people would otherwise miss out on. For Botswana, 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.

Technology is constantly transforming the way the agricultural sector does business. Digital agriculture, and specifically precision agriculture, are democratizing data, empowering farmers with access to reliable data to make informed, effective decisions. Data-driven decisions have the potential to make farm management more productive, more consistent, and to use time and resources more efficiently. “Big Data” brings critical advantages for farmers and wider social benefits around the world.

At the beginning of 2022, there were approximately 1.48 million internet users in Botswana, representing about 61% of the total population and an increase of 1.9% from 2021. Just over half of the pages accessed online were accessed via cell phones, while around 47% of the pages accessed were opened using laptops and desktop computers.
Tablets and other devices account for only a vanishingly small percentage of the devices used for web browsing. There were around 1.2 million active users of social media at the beginning of 2022, which corresponds to a share of 49.6% of the total population, roughly the same as in the previous year. A large proportion of these social media users, 96.4% to be precise, access them via mobile devices, mostly with the aid of the Android operating system, while the most frequently used platform is Facebook.

In Botswana, internet connectivity is an important prerequisite for various data-based technologies, such as remote monitoring of farms and animals. In the following, it is explored how a stable, affordable internet connection can be realized in rural areas of Botswana and made accessible with suitable devices.

In the age of fast internet access, a Low Earth Orbit satellite that orbits the earth at an altitude between 200 and 2000 km such as Starlink, Eutelsat Oneweb, represent a potential solution to provide internet connectivity for remote areas. Because LEO satellites are closer to the earth's surface, the lower latency of only about 50 ms ensure that rural communities can access higher bandwidth and thus greater capacity for users.

An existing internet connection only offers added value for end users if they can access it via an appropriate device. Therefore, for much of Botswana, digitization of agricultural sector can only be successful if smallholders in Botswana have internet-enabled devices and are able and willing to use them. As mobile phones are already widely used in Botswana, especially for connecting via social media platforms, the use of such devices also seems to be appropriate for accessing digital platforms in the agricultural sector.

Although most farmers do not own laptops, these devices, along with mobile phones, have the potential to allow multiple farmers to access digital applications. It is sufficient if one or a few people per community own a laptop when they make these devices available in some kind of supported internet café.

Farmers can then visit such internet cafes and access digital services with the help of the farmers who own and operate the laptop. Farmers who can afford a mobile phone can use it from the comfort of their own home or on the way, while farmers without their own device and know-how can visit the farmers with a laptop and use the digital services with their help.

Without access to digital agriculture, farmers are making these key decisions based on a combination of manual measurements, experience and corporate recommendations which often tend to be conservative in nature. A digital agriculture system works by gathering data more frequently and accurately, often combined with external sources such as weather information, subject to analysis and interpretation by expert agronomists. 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..
When it comes to pest management, the opportunity cost of forgoing precision agriculture is simply too high. On a global scale, pathogens and pests are reducing crop yields for five major food crops by 10 percent to 40 percent. Digital agriculture enables data-driven decision-making that helps integrate pest management into the day-to-day management of farms.

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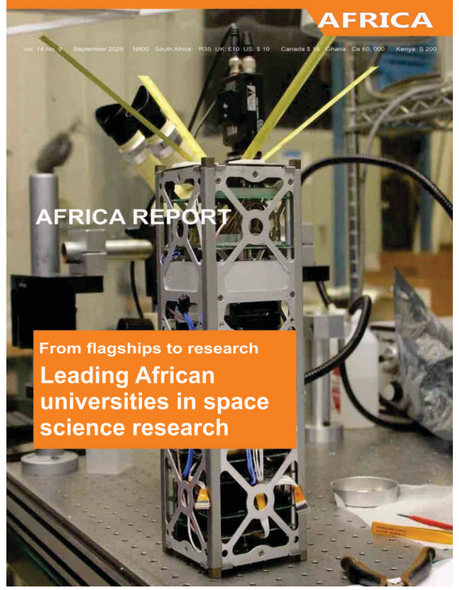
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2024: A review of operation of Inmarsat GDMSS network



In December 1994, nearly 1,000 people were rescued from the cruise ship Achille Lauro, which caught fire as she sailed around the Horn of Africa enroute to the Seychelles. First news of the incident was received at the Norwegian maritime rescue co-ordination centre (MRCC) at Stavanger, when the Dutch livestock carrier Corriedale Express sent in an Inmarsat-A call, relaying information received from another ship via 500kHz, that the Achille Lauro was on fire and needing assistance. Stavanger MRCC notified all vessels in the area through broadcasts on the Inmarsat systems.

Several ships responded and Stavanger appointed the Shell tanker Lima as surface search co-ordinator. As there were no MRCC facilities on the east coast of Africa, Stavanger continued to co-ordinate the rescue from Norway, first plotting the positions and courses of ships in the area. The first on the scene was the tanker Hawaiian King, which established VHF radio contact with the Achille Lauro and reported to Stavanger that all passengers and most crew had bene evacuated into lifeboats or liferafts. Hawaiian King took most of the people from the lifeboats and liferafts, while the bulk carrier Bardu took the rest from the ship. Stavanger meanwhile kept in contact with the rescue vessels via Inmarsat A and C. The only problem came as media and other authorities tried to get through to the rescue ships – occupying Inmarsat lines and causing Stavanger t o lose contact for two hours. Eventually, Stavanger set up an exclusive telex link with Lima and Hawaiian King through Telenor's Inmarsat coast earth station at Eik. As a result of the rescue efforts, nearly 1,000 people were rescued from the burning ship. Two people lost their lives.

One of the advantages of the Inmarsat system, from the shipowners' point of view, is the business opportunity it provides. Inmarsat not only provides good quality radiotelephone channels, it also provides a service for telex, facsimile and high-speed data transmission. Moreover, there is guaranteed privacy of communications between ship and owner - an important point in a commercial operation - whereas terrestrial radio messages

can be overheard by anyone with the right receiver. Communications in either direction are simple and in many countries the ship can be contacted by merely dialling the appropriate telephone number. The system also provides for reception of medical advice and assistance, meteorological reports and weather forecasts, navigational reports and warnings and ship position reports.

From IMO's point of view, Inmarsat's most important function is the provision of improved distress and safety communications. By using the Inmarsat system, a ship can send a distress message and know with certainty it will be received.

Until the invention of radio, there was little a ship could do if it was in trouble on the high seas, except set off flares and hope a ship in the vicinity would see and come to the rescue. The invention of radio by Guglielmo Marconi in 1895, and the subsequent development of the technology of radiocommunication through the efforts of several other scientists, created a revolution in maritime communications.

The introduction of telephony and telegraphy was of little use at sea, since they both depended upon cables and once a ship was out of sight of land it was effectively cut off from all contact with other persons, except for the chance sighting of another vessel. The first rescue at sea resulting from a radio message was in 1899, when the lightship on the Goodwin Sands in the Straits of Dover sent a message ashore when the steamship Elbe ran aground, enabling a lifeboat to be launched in time to rescue the ship's crew..

The GMDSS is essentially a worldwide network of automated emergency communications for ships at sea. All ocean-going passenger ships and cargo ships of 300 gross tonnage and upwards are equipped with radio equipment that conforms to international standards as set out in the system. Over the years, Global Mobile Distress and Search System have been offering search and rescue authorities ashore, as well as shipping in the immediate vicinity of the ship in distress, and are rapidly alerted through satellite and terrestrial communication techniques to a distress incident so that they can assist in a coordinated SAR operation with the minimum of delay.

Inmarsat GMDSS services

Today, maritime crews must be prepared to go anywhere, at a moment's notice. To conduct their missions, military forces at sea, Coast Guard operations, special operations vessels and other maritime units depend upon consistent satellite performance that is unaffected by geographic changes. From its very beginning in 1979, Inmarsat has sought to improve communications at sea. That's why the company is strongly positioned to support today's vessels. These ships often head into adverse weather environments, which means they require a dependable failover system should a powerful storm prove disruptive, or even if a signal gets blocked by a part of the ship. Thanks to Inmarsat, crews stay connected regardless of conditions.

Built from the ground up as a worldwide satellite service, Global Xpress provides the best coverage in the industry. This allows government customers to quickly and cost-effectively augment the WGS system whenever and wherever needed, through Inmarsat's leased or subscription service.

Using Global Xpress' high capacity, steerable spot beams, vessels on the move pass beam-to-beam completely seamlessly, establishing continuous connections during mission critical maritime operations. Additionally, only a minimal amount of time is required for satellite-to-satellite handoff.

At the beginning of 2024, the global merchant fleet comprised approximately 109,000 vessels of 100 GT or more, including 58,200 which were over 1,000 GT. The global fleet's carrying capacity was around 2.35 billion dead weight tons (dwt), an increase of 77 million dwt (3.4%) from the previous year with oil tankers and bulk carriers comprising 71% of total capacity.

In 2024, 86% of registered Global Maritime Distress and Safety System (GMDSS) distress calls contained vessel type information (689 of 801 calls) compared to 72% in 2023. This additional data is crucial as it allows for better understanding of the number of safety incidents across different vessel types, which could be used to help prioritise the development of safety measures.

However, the variation also complicates year-on-year comparisons and trend analysis, as the number of calls per certain vessel type is as likely affected by the additional granularity as an actual increase or decrease in incidents.

For example, tankers registered 194 calls in 2024 compared to 159 in 2023, and fishing vessels registered 86 calls in 2024 compared to 33 in 2023. While safety incidents may have accounted for some of the increase, the annual variation is also likely attributable to the availability of additional data, which provides more detailed categorisation of calls by vessel types.

The fourteen vessel-types considered in this report are derived from Lloyd's List, with only its 'other non-cargo' vessel category excluded from analysis due to its small market size, 31 registered vessels and absence of registered distress calls in 2024. As an average across the 14 types, vessels registered 49.1 distress calls in 2024 (by count) at a rate of 40.4 distress calls per 10,000 registered vessels.

Recently, the spike in physical attacks against shipping by Houthi rebels in the Red Sea has been mirrored by an increase in jamming and spoofing of GPS signals, effectively removing position, navigation and timing information from the control of the ship's navigators. Examples have included vessels travelling at supersonic speeds or positioned on land, sometimes in circles surrounding targets that bad actors are trying to protect. As well as reducing the vessel's ability to navigate, these Radio Frequency cyber attacks can impact mandatory GMDSS safety services, potentially removing the ability of ships to send a distress call.

The Red Sea connect the Suez Canal in the north and the Bab-el-Mandeb Strait in the south forms have become one of the main global maritime chokepoints. Approximately 14% of global maritime trade and 30% of global containerised trade transits through the Red Sea. Hence, blocking access to the Red Sea can have significant impacts on global maritime trade.

Since mid-November 2023, Houthis stationed in Yemen have intensified attacks on commercial shipping, substantially complicating navigation through the Red Sea. This background paper assesses the situation with regards Red Sea navigation and the impacts on global maritime trade. Drawing lessons from similar blockades in the past it concludes with a brief set of policy considerations.

Since Russia's invasion of Ukraine, reports say there has been an increase in the number of vessels operating in the Black Sea 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 (STS) activity.

A vessel's automatic identification system (AIS) plays an important role in commercial shipping, transmitting information about a vessel including its location to help avoid collisions. The use of AIS is mandated by the International Maritime Organisation (IMO) but the ability to turn it off and hide a ship's location has been increasingly used as a tactic to hide illegal or sanctioned activity. Short periods of AIS blackout are relatively common and can occur in areas of poor coverage. Kpler uses a wide range of AIS data sources, reducing the likelihood of falsely indicating a vessel has gone “dark” due to poor coverage.

Most of the instances of vessels going dark in the Black Sea have been for less than one day. These periods are so short these can almost certainly be due to loss of signal, rather than intentionally turning off the transponder. Most of the cases where a signal was lost for longer have been vessels less than 5,000 dwt transiting the Kerch Strait between the Black Sea and the Sea of Azov, a body of water in close proximity to areas of conflict within Ukraine. These vessels may be turning off their AIS signal to mask their location for the safety of the crew and vessel, rather than illicit trade.

If sanctions on the import of Russian oil are implemented more widely by Europe, which may include carrying Russian cargo, there will be a sharp decline in the number of owners willing to engage with Russia. But as we have seen in Iran in recent years since sanctions were re-imposed, there will still be shipowners who take the risk, particularly if India and China continue to buy from Russia. Those owners that do would use all tools available to hide their location.

But there will be significant scrutiny of these cargoes making evading sanctions difficult. In addition, vessels leaving the Black Sea and Baltic must pass through geographic bottlenecks where vessels can easily be observed from the land. The Bosphorus Strait at the mouth of the Black Sea and the Danish Great Belt Strait in the Baltic Sea. Once beyond these regions vessels can go dark and move the cargo via STS, but as shown with Iranian cargoes, when a vessel arrives at a port, Kpler's wide range of sources and tracking makes hiding the true origin of any cargo difficult.

The shipping industry has been affected on multiple fronts, with the loss of life and vessels in the Black Sea, disruption to trade with Russia and Ukraine, 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.

“Despite the tragic situation in Ukraine, and the threat to seafarers caught up in the conflict, the direct impact on shipping from the war in Ukraine has so far been largely contained to the Black Sea,” says Captain Rahul Khanna, Global Head of Marine Risk Consulting at AGCS. “However, the war is creating an additional burden on the maritime industry, which is already dealing with ongoing supply chain disruption, port congestion and a crew crisis caused by the pandemic.”

A large part of the shipping sector will in some way be touched by the conflict, says Khanna. “In addition to the physical threats to shipping in and around the Black Sea from mines and rocket attacks, which is affecting trade, the availability and cost of bunker fuel, and the safety and welfare of crew, many container companies have already pulled out of Russia while the tanker sector faces huge restrictions and disruption, as do bulk and general cargo operators shipping Russian coal, wood and grain.”

At the start of the conflict approximately 2,000 seafarers were stranded aboard 94 vessels in Ukranian ports, according to the International Maritime Organisation, IMO.

At least eight merchant vessels were attacked in Ukrainian ports and the Black Sea during the first month of the conflict. Three cargo ships including Japanese-owned Namura Queen, Lord Nelson and Helt were attacked in the Black Sea, according to Panama’s Maritime Authority.

The Helt sank off the coast of Odessa having likely struck a mine, killing two crew. The sinking came shortly after a Banglaesh cargo ship was attacked in the Ukrainian port of Olivia, killing one of its crew members. The Moldovan-flagged chemical tanker, the Millennial Spirit, and the Turkish-owned bulk carrier Yasa Jupiter were also attacked, while the Malta-owned Dominica-flagged cargo ship Azburg sunk in April after it was hit in the Ukrainian port of Mariupol.

Tanker shipping

Meanwhile, tankers continue to be a key component of the global economy, yet transporting crude oil, refined oil products, chemicals and liquefied gas by tankers and



transferring cargo to and from terminals is inherently associated with risk. Therefore, it is perhaps unsurprising that for the seventh successive year, tankers were responsible for more distress calls in 2024 than any other vessel type.
Over the year, tankers registered 194 GMDSS distress calls at a rate of 65 calls per 10,000 vessels, compared with 159 calls in 2023, a 22% increase.

In part, this can be attributed to the availability of more vessel-type variable data in 2024 and the 1.9% growth of the tanker fleet22. The comparative age of the tanker fleet plus an increase in security incidents may also be factors.
In 2024, distress calls were registered in both coastal and open ocean areas. High call frequencies in the English Channel, Strait of Gibraltar and the Bab el-Mandeb Strait, are consistent with high density shipping operations, although the latter also reflects maritime security risks.
Clusters in the Strait of Hormuz, SOMS and South China Sea, likely indicate maritime traffic densities, extreme weather events, piracy and armed robbery, geopolitical tension and activities of the 'shadow' fleet. In 2024, the average tanker age was 13.2 years, the highest since 2003. Product tankers are older still, averaging around 13.6 years old, five years older than the 2011 average, with 13% of the fleet above the age of 20, particularly the number of tankers aged 20 years or older has risen by 70% since 2022.

Conscious of the need to drive continuous improvements in tanker operations, the Oil Companies International Marine Forum's launched Ship Inspection Report Programme 2.0 in September 2024. The updated methodology reflects the tanker industry's changing risk profile and the opportunities afforded by digitalisation to help evaluate the quality and likely future performance of a vessel and its crew.

While the ability to measure and, to a degree, predict performance has improved, adverse weather can catch out the professional and unwary seafarer alike. For example, the Keoyoung-Sun capsized in heavy seas, while anchored off the west coast of Japan on 20 March 2024 with the loss of eight crew and a further two missing.

Two more tankers, the Volgoeft-212 and Volgoneft-239, were lost to the same storm in the Kerch Strait on 15 December 2024, with vessel age and seaworthiness likely to be key contributing factors. One seafarer was lost in the former incident and most of the vessel's 4,300 tonne cargo of mazut, a low-grade oil, was spilt after it broke in two.

That said, spills have significantly decreased in frequency and volume over the last 30 years. The International Tanker Owners Pollution Federation reported six large and four medium tanker oil spills in 2024, excluding spills with unconfirmed volumes and incidents resulting from acts of war releasing about 10,000 tonnes of oil. However, inconsistent reporting and data accuracy remains a challenge, and small spills are often not reported, especially in areas with limited monitoring resources.

For example, spills of less than 1 tonne are not documented in the Niger Delta region. The 'shadow' fleet continued its unauthorised trade of sanctioned oil throughout 2024, further increasing safety and environmental risks, contributing to economic instability and undermining international sanctions. Nearly 600, typically ageing, poorly maintained and inadequately insured tankers were suspected of involvement by the end of the year.

Although only a relatively small percentage are thought to ply the trade on a regular basis, around 89% of Russian crudeoil exports are now thought to be shipped on such tankers. Perhaps not unexpectedly, a suspected 'shadow' tanker was involved in a serious incident in 2024. On 19 July, the tanker Hafnia Nile collided with the Ceres I, approximately 25 nautical miles east of Malaysia, engulfing both vessels in flames.

At least two seafarers were evacuated for treatment ashore. The Ceres I allegedly disabled its AIS and sailed from the scene, highlighting the risk to safe navigation posed by the 'shadow' fleet. It was later located, intercepted and detained by the Malaysian Coastguard. In another incident, the fleet tanker Andromeda Star was detained in Denmark after it collided with the MV Peace in March 2024.

'Shadow' fleet tankers continue to pose significant navigational and environmental risks, but security incidents involving tankers engaged in legitimate trade can likewise endanger both, albeit through no fault of their own.

On 26 January 2024, the Marlin Luanda was hit

by a Houthi anti-ship ballistic missile in the Gulf of

Aden. The crew 22 Indians and 1 Bangladeshi battled the ensuing fire for 19 hours before nursing their vessel to a safe harbour. And the Sounion, carrying approximately 150,000 tonnes of crude oil, was attacked on 21 and 22 August. Despite leaking oil and remaining on fire for weeks after the incident, an environmental disaster was narrowly averted. The cargo was successfully removed in January 2025.

Similarly, acts of piracy and armed robbery also continue to pose a risk to tanker operations. In the Regional Cooperation Agreement on Combating Piracy and Armed Robbery against Ships in Asia reporting area, tankers endured the second-highest number of armed robbery incidents: of the 107 reported incidents, 20 about 19% involved tankers.

In addition, tankers were also targeted off the coast of Africa. On 10 May, pirates attacked the MT Chrystal Arctic 100nm north of Somalia, exchanging gunfire with a security detail aboard the tanker. Another tanker, the Maersk Tangier, had reported a suspicious approach two days earlier Using a ship as a weapon has long featured on maritime security risk registers. The suspected 'shadow fleet' tanker Eagle S was intercepted by Finnish authorities on 26 December, after its anchor severed the undersea power cable Estlink and damaged four data cables in the Baltic Sea. The suspects, all crew were accused of aggravated damage and aggravated disruption of telecommunications. It was not the first ship suspected of intentionally damaging submarine cables in the area: the bulker Yi Peng 3 is under investigation for allegedly damaging two cables in November 2024..

Containerships

As of 1 January 2024, containerships accounted for 14% of the global fleet by dwt, up from 13.4% in January 2023. Yet the sector did not stop there. Echoing the growth of the fleet, the number of distress calls registered annually from container ships continued its upward trend in 2024. Compared to 29 distress calls registered in 2018, 59 distress calls were registered in 2024, up from 49 in 2023.

By rate, containerships were responsible for 72 distress calls per 10,000 vessels in 2024, the second highest rate of calls below gas carriers and significantly above the all-vessel average of 40.4. By comparison, the call rate was 85 in 2023, with the lower rate, despite the rise in registered calls, perhaps reflecting the increase in the size of the fleet in 2024.

Containership operations in 2024 were significantly affected by geopolitical events and climate-related factors, resulting in vessels transiting the Suez and Panama Canals being redirected to longer alternative routes. Ordinarily, the Suez Canal accounts for about 10% of global maritime trade and 22% of container trade, while the Panama Canal handles roughly 3% of maritime trade. However, by June 2024, ship transits through both canals had dropped to less than half of their previous peaks.

Rerouting vessels around the Cape of Good Hope had a particularly significant impact on global trade by increasing travel distances and prolonging eastwest transit times, which resulted in a 12% rise in global containership demand. These extended routes introduced market inefficiencies, including port congestion, elevated operational costs, increased carbon footprint, and greater challenges in adhering to regional environmental regulations.

Diverting containerships around the Cape also exposed containerships to additional weather risk in 2024. Renowned as a weather-intensive passage, the South African Maritime Safety Authority reported nearly 200 containers lost in this region alone, or 35% of the estimated 576 containers reported lost around the world in 2024.

However, the highest density of distress calls emanated from the East China Sea in 2024, with congested ports, high traffic density and adverse weather being the likely causes. Other clusters are evident at strategic choke points, including the SOMS and the English Channel. Of course, containership incidents occurred globally in 2024. The Lobivia was attacked by missiles on 19 July, southeast of Aden,

forcing the vessel to sail to a port of refuge for a damage assessment, and there were 7 incidents of armed robbery against container ships reporting area with 6% of the annual total.
And the most notorious incident of 2024, the collapse of the Francis Scott Key Bridge, occurred in the United States on 25 March. Struck by the Dali after the vessel lost electrical power and propulsion, the allision resulted in the deaths of six members of a bridge maintenance crew. The collapse blocked most shipping to and from the Port of Baltimore for 11 weeks and the incident remains the subject of marine accident investigations and a furious legal battle.

While containership collisions and allisions rarely result in such catastrophic disruption and financial loss, fire continues to endanger crew and destroy property. A fire on board the Stride on 8 January 2024 claimed the lives of two crew, with a third injured while the vessel was docked at Port Houston. On May 26, the Northern Juvenile caught fire off Singapore and the Maersk Frankfurt suffered a similar fate off the west coast of India on 19 July, resulting in the loss of another seafarer.

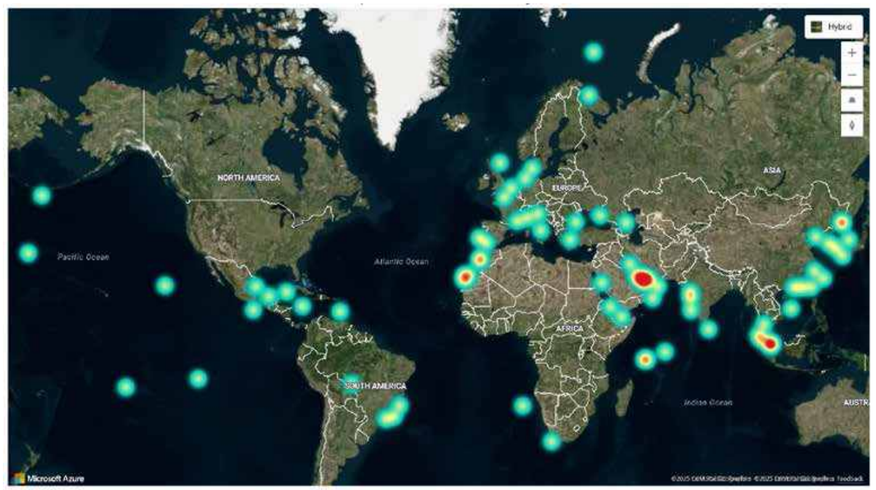
Bulk Carriers

The bulk carrier fleet increased by 3.1% between 2023 and 2024 to 1,004,281 thousand dwt, although it fell 0.1% in terms of overall percentage share of world fleet capacity to 42.7%. The bulk carrier fleet remained the youngest vessel type, averaging 11.1 years.
Bulk carriers registered 110 distress calls in 2024, up from 105 calls in 2023 - at a rate of 61 per 10,000 vessels. The number of distress calls was the second highest by vessel type, after tankers, and the rate was fifth highest. The number of distress calls has consistently increased year on year, from an average of 46 between 2018 and 2020, to 82 in 2021 and 91 in 2022.
However, it should be noted that more accurate messaging, such as including vessel type in the distress call, is likely to be a contributing factor in 2024.

Incidents involving bulk carriers occurred worldwide, but analysis of 2024 GMDSS data reveals a distinct concentration between the East China and South China Seas, the Red Sea and the Persian Gulf. This suggests that weather, congested waterways and illegal interference are significant causes.

The relatively high count of GMDSS distress calls in 2024 also suggests that safety issues related to repurposing bulk carriers to transport containers





may still be a concern. INTERCARGO's Bulk Carrier Casualty Report 2015-2024 confirms the total loss of 20 bulk carriers over 10,000dwt over the period, or an average of two per year - although smaller bulkers and those engaged in cabotage are not within its scope. Cargo liquefaction continues to be the greatest contributor to loss of life and groundings cause the most vessel losses. In 2024, the sole accidental total loss reported by INTERCARGO was attributed to adverse weather, the 15-year-old Blue Lagoon ran aground on 1 October off Orchid Island, Taiwan during Typhoon Krathon. Although the 19 uninjured crew members were safely rescued, the vessel broke in two on 4 October.

Although improved vessel design, crew training and regulatory frameworks are undoubtedly reducing losses and fatalities, improperly declared cargo and navigation errors continue to pose significant risks to both vessels and seafarers. Furthermore, risk profiles continue to evolve as new propulsion technologies are introduced to the global fleet.

A collision between two bulk carriers, the HL Eco and YM Serenity, in Queensland Australia on 16 July 2024, raised concerns about the safety and placement of LNG storage tanks on ships. A poop-deck mounted LNG tank on the HL Eco ruptured after it lost propulsion control while manoeuvring to anchor. Fortunately, it was empty as the vessel was still operating on fuel oil, which prevented a potential explosion.

However, the potential safety implications were readily apparent. Deck tanks are also being proposed for the carriage of ammonia which is both toxic and highly flammable. Should ship owners and designers rethink plans to install them instead of more expensive underdeck solutions? At the very least deck tanks should be positioned as far away from crew accommodation as possible.
From a maritime security perspective, bulk carriers continued to be disproportionately at risk from piracy and armed robbery in 2024.

Fishing vessels

The global marine capture fisheries officially harvested 80 million tonnes in 2022, and the fishing fleet was estimated to comprise 4.9 million vessels, two-thirds of which were motorised.

Asia continued to host the world's largest fishing fleet with 71% of the total and 80% of the motorised fleet, followed by Africa, 19% of the total fleet. Of these, approximately 24,000 fishing vessels and related vessels such as research, survey, and fish factories have been allocated a unique IMO number. However, the IMO figure is at odds with IHS Markit's Seaweb database, which listed over 30,500 IMO registered fishing vessels in December 2020.

The discrepancy highlights the need for greater uniformity in data collection and archiving. It also underlines the importance of developing interoperable systems to ensure accurate and consistent record-keeping. Understanding the scale of a challenge is vital before developing coherent initiatives to address it. Notwithstanding IMO numbers, fishing vessels accounted for close to 40% of vessels over 100GT lost during 2024 (10) and registered 86 GMDSS distress calls, the fourth highest vessel type. This represents a remarkable 261% increase compared to the 33 calls registered in 2023 and is also notably higher than in 2022 and 2021.

2024 data analysis revealed distinct hotspots of distress calls off the coasts of Morocco and Mauritania, and around the Seychelles in the Indian Ocean. This aligns with the nature and localised operations of the fishing fleets sailing out of these countries, as well as the number of distress calls registered by fishing vessels flying their flags with 41 Moroccan-flagged and eight Seychelles-flagged vessels.
In the case of Moroccan-flagged vessels, another factor is probably skewing the results – migrants attempting to reach the Canary Islands (Spain) from mainland Africa. While the craft carrying the migrants are highly unlikely to be equipped with communication devices, distress calls are often made by fishing vessels operating in the vicinity. For example, two disasters off the coast of Mauritania in July 2024 are known to have claimed the lives of at least 114 migrants with over 230 declared missing.

In terms of the rate of distress calls, fishing vessels made 20 calls per 10,0000 vessels compared with the all-vessel-type average of 40.4 calls. However, this analysis is based solely on Inmarsat Maritime GMDSS data.

Underreporting of safety incidents continues to conceal the true extent of the problem; marine fishing remains a hazardous profession, with incidents occurring throughout the year.
On 4 March, the *Fukuei Maru No. 8*, a 56-metre Japanese-flagged tuna boat, ran aground on Kozushima Island, south of Tokyo, after experiencing an engine failure and loss of power in rough seas. The Japanese Coast Guard rescued 24 crewmembers, but tragically one person died after being thrown into the water. According to the Coast Guard, the captain only sent a distress signal after his vessel had run aground, about five hours after losing power.

This delay corresponds with anecdotal evidence that seafarers too often wait until the vessel or crew are in grave and imminent danger and require immediate assistance, rather than sending a GMDSS urgency call to notify persons ashore of a situation. Early warning gives Search and Rescue authorities, and others, time to mobilise an effective response.
And fishing vessels are not just vulnerable to weather events. On 3 April 2024, the Chinese-flagged *Yuenan Aoyu 36062* was sunk in a collision with the *SITC Danang*, a Panamanian-flagged feeder vessel, off the coast of China with eight crew reported missing.

Other Dry Cargo

Containerisation is continuing to reduce demand for general cargo ships, as more breakbulk cargo moves in containers. As a result, the general cargo fleet grew by only 1.6% between 2023 and 2024, the lowest percentage growth of any of the named vessel types specified in UNCTAD's Review of Maritime Transport 2024.
General cargo vessels were once again the oldest type across the global fleet with an average age, according to UNCTAD, of 28 years at the start of 2024 up from 27.4 years in January 202. Older vessels are increasingly being retained in operation or transferred to new owners as companies evaluate future fuel options and emerging decarbonisation technologies.

Additionally, elevated freight rates driven by geopolitical tensions have contributed to this trend as owners look to maximise income. 88 GMDSS distress calls were registered from other dry cargo vessels in 2024, continuing a three-year upward trend 77 in 2023 and 68 in 2022.

In 2024, this equated to the third highest number of calls per vessel type. By rate of calls, other dry cargo vessels ranked eighth at 36 per 10,000 registered vessels against an all vessel-type average of 40.4.

Although distress call numbers rose in 2024 potentially due to the availability of additional vessel-type data Allianz reports that fewer "cargo" vessels were classified as total losses in 2024 than in 2023 or 2022. While only fishing vessels suffered more total losses in 2024 the reduction in total losses is marked.

Weather also took its toll on dry cargo vessels in 2024. Multiple vessels were driven ashore on Taiwan during Typhoon Gaemi in July, and the ITT Puma, capsized in rough seas in the Bay of Bengal on 25 August, with three crew declared missing.
As per other vessel-types, machinery breakdown also affected general cargo vessel operations in 2024. On 22 August the Heemskerkgracht ran aground, after losing power, near the entrance to the South Shore Canal, St. Lawrence Seaway.



While the vessel was refloated on 25 August, it continued to impact the passage of ships for a further three days.

Passenger vessels

Passenger vessels sent nine GMDSS distress calls in 2024, up slightly from the eight registered in 2023, but on par with the four-year average of calls registered between 2021 and 2024. They were responsible for the third-lowest distress call rate of the 14 vessel types analysed, registering 9 calls per 10,0000 registered vessels. The distress calls were most prevalent in Europe with four calls and Southeast Asia made up of two calls.
On 11 August 2024, three crew of the RO-RO passenger vessel Lastovo lost their lives and one was seriously injured when the bow ramp collapsed during an inspection of the bow visor. The accident investigation report concluded that multiple factors contributed to the tragedy but identified the primary cause as the lack of instructions for the hydraulic system.

In another tragedy, thirteen people died and 98 were rescued with two missing on 18 December 2024 after a naval vessel lost control during engine trials and collided with the passenger ferry Neel Kamal near Mumbai, India.
According to early reports, the ferry was licenced to carry 90 persons but was believed to be carrying over a hundred at the time of the incident.

Safety incidents also affected cruise vessels in 2024. While there were no reports of groundings, there was one reported instance of a ship listing. On 26 January 2024, the Voyager of the Seas encountered a heavy storm enroute from Mexico to the United States, resulting in interior damage and minor injuries to some passengers.
Moreover, seven cruise vessels were involved in collisions and allisions, six suffered fires onboard, one reportedly caused by a lightning strike and 12 lost propulsion and/or power. Fortunately, none of these incidents resulted in serious injury.

Regrettably, man-overboard incidents did claim lives in 2024. Despite onboard safety measures to reduce the risk of accidental falls, the cruise industry confirmed 19 incidents involving passengers and crew members.

In all but one case, the incident resulted in fatalities or the person being declared missing at sea. The industry continues to improve safety protocols to lower the risk of such events, and it seems that most are unfortunately linked to reckless behaviour or deliberate acts.
The low distress call rate also continues to belie the safety of ferry services in certain parts of the world. While many countries with historically poor safety records have made significant improvements, according to Baird Maritime, underregulated services continue to exact a heavy toll across Africa.

Of the 2,033 known fatalities recorded in 2024 there was 55% increase on the 1,308 fatalities recorded in 2023, 72% occurred in just three countries: the Democratic Republic of Congo, Nigeria and Mozambique.

For instance, over 100 people, were reported lost on 8 October 2024 after an overloaded fishing boat sank off Mozambique's northern coast. The vessel was not licenced to carry passengers but was reportedly transporting 130 people fleeing an outbreak of cholera. Only 10 were rescued.

It seems clear that despite the adoption of the IMO Model Regulations on Domestic Ferry Safety in 2022, and subsequent release of two training modules, greater efforts are necessary to build capacity in States with high incidence rates. Until this is achieved, deficiencies in crew training, onboard safety equipment, exceeding passenger capacity, poor vessel maintenance and general negligence are likely to continue claiming lives.

Yachts

The global yachting industry saw a significant downturn in 2024, with a 27% decrease for new builds over the first nine months and a 20% year-on-year fall for pre-owned yachts. Luxury yachts sales also fell, and the segment experienced a 14% reduction in average prices globally.

Economics, geopolitics, supply chain issues and changing consumer preferences, including environmental considerations and the rise of boat sharing platforms, were seen as contributing factors. While sales fell, in comparison to 2023, when only six distress calls were registered from yachts, 2024 saw an increase to 14 at a rate of 31 calls per 10,000 registered vessels as against a call rate of 18 in 2023.

Taken in isolation, this appears to be a significant increase, however seen in the context of preceding years, 2023 appears to be an outlier, in 2022 and 2021, 19 and 13 calls were registered respectively.

Social media no doubt amplifies public knowledge about such casualties. However, the summer of 2024 witnessed a slew of high-profile yacht losses and incidents, including the sinking of the superyacht Bayesian and loss of seven lives in August 2024. At the time of writing, the loss is being investigated by the Public Prosecution Office in Sicily.

According to BoatPro, 19 superyachts suffered fires, collisions or were sunk over the course of the year, with new propulsion technologies, adverse weather, and the ageing fleet cited as potential causes. Overcrowded marinas and ports may also be an issue, not only by posing a risk to navigational safety risk but also by leaving yachts unsheltered during bad weather.

BUSINESS

LEO versus GEOs: As battles shift to inflight connectivity



The satellite industry is in the midst of the largest transformation since the inception of satellite communications over five decades ago. There is an interesting parallel between today's drive for change and that of the “Space Race” era that unfolded in the late 50's between the United States and the Soviet Union. Starting with the successful launch of Sputnik-1, the first artificial satellite put into orbit in 1957, and peaking in 1969 with the landing of a Man on the Moon, this period gave birth to the satellite industry.

Today, we are transiting into a new space race era, a “21st-Century Space Race that shares common goals with the old race, space exploration and launch of artificial satellites, however, it's taken to a much higher level. This modern Space Race involves the launch of thousands of satellites across different types of orbits, deep space exploration, space travel, asteroid mining, and -ultimately- Mars colonialization and a multi-planet civilization.

After the demise of Connexion by Boeing in 2006, it took a couple of years for the idea of inflight connectivity to regain attention. Eager to seek out new revenue streams and differentiate in what has become an increasingly competitive marketplace air lines once again began looking to turn their fleets into flying hotspots in the immediate aftermath of the global recession. Led by the likes of Gogo, OnAir Global Eagle Entertainment and Panasonic Avionics, the number of WiFi aircraft passed the 1000 mark in 2010.

Since 2014 and the number of connected aircraft has exceeded 4,000. However, much of the global fleet flying out of hubs outside of the United States remains untapped. Connectivity service providers are desperately scrambling for a slice of this pie and with aeronautical Ka band now no longer a pipedream but a reality, many airlines are unsure about which type of communications systems they should adopt. Similarly, the introduction of LEOs connectivity solutions is disrupting the inflight connectivity business.

Indeed, it is only now that there is a growing realization that take rates will likely not reach initial expectations and that the real elephant in the room is the huge potential this technology has to improve business operations, rather than boost revenues.

In their report, published in The Future of Inflight Connectivity 2923, Valour Consultancy, analysts in the in-flight connectivity and in-flight entertainment space, predict that more than 22,000 aircraft will offer Wi-Fi onboard by 2032. There's a high-stakes race to supply the connectivity on those planes.
.Qatar Airways was the first major global airline to announce a partnership with Starlink, offering free high-speed Wi-Fi on long-haul flights. The airline's deployment of Starlink is under development. But when it is live, Starlink promises it will give passengers Wi-Fi speeds of up to 350 megabits per second, which they can use for gaming, VPN access, sports streaming, and other high-demand activities onboard.

Qatar Airways Group Chief Executive H.E. Akbar Al Baker said the “collaboration is not only in line with our industry-leading approach to technological adoption but also serves as an unmissable opportunity to connect Starlink to our global passengers.”

SpaceX's Vice President of Starlink Commercial Sales, Jonathan Hofelleras, highlighted the seamless ground-to-air advantage of Starlink connections. “As soon as passengers step onboard the plane, the internet works seamlessly throughout their flight from gate to gate, and all from the comfort of their seats,” he said

According to David Whelan, author of the Valour Consultancy report, how vendors position themselves over the next couple of years will be vital to how the market grows in the long term.
“You have a really interesting contrast between Starlink and its disruptive portal-less, direct-to-airline, pure connectivity approach, and fellow low Earth orbit satellite operator OneWeb, which has taken an indirect approach, choosing to work with longstanding service providers and partner with geostationary orbit satellite operators. The aviation industry is typically cautious, so OneWeb's approach seems a sensible way to enter the market. But Starlink comes with a huge amount of hype and has had some impressive early wins.”
Starlink is new to the market, with three airlines and two private jet charter services signing up before the Qatar Airways announcement. Flexjet and JSX have deployed their Starlink connections. Hawaiian Airlines, airBaltic in Latvia, and ZIPAIR in Japan have also announced they will implement Starlink connectivity, though they still need to be activated.

“Starlink will quickly increase its market share,” Whelan predicts. “However, many airlines will want to wait and see what happens with Starlink's Qatar and Hawaiian rollouts. Starlink will undoubtedly act as a disruptor. They are going directly to airlines with a portal-less, free Wi-Fi business model. In the short term, they have succeeded in appealing to airlines that have been typically unhappy with the status quo in the IFC market.”

By the end of 2022, the installed base of connected aircraft had surpassed the milestone of 10,000. Valour Consultancy expects connectivity service providers to generate $1.1 billion in revenue by 2023, up from $0.6 billion in 2020.

Passengers and airlines will need consistent and quality connectivity as equipped aircraft increase. The challenge for the industry is keeping up with demand. As a result, the IFC market is experiencing one of the most disruptive periods in its history, leading to consolidation.

After acquiring Inmarsat, Viasat now holds a 35% share of the global installed base, overtaking Intelsat as the leading IFC provider. Panasonic Avionics Corporation, which, according to Valour Consultancy, holds a 23% market share of IFC, recently announced Airbus had selected them as a managed service provider for its premium Airspace Link HBCplus Ku solution.

Viasat's United Airlines contract loss by itself is manageable, but indicates a more competitive backdrop. “We estimate that Viasat serves about 50% of the United fleet, or 500 aircraft, which accounts for 10%-15% of its IFC revenue, 2%-3% of total revenue, and a tiny portion of its backlog. Viasat will continue to service these aircraft through the life of the contract”. Separately, Air France, which recently opted for Starlink operates a much smaller fleet than United and also had three incumbent suppliers, so we estimate minimal impact of this loss to Viasat. “We continue to expect Viasat to increase IFC revenues meaningfully over the next 2-3 years, supported by a backlog of more than 1,500 aircraft that provides good visibility despite the recent loss to United. Still, the United contract win is a landmark win for Starlink, potentially signaling that other airlines might be more comfortable selecting it”.

Intelsat's multi-orbit network offerings, relying on low Earth orbit and geostationary satellites, will be available to airlines and aircraft lessors through Airbus' Airspace Link HBCplus solution. Intelsat has a 28% share of the IFC market and will be the largest provider listed on Airbus' IFC service catalog.

Air Canada and Intelsat recently announced that an additional 95 aircraft in the airline's fleet will have connectivity systems to support in-flight Wi-Fi. These aircraft will be equipped with Intelsat's new electronically steered array antenna.

At the same time, IFC capacity is increasing, now augmented by constellations in medium Earth orbit and low Earth orbit, a trend that has led to new players like OneWeb and Starlink entering the market.
Intelsat has 15%-20% market share, including 25 commercial airline partners and close to 3,000 aircraft with a backlog of about 800 aircraft after acquiring Gogo Inc.'s commercial unit in 2020. Industry players argue that vertical integration will allow it to compete effectively, but recognize that it lacks the reputation and stronger brand of Viasat.
Hughes, a new entrant into the IFC market with Jupiter-3, has secured a contract with Delta Air Lines to offer service on 400 planes, including regional jets. It also has partnered with Eutelsat OneWeb to offer LEO service. It could be more challenging to win new awards, but IFC does not constitute a meaningful portion of its service revenue. Conversely, the company designs and manufactures a LEO antenna used by Eutelsat OneWeb and Gogo business jets that could help drive revenue growth.

Gogo operates entirely in business aviation, serving smaller aircraft with a highly fragmented customer base utilizing its air-to-ground network. Gogo is rolling out its own LEO service, but does not own these satellites and will lease capacity from OneWeb. While Starlink does not have antennas capable of serving smaller crafts, however, this technology can be developed. Gogo's fragmented customer base also helps somewhat insulate it from near-term pressure as Starlink targets larger contracts. Gogo is acquiring Satcom Direct, which also operates primarily in business aviation. However, Satcom tends to serve larger planes that could more easily equip Starlink's antennas.

Eutelsat's IFC is included in mobile connectivity, which is 14% of its sales. The company aims to combat the shifting environment by offering its own multi-orbit product with OneWeb LEO, which should position it well.
Telesat exposure is slight, providing broadband communications to airplanes as one of many parts of its enterprise segment that constitutes 51% of total revenue. However, IFC could be a growth vehicle as Telesat continues to develop and invest in LEO satellites that it expects to launch in 2027.
In the US alone, more than 7 million homes lack a high-speed internet option, according to the FCC National Broadband Map. Starlink is likely running into capacity constraints of its own as subscriber growth has slowed considerably in 2024 and the company raised prices.

LEOs versus GEOs

As for provider, Starlink, the distinction between geostationary orbit (GEO) and low earth orbit (LEO) satellites is crucial; while GEOs cover larger areas, LEOs, being closer to Earth, offer lower latency but require more satellites for comprehensive coverage.

In terms of revenue, the research estimates that satellite Internet operators will generate over USD1 billion million in 2025 following Starlink's regional launch. This figure is forecasted to grow significantly by 2030, with an average annual growth rate of 50.2%. However, the growth of the satellite broadband market is intertwined with regulatory challenges and the limited availability of spectrum.

In just 3 years, Starlink has become the leading entity in the global broadband satellite market. The report states that by September 2023, Starlink had nearly 4 million subscribers globally, with the largest markets being in North America and about 430k subscribers in the Asia Pacific region.

S&P Global Ratings reveals that Viasat GEO satellites face challenges from increased capacity coming online from low-earth-orbit (LEO) providers, including Starlink and Kuiper. Separately, geostationary earth orbit (GEO) competitors are consolidating, which creates a more competitive backdrop. We believe these factors elevate risk of slower volume growth due to market share erosion or pricing concessions to retain relationships, which could pressure revenue and profit margins.
According to analysys mason, Starlink has asserted itself in the consumer broadband market, and many of the customers of incumbent GEO players Hughes and Viasat have moved to Starlink in the USA. Starlink has expanded its services portfolio to serve business customers in the enterprise, backhaul and mobility verticals. Starlink's wholesale capacity pricing substantially undercuts that of the rest of the industry. Therefore, GEO operators are adding value through managed end-to-end services, in order to preserve their profit margins and create barriers to entry.

Hughes' broadband service, HughesNet, has lost over a third of its subscribers since December 2020, from a base of 1.56 million. Today, Starlink surpassed 1.3 million subscribers in the USA. Hughes and Viasat suffered from capacity supply saturation during this period, and struggled to match Starlink for user speeds. Hughes hopes the 500Gbit/s of Ka-band capacity from its Jupiter-3 satellite will help to reverse the subscriber trend of recent years. However, Viasat will continue to be constrained, given the failure of the ViaSat-3 F1 satellite in July 2023. Both GEO operators announced upgraded plans for 2024 to compete with Starlink.
These new broadband plans from Hughes and Viasat are comparable in price to those from Starlink, and include unlimited data, but they offer lower peak and average download speeds. The disparity in user speeds implies that Starlink's capacity price is around half that of the GEO operators. The GEO operators offer cheaper user hardware, and offer add-ons such as cyber-security, voice, or express repair, which could persuade some new customers to choose their service. Additionally, Hughes' entry-point 'Select' broadband plan is a cheaper option for customers that want basic internet and are unwilling to pay for Starlink's 'one-size-fits-all' plan.

Starlink has entered business-facing demand verticals, in most cases undercutting the incumbent GEO players on price. Japanese operator KDDI was an early adopter of Starlink for backhaul in 2021. Since then, Starlink has signed a range of agreements in this segment. Highlights include partnerships with Africa Mobile Networks and Telcel in Mexico. Starlink is enticing telcos with a significant discount on capacity price compared to the rest of the market.

LEO providers have an advantage given latency comparable to a fiber connection that allows customers to take video calls and play video games in real time. In comparison, geostationary satellite (GEO) satellite home internet is more of a service of last resort given its higher latency and often slower download speeds.
Thus, Starlink has taken market share from Viasat Inc. and Hughes Communications Inc. in the U.S. over the past three years.
Hughes had 714,000 U.S. broadband subscribers as of June 30, 2024, down from 1.144 million three years ago. In contrast, Starlink has expanded to about 1.4 million U.S. subscribers as of August 2024, according to a report filed with the U.S. Federal Communications Commission (FCC), since its debut in 2021.

However, in the next 2-3 years, industry players expect that Viasat and Hughes will stabilize subscriber trends. This is due to new satellites coming online, Viasat-3 and Hughes' Jupiter-3. These companies have been capacity constrained in recent years. We believe there are still enough U.S. homes that lack a viable alternative, which for now will drive overall industry growth when capacity is available.

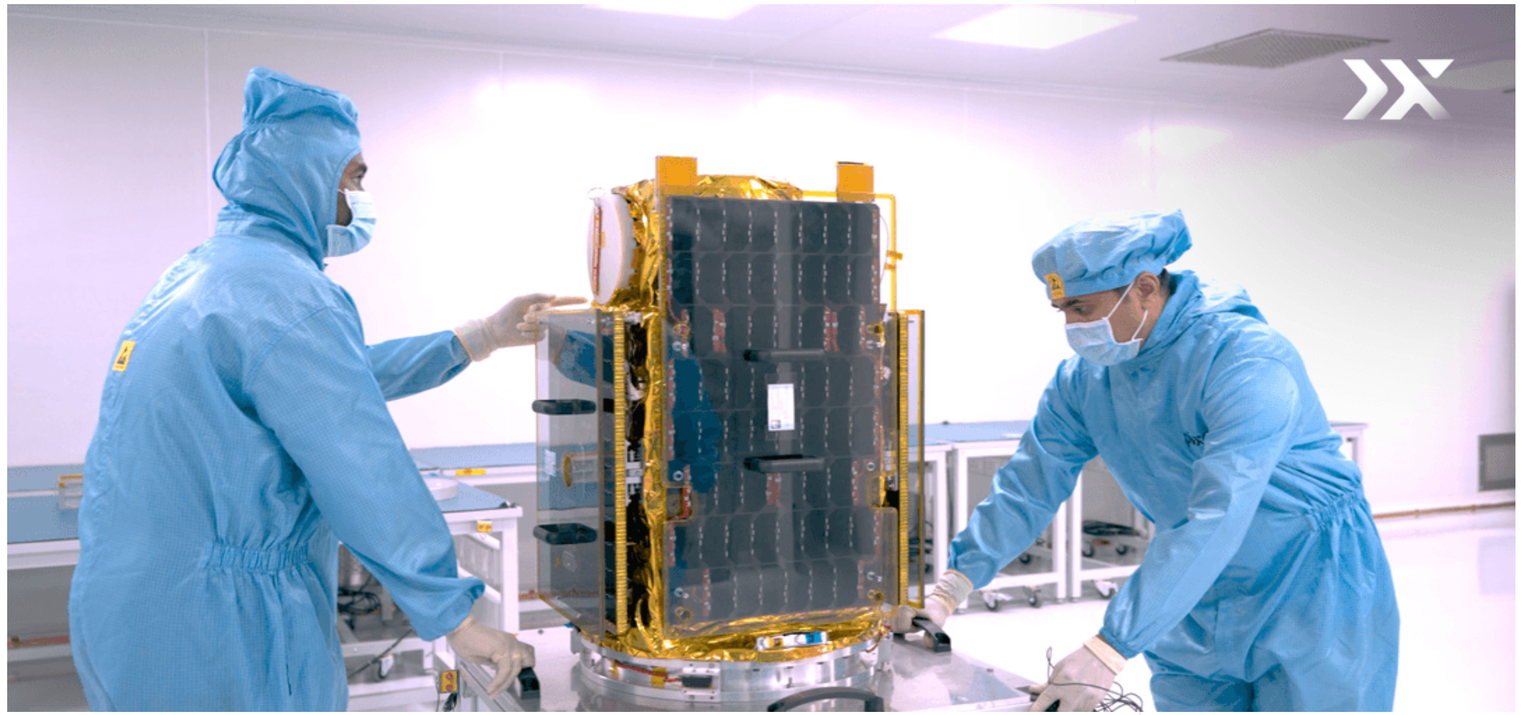
More than 7 million homes lack a high-speed internet option, according to the FCC National Broadband Map. Starlink is likely running into capacity constraints of its own as subscriber growth has slowed considerably in 2024 and the company raised prices. A major hurdle is that LEO satellite capacity is uniform, static, and mostly stranded over the oceans. Unlike with GEOs, with high-throughput spot beams, it is not possible to dynamically allocate more capacity where it's needed.

Over time, residential internet will become even more challenged. Starlink will continue to increase capacity by adding depth to its network and expand its subscriber base. It has 12,000 satellites approved to be deployed, which could increase as high as 42,000. New players include Amazon.com Inc.'s Kuiper, which will enter service with a planned constellation of more than 3,000 satellites half of which must be deployed by 2026.

SPECIAL REPORT

Why NASA is pulling back on its Earth observation satellites

By Andrew Parsonson



On 14 August, 2025, the acting NASA Administrator Sean Duffy appeared on Fox News and announced that the agency would no longer prioritise Earth science, choosing instead to focus on exploration.

"All the climate science and all of the other priorities that the last administration had at NASA, we're going to move aside, and all of the science that we do is going to be directed towards exploration, which is the mission of NASA," said Duffy. "That's why we have NASA, to explore, not to do all of these Earth sciences." Later in a social media follow-up, Duffy doubled down, stating that NASA would be getting rid of the "nonsense on climate change."

While the loss of NASA's more than $2 billion Earth science budget would undoubtedly have an impact on global efforts to understand our planet, this is an area where Europe not only contributes, but leads both in capability and spending. In 2024, the agency outspent NASA, with €2.3 billion allocated to Earth observation, accounting for around 30% of the agency's entire budget. A significant share of this budget is devoted to supporting the Copernicus programme, a crown jewel of European space efforts.

The Copernicus programme, jointly managed by ESA and the European Union, is the continent's flagship Earth observation initiative, featuring a fleet of Sentinel satellites equipped with a variety of instruments and sensors that continuously monitor the Earth's land, oceans, and atmosphere. The constellation delivers more than 25 terabytes of open-source data every day, giving scientists, businesses, public institutions, and citizens worldwide access to an unprecedented resource.

According to the European Union, Copernicus is the single largest provider of space-based Earth observation data in the world, supporting everything from climate-change research and weather forecasting to agriculture and disaster response.

Speaking on Europe's role in the field following Duffy's comments, Simonetta Cheli, ESA's Director of Earth Observation, told European Spaceflight that the agency was closely monitoring the situation and stressed the importance of maintaining Europe's leading role in Earth observation.

“NASA is a key global actor in the domain of Earth Science and Earth Observation. The partnership of ESA and other European actors with NASA in this domain is mutually beneficial to better manage the critical challenges of our planet, as well as serving many economic domains from agriculture to disaster management.”

“We are closely monitoring the debate on US Federal budget appropriations and look forward to continuing working with NASA – as well as other international partners – on Earth science for the benefit of our economies and citizens.”

“The current geopolitical context and discussion on budgets in the US underline how critical ESA and all European Earth Observation initiatives are – from technology developments to satellite missions to data processing and archiving. It is more critical than ever to ensure [the] continuation of the great strides made in Europe to use satellite Earth Observation to better understand and address pressing global issues.”

In addition to the capability offered by the Copernicus constellation, the past two to three years have seen something of a renaissance in European national Earth observation programmes.

In late 2023, Spain and Portugal began work on the Constelación Atlántica (Atlantic Constellation), each committing €40 million to build a 16-satellite Earth observation constellation. In November 2023, the UK contributed £3 million to the project, allowing the addition of a thirteenth satellite to the system. Once complete, the international partnership will use the data collected by the constellation to support the early detection of climate change indicators and the mitigation of natural disasters. The data will also be used to increase agricultural productivity and improve energy management.

In September 2024, Greece contracted OroraTech and ICEYE to deliver six Earth observation satellites for its National Microsatellite Programme. According to Deputy Minister of Digital Governance Konstantinos Kyranakis, the country plans to use the satellites to "protect key areas of interest, both on land and at sea." The contract awards for the constellation totalled €53 million.

Italy's IRIDE constellation is by far the most ambitious, with a €1.1 billion budget. The system will consist of Earth observation satellites of various types and sizes, combining SAR, optical, panchromatic, hyperspectral, and infrared sensors. According to the Italian government, once operational, IRIDE will be used to track the impacts of climate change and provide data to support startups and SMEs in developing commercial applications. An initial pathfinder satellite was launched in January 2025, followed by the first seven operational satellites in June.

Commercial Earth Observation

While ESA officials examine the fallout of NASA's shift away from Earth sciences, some commercial Earth observation operators in Europe see it as a potential opportunity.

“While NASA stepping back from Earth observation missions is unfortunate, it also highlights the growing opportunity for innovative companies to fill the gap and add value,” explained Thomas Grübler, Chief Strategy Officer and Co-Founder of OroraTech. “Private earth observation firms already offer a broad range of data and intelligence to governments and taxpayers, often at a much lower cost and with greater flexibility.”



OroraTech was founded in 2018 as a spin-off from the Technical University of Munich. As of mid-2025, it operates around ten proprietary thermal-infrared satellites, while also leveraging data from a broader network of over 25 satellites. The company aims to expand to a constellation of up to 100 satellites by around 2028.

“The potential rollback of NASA's Earth observation programmes should not be seen as a loss, but as a turning point,” said Anthony Baker, CEO and cofounder of SatVu. “It highlights the opportunity for Europe and the commercial Earth observation sector to step up and ensure the world continues to have access to the trusted data needed for climate resilience, security, and economic stability.”

“Over the past three decades, the commercial remote sensing industry has matured into a reliable, responsive partner - delivering data more efficiently and cost-effectively than government programmes alone. Just as telecoms shifted from a government monopoly to a commercial industry that now meets almost all global demand, Earth observation is at the same inflection point.”

Baker also acknowledged Europe's continued leadership in institutional Earth observation capabilities and noted how those institutions are already adapting to incorporate commercial operators.

“Europe is already showing leadership through strategic initiatives like Copernicus - the EU's flagship Earth observation programme - which guarantees independent, sovereign access to vital data. SatVu's recent award of a Category 1 Copernicus Contributing Mission contract with ESA is one example of how emerging European capability is being integrated into this system.”

London-based SatVu was founded in 2016 and provides high-resolution thermal data that provides actionable insights for environmental monitoring and industries such as energy and infrastructure. Its first satellite, HotSat-1, was launched in 2023, providing high-resolution thermal data to track heat loss, urban heat islands, and industrial activity.

Airbus Defence and Space, Unseenlabs, and ICEYE all declined to comment when contacted, referring inquiries to ESA for an institutional response.

While NASA's pulling back on its Earth observation satellites may be an inflection point for commercial operators, as Baker suggests, it's certainly not as simple as the statement may imply. The telecoms comparison, for example, is an incomplete analogy. At its inflection point, the telecoms industry had a vast potential market, with applications spanning consumers, businesses, and governments alike. Earth observation's potential applications are more niche, grounded in use cases for governments and businesses. While an individual may indirectly benefit from the data through, say, cheaper produce as a result of increased agricultural productivity, they are unlikely to have any need to engage with that data directly. Additionally, applications like climate change have limited commercial value beyond their value to governments and maybe the agricultural sector.

Europe's commercial capability is also still less mature than its institutional programmes, making it difficult for the industry to seize this opportunity. That imbalance was thrown into sharp relief in July, when Germany opted to procure Earth observation data services from US-based Planet Labs under a €240 million multi-year deal. The decision underscored a structural gap: while Europe leads in building institutional systems, its domestic commercial sector is not yet meeting the full scope of government demand.

Whether NASA's retreat proves to be a genuine turning point for commercial Earth observation or merely a temporary political detour, Europe appears focused and reliable. Through institutional programmes like Copernicus, ambitious national constellations, and a rapidly expanding commercial sector, the continent is positioned as a guarantor of vital climate and security data.

AFRICA REPORT

Unlocking potential of RF to address illegal mining in Africa

In West Africa, Niger is a landlocked country with broad participation in livestock and agricultural production, an industry highly vulnerable to external shocks like climate impacts, commodity price fluctuations, and cross-border disease.

According to the UN, 15 million people work in the Artesain small mining sector globally, including 4.5 million women and over 600,000 children. The Artesian small mining sector accounts for 20 per cent of the annual gold production. Artesian small mining business is a development opportunity and livelihood for rural populations. The rise in the price of gold, allowing for higher remuneration, has made this activity more attractive. Open sources mention regular gold rushes in the region. In Chad, the discovery of gold in the Baatha central region led to an important gold rush.

However, Niger remains one of the poorest countries in the world, with limited access to healthcare and education inhibiting development. Resource competition remains a problem for the country, particularly around the mining of gold. Major gold rushes occurred in 1984 and 2014 before the Government of Niger finally closed the approximate 25 sites in 2017. Despite the closure, extensive mining has continued, according to HawkEye 360 collections between January and June 2021 that showed ongoing RF emissions over known mining locations throughout the border region.

African country featuring among the top 10 gold producers in the world. The key gold-producing African countries are Ghana, Mali, Tanzania and Guinea. In total, there are at least 34 African countries producing gold, though only about 20 countries so far have been producing more than a ton per annum2, according to Geological Survey. The leading gold producers in the world are China, US, Australia, South Africa and Russia. In addition to gold that comes from mines, an additional 1,500MT of annual global output on average comes from recycling.

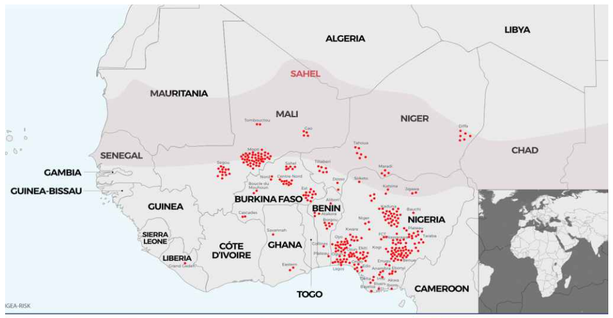
Over the years, artisan Small-scale Mining has continued to pose devastating impacts on the global environment and regional human health efforts. For instance, strip mining destroys landscapes through deforestation and land degradation, leading to flooding and depletion of nutrients from the soil, destroying wildlife habitats and harming species.

This practice poses health hazards to millions of poverty-stricken workers, including children forced to work in the hot sun and being exposed to a variety of health risks such as mercury pollution, dust inhalation, and problems due to accidents, overheating, and overexertion.

A significant number of gold mines are illegal meaning that they often do not pay the local or national taxes, and that the working conditions for the miners are dangerous. Using Digital Earth Africa's EO data and tools to identify gold mines will enable countries to know where the legal and regulated mines are, and where the illegal unregulated ones are. It is estimated if this could prevent just 10% of illegal mines it could generate savings of $900 million per year.

In addition, illegal mining also causes environmental damage by not complying with regulations to safeguard the natural world. This can be from releasing chemicals and minerals in the groundwater table and air, to deforestation, river diversion and biodiversity loss. Across Africa it is estimated that illegal gold mining cause's $1.4 billion damage to the environment, and so preventing just 10% of this loss would saving $140 million.

Due to the lack of machinery, it is a labor-intensive process that produces little output per person.



VARIOUS FARMER-HERDER CONFLICTS IN THE WEST AFRICAN SAHEL

However, the lack of capital required to initiate small-scale mining makes it attractive to groups in search of minerals.
It has become an important source of income for impoverished people in many of the least developed countries. An estimated 40.5 million people are involved worldwide, up from 6 million in 1993. The small scale industry is largely reliant on child labor and ecologically-dangerous techniques and it is growing all the time. However, poverty and growing demand for rare earth materials are seen to be the biggest factors driving the growth.

Africa holds a large share of global reserves for cobalt, manganese, graphite, copper, nickel, and lithium, making it a key player in the race to secure the critical minerals that underpin the global green energy transition and the world's technology needs.
According to the United Nations Conference on Trade and Development, Africa has 55 percent of global cobalt supplies, 47 percent of manganese, 21 percent of natural graphite as well as large copper, nickel, lithium, and iron ore reserves. It is unsurprising then that interest in Africa's mining opportunities is on the rise.
Regulating this mining is a major challenge, requiring constant vigilance from local governments and NGOs. Authorities have struggled to detect and mitigate artesian mining as expansive geography and lack of resources challenge consistent and effective monitoring. Today, Hawkeye 360's satellites are able to find RF frequencies across large regions of the globe, providing much-needed intel to help pinpoint the mining activity in vast wilderness areas.

South Africa remains another prominent example of growing presence of illegal artisanal miners or 'zama zamas' controlled by organised criminal networks. Illegal mining in South Africa, primarily in disused mines, has evolved into vast underground networks engaged in extortion, forced labour, and violent turf wars. The recent months-long standoff between police and zama zamas at an abandoned mine in Stillfontein, outside Johannesburg, for example, resulted in over 78 casualties after police cut off food and water supplies in an attempt to force the illegal miners out of the mine.

The Department of Mineral Resources and Energy estimates there are over 6,000 illegal mines across the country, costing the South African economy over USD 3 billion in lost revenue per year. The crisis is further fuelled by organised crime networks trafficking humans, weapons, and precious metals. And, in response, industrial miners have had to invest in heightened security as zama zamas increasingly infiltrate operational sites.
In January, Belgium launched a criminal probe into Apple Inc. after allegations by the Democratic Republic of the Congo DRC that the company had knowingly sourced minerals from conflict affected areas in the country. According to the law firm representing the DRC, Amsterdam & Partners LLP, the tech giant had used minerals supplied by the M23 rebel group in its supply chain. M23 has committed various human rights abuses in the eastern DRC, raising concerns among investors and consumers regarding the use of conflict minerals in Apple products
Across the continent, in Mali, Canadian mining company, Barrick Gold, has also found itself facing legal challenges after the ruling military junta accused the company of owing over USD 500 million in taxes; a claim Barrick Gold has denied. Though the legal dispute is still unfolding, the junta has taken strict
action against the company, restricting gold shipments from its Loulo-Gounkoto mining complex, seizing gold worth approximately USD 245 million, detaining in-country personnel, and issuing an arrest warrant for Barrick CEO Mark Bristow. Although these are vastly different cases, both serve as a stark reminder of the dynamic and complex nature of political risks in Africa's mining industry. These risks may be well known, but with the potential for high returns increasing amid growing demand for technology-linked minerals, the stakes for investors, governments, and even non-state actors are high.

Meanwhile, banditry and various farmer-herder conflicts have become a growing security concern for miners in the West African Sahel. Since 2019, for example, banditry in parts of Nigeria has escalated from robberies and communal clashes to sophisticated operations targeting natural resources, particularly gold and lithium. Zamfara and Niger states have become hotspots for illegal mining with over 100 armed groups and criminal cartels, often linked to foreign networks, operating in the region. Despite a five-year mining ban in Zamfara, imposed in 2019 to curb banditry, groups have continued to smuggle vast quantities of minerals into global supply chains, with illicit activities fuelling local insecurity. Recent security improvements led to the ban's lifting in December 2024, enabling legal mining to resume operations amid hopes of revitalising the state's economy, but challenges remain.
According to the Ghana Chamber of Mines and other studies, the rise in illegal mining activities can be attributed to various factors, including poverty, unemployment, inadequate enforcement of mining regulations, and the high profitability of gold and other mineral resources. The lure of quick financial gains has led to the proliferation of illegal mining operations, with widespread negative implications for the Ghanaian economy. Illegal mining has become a significant challenge in Ghana, with detrimental effects on the country's economic growth and development. The prevalence of illegal mining activities poses various environmental, social, and economic risks, hampering sustainable development goals.

Illegal mining is organised and sustained by crime syndicates. This means that illegal miners are often heavily-armed criminals who
murder those trying to stop their activities. They not only trespass on operating mines, but will set ambushes and booby traps to ward off rivals, or ward off our employees. When arrested, criminal miners are primarily charged with trespassing and often escape prosecution for the criminal offences they commit. The purpose of illegal mining is to steal product like gold-bearing material or similar valuable minerals. Unless they are found in possession of such product, illegal miners cannot be charged with theft of gold and minerals.



The HawkEye 360's RF Data effect

In July 2021, HawkEye 360 observed the emergence of new Radio Frequency activity about 8 km away from an area associated with previous mining near Djado. Soon after, Planet medium-resolution imagery began to show a new and quickly growing ASM site. Between June and July, the mining expanded from roughly 11.5 hectares to 160 hectares in size.

HawkEye 360 tasked Planet's high-resolution Skysat constellation to further characterize what was happening on the ground.
Planet Labs' high-resolution imagery revealed soil disturbances indicative of ASM practices in this region. The Djado Plateau is alluvial, with gold deposits close to the surface the kind easily revealed with earth-moving equipment or hand tools.
The Planet collection identified extensive topsoil scraping and at least one bulldozer: potential indications of a newly discovered and particularly productive gold site. Imagery also showed discolored spoils and tarped shelters, indicating soil contamination and further on-site processing.

HawkEye 360's constellation regularly examines the use of radio frequency (RF) equipment across vast regions of Africa, covering thousands of square kilometers per satellite pass.

Since Hawkeye 360 can detect and locate communication signal emissions from a wide variety of radios and satellite mobile devices, this offers valuable information needed to find human activity. HawkEye's RF geospatial data serves as a powerful tool to monitor Artesian mining networks and flag their locations for further inspection, both assessing ongoing mining and offering early warning of new site development.

In this recent analysis of RFGeo™ data, HawkEye 360 first discovered many instances of L-band mobile satellite communications occurring in the Sahara Desert, where settlements were not otherwise present. L-band is often associated with industrial operations in remote areas where other forms of communication are not available. This signal became the tip for a deeper examination, to identify what activity was occurring in this sparse terrain.

HawkEye 360 partnered with the commercial imaging firm Planet to access near-daily, medium-resolution, electro-optical imagery. The imagery showed mining associated with the RF signals. Once a mining site was validated with medium-resolution imagery, analysts investigated further by using high-resolution imagery to classify the type of mining visible. This approach is cost-effective and streamlines workflows by quickly zeroing in on the activity of interest without wasting other resources.

Unleashing LEO satellite networks in the maritime shipping

The maritime industry has long been an essential driver of global trade and commerce, facilitating the movement of goods and people across vast distances. However, despite the advances in ship technology and navigation, the industry has faced persistent challenges in communication and connectivity.

In recent years, the introduction of Low Earth Orbit (LEO) satellite networks has presented an opportunity to revolutionize the way maritime stakeholders communicate, enhancing operational efficiency, safety, and crew welfare.

In late 2022, Japanese shipping company, Mitsui O.S.K. Lines (MOL), agreed with smart hybrid digital solutions provider Marlink to integrate the LEO satellite network service, Starlink powered by SpaceX, alongside its Sealink (GEO) VSAT service and its digital platform on selected vessels in the MOL fleet. After trials on actual ships, MOL verified how Marlink's unique network can enhance operating safety and improve high-speed communications for seafarers. Starlink high speed, low latency connectivity will form an integral part of this hybrid solution.

"High expectations accompany high-speed internet onboard. Not only does it promise smoother business operations and enhanced safety, but it also significantly impacts the welfare of the crew. A happy crew makes for a happy ship. Poor internet affects our work, especially when sending important emails and correspondences related to port requirements. It also impacts our personal lives when our data is consumed waiting for connectivity to talk with our families. With high-speed internet, our life onboard becomes easier and happier.

As a Master onboard, I want to see my crew happy, just like a father wants to see his children happy. A satisfied and motivated crew leads to safer operations and overall improved ship safety. High-speed internet is not just a luxury - it's a necessity for our well-being and effective operations onboard."

Satellites are typically launched into one of three popular orbits: LEO at 160 to 2,000 kilometers, medium Earth orbit (MEO) at 2,000 to 35,786 kilometers, or geosynchronous orbit (GEO) at up to 42,164 kilometers. All three orbits have varying advantages and challenges for satellites operating within them. For instance, a constellation in GEO can have global coverage with only three satellites because of its distance from the Earth's surface; GEO is popular for communications for this reason. However, because the satellites are so far away from Earth there is a longer period of latency, for instance, the time it takes for the signal to route to a satellite in GEO and back down to Earth.

The maritime industry has long relied on traditional satellite systems, such as Geostationary Earth Orbit (GEO) satellites, for communication and connectivity. However, communications from LEO also experience a lower latency than satellites in GEO because they are so much closer to the Earth's surface. LEO satellite operators tout that a web page can be opened around eight times faster when using LEO satellites than when using a traditional SATCOM system at GEO, something that has become more important to consumers who want to interact online in near-real time.

In the Seafarers Happiness Index (SHI) 2023 Q1 report, seafarers shared their experiences and thoughts on the current state of connectivity at sea. While there were positive sentiments regarding the affordability of contacting family and the stress relief provided by online access, several issues remained. Respondents noted concerns about the quality of internet connections, data allowances, and speed, as well as disparities in connectivity experiences across different companies and even within the same fleet.

The SHI report highlighted the importance of reliable and affordable internet connectivity for seafarers to maintain communication with their families, manage their work-life balance, and access information and entertainment. Challenges with data allowance, speed, and availability, as well as variations in connectivity across company fleets, suggest the need for improvements in the provision of internet services to seafarers to enhance their well-being and job satisfaction.

This means that satellite internet are capable of supporting high-throughput applications such as streaming, video conferencing, and real-time gaming. At the time of publication, LEO broadband constellations are capable of download speeds up to 250 megabits per second (Mbps), upload speeds of 30 Mbps, and latency of 25 milliseconds. This can be compared to cable internet, which in the United States can reach download speeds of up to 500 Mbps and upload speeds of 50 Mbps, with 100 milliseconds of latency. As more satellites are added to each constellation, these numbers will continue to improve for each respective provider.

MOL's analysis, which would be recognized by many of today's shipowners – defines the impact on efficient vessel operations and crew welfare services in terms of three major gaps: time, information, and quality of life if sufficient bandwidth is not available.

First, low bandwidth allows vessel crew to receive information only at irregular intervals instead of on a real-time basis. Communication can take time to establish, causing issues in case of emergencies because the Master and crew must create a text-based report for shoreside teams, rather than being able to convey the situation via video.

Real-time data can be hard to access because network stability depends on the circumstances at the vessel's location. For example, when a vessel encounters heavy weather, it is most in need of real-time weather data and forecasts, but access may not always be possible.

Next, low bandwidth availability allows crews to receive only limited information from shore which can make it harder for them to understand what's going on in their company or at home, which makes them feel isolated.

Lastly, because of bandwidth scarcity, crews onboard ships must be highly self-sufficient. Even when crew members are injured or sick, they must manage the situation by themselves. In terms of entertainment onboard, the options are highly limited. Crews are mainly restricted to outdated movies or entertainment using physical media. They can enjoy their local food only if a versatile cook is onboard or if it is possible to translate recipes.

For ships and other operators in Polar regions, Antarctic circle connectivity has always been a valuable resource. While conventional satellite networks can be used in Polar regions, each will face challenges when used on a standalone basis.
Polar connectivity currently available is heavily impacted by the latitudes at which users operate. Both Arctic and Antarctic regions extend from their respective Polar circles at 66.5 degrees north and south to the geographic north and south poles. Between 65.5 degrees and 80 degrees, network choice and throughput are close to normal, but both become more limited above 80 degrees. In a Polar hybrid network, Ku-, Ka- and C- band VSAT provides the main conduit for data in addition to smaller vessels and late broadband adopters who still use low throughput satcom services.

For conventional Polar connectivity, it has traditionally been the case that bigger equipment provides a better signal and 'more means more'. Physics determines that a larger dish will deliver a more efficient service, utilize bandwidth better and increase the user's chances of staying connected at high altitudes compared to a smaller antenna.

A larger, higher powered 2.4m VSAT antenna will have the ability to provide higher throughput and better service quality at the edge of coverage areas. A 1m antenna might provide slightly lower speeds but still deliver acceptable service quality for most vessels sailing in the region. Once again this equation will be altered by the availability of new NGSO constellations. New constellations in Low Earth Orbit will need less power and can use smaller antennas but still promise high throughput.

Where ships sail will of course depend on the markets they serve and in the case of cruise operators and research there is some demand in the southern Antarctic peninsula. Northern regions are expected to be a much larger consumption market, with voyages to Svalbard and Greenland and more extreme journeys to the geographic North Pole.

LEO Satellites: Soaring to new heights

LEO satellite networks offer a groundbreaking solution to the connectivity challenges faced by the maritime industry. Orbiting at an altitude of 1,200 kilometers or less, LEO satellites are significantly closer to Earth than their GEO counterparts. This proximity allows for lower latency, higher data transfer speeds, and more consistent global coverage, including hard-to-reach polar regions

LEO networks are comprised of hundreds or even thousands of small satellites, working together in a constellation to provide continuous, seamless coverage. This approach ensures that even if one satellite fails or becomes obstructed, others in the constellation can compensate and maintain connectivity. The launch of mega-constellations, such as SpaceX's Starlink, OneWeb, and in the future Amazon's Kuiper has accelerated the development and implementation of LEO technology, making it a more viable option for industries like the maritime industry that require reliable, high-speed communication.

The introduction of LEO satellite networks holds the promise of greatly improving connectivity in the maritime sector, offering more efficient communication, enhanced safety measures, and better overall crew welfare. In the next section, we will delve into the wide array of LEO satellite network applications that stand to benefit the maritime sector, as well as explore the direct impact on crew welfare. We will also discuss the challenges that must be addressed to fully harness the potential of this groundbreaking technology.

Future of maritime connectivity

With low-latency, high-speed data transfer capabilities, LEO satellite networks enable seamless real-time communication between vessels and shore-based offices, improving operational efficiency and decision-making. Maritime professionals can access vital data, such as weather updates, navigational charts, and route optimization information, allowing them to make well-informed decisions and respond more effectively to changing conditions.

LEO networks can improve safety and emergency response by providing reliable, high-speed communication, even in the middle of the ocean. This ensures that vessels can maintain contact with rescue services, monitor distress signals, and access vital information during emergencies. Additionally, the



ability to share real-time data and analytics can help in identifying potential risks, preventing accidents, and reducing response times. Vessels will be able to share real-time navigational data with shore and carry out remote inspection and troubleshooting with shore-based teams. Maintenance procedures can be upgraded to include streaming services for tutorials and Augmented and Mixed Reality devices with experts assisting crew onboard.

The adoption of LEO satellite networks can accelerate the integration of advanced Internet of Things (IoT) and automation technologies in the maritime industry. Enhanced connectivity facilitates the collection and analysis of large volumes of data from sensors and devices installed on vessels. This data can be used to optimize ship performance, predict maintenance needs, and enhance the overall efficiency of maritime operations.

Additionally, vessels can be equipped with sensors to collect and share real-time information about weather conditions, piracy activities, and other incidents in their vicinity. This shared network of data enables better situational awareness and decision-making for the entire maritime community, leading to improved safety and operational efficiency.

LEO satellite networks can play a critical role in streamlining the supply chain and logistics operations by providing continuous, real-time tracking of vessels and cargo. This enables stakeholders to optimize their

operations and minimize delays, improving the overall efficiency and profitability of the maritime sector. In the longer term, vessel operations will become more automated, not in terms of crew presence, but potentially in making their own operational decisions without the assistance of shore staff.

The introduction of LEO satellite networks promises to revolutionize the maritime industry, addressing long-standing connectivity challenges and opening new possibilities for enhanced communication, safety, operational efficiency, and crew welfare. By enabling real-time decision-making, advanced IoT and automation technologies, streamlined supply chain and logistics, remote medical assistance, and diverse entertainment options, LEO networks have the potential to significantly improve the lives of seafarers and bolster the overall performance of the maritime sector.

However, to fully harness the benefits of LEO satellite networks, it is crucial to overcome the challenges related to regulatory hurdles, international waters regulations, cost and infrastructure. Collaborative efforts among LEO satellite operators, regulatory bodies, and the maritime industry are essential to develop harmonized regulations, and affordable infrastructure solutions.

As the maritime industry continues to evolve and adapt to new technologies, the widespread adoption of LEO satellite networks can pave the way for a more connected, efficient, and resilient global maritime ecosystem. By investing in LEO network technology and addressing the associated challenges, stakeholders in the maritime sector can unlock new opportunities for growth and innovation, while significantly enhancing the well-being and job satisfaction of seafarers who are at the heart of this vital industry.

Thanks to a recent regulatory change by the IMO, maritime users can also access the Global Maritime Distress and Safety Service, reporting safety incidents using L-band LEO services at both poles, marking the first time the service has been extended to truly global coverage.

Despite the lower level of human activity in Polar regions, the bandwidth scarcity is set to change when the new Non-Geostationary constellations begin to offer commercial services. The increase in demand from merchant and cruise shipping, military and government users will be addressed by the emergence of these new satellite services which will provide close to seamless coverage in the areas north and south of 80 degrees where VSAT is not available.

SPECIAL REPORT

Humanity’s battle against the sun



Cin 1859, the most powerful solar storm on record, also known as the Carrington event, caused widespread telegraph outages and even fires across North America and Europe, when electrification was still in its infancy. Since that extraordinary event, various geomagnetic storms, although less intense, have left their mark across the globe.
The heavy reliance of modern society on technology, which continues to expand exponentially, leaves us highly vulnerable to the consequences of a major solar storm. Such an event could disrupt the lives of millions and cause very extensive damage. This could include direct and widespread damage to vital infrastructure, including power grids, digital communication networks, and satellite systems.

A Carrington-scale event today would have severe consequences for our societies. It has been estimated that, 20 to 40 million people could be without electricity for a period of between 16 days and 1-2 years.
Some studies have estimated that it could take weeks, and possibly months, to repair damage to the power grid system from an extreme geomagnetic storm. The worldwide losses due to an extreme magnetic storm would be between $7bn and $42bn per day, according to a report.
Although strong solar storms are rare events, the question is not whether they will occur, but rather when the next one will take place.

However, determining the frequency of extreme space weather events is extremely difficult, yet various estimates suggest that relatively strong events happen about every 50 years, and anything between 150 to 500 years for extreme storms such as the Carrington event. Whilst the future behaviour of the sun remains difficult to predict, the 11-year solar cycle, with its solar peaks, is a useful factor in helping predict solar weather events. The next solar peak is expected in 2025.

In the short to medium term, the economic repercussions of a Carrington-scale solar storm would be felt first when technologies which are integral to our daily lives start to fail. For instance, financial payment systems could be blocked, with credit cards no longer usable as transactions rely on satellite systems. This could lead to significant disruptions in financial transactions, creating major challenges for the integrity of the banking system.

Simultaneously, stock markets could experience turmoil, with temporary shutdowns leading to market instability. The solar storm would also impact on the supply chain, which could extend across various sectors, including agriculture, food supplies, and water distribution systems. In addition, transport networks, including air, sea, and land routes, would face significant difficulties. Similarly, air traffic control systems could experience malfunctions, and electric vehicles might cease to operate and recharge effectively.

Overall, these circumstances could generate substantial economic disruption, hitting growth and putting strains on financial systems as countries struggle to repair damaged systems, whose aftermath of a solar storm would lead to a series of social challenges.

However, prolonged disruptions could trigger a temporary dislocation of population from the most severely affected areas. Among the most vulnerable would be the older generations, who would have to face the consequences of failing heating and cooling systems. This could result in an increase in weather-related health issues and place additional strain on healthcare access, which might in turn be more difficult to access due to technology failure.

In order to address some of these challenges, authorities might need to establish distribution centres for essential supplies. In the wake of a solar storm, security concerns will loom large, necessitating for instance immediate action to avert incidents at nuclear plants. The implications extend to external security, affecting weapon systems and military strategic communications, potentially deteriorating the ability of the military to respond to opportunistic actions by state or non-state actors. Extremist groups might take the opportunity to exploit vulnerabilities and further destabilize the situation. The disruption to communication systems and the difficulties of authorities to cope with a wide range of cascading effects could lead to a surge in disinformation, fueled by the blame game and a proliferation of conspiracy theories.

Nonetheless, the magnitude of the crisis could strain governments 'ability to respond effectively. Faced with limited resources, prioritizing support, especially in restoring power supplies, would constitute a significant challenge. Also, tensions and divisions may emerge, at both the national and European level, as the question of solidarity comes to the fore. Solar storms can have a prolonged duration, occurring in successive waves. That means they might initially strike a region thousands of kilometers away but can hit closer to home in the subsequent days. For this reason, national authorities might be reluctant to lend critical plant such as spare transformers out of concern that they might need them themselves.

Space weather event and Space-X Starlink launch

A NASA-led study has revealed that Solar storms are dramatically shortening the lifespan of low-orbit satellites, particularly affecting SpaceX's Starlink devices. During the recent solar maximum, some satellites re-entered the atmosphere after just five days, well below its expected operation of fifteen. The phenomenon, observed between 2020 and 2024, has coincided with the massive deployment of satellite constellations, generating a new front of risk for space infrastructure. The scientific community warns that we are facing an unprecedented scenario in the history of modern space exploration.

The peak of solar maximum in late 2024 triggered a wave of geomagnetic storms that seriously affected satellites in low Earth orbit LEO. The team led by Dr. Denny Oliveira at NASA demonstrated how these solar flares heat and expand the upper atmosphere, increasing friction on the satellites and accelerating their fall.
In the specific case of Starlink, 37 satellites re-entered the Earth's atmosphere after only five days of operation, when they were expected to last fifteen. This acceleration not only represents a high economic cost, but also introduces an unprecedented operational uncertainty for the mega-constellations currently orbiting the planet. Between 2020 and 2024, 523 Starlink satellite re-entries have been documented, demonstrating structural fragility in the face of extreme solar events.



Benefit disguised as threat

Interestingly, the phenomenon also brings with it an unexpected positive effect: the fastest cleanup of inactive satellites from low orbit. As solar weather intensifies, atmospheric drag increases facilitates natural deorbitalization from old satellites, thus reducing the risks of space debris.

However, this same effect also complicates planning of active missions. What was once a stable operating window of weeks can now be reduced to days. Fully operational satellites, designed to operate for up to 15 days, are hurled back to Earth after just 120 hours. The era of solar maximum is testing the robustness of traditional orbital models and forces companies to integrate solar variables into their navigation and prediction algorithms.

Pieces of heaven on solid ground

Although Starlink satellites are designed to disintegrate completely during reentry, reality has shown that Not all components volatilize. In August 2024, a 2,5 kg piece fell intact on a farm in Saskatchewan, Canada. This raises questions about the physical risks to people on land.
The frequency of these re-entries could increase from weekly to daily as the Starlink network grows toward its goal of more than 30.000 satellites. The design and materials of satellites will have to be reconsidered, prioritizing complete and safe disintegration. Meanwhile, the unpredictability of solar storms threatens to turn every launch into a gamble.

A storm of challenges for the orbital future

SpaceX engineers face a new generation of orbital problems. It is no longer enough to calculate clean trajectories: now they must anticipate solar disturbances, adjust altitudes, reinforce propulsion systems and, above all, ensure the continuity of service under unforeseen conditions.

Starlink users already reported service interruptions during a solar storm in May 2024, which casts doubt on the reliability of the promised global coverage. As the Sun becomes a leading player in the private space race, the sector will need to innovate not only in hardware, but also in orbital resilience models.

The interaction between solar weather and orbital technology is no longer an academic curiosity: it is a real and constant threat 21st-century space infrastructure from satellite internet to climate observation and defense relies on devices operating in an increasingly unstable region of space. And the unpredictable and brutal sun has begun to flex its muscles.

This new context demands a profound transformation in how we design, deploy and operate satellites. The era of mega-constellations requires adapting to more aggressive atmospheric dynamics, integrating solar factors into every technical decision. More than a matter of engineering, it's a matter of orbital survival. If the last century was that of the lunar challenge, the present one will be that of the battle against the sun. A silent race, but one laden with very tangible consequences.

APPOINTMENTS

Starlab Names Marshall Smith Chief Executive Officer

Starlab appoints Marshall Smith as chief executive officer to lead the next phase of growth, advancing the company from design into development and flight. “Tim's leadership of Starlab's formulation and design positioned us strongly for the next phase,” said Jim Bridenstine, Starlab Board of Directors and former NASA Administrator. “As we approach critical design review, Smith will carry that momentum forward to development and flight. Our commitment to the next commercial LEO destination and a continuous human presence in space remains unwavering.”

Smith's 30+ years of NASA experience and leading large-scale programs such as Artemis, Gateway and Aries I-X is critical as Starlab advances into hardware development. His early involvement in Starlab's Space Act Agreement and recent tenure as president of Space Solutions at Voyager Technologies allows him to hit the ground running, enabling execution and AI-driven solutions.

Kopra built and led the team through 25 milestones for NASA, a significant achievement, and his astronaut experience was instrumental in shaping Starlab's formulation and initial design. He is now promoted to Chief Human Exploration Officer at Voyager Technologies, bringing his extensive experience to attract new customers and partners to Starlab.

“Starlab is one of the most advanced commercial LEO destination programs in development, with a clear path to meet NASA's schedule and technical requirements under any scenario,” said Smith. “Our commercial LEO destination model leverages private investment – reducing NASA's long-term station costs – and maximizes commercial industry's ability to deliver technology and innovation. It's important, not just to me personally, but to our country, that we maintain our leadership in space, and I'm ready to lead Starlab to do just that.”

Avio announces appointment of new head of investor relations

Avio S.p.A., announces that the Board of Directors had resolved to appoint Nevio Quattrin new Head of Investor Relations, effective today. Nevio Quattrin, who has been overseeing the Company's investor relations activities since February 2024 in support of the *Chief Financial Officer*, will thus ensure continuity in managing the relations with investors, at the same time further consolidating his position in Avio. Starting from today, Nevio Quattrin will take over this role from Alessandro Agosti, who resigned on May 30. At the date hereof, Nevio Quattrin does not hold any share in the Company.

Donald Tremblay Joins Telesat as Chief Financial Officer

Telesat, one of the world's largest and most innovative satellite operators, announced the appointment of Donald Tremblay as its new Chief Financial Officer (CFO), effective October 20, 2025. A highly experienced CFO, Mr. Tremblay brings over 35 years of financial expertise and leadership, including at publicly listed companies in high-growth, capital intensive industries. He has deep experience in equity and debt capital market transactions, mergers and acquisitions, compliance, and risk management. Mr. Tremblay will be succeeding Andrew Browne, who announced in March of this year that he would be retiring after serving as Telesat's CFO since 2019.

Most recently, Mr. Tremblay served as CFO of Champion Iron, where he was responsible for managing the company's finances and treasury, playing an important role in positioning the company to successfully execute its operating and growth strategies. During his tenure as CFO of Transalta, he restructured the company's balance sheet to strengthen its financial position and enhanced its capital management discipline. As CFO of Brookfield Renewable, Mr. Tremblay played an instrumental role in growing the organization's market capitalization from $300 million to over $2.5 billion.

“Donald's extensive leadership experience, broad financial expertise, and deep understanding of capital markets make him a valuable addition to Telesat's executive team,” said Dan Goldberg, President and CEO of Telesat. “We look forward to welcoming him onboard as we execute on our compelling growth plans with a focus on delivering the highest quality services to our customers and creating significant value for all of our stakeholders.”

ReOrbit Appoints Simon Wheeler as VP of Software

ReOrbit, a leading manufacturer for sovereign communications satellites, has appointed Simon Wheeler as VP of Software, effective August 2025. Simon brings over two decades of experience in the space and telecommunications industries, having held senior roles at Thales Alenia Space, SCISYS, and other engineering-focused companies. His expertise spans the full software product life cycle, from embedded flight systems to ground operations, AIT and EGSE—alongside experience in managing safety-critical systems and leading cross-functional engineering teams.

“Simon's deep experience in software engineering and leadership across both embedded and mission-critical systems makes him an ideal fit to lead ReOrbit's software efforts,” said Sethu Saveda Suvanam, CEO and Founder of ReOrbit. “As we continue to advance our software-defined satellite architectures, his experience and leadership skills will be key assets ensuring mission success,” Suvanam continues.

French former NATO commander joins military AI start-up Alta Ares

General Philippe Lavigne has joined young French firm Alta Ares to develop its business within NATO. In particular, Lavigne will be promoting the company's Shahed-136 artificial intelligence system for drone detection. A strategic tool at a time when both Kyiv's and Tel Aviv's respective anti-aircraft defences have been overwhelmed by massive attacks by these aircraft.

General Philippe Lavigne, French Air and Space Force, has completed his three years in charge of Allied Command Transformation. In the most challenging period the Alliance has known in a generation, General Lavigne has worked diligently to prepare NATO for the future by developing the Alliance's military instrument of power.

From 2018 to 2021, he served as Chief of Staff of the French Air and Space Force, overseeing strategic operations, modernization efforts, and international defense cooperation. Most recently, from 2021 to 2024, he was NATO's Supreme Allied Commander Transformation, responsible for Anticipation with strategic foresight analysis, for operational Strategy to capability development through Transformation including innovation, and for Talents challenges, across the Alliance.

A seasoned fighter pilot, Philippe has flown over 2,000 flight hours, including more than 50 combat missions in the former Yugoslavia and Iraq. He has led key military operations, including in Afghanistan as the last French forces commander and the Director of the Kabul international airport. His expertise spans defense policy, space and European security cooperation, operational strategy and military technology innovation.

GHGSat Appoints Sonia Kim as Chief Product Officer

GHGSat, the global leader in emissions-monitoring technology, announced the appointment of Sonia Kim as its new Chief Product Officer (CPO). Kim will lead GHGSat's global product strategy with a sharpened focus on advanced analytics, building new pathways to integrate emissions intelligence into decision-making across carbon-intensive industries, governments, and financial institutions.

Kim joins GHGSat from S&P Global's Sustainable1 (S1), where she served as Global Head of Product and Managing Director. At S1, Kim spearheaded the development and launch of the company's inaugural sustainability data solutions suite, enabling global clients to evaluate risk and unlock opportunity across financial assets and corporate operations. Her leadership was pivotal in integrating the capabilities of acquired firms, driving innovation in ESG Scores, Climate & Nature Risk, and overseeing cross-divisional collaboration as the chair of the S&P Sustainable Product Leadership Council. Before joining S&P Global, Kim served in leadership roles in strategy, research, and product development at organizations including Moody's Analytics and Fitch Solutions. Kim holds an MBA from NYU Stern School of Business and a Bachelor of Arts from Barnard College.

Space Forge appoints Scott White as Chair of the Board to accelerate next phase of growth

Scott White is a highly respected serial entrepreneur and deep tech leader, best known for founding and leading Pragmatic Semiconductor for over a decade. He raised more than $400 million, established Pragmatic as a pioneer in flexible electronics, and championed applications of its technology across sustainability, healthcare, and national security.

He has been directly involved in 9 other startups spanning telecommunications, photonics, machine learning, and advanced manufacturing, and currently chairs boards in robotics, quantum computing, and space technology. White is also an advisor to two venture capital funds, a member of the UK Government's Semiconductor Advisory Panel, and was named Deep Tech Entrepreneur of the Year at the 2022 Enterprise Awards.

In June 2025, Space Forge successfully launched its ForgeStar-1 satellite, receiving the UK's first licence for in-space manufacturing. Still currently active, the mission will demonstrate the company's capability to manufacture advanced materials in microgravity, validating Space Forge's model as the world's first dedicated materials production business in space.

Building on the success of ForgeStar-1, Space Forge is now preparing for its next missions, moving from proof-of-concept to sustained, scalable materials manufacturing in orbit. By harnessing the unique conditions of microgravity, the company aims to deliver breakthroughs in semiconductor material production, addressing the global demand for ultra-high quality substrates that underpin next-generation technologies in quantum computing, telecommunications, and advanced electronics.

Scott White's appointment as Chair comes as Space Forge moves towards its Series B raise. His expertise in the semiconductor sector, coupled with his deep experience in scaling technology companies and raising substantial growth capital, will be instrumental in positioning Space Forge as a global leader in advanced materials, with a presence in the UK, US, and international markets.

True Anomaly appoints Sarah Walter as Chief Operating Officer

True Anomaly Inc., the defense technology company building advanced systems for space superiority, announced the appointment of Sarah Walter as Chief Operating Officer. Walter brings nearly two decades of leadership in aerospace, defense, and advanced manufacturing. At True Anomaly, Sarah will lead the company's cross-functional strategy and execution across spacecraft engineering, manufacturing, supply chain, programs, and mission operations teams, ensuring disciplined and efficient execution on all efforts that support the delivery of spacecraft and software systems.

“Sarah is a standout leader in the aerospace industry. She brings the right expertise to leverage our high-speed tempo and accelerate our growth into an enduring prime contractor,” said Even Rogers, CEO and co-founder of True Anomaly. “Sarah will ensure that our operational capabilities match the ambitions of our mission, combining the disciplined systems engineering, supply chain rigor, and quality standards she honed at Rolls-Royce with the execution speed and adaptability she proved at York. Sarah will be a force multiplier for True Anomaly's mission success by creating the operational environment in which our teams can consistently deliver breakthrough space superiority capabilities.”

As COO, Sarah will align engineering operations across spacecraft and software programs, ensure success of upcoming Mission X-3 and VICTUS HAZE missions, and will architect the operational framework to deliver complex systems at scale, on schedule, and with the performance and agility required for space control missions. Sarah will not just manage operations—she will shape the culture, tempo, and execution standards that define True Anomaly's long-term competitive edge.

Phantom Space Appoints Chris Crosby of Compass Datacenters to Board of Directors

Phantom Space Corporation has announced the appointment of Chris Crosby of Compass Datacenters to Board of Directors to drive its mission of revolutionizing access to space through scalable launch systems, modular satellites, and orbital data infrastructure.

Crosby is best known for founding and scaling Compass Datacenters into one of the world's premier providers of modular, mission-critical data center infrastructure. Since its launch in 2011, Compass has become a trusted partner to the largest cloud and hyperscale customers globally, thanks in large part to its manufacturing style



approach to delivering large-scale, long-lived data center campuses. Under Crosby's leadership, Compass has raised and deployed over $5 billion in debt and structured capital to fund its rapid expansion, making one of the nation's fastest growing companies according to Inc. Magazine and the Financial Times. Through years of exponential growth, Compass has maintained strong unit economics and cultural cohesion across global teams. “Chris has done what few in infrastructure have, he's built a platform at industrial scale without losing agility, fiscal discipline, or soul,” said Jim Cantrell, Co-founder and CEO of Phantom Space. “As Phantom scales into its next growth phase, expanding launch cadence, deploying orbital infrastructure, and securing long-term commercial and government contracts, Chris's operational insights and capital expertise will be invaluable. He brings a rare blend of systems thinking and leadership rooted in values.”

Crosby's experience includes leading global operations at Digital Realty Trust, where he managed billions in data center assets and helped transform the company into one of the largest REITs in the world. With a background in institutional capital structuring, enterprise sales, and technical operations, he understands how to scale complex physical systems while aligning culture, governance, and capital strategy. His leadership has earned him accolades across the technology and real estate sectors, and Compass has been repeatedly recognized for growth, innovation, and employee experience.

“I've spent my career building infrastructure that disappears into the background—quietly powering the digital world,” said Crosby. “What Phantom is building in orbit will be no different: foundational, resilient, and largely invisible, but essential to the future of communications, autonomy, and national security. The company has the right team, vision, and technical core. I'm honored to join the board and contribute what I can to support Phantom's mission.”

Phantom's multi-pronged model, combining mass-manufactured launch vehicles, modular satellite platforms, and the Phantom Cloud orbital data network, mirrors the vertically integrated, high-reliability systems that Crosby has championed throughout his career. His focus on culture and clarity has driven strong employee engagement and repeatable results at Compass, and he brings the same lens to Phantom's leadership team and board.

Astroforge welcomes Dr. Dante Lauretta as strategic advisor

Astroforge announce that Dr. Dante Lauretta, principal investigator of NASA'S Osiris-rex mission, has joined the company as a strategic advisor. Dr. Lauretta, a Professor of Planetary Science and Cosmochemistry at the University of Arizona's Lunar and Planetary Laboratory, has spent his career at the forefront of asteroid science and planetary exploration. As the Principal Investigator of NASA's OSIRIS-REx mission, he led the team that successfully collected and returned a sample from the near-Earth asteroid Bennu—marking one of the most significant achievements in modern space exploration.
His groundbreaking work has deepened humanity's understanding of the origins of the solar system, the role of asteroids in delivering the building blocks of life, and the potential hazards they pose to Earth. Under his leadership, OSIRIS-REx not only advanced planetary science but also provided vital insights into the composition of asteroids—knowledge that will directly inform the development of sustainable asteroid resource utilization.

By joining AstroForge as an advisor, Dr. Lauretta brings his decades of experience in mission leadership, spacecraft operations, and planetary materials science to the company's bold vision of harvesting resources from near-Earth asteroids. His guidance will be instrumental in refining AstroForge's approach to mission planning, target selection, and technology development as the company works to commercialize extraterrestrial resources.

“The best minds in science and engineering are helping AstroForge undertake one of the hardest endeavors in space. Dr. Lauretta led OSIRIS-REx as a scientific mission, and now his expertise will help us commercialize this work. His unparalleled knowledge in asteroid science and exploration aligns perfectly with our mission to make space resources accessible. Having the leader of the OSIRIS-REx mission advising our efforts is a tremendous validation of our approach.”

Earth Observation to address agricultural production challenges



Food security is one of the world 's most pressing challenges in the face of a continuously increasing world population, and even more so as climate change puts more pressure on the natural resources we depend on.
Food security at the individual, family, national, regional and global levels is when all human beings have, at all times, physical and economic access to sufficient and healthy food meeting their energy needs and food preferences to have a healthy and active life.
FAO's global projections for 2050 indicate that the world population will still grow in the coming decades and that world agricultural production will have to increase by about 70% compared to 2005 production to meet the growing demand for food. Considering the low availability of areas for agriculture expansion, projections point out that about 80% of the agricultural production increase to meet this demand will have to occur through increased productivity and/or the intensification of production systems

Agricultural development is a sine qua non of ending poverty in developing countries. Growth in the agriculture sector is a very effective way of raising income among the poorest. Due to climate change, however, amongst other factors, agricultural growth is at risk. Agricultural production also has unique characteristics that differ from other forms of production; several random phenomena, with a high degree of spatial and temporal variability, especially climate, may adversely affect crop and cattle production.
A fast growing population compounded by the effects of climate change represents challenges to Africa's farming industry. Threats like weather hazards, loss of soil fertility, water scarcity, postharvest losses and limited market access need to be addressed.

In light of these concerns, sustainable and more efficient farming practices are gaining traction, demanding the use of digital technology to increase productivity and yield.

The UK Space Agency has forecast that satellite solutions for agriculture will be almost seven times more cost effective in the long term than non-space alternatives for improving crop yields. The combination of analysis ready satellite data, ground measurements and near-real-time weather data can be used to develop notifications and informed recommendations, which farmers may receive through mobile phone apps, call centers, websites, or personal advice from extension officers.
As of 2023, approximately 733 million people worldwide are chronically undernourished, including 298 million in Africa, with 33.1 million in West Africa. In West Africa, smallholder farmers cultivate > 80% of the cropland, employing about 42% of the labor force.

Africa is the world's second largest and second most populous continent after Asia. At about 30.3 million km² including adjacent islands, it covers 6 per cent of Earth's total surface area and 20 per cent of its land area. With 1.3 billion people as of 2018, Africa also accounts for the planet's fastest growing population. At this point it is even more critical to support Africa on its path to climate change resilience, food security and sustainable management of natural resources.
Yet, Sub-Saharan African (SSA) countries have not yet benefited from their huge agricultural potential and still experience high prevalence of undernourishment. As a result, countries import more agricultural products than they export. More than 60 per cent of the population of Sub-Saharan African are smallholder farmers, and about 23 per cent of continent's gross domestic product GDP comes from agriculture.

Here in Africa, smallholder farmers are the backbone of food security in low- and middle-income countries, and they are also most exposed to the impacts of climate change and other environmental and economic shocks. Science can support them.

Smallholders are small-scale farmers who manage areas from less than 1 ha up to 10 ha and are characterized by family-focused motives such as favoring the stability of the farm household system, using mainly family labor for production, and using part of the yields for family consumption. Their limited resources and rainfall-dependent farming practices make them highly sensitive to the effects of climate change. Among the regions where smallholder farming is predominant, West Africa is considered one of the most important because of its geographical size and the potential for yield growth in the coming decades.

However, the large increase in population urgently demands enhanced production and improvements in the governance of food production systems. These improvements are also a prerequisite for achieving the United Nations (UN) Sustainable Development Goals (SDG).

Food security plays a prominent role in SDG2 “Zero Hunger” as well as SDG1, as the agriculture and food sector is key to eliminating poverty for many people. More specifically, SDG target 2.3 aims to double the agricultural productivity and the incomes of small-scale food producers by 2030, in particular for women, indigenous peoples, and family farmers.

Smallholder systems are characterized by large yield gaps, which arise from the numerous challenges they face. These challenges include their small plot size, often less than 1 ha, environmental variability, low soil fertility, mixed cropping systems, and suboptimal practices. These obstacles continue to impede sustainable improvements in agricultural productivity and quality.

As a result, a large proportion of these households are themselves food insecure and fall below the poverty line. The probability of smallholders escaping poverty depends directly on their ability to increase the productivity of their crops. These constraints may be reduced through integrated soil fertility management, improved crop–livestock integration, multi-purpose crops, and various other sustainable intensification practices.

In Côte d'Ivoire, Ghana, Niger, and Mauretania, more than 20% of cropland is dedicated to leguminous crops. Although their economic distribution is modest, accounting for mainly around 10% and over 20% in Côte d'Ivoire of agricultural revenue, they serve as both subsistence and cash crop. Additionally, they play a crucial role in regional food security.
In Senegal, a large agricultural area is referred to as “Groundnut basin”, which exemplifies the crop's importance in both terms of land area and economic output. Almost 40% of the reviewed literature on groundnuts focuses on Senegal and Mali, whereas the importance of groundnuts in Mali is far less.
However, the category “Maize and Sorghum” accounts for the largest shares of agricultural land in most countries, with the exception of Senegal, Côte d'Ivoire, Niger, and Ghana, where it still plays a considerable role. The highest share in Mauretania is remarkable,
though the country is underrepresented in the studies analyzed. As a key subsistence crop for smallholder farmers, their importance is reflected both in the reviewed literature and real-world agricultural data based on FAO, underscoring their central role in food production systems across the West African region.

“Vegetables”, despite their limited land use, consistently rank high in economic value, with Nigeria standing out for its large share of agricultural land devoted to vegetable farming. Vegetables account for over 40% of Nigeria's agricultural revenue, highlighting
a contrast between vegetables economic weight, and their relatively small agricultural footprint.

Agricultural production is at the forefront of climate change and population growth impacts as the ecosystems on which it relies are increasingly degraded and the availability of suitable land for food production declines.
In order to help combat the threatening pressures of climate change there is an urgent need for accurate and consistent information for well-informed risk-assessment and decision-making and governance at many levels. Earth Observation (EO) technology has become a regular tool in the large-scale agricultural production systems of industrialized and emergent countries.

EO in agriculture

Capturing images of the earth from the sky is not news anymore. In fact, the photographic images of earth were recorded since 19th century, while the information from remote sensing has been used for economic reasons since 1930s. it is known that 75 per cent of earth's surface is water, while the rest is vegetation, recognizable with the green colour, can be depicted by the naked eye, but nowadays thanks to many instruments and satellites, this vegetation can be analyzed way better.

More than 780 Earth Observation satellites are currently orbiting and provide data at various spatial resolutions, from 30 centimeters to several kilometers, with multiple revisit periods usually hourly, daily, fortnightly, and varied and complementary spectral bands.
Before, access to images and processing tools was hard to achieve, now, the true challenge is the volume of data to be processed. A first response is provided by computer technologies





such as “cloud computing”, which give remote access to image computing and processing resources, and by free image processing and Geographic Information Systems (GIS) software. However,
these technologies require increasingly sophisticated equipment, knowledge and skills, as well as a good Internet connection. The democratization of access to data and tools is tangible, but their use is linked to a complex and a rapidly-evolving technology.

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.

While agriculture has been an early adopter of many productivity-boosting new technologies, it has nevertheless shown less readiness to adopt and innovate with others, in spite of their demonstrated potential. One such technology is remote sensing from Earth observation satellites, which has a long history in the agriculture sector. Remote sensing has been used to monitor large land surface areas on a regular basis since the 1970s. Over that time Earth observation data and services have grown substantially, with data from over 300 satellites now being available for agriculture applications.

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.

When combined with the increased computing power accessible through cloud-based services and the trend towards digital transformation of the industry itself, the agriculture sector should be reaping significantly greater benefits than it currently is from the utilization of Earth observation across the value chain. Yet, Earth observation remains underutilised across the industry.

The use of space and satellite technologies in the agricultural field provides the advantage of quickly collecting reliable information on the state of crops by highlighting spatial and temporal variability and by making it possible to establish a substantial assessment helping take timely decisions and make field actions. A wide variety of satellite imagery as well as the operational tools for having it processed have been disseminated, in order to have the necessary information for decision-making.
However, the potential of remote sensing is still underevaluated and undervalued, which significantly limits its use. The private and public sectors' investments in the development of applications using remote sensing are still lagging behind.

Even though an adequate understanding and ownership would contribute to providing suitable responses to the crop growth monitoring, the production forecasting and the need to come up with strategies for agriculture, self-sufficiency and food security. Only a few African countries have managed to achieve sustainable food security, as almost 20% of the African population is prone to malnutrition, according to the World Bank report.

Africa-wide geospatial information management

In early March 2019, heavy rains inundated Mozambique, causing deadly floods. The storm soon developed into tropical Cyclone Idai, affecting an estimated 1.8 million people, and destroying thousands of livelihoods. 90% of the communities rely on agriculture as their main livelihood source, with livestock rearing and fishing coming in second and third, respectively. Farmers reported up to 50% reductions in crop harvest postcyclone, mostly due to high winds and flooding of agricultural fields.
The Ministry of Agriculture and Food Security, in a codevelopment frame with CropWatch, a GEOGLAM partner, worked together to create flood maps to track the impact of the disaster on agricultural production. The analysis used to cloud-penetrate Sentinel 1 satellite imagery to accurately map out the inundated areas in near real-time. This information was complemented with daily rainfall data and cropland maps for each of the affected districts, helping the Ministry of Agriculture to understand the extent of flooded cropland, and to effectively target food security response to such areas.

The 2030 Agenda for Sustainable Development (2030 Program), adopted by the UN General Assembly in September 2015, and the Agenda 2063, endorsed by the African Union in January 2015, are both initiatives that emphasize the need for a mechanism to ensure global coordination of geospatial information management.

The United Nations Global Geospatial Information Management Initiative (UNGGIM), was launched in 2011 by the Secretariat of the United Nations (UN), with a view to establishing a formal mechanism for Member States to review and coordinate their geospatial information management activities. The initiative put forward an action plan for Africa called “African Action Plan for the 2016-2030 period”. This action plan should be conducted in key areas such as geospatial information policies and governance, (common framework and tools, capacity

building and knowledge transfer, and international coordination and collaboration in response to regional and global needs. This action plan also targets a specific field of action: the geospatial and statistical information integration, with a view to providing decision-makers with information products and services which, by relying on national statistical and spatial frameworks, shall achieve the UN Sustainable Development and African Union's Agenda 2063 Goals.



The sensors capturing and delivering Earth observation data have also rapidly evolved over the past 5 years. The commercial exploitation of Unmanned Aerial Vehicle technology and constellations of micro satellites, such as Planet's SkySat fleet, has made high spatial resolution Earth observation imagery much more accessible to service providers and product users, though the cost-benefit challenge of providing decision-ready data over large areas of agriculture land remains a barrier to the greater uptake of Earth observation technology across the agriculture sector. Today, as the agriculture industry undergoes digital transformation, there are significant opportunities for Earth observation to contribute to the delivery of productivity benefits across key production sectors.

Industry watchdog Deloitte reports that Agribusiness is one of the five industry sectors with the potential to take over from mining as the key driver of growth for the economy. Agriculture is seen as the sector with a strong global competitive advantage in producing food products that the rest of the world increasingly wants to consume.

Despite the increasing accessibility of satellite data, translating it into usable information still requires substantial skills and resources. Before data is ready for analysis, satellite images must be ortho-rectified and cleaned from atmospheric attenuation and radiation irregularities. Analysis ready data offers an efficient and timesaving approach to unlock the immense amount of information contained in such data collections. The idea of pre-processed, standardised stacks of imagery, together with adequate analytical tools and algorithms that allow access even to novice users is considered as a game-changer in Earth observation technology.

Earth observation has a long history of application in the agriculture sector, due largely to its capability to remotely sense and monitor large areas on a regular basis. The impact of Earth observation in agriculture began with the launch of the Multispectral Scanner System aboard Landsat 1 in 1972. The four bands of Multispectral Scanner System included both red and near-infrared wavelengths allowing production of the Normalised Difference Vegetation Index (NDVI) that remains a mainstay of Earth observation in agriculture today.

Satellites produce ever-increasing amounts of data. Sentinel 1 alone generates 1.6TB/day, which needs to be downlinked to a ground station. This puts a huge strain on the downlink in the service chain, especially when the end user might only use a fraction of this data to extract the desired useful information. The move from edge computing where the intelligence analytics is undertaken in the cloud to fog computing where the intelligence takes place at the end of the network (at the sensors) will reduce data exchange and increase system responsiveness.

The EO landscape is evolving rapidly, Planet Labs Inc design and launch miniature satellites mass between 1 and 100kg called Doves which continuously scan Earth and form a satellite constellation that provides a complete image of Earth daily at 3–5 m optical resolution.

Planet's daily satellite imagery can reveal patterns in rapidly changing infrastructure, stockpiles and water resources, identifying areas of risk and opportunity. This data can be used in many ways, including the construction industry where systematic tracking of development is key to monitoring areas, and for financial analysts who are gathering research for investments.

Future of agricultural production

Agriculture is more than ever, at the heart of the world's political, economic, societal and environmental challenges. Limited land and water resources, climate change and extreme events are also a serious threat to agriculture and food security.

In order to address these concerns shared by all African countries, it is very important to focus on the production, dissemination and use of reliable, objective and up-to-date information on agriculture.

The appearance of new technological solutions for data acquisition and processing Including workstations, storage servers, tablets and mobiles, makes information collection and sharing much easier for agricultural management assistance.

Nevertheless, Africa still suffers from the lack of geospatial information because of the weak synergies between the traditional national statistical systems and the mapping agencies. Besides, non-specialists are still having trouble acquiring satellite data.

In addition, the expertise necessary for the production of successful products and relevant information, requiring the different data sources to be merged, is not available in sufficient quantity. To meet this demand, Africa has become aware of the need to come up with enough technicians, professionals and researchers who have a perfect command of the technology and above all, to develop and maintain applications adapted to its environment.
Sendai City, selected as a “startup Sendai

REPORT

After ISS, ElevationSpace aims at future where everyone can live in space

Sendai City, selected as a “startup ecosystem hub city”, is gaining momentum for new business creation. While many influential startups are emerging from Tohoku, one of the companies that is attracting particular attention is Tohoku University's space venture ElevationSpace.

According to Japanese media, their mission is to "create a world where everyone can live in space and enrich the future of mankind." It is a start-up company aiming to construct a space building while developing the world's first private space environment utilization platform "ELS-R" to replace the International Space Station.

The city is the central city of the Tohoku region. Many IT companies from Japan and abroad are now expanding into this city called "City of Trees". Sendai attracts a large number of companies regardless of size or field, including major foreign companies such as Ericsson Japan and IBM Japan, leading domestic companies such as Mercari, Rakuten, and V-cube, as well as venture companies headquartered in Tokyo.

Sendai City is home to 14 universities, including Tohoku University, 5 junior colleges, and many vocational schools, attracting talented young students from all over Japan, including the Tohoku region. Currently, the IT industry is facing a serious labor shortage. The environment that makes it easy to secure excellent students is also very attractive for companies that are suffering from labor shortages. In addition, it is highly rated for its easy access to Tokyo and its excellent living environment.

Since 2010, the space business market has expanded rapidly. In recent years, not only state-led development, but also the entry of private companies such as small-scale start-ups has become conspicuous. Among the efforts of Japanese companies, the news of the launch of a lunar lander by the space startup ispace, which attracted attention as the “world's first private company”, is still fresh in our minds. Mr. Kobayashi describes the recent boom in the space industry as "a return to the Age of Exploration in the 15th century." It is said that the world is just beginning to move toward the new continent of "universe."

In our daily lives, it is fair to say that there are almost no opportunities to feel close to the universe. However, in the near future, Mr. Kobayashi says, "There will come a time when we can easily go on a space trip, just like traveling abroad."

For over two decades, the International Space Station (ISS) has been a symbol of international cooperation and scientific achievement in low Earth orbit (LEO).

However, as the ISS nears its planned retirement in 2030, the stage is set for private companies to step in and fill the void.

ElevationSpace's goal is to build a space hotel in Earth orbit by 2040. Currently, space travel is expensive, but Kobayashi says, "If a space hotel is realized, we will be able to experience space at a lower cost." However, there are still many hurdles to overcome, such as clothing and food, for people to live in outer space. That's why it's important to create an environment where various companies can easily prototype products and services that can withstand the space environment.

The company's main service, ELS-R, is an unmanned small satellite platform that enables demonstration experiments and the manufacture of special materials that are impossible on Earth. In recent years, while "transporting goods into space," which involves launching private rockets and artificial satellites, etc., has become popular, it is said that there are still high hurdles to "recovering goods from space," bringing back the launched goods back to Earth.

ElevationSpace's greatest strength is its "re-entry" technology that allows satellites that have left space to return to Earth. This technology, which has the potential to realize a new "return flight" from space to the earth, is currently attracting attention from research institutes and companies around the world. In April 2023, we will start collaborating with JAXA under the business co-creation program "JAXA Space Innovation Partnership", and various forms of movement toward service development are underway.

With the realization of the ELS-R project, it is expected that the need for research and development using the space environment will increase if it becomes possible to collect and analyze the products of space experiments at low cost on the ground. It can be said that many industries are working on the realization of "a world where everyone can live in space" by creating a field where they can more easily get involved in space.

The reason for starting ElevationSpace was when I was 19 years old when I encountered space architecture. Kobayashi, who was studying architecture at the time, was more and more fascinated by the scale of buildings compared to those on Earth and the future possibilities of space architecture.

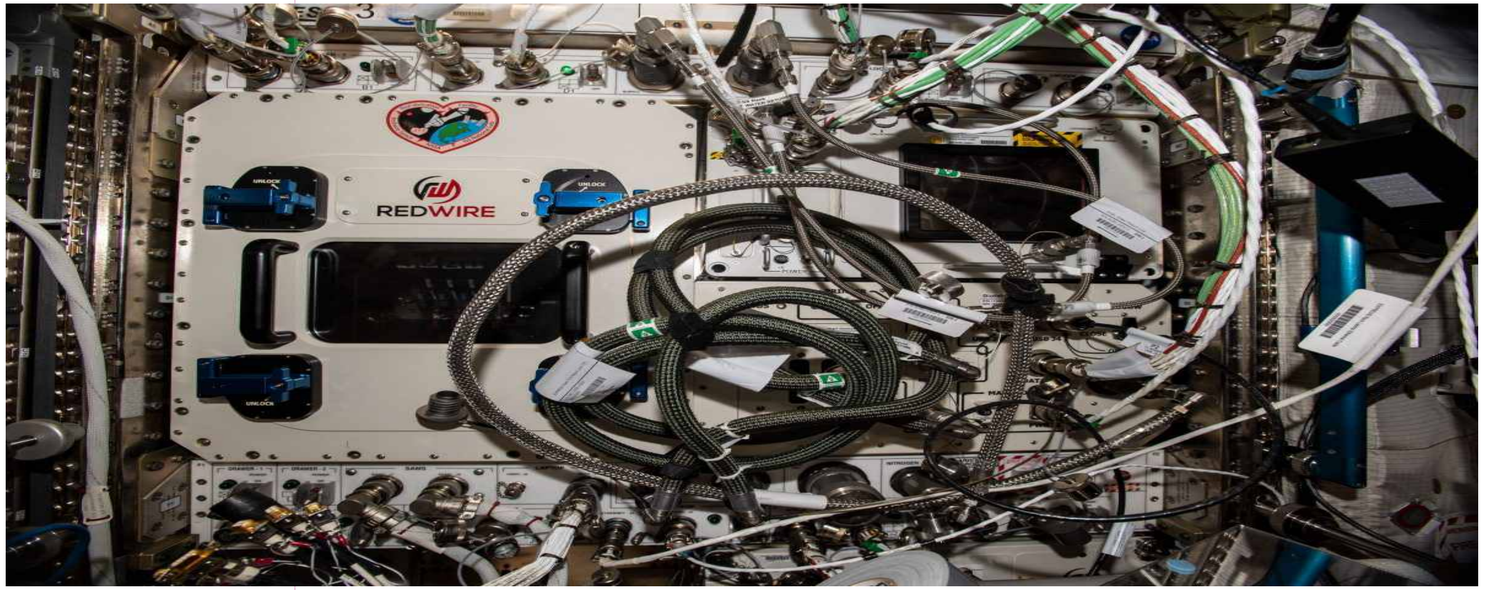
After that, he majored in architecture and space engineering at Tohoku University and obtained a master's degree (engineering). During his time at school, he worked on a satellite development project and an internship at a space venture, which strengthened his interest in space architecture. It was around this time that she met Mr. Kuwabara, an associate professor at Tohoku University and co-founder of the company. ElevationSpace was founded in 2021 after repeated discussions with Mr. Kuwahara, who has experience in developing and operating more than 15 satellites in the past.

Space architecture is a relatively new research field. Furthermore, there were almost no research institutes or private companies working on social implementation. Kobayashi was only 23 years old when he founded the company, but he said he had no hesitation about starting a business. "A long-term perspective is essential for space development.

ElevationSpace is growing rapidly not only as a business but also as an organization. As of 2022, the number of members increased from four to 25 in one year. We will continue to actively recruit excellent human resources both in Japan and overseas, aiming for a scale of 100 people in three years. Participating members include professionals who have been active in various industries such as manufacturers, IT, human resources, finance, and consulting. As of May 2023, about half of all employees are from industries other than the space field.

In addition, about one-third of the engineers who support the company's satellite development come from outside the space-related industry. When it comes to space development technology, people tend to have an image of requiring technology that is significantly different from other fields. However, at the actual satellite development site, there are situations where existing manufacturing technologies such as machinery, electricity, and communication can be used. In order to reach the unknown space of the universe, it is necessary to combine various knowledge.

What the members have in common is a deep empathy for the mission of creating a world where everyone can live in space and enriching the future of mankind. Although startups have a glamorous image, they may face a tough environment, such as fierce competition and management of a rapidly growing organization. “In order to move forward



even in such an environment, it is important to see if our directions (missions) are aligned,” he says.
On the other hand, the reason for joining is different for each person, from those who "like space and want to work on space-related work" to those who "want to experience various organizational stages" and "want to try a completely new business", Mr. Kobayashi said, "If you think that you can realize what you want to do through the company, please feel free to knock on the door."

Accelerating satellite development

From the founding to the present, we have been designing, procuring and manufacturing satellites for the realization of ELS-R. In 2023, the development of the first unit reached its climax, and the company established a new base in Minamisoma City, Fukushima Prefecture.

After the Great East Japan Earthquake, Minamisoma City is an area where bases such as the Fukushima Robot Test Field are being developed based on the national project "Fukushima Innovation Coast Concept" aimed at creating new industries. These efforts have paid off, and now a field is in place where the tests necessary for the development of robots and satellites can be conducted. In recent years, companies and parts factories involved in the space industry have gathered here, and it seems that it is becoming a major base for the space industry in Japan.

ElevationSpace is already working on satellite development in collaboration with parts manufacturing and processing companies in Fukushima Prefecture. The company, which has upheld the concept of "from Tohoku to space" since its founding, expresses its desire to "continue to actively cooperate with companies in the Tohoku region to develop satellites." Even at the actual satellite development site, when it becomes necessary to manufacture parts or process metals, the first thing to do is research whether it is possible to ask a company in the Tohoku region to do so.

"Since this is the first consecutive space challenge, many companies are likely to be concerned about durability and performance hurdles," said Mr. Kobayashi. I want to raise the bar,” he said.

“From Tohoku to Space” and Giving Back to Tohoku

When asked about the future development of ElevationSpace, the answer was "Aiming to go global." The ELS-R business that we are currently working on is expected to be in demand worldwide. From the perspective of revitalizing Tohoku, it is essential to capture overseas demand. "In the future, I would like to set up bases around the world and invite overseas companies to Tohoku," he said.

We also asked Mr. Kobayashi, who was born in Akita prefecture and grew up in Tohoku, about his thoughts on Tohoku. “In order for the Tohoku economy to develop, it is important to focus on new industries that will grow in the future. I can't win because of it.”

And Tohoku is a land that has a deep connection with outer space. JAXA has bases in Noshiro City, Akita Prefecture and Kakuda City, Miyagi Prefecture. In addition, Aomori's brand rice "Seiten no Hekireki" is produced using satellite data, and Iwate has attracted an experimental facility "International Linear Collider" to elucidate the history of the birth of the universe. Tohoku has the potential to grow the space industry.

Mr. Kobayashi said, "From now on, the space industry will become a major foundation for supporting economic activities in Tohoku. By starting the challenge of space in Tohoku, I would like to contribute to 'enriching the future of mankind.'" concluded strongly.

Lake Chad: Africa losing biodiversity hotspot



Seen from space, the Earth appears as a largely blue planet, suggesting the presence of vast quantities of water. Although this is true, only about two per cent of the Earth's water is fresh, with the majority of this small fraction locked up in icebergs and glaciers, or located far underground beyond our easy reach. Lakes appear like blue diamond mosaics in the terrestrial mass. As a relative perspective, if all the water on Earth could be put into a four-litre bottle, the readily-available quantity for use by people would be about one tablespoon, or less than half of one per cent of the total. Nevertheless, even this small amount is deemed sufficient to meet all the present and foreseeable people's needs – if it were evenly distributed around the world and protected from degradation.

In contrast to flowing streams and rivers, lakes provide a means for pooling or storing water for varying periods of time. Lakes are one of our most important natural resources, especially in the tropics, where they form highly productive biological systems. They provide water for consumption, fishing, irrigation, power generation, transportation, recreation, and a variety of other domestic, agricultural andindustrial uses.
For much of our history, human impacts on the Earth's surface have been relatively minor. However, during the past two centuries, these impacts have grown exponentially. Changes brought about by human activities can now be objectively measured; many of them can even be seen from space.

A study by the National Aeronautics and Space Administration, known as 'The Human Footprint', provides a quantitative analysis of people's influence across the globe and illustrates the growing impact of people and their activities on the Earth While evidence of change is not always clearly visible on lakes, wetlands and coastal environments, human impacts on Africa's lakes can be “seen” by detecting and measuring rising water temperatures, sediment accumulation, and various chemical contaminants in their waters.

Another obvious human impact is the rapid decline in fish species and numbers in many lakes. A recent 10-year study on the ecological effects of industrialised fishing in Africa's lakes found that large predatory fish species have declined by at least 20 per cent from pre-industrial levels.
With human populations has continue to grow, this pressure shows no sign of abating. While some countries may have high annual averages of available water per capita, many already face water stress, 1 700 m3 or less per person annually or scarcity conditions 1 000 m3 or less per person, according to UNEP report.

Satellite images of Africa confirm that dramatic environmental changes are affecting the continent's 677 natural and human made reservoirs, which contain an estimated 30 000 cubic kilometres of fresh Water the world's largest volume.

Today, increases in atmospheric concentrations of greenhouse gases are expected to cause more rapid changes in the Earth's climate than have been experienced for millennia. At least some of the global increase is due to human activity, and certainly local impacts such as urban 'heat islands' have profound effects on regional climatic conditions, which will in turn impact on Africa's lakes, wetlands and coastal environments.

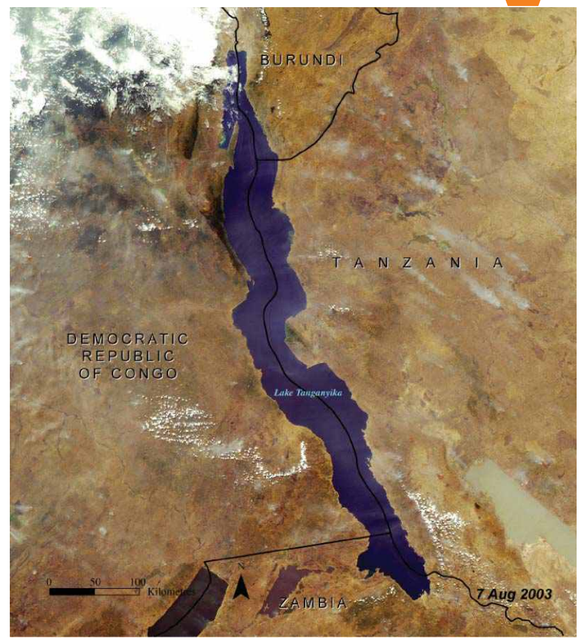
Lakes in Africa have become major sites for water extraction and waste disposal, often with a negative impact on human health. Some contain vast amounts of CO 2, which when released can kill thousands of people. There is a need for continuing assessment and monitoring of these lakes, most of which are located in the Great Rift region, making them also susceptible to earthquakes and volcanic eruptions, which can cause flooding.

Several globally significant environmental trends that occurred between 1980 and 2000 may also be contributing to the pollution and degradation of Africa's lakes, including global warming, three intense El Niño events, changes in cloudiness and monsoon dynamics, and a 9.3 per cent increase in atmospheric CO2. Although these factors are thought to exert their influence globally, their relative roles are still unclear and their impacts are likely to be significant for African communities whose livelihoods depend upon resources from lakes, wetlands and coastal environments.

An observed decline in freshwater fisheries is one of the more important recent challenges to African governments that depend upon the export of aquatic resources, although none of the existing surveys can accurately simulate this effect. It is known that continued reductions in fresh water, if accompanied by reduced rainfall, will have profound implications for poor communities that depend upon lake and wetlands resources for a living.

At present, 14 African countries are subject to water stress or scarcity, with those in Northern Africa facing the most pressure with 11 more countries expected to join them within the next 25 years.

Africa is endowed with hundreds of lakes, both natural and artificial. For example, Lake Bosumtwi is a natural lake that was formed by a crater when a large meteoroid smashed into the continent. Lake Nasser, on the other hand, is a reservoir or artificial lake created behind the Aswan Dam in Egypt. Africa is also home to some of the largest lakes in the world, many of which are bordered by two or more countries.



Lake Victoria is the largest of all African lakes and the second largest freshwater body in the world, with a surface area of about 68 800 km2 about 27 000 square miles. Its extensive surface is divided among three countries: the northern half to Uganda, the southern half to Tanzania, and part of the northeastern sector to Kenya.

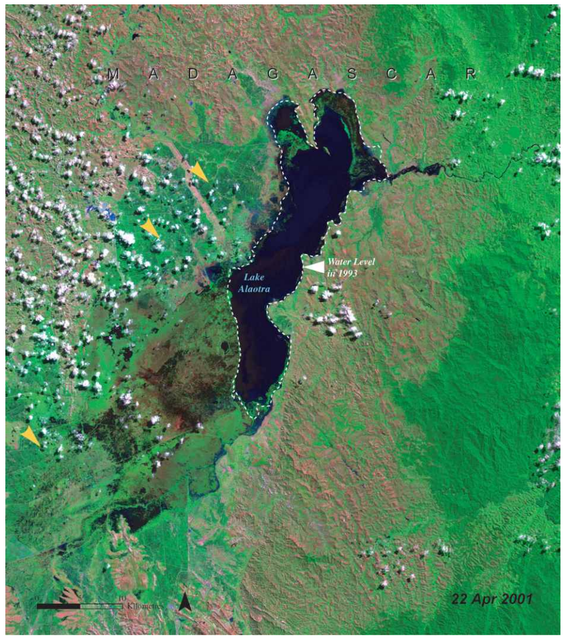
Africa, and particularly East Africa, has numerous lakes that support very important fisheries, providing a livelihood to millions of people, and contributing significantly to the food supply. In many of these lakes, however, fisheries are reaching a state of maturity and unsustainability. The fisheries of just 11 lakes in the 11 countries of eastern Africa employ close to half a million people, with perhaps three times as many engaged in secondary activities and related services—thus supporting about four per cent of the region's entire population.

More than half of Africa's people lack access to safe drinking water, leaving them vulnerable to water-borne diseases. Whatever the quality, water is often in short supply. In rural Africa, people use four to nine gallons of water a day per person for domestic purposes, and much of this is untreated water drawn directly from rivers or lakes. Food production also suffers from major water shortages. Of all the renewable water available in Africa each year, only four per cent is actually used, because most Africans lack the wells, canals, pumps, reservoirs and other irrigation systems needed to make use of potential water supplies from their lakes.

Water withdrawal from lakes

On the African continent as a whole, 85 per cent of water withdrawals are used for agriculture—and the percentage is even higher in sub-Saharan Africa. Sub-Saharan Africa lags far behind the rest of the world in the proportion of irrigated arable land to its contribution to the total food supply. In North Africa, 11 per cent of the land is irrigated excluding Egypt's 100 per cent, whereas in sub-Saharan Africa, it is only 3.5 per cent of total cropped land, based on Food and Agricultural Organization report.

In North Africa, 3.4 million ha are irrigated by large-scale systems, whereas in sub-Saharan Africa, half of the 5.3 million ha is irrigated by large- and medium-scale systems; the other half is by small-scale systems. In terms of value,



irrigation is responsible for an estimated 33 and nine per cent of the crops produced in North Africa and sub-Saharan Africa respectively.

The ways in which freshwater resources are used for agriculture leave much to be desired. In some places, water use exceeds renewable supply rates and cannot be indefinitely continued. Elsewhere, overuse in one area deprives users in other areas, leading to agricultural production decreases and the loss of jobs. Misuse occurs where water is returned to the water system in an unusable state. Used irrigation water is often contaminated with salts, pesticides and herbicides.

Impacts on Africa's Lakes
Lake Chad

Persistent droughts and the ravages of a rapidly growing human population have decimated once the sixth-largest lake in the world, Lake Chad, straddling the borders of Nigeria, Chad and Cameroon. Over the past four decades, the lake's surface has reportedly shrunk from 22 000 km2 to a meager 300 km2. Today, it is hard to reconcile the fact that this largely dry lakebed was once the second largest wetland in Africa, supporting a rich diversity of endemic animals and plant life.

Seen from space, the shallow Lake Chad is a circular wetland with open water in two distinct basins, divided by ancient sand dunes, which act as a swamp belt. Seated at the southern edge of the Sahara Desert, where temperatures often exceed 40°C (104°F), the lake's very existence is a fascinating enigma.

Lake Chad's maximum-recorded depth, prior to the start of its decline in the 1970s, was 12 metres. Today, the lake is far shallower, although fluctuations in volume result in substantial changes to its surface area. The lakebed itself is not flat, but lies on an ancient bed of fossilized sand dunes, many of which surface as islands when the lake level falls.

Submerged dunes form hidden anchorages for floating vegetation, covers vast areas of the lake. About 90 per cent of Lake Chad's water comes from the Chari-Logone River, which enters the lake from the southeast, with its sources in the humid uplands of the Central African Republic. The Komadougou-Yobe River, which enters the lake in the northwest, historically has contributed about 10 per cent of its water.

As well as a vital source of fresh water for local communities, Lake Chad's unique mix of terrestrial and aquatic habitats hosts biodiversity of global significance, although most of its large mammal species have been hunted virtually to extinction Crocodiles and hippos were particularly important agents for maintaining a healthy wetlands ecosystem.

Today, however, the replacement of these mammals with cattle has severely degraded the wetlands ecosystem. Within Lake Chad itself, the major plant communities comprise floating 'sudd' weeds, permanent reed swamps, and seasonal herbaceous swamps. Grasslands dominate in areas that flood, interspersed with acacia woodlands, with dryland woodlands in sandy soils further from the lake Some 50 000 years ago, Paleo-Chad formed a freshwater inland sea covering nearly 2 million km2. Lake levels regressed until, between 5 000 and 2 500 years ago, the lake assumed its current level with periodic oscillations. By 1908, lake levels were so low that the lake resembled a vast swamp with small northern and southern pools.

During the 1950s, levels again increased, joining the southern and northern pools, so that by 1963 the lake covered 22 902 km2. Water levels then decreased, and by 1972 the lake covered 16 884 km2. The most dramatic reductions occurred between 1972 and 1987, by which time the lake had shrunk to just 1 746 km2. From the mid-1980s, the north basin rarely held any water at all, although, since the mid- 1990s, levels have once again started to rise in response to increased rainfall The dramatic fluctuations of Lake Chad are usually attributed to a complex interaction of climatic and human forces.

In the late 1960s, the western Sahel appears to have undergone an abrupt hydro-climatic transition from a wetter to a drier rainfall state. Rainfall became intermittent at Lake Chad, culminating in two major droughts in 1972-74 and 1983-84. In the mid-1990s, rainfall again increased with several good years ensuing. Areas of the lake that once experienced a mean rainfall of 320 mm currently receive less than 210 mm. The size of the region affected by this change and its duration are without precedent in hydro-climatic chronicles. Some authors have speculated that the change is symptomatic of a “climate rupture”

In addition to irrigation, dams have influenced the rivers that feed Lake Chad. In the Kano and Hadejia basins, there are believed to be about 23 earth dams. The Komadougou-Yobe river system provides an example of the dramatic impact of human diversion. The upper basin used to contribute approximately 7 km3/year to Lake Chad. Today, the bulk of this water is impounded in reservoirs within Kano province in northern Nigeria, and the system provides just 0.45 km3/year.

Nor is there any likelihood of increasing discharge down the Komadougou-Yobe, as demands for water for irrigation in the densely populated upper basin near Kano will never decrease. Although the contribution from the Komadougou-Yobe drainage system was only 10 per cent of the total contribution to Lake Chad, once the lake divided into a north and a south basin its loss to the north basin became critical, as good pasture for livestock became harder to find.

Research suggests that dam construction in the upper Komadugu-Yobe system is largely to blame for the change in the flow regime. According to report, the river course was heavily influenced by the spring flooding prior to the dams' construction, and that the leveling out of the flow would result in less water reaching downstream provinces and Lake Chad, even if the flow volume was increased. By contrast, decreasing input from the Chari-Logone river system, where human consumptive use has been estimated at less than five per cent of the basin yield, is attributed mainly to lower rainfall.

From 1956 to 1975, decreases in the lake's level and surface area resulted primarily from long-term climate change, with only five per cent of the lake level decrease attributed to water management practices. Since the 1970s, however, with marked population increases, human activities have begun to play a more significant role in accelerating lake-level declines. The onset of dry climatic conditions in the early 1970s induced people to dramatically increase their irrigation activities, almost doubling water loss from Lake Chad.

The balance between the lake and its wetlands has always been precarious, as inputs balance losses to groundwater and evaporation. However, increased irrigation, which would be modest for many river systems, is particularly critical to the fate of the carefully balanced climatic-ecological system of Lake Chad.
Traditionally, fishing and farming near the lake have followed its rise and fall, both seasonally and through the years. During dry seasons and years, farmers move to the rich soils of the newly exposed lake bottom, and then fish during floods. However, as lake levels recede, the danger increases that the lake will not reach villages during the annual floods.

The cost of exporting surplus crops has also increased as cheap water transportation across the open lake is increasingly being replaced by transport via road or maintained canals. The introduction of irrigation and the movement of people to the lake, who only know the lake in its present state, shift the perspective from water use to water management. In fact, a danger exists that, if the water were to rise again to 1960 levels, the long-time inhabitants of the basin may no longer be able to retreat from its rising waters, as the land behind them is increasingly exploited for irrigated agriculture.

With little fresh water entering the north basin from the Komadougou-Yobe, the basin becomes more saline if it is isolated for long periods. As annual grasses replace productive perennial grasslands, biodiversity is also declining Declines in vegetation associated with the lake ecosystem may result in increased erosion, and ultimately in desertification. The IPCC has predicted reduced rainfall and run-off, and increased desertification, in the Sahelian belt near Lake Chad.

In Northern Nigeria, an extensive floodplain exists where the Hadejia and Jama'are Rivers converge. The floodplain provides essential income and nutrition benefits in the form of agriculture, grazing resources, non-timber forest products, fuelwood and fishing for local populations. It also helps to recharge the regional aquifer which serves as an essential



groundwater source. However, in recent decades the floodplain has come under increasing pressure from the construction of the Tiga and Challawa Gorge dams upstream.
The maximum extent of flooding has declined from 300 000 ha in the 1960s to around 70 000 to 100 000 ha more recently and there are plans for a new dam at Kafi n Zaki. Economic analysis of the Kano River Project, a major irrigation scheme benefiting from the upstream dams and traditional use of the floodplain, showed that the net economic benefits of the floodplain agriculture, fishing, fuelwood were at least US$ 32 per 1000 m3 of water. However, the returns per crops grown in the Kano River Project were at most only US$ 1.73 per 1000 m3 and when the operational costs are included, the net benefits of the Project are reduced to US$ 0.04 per 1000 m3.

A combined economic and hydrological analysis was conducted to simulate the impacts of these upstream projects on the flood extent that determines the downstream floodplain area. The economic gains of the upstream water projects were then compared to the resulting economic losses to downstream agricultural, fuelwood and fishing benefits. Given the high productivity of the floodplain, the losses in economic benefits due to changes in flood extent for all scenarios are large, ranging from US$2.6-4.2 million to US$23.4-24.0 million.

As expected, there is a direct tradeoff between increasing irrigation upstream and impacts on the floodplain downstream. Full implementation of all the upstream dams and large-scale irrigation schemes would produce the greatest overall net losses, around US$20.2-20.9 million.

The Challawa Gorge Dam, completed in 1993, is the second largest of the 23 dams along the rivers in Nigeria's Hadejia-Jama'are River Basin. Although the dam has improved the water supply for irrigation, it has also ruptured the fragile natural balance along this stretch of water.

When it rains heavily, the river can break its banks and flood farms and land upstream from the dam. Areas downstream, meanwhile, do not receive enough water to maintain the wetlands bordering the river. Under these conditions, the soil dries out and overgrazing occurs, which in turn leads to wind erosion of the topsoil. These satellite images provide a comparison of the area before and after the dam's construction. The 1999 image shows the degree to which flooding upstream impacts the landscape, and how the lack of water downstream negatively affects riverine wetlands and cropland. The colour of the water in the flooded area is also indicative of high-sediment content.

The biodiversity of fish and birds in the Lake Chad region is also under threat. The drying up of water basins and ponds both directly and indirectly increases fish mortality. The Alestes naremoze, a species that once contributed up to 80 per cent of the local catch, is becoming rare due to the disappearance of its natural spawning beds. Migratory birds like the European white stork, which depend upon Lake Chad as a key resting place on their migrations across the Sahara, may no longer be able to complete this vital part of their annual lifecycle.

Diminishing water resources and continued ecosystem decline also, of course, have severe health and economic implications for the people living around Lake Chad. The northern states of Nigeria and Cameroon are among the poorest in these two countries, says the World Bank. Report also reveals a rapidly shrinking average annual fish catch in the Lake Chad Basin, from 243 000 tonnes in 1970-77 to 56 000 tonnes between 1986 and 1889.

For now, the future of Lake Chad does indeed look bleak. With a high population growth rate, pressures on water resources in the lake basin will invariably continue.

While in the past Lake Chad has been able to rebound from low to high water levels, climate change and people's water use may now act in concert to block the natural forces of recovery. While renewed rainfall has recently returned to the region, it is clear that the lake's future continues to hang in the balance, and will require very careful planning and multilateral management commitments in order to prevent one of Africa's greatest life-forces from becoming yet another extinct species.

Persistent droughts have shrunk it to about a tenth of its former size. The lake has a large drainage basin 1.5 million km2 but almost no water flows in from the dry north. Ninety per cent of lake's water flows in from the Chari River. The lakebed is flat and shallow; even before the drought, the lake was no more than 5-8 m deep. Considered a deep wetland, Lake Chad was once the second largest wetland in Africa, highly productive, and supporting a diversity of wildlife.

As fish decline, economic losses may also lead to cultural losses particularly among the Yedina, a unique fishing people that occupies the lake's islands and swamps. Around the lake, domestic plant and animal production may become untenable due to increasing soil erosion and desertification. In the lower Yobe, dunes and layers of sand are already invading date palm plantations. And finally, health problems also appear to be increasing, with less potable water leading to cases of diarrhea, cholera and typhoid fever throughout the basin.

STARTUP SPOTLIGHT

Look Up Space: the French startup revolutionizing space debris monitoring



Securing Low Earth Orbit is relatively recent, but major for space agencies and satellite operators. With the advent of New Space, companies have begun to overexploit low Earth orbit (LEO), an area of Earth's orbit up to 2,000 kilometers in altitude, located between the atmosphere and the Van Allen belt.

This area is now infested with debris that can cause colossal damage and could, in the long run, prevent the launch of satellites into low orbit. This scenario was envisaged in the late 1970s by a NASA consultant, Donald J. Kessler, based on the principle: the more debris there is in orbit, the more it will collide with objects or other debris, causing a chain reaction that will increase the number of debris exponentially.

Indeed, tens of millions of pieces of space debris are currently orbiting the Earth and their quantity is constantly increasing. These are generally pieces of old satellites and rockets, but they can also be debris from collisions or anti-satellite missile launches such as those recently carried out by the United States, India, China and Russia.

Using statistical models, it is estimated that there are **1 million** pieces of space debris measuring at least 1 cm, and 150 million pieces of debris measuring at least 1 mm. On February 10, 2009, the Russian military satellite Kosmos-2251, deactivated since 1995, collided with the American communications satellite Iridium**-33**, which was still operational, at an altitude of 789 km over Siberia. This collision alone created 2,300 pieces of debris larger than 10 cm and countless smaller ones.

For all experts, the question is no longer whether another accident of the magnitude of the one in 2009 will occur in the future, but when. Look Up Space's algorithms detect between 50 and 100 collision risks every day with a probability greater than 1 in 100,000.
This activity has created, since the 1960s, extremely high pollution. Late in 2023, this debris forced the ISS to change orbit in record time for less than 6 hours, instead of the usual 24 hours before a possible impact. The European Space Agency estimates that there will be more than 100 million pieces of debris larger than 1 centimeter in orbit by 2030. The threat of closing the door to space and no longer being able to send rockets or spacecraft is therefore real.

Just as pollution is a problem on Earth, and it's becoming a problem in space! There are many satellites in orbit, and their collisions create millions of pieces of debris. "Most go undetected and travel at over 25,000 km/h. A collision can destroy a satellite in a fraction of a second," says Michel Friedling, CEO of Look Up Space. A former space commander, he co-founded the startup with Juan Carlos Dolado-Pérez, former head of the space surveillance department at CNES.

To avoid collisions, space traffic management is urgently needed. This requires the precise detection of artificial objects in orbit. While institutional systems already exist, such as the Graves radar in Dijon, they are not sufficient. This is where Look Up Space comes in: to detect debris in real time, the startup is deploying Sorasys, a network of space surveillance radars, on the ground.

Two years after its creation, Look Up Space employs 35 people and is experiencing strong growth. The company was founded by Juan Carlos Dolado Perez, former head of the space surveillance service at CNES, and General Michel Friedling, commander of the French Space Command, with one leitmotif: to make space safer through precise mapping of all “objects” orbiting the Earth.

After a fundraising round, the largest in seed funding for French Spacetech in 2023, and composed of grants from the France 2030 program and winner of the European Union's EIC accelerator program, Look Up Space announced a new Series A round in 2025 to continue expanding its radar network and offer a French alternative to the American market leader. The promises of this surveillance and knowledge of space are numerous and dizzying, especially at a time when SpaceX, Blue Origin and Virgin Galactic are propelling space tourism to the forefront.

An aeronautical engineer, graduated from the Polytechnic School of Madrid and Supaéro in Toulouse, he joined CNES, the French National Center for Space Studies, in 2008. There, he held several successive positions related to this theme, up to the management of space surveillance services. In June 2022, he created Look Up Space with Air Division General Michel Friedling, formerly head of the Space Command. The idea is to develop a dual solution both civil and military, based on a network of eight radars, in mainland France and the French overseas departments and territories, to monitor low orbit of less than 2,000 km altitude in real time.

Look Up Space has completed a €7 million private fundraising round, the largest seed round in the space sector in France, which is in addition to the €7 million in public funding from the France 2030 plan. The first radar will be operational by 2024. .

"When I was at CNES, to manage the risks of collision of several hundred satellites in orbit, we used 90% of data of American origin," recalls Juan Carlos Dolado Pérez, former head of the space surveillance service.

Faced with this lack of French and European strategic autonomy, in 2022 he co-founded Look Up Space with General Michel Friedling, former Space Commander, a company specializing in the surveillance and security of civil and military space operations. "Our mission is to develop a 360° sovereign solution that goes from observation to action," he summarizes.

A radar network continuously monitors objects in each orbit. A multi-source digital platform provides real-time processing capabilities for the collected data. The first sensor was developed in less than two years. Based in Lozère, it will enter service in the summer of 2025. A second radar, 45% funded by the European Commission, is under construction in French Polynesia. Five other sensors will be deployed in the overseas territories by the end of the decade.



The startup, the result of a spin-off from CNES, is also supported by the space component of France 2030. "CNES helps us develop our systems thanks to its expertise. Its critical yet caring perspective, at every stage of our projects, is key for us."

The Franco-Spanish engineer has a long history with CNES. Fresh out of ISAE-Supaero, he began an internship in 2008 in the Orbital Maneuvers department. Hired in the Universe Exploration department, he joined the orbitography department two years later. Between 2010 and 2022, he supervised the teams dedicated to space surveillance.

"There were two of us when I started, 50 when I left CNES," he points out, illustrating the growing awareness of the constraints induced by the risk of collision on satellites. A strategic subject for the conduct of military operational missions. "I worked on all aspects related to observation: the processing of radar, telescope, and laser data, to build a space station with the most accurate knowledge of the space environment possible," he explains.

Our challenge is to respond to security and sovereignty issues for both civil and military needs, thereby strengthening the capacity of CNES and the Ministry of the Armed Forces to carry out their missions with greater precision, responsiveness and autonomy.

Juan Carlos Dolado Perez also took part in missile tests carried out from Biscarrosse and the submarines. "I am very proud to have participated in the deterrence program and contributed to this military mission while being a civilian." Aboard the *Monge*, Juan Carlos Dolado set up a calibration campaign for the radars involved in space surveillance. A significant cooperation for him as well as for the crew. "The sailors had created a rock group called *Les Débris Spatiaux*," the engineer says with amusement.

He also collaborates with his military counterparts to integrate Space Command officers into his department. It was there that he met his future partner, General Friedling. "Our challenge is to address security and sovereignty issues for both civilian and military needs, thereby strengthening the ability of CNES and the Ministry of the Armed Forces to carry out their missions with greater precision, responsiveness, and autonomy," he summarizes.

And current events prove him right: at the end of January 2025, American data were no longer delivered for nearly a week. "In the current geopolitical context, this event demonstrates the importance of being able to address this strategic issue independently and only strengthens our mission.”

10,000 active satellites in orbit, according to Look Up Space

Look Up Space announces a major milestone in space history with the passing of the milestone of 10,000 active satellites in orbit this month. On June 19, 2024, Look Up Space counted 10,019 active satellites, two-thirds of which (6,646) belong to Starlink, the constellation of SpaceX, the company founded by Elon Musk. The majority about 9,254 of these satellites are in low-Earth orbits, mainly between 400 and 1,200 kilometers from the Earth.

Look Up Space also counts nearly 3,200 rocket stages and 13,326 pieces of debris orbiting the Earth. This is just a small fraction of the currently unaccounted-for debris, which is estimated to a number close to a million pieces measuring a centimeter or more in size.

Every day, Look Up Space's SYNAPSE data fusion platform, equipped with advanced algorithms, detects almost a thousand collision risks with a probability greater than one chance in a million, and between 50 and 100 risks with a probability greater than one chance in 100,000. These statistics reveal a worrying reality: the risks of collision in space are real and frequent.

"Even if the comparison is debatable, the probability of one of these collisions occurring is much greater than that of winning the lottery jackpot. "explains Michel Friedling, former space commander and co-founder and CEO of Look Up Space.

"These risks make space increasingly vulnerable, posing the question not if a major collision will occur, but when and who will be the victim," says Juan Carlos Dolado, co-founder and CTO of Look Up Space, and member of the International Academy of Astronautics.

Look Up Space, which develops and deploys a worldwide network of radars to detect and track objects in Earth orbit, is entirely dedicated to making space safe and sustainable, so that future generations can continue to benefit from space-based services.

Look Up Space, the choice of radar

Rather than telescopes, which can only track objects both active satellites or debris, if certain weather and lighting conditions are met, or radio frequencies, which only detect active satellites, Look Up Space has opted for radar technology. The first, installed in Lozère, is presently operational. It is modular and will ramp up this year. But to be effective, Look Up Space's surveillance system must rely on a network of sensors positioned at different latitudes and longitudes.

One of the major weaknesses of GRAVES, the French Ministry of the Armed Forces' radar dedicated to this task, besides only detecting large objects larger than 80 cm, is that it is isolated, providing information on an object only when it crosses its field of view. This is why the company's plan is to exploit the multitude of "shots" offered by its overseas territories: by 2030, other modular radars of the same type will be deployed in Polynesia, New Caledonia, in Mayotte, in French Guiana and in Saint-Pierre-et-Miquelon.

Naturally, the stewardship will have to follow. And stewardship here means IT and algorithms, each radar producing an enormous volume of data that will have to be merged with data from other sources, American data, in particular. Look Up Space benefited from the support of the public authorities, via the France 2030 plan, to carry out this important project, a true issue of national sovereignty in the era of “new space".

The information collected by this future radar will be analyzed in Toulouse, where the company's headquarters are located. This information is crucial because, according to the engineer, "it is estimated that a 3 cm piece of debris can be lethal for a satellite if it hits solar panels or tanks. It is important to keep in mind that objects orbiting the Earth have a speed of 28,000 km/hour. " Knowing that there are around 10,000 active satellites and nearly 30,000 pieces of debris in low orbit, mapping space allows the Toulouse-based company to assess the risk of collision with debris.

SPECIAL REPORT

Why smallholder farmers are struggling with precision technologies



Agriculture is a major mainstay in Africa. Over half a billion Africans, around 65–70 percent of the African population, depend on small or micro-scale farming as their main source of livelihood. Still, about 23% of the gross domestic product of sub-Saharan Africa comes from agriculture, and the figure stands at 32% for the continent. The agricultural sector accounts for the high employment of almost two-thirds of citizens in Africa. Despite the growth of agriculture, there are still untapped and uncultivated aspects of agriculture in Africa.

Over the next few decades, the world will confront the challenge of feeding a growing population that is predicted to reach almost 10 billion by 2050. Smallholder farmers are expected to play a crucial role in this. Already, an estimated 80 percent of the food produced in Asia and sub-Saharan Africa comes from small farms. About 90 percent of the world's farmers are smallholders, owning less than two hectares of land.

Farming still remains the primary source of revenue for smallholder farmers, making them vulnerable to price fluctuations and extreme weather events. Smallholder farmers not only suffer from a lack of access to resources such as financing, land, water but also from various asymmetries in markets, including in power structures and information access.

Yet, small farm size poses several challenges for farmers. It makes technological investments to enhance productivity and yields infeasible and acts as a barrier to benefiting from economies of scale.

In Ethiopia for instance, Agriculture is the backbone of the economy as it employs over 70% of the population. In Ghana, agriculture employs 52% of the workforce and accounts for 17% of the GDP. In Zambia, agriculture contributes 20% of the GDP and employs 54.8% of the population. This contribution is evident across many African countries. Despite the positive effect of agriculture across the continent, the sector remains unattractive to young people.

Many of these farmers, despite their years of farming experience, are faced with the problem of low productivity caused by a combination of adverse climatic conditions and harmful farm practices. Even though smallholder farmers are faced with the problem of low productivity, they have found it difficult to adopt the technology that will help them scale their farms and remove the uncertainty attached to their means of livelihood. Only about 15 percent of Africa's 250 million smallholder farmers have reliable access to information, markets and input credit, which can significantly increase productivity, yields and income. Climate change, water scarcity, crop and livestock disease and post-harvest losses, are also global challenges for these farmers, as are a lack of adequate rural infrastructure, knowledge gaps, including financial literacy, and a lack of reliable data. However, the lack of access to finance and a significant share of the global market is of particular interest.

In Sub-Saharan Africa, where investor capital is becoming more available, funding remains a major challenge for agritech companies, primarily due to the high perceived risk of investing in the agriculture sector and the knowledge gap investors face in agricultural value chains. In 2019, of all the funds raised by African technology start-ups over USD 1 million, just four per cent around USD 38 million was raised by agritechs.

Startups like ThriveAgric in Nigeria, Grainpulse in Uganda, Agrocenta in Ghana and Agriprofocus in Tanzania are using technology to improve the capacity of the agriculture sector in Africa. Despite this potential of technology to change Africa's agriculture sector, smallholder farmers are faced with the challenge of incorporating technology in their agricultural practices.

Precision farming

As Agriculture 1.0 with manual labour and animal power moved to Agriculture 2.0, the Green Revolution erupted through the agricultural sector. As a result, new management practices were developed to increase yields and use new machinery. The soil was tested at various depths on different grids in the following years.

Precision farming led the movement to Agriculture 3.0, using GPS technology in the late 1980s to make soil sampling and the application easier. In 2017, the journey to Agriculture 4.0 began as the rapid development of specialised machines progressed, producing GPS sprayer booms and advanced sensor and guidance system technology that enables autonomous farming.

With its three significant aspects, including technology, information, and management, Precision farming has transform agriculture all over the world.

Africa's pre-historic farmers gained by seeding and growing a precise crop species in those backyards of their dwellings. It overcame difficulty in tedious collection of grains from swamps or plains that had admixtures of all kinds of plant species.

During this period of history, farmers literally gained in efficiency and productivity by adding precision to farming procedures. Most glaring of the procedures introduced by farmers that added precision are precise planting dates to match with precipitation pattern and season. Even today, we strive hard to add precision into planting dates, seeding depth and plant population because it improves nutrient scavenging, moisture absorption and grain harvests significantly. Precise crop species and precise field to match fertility requirements of crops are other measures that improved productivity. Irrigation channels helped farmers in the supply of precise quantities of water at various stages of the crop development.

Since mid-1900s, precision as a concept was imbibed as a matter of routine into almost all aspects of farming. Throughout past decades, almost every modification in traction machinery, types of coulters, their shape, size, seed drills, fertilizer drills, hoes, weeders, harvesters, right up to development of elaborate combine harvesters have all aimed at enhancing accuracy of specific tasks. Gadgets driven mechanically or through electrical power added further to precision of agricultural techniques. Electronic controls and timing too added precision to various farm operations.

Historically, most recent of the farming measures that seems to add precision into farming procedures, yet again and in significant amount, is the use of satellite-guided seeding, fertilizer application, irrigation, pesticide spray, harvesting, and yield monitoring. Satellite-guided procedures and computer-aided decision support systems are forecasted to revolutionize the way agricultural farms are managed, and these procedures are collectively termed Precision Farming because they add accuracy to soil fertility and moisture management, rather enormously. In summary, precision is a concept that has been imbibed into farming. It has helped farmers to carry out various tasks efficiently with due gains in input efficiency and grain and forage harvests.

Today, numerous mobile phone-enabled services for agriculture also known as 'm-Agri services' have spawned, enabled by growing mobile phone and Internet penetration, providing farmers with access to inputs, credit, insurance and markets to sell their produce. Mobile phones have enabled two-way communication between farmers and experts, real-time monitoring capabilities, and digitisation and easy collection of field data. GPS-enabled smartphones can help collect accurate location data and enable delivery of tailored information to farmers. Mobile phones are a highly accessible medium for disseminating information and insights generated using other technologies like satellites, Unmanned Aerial Vehicles, and on-site sensors. Even a phone with basic functionality and lacking 'smart' capabilities offers multiple capabilities for farmers to access customised information, allowing farmers who cannot afford a smartphone or those living in areas with limited or no Internet connectivity to avail precision agriculture services.

Mobile phone is perhaps the most impactful technology for making precision agriculture accessible for smallholder farmers. Mobile phone penetration has grown rapidly over the last decade. Close to seven out of ten households around the world today have a mobile phone. In Africa alone, more than 80 percent of the rural population has some mobile coverage at least 2G. Growing mobile phone penetration has rapidly scaled up access to the Internet in developing countries.

In China, effort to introduce precision farming was guided by the Chinese Academy of Agricultural Science, Beijing after conducting series of experimental evaluations on crops like cotton, maize, and wheat in the provinces such as Hebei, Shanxi, and Shandong. According to reports, Chinese farmers used soil fertility maps, GIS, and GPS guided systems on maize grown in Shandong. State Agricultural Agencies and farmers were driven to adopt precision farming mainly to improve fertilizer efficiency and productivity of land per unit time.

According to FAO, pests account for 20 to 40 percent of annual global crop loss yearly. In monetary terms, the annual economic damage attributable to invasive insects is $70 billion, while plant diseases account for about $220 billion. Therefore, the monitoring of farms for insects and other pests is thus critical to improving farm production.

Therefore, pest and disease monitoring solutions are employing simple hand-held devices, remote sensing and on-site sensors to provide timely and reliable advice for integrated pest management. Depending on the disease and pest, different sensor technologies are appropriate.
Because of the ubiquity of smartphones, innovators are developing mobile applications which allow farmers to snap a picture of the infected crop and receive an immediate diagnosis. They are sometimes combined with SMS services to send alerts to other farmers in the community when a disease or pest is detected.

The data collected could include information on soil fertility, pathogen and pest presence, and soil fertility. These data points are then analysed using big data analytics, digital signal processing, image processing





techniques and computer vision. Insecticide spray programmes, for instance, use such data to precisely administer insecticide where pest infestation is severe.
Some monitoring solutions are even paired with camera-equipped traps, which would either automatically or semi-automatically remove these harmful pests. These solutions promise to reduce pesticide, water and fertiliser usage. In some cases, savings on fertilisers can be as much as 15–20 percent. Pest management solutions using remote sensing and hand-held devices are more suitable for smallholder farmers in low- and medium-income countries. For instance, AgrioShield, a mobile app for pest alerts by Israeli start-up Saillog, currently costs $2 per month.

Satellite technology has also evolved greatly over the decades. Spatial resolution has improved from 80m in the 1970s to submetre resolutions available today. Similarly, temporal resolution has improved from 1-2 days to few hours. Spectral bands have doubled from four to eight. The improved resolution and increased availability of satellite data have enabled its use for precision agriculture.

New ventures including companies like BlackSky, Planet Labs, Maxar Technologies, Capella Space and Orbita Aerospace are aiming to launch constellations of small low Earth orbit (LEO) satellites. LEOs have the advantage of faster orbit times and continuous coverage. Moreover, small satellites use commercial off-the-shelf technology, which fundamentally changes the economics of launching space missions and reduces the barriers of entry for an increasing number of private ventures. Currently, private sector players in satellite imaging offer daily imagery with higher spatial resolution than government satellites. This high frequency of data access allows farmers to react to issues, such as crop stress, in a timely manner..

Also, spectral data from satellites can generate spectral index maps that visualise farm health and inform the farmer which parts of the farm to focus on. Some of the commonly used spectral indices include the Normalised Difference Vegetation Index (NDVI), Normalised Burn Ratio (NBR), and Atmospherically Resistant Vegetation Index (ARVI). NDVI measures the greenness of vegetation and can be used as a proxy for understanding crop health across the field. NBR assesses burn extent and is deployed for monitoring active fires.

Farm maps showing intra-farm variability in crop health as well as farm-specific advisory can be delivered to farmers over mobile phone apps. Satellite data can also be integrated with other data like weather, on-site sensors and farming records such as fertiliser use, planting dates then processed with machine learning algorithms to generate even more accurate information for individual farmers. Several start-ups, including CropIn, OneSoil and Agrosmart, provide precision agriculture services such as fertiliser application advice and yield estimation based on satellite imagery.

Another capability offered by satellites is geopositioning. Satellite-based navigation systems such as GPS help collect georeferenced data and help identify accurate field locations for precise placement of seeds and agrochemicals, manage the efficient use of water and assist in overall farm management practices. The combination of satellite and navigation systems characterise the farms' soil and crop variability, allowing for more intensive and efficient cultivation practices.
The Food and Agriculture Organization of the United Nations (FAO) estimates that the agriculture sector in developing countries absorbs 25 percent of the total damage and losses caused by climate-related disasters, such as droughts, floods and storms.

In financial terms, natural disasters alone have been responsible for more than $200 billion of economic losses since 2016. Weather monitoring involves the continuous study and analysis of key weather parameters such as temperature, moisture, pressure and wind velocity to make informed planting, harvesting and irrigation decisions.
For instance, if a crop were expected to be at peak quality in a week, but there was a forecast for heavy rain tomorrow, a farmer could decide to harvest today and avoid the risk of crop damage.

Typically, weather information comes from centralized sources where meteorologists make predictions for a large geographical area. In fact, the data that informs these predictions may be collected by a weather station nearest to farmers' location but could still be relatively far away.
It is forecasted that a growing population and rising incomes will lead to an increase in demand for agricultural products by 35–50 percent between 2012 and 2050, exerting even more pressure on the world's arable land.
Today, arable land is decreasing, accelerating the need to find solutions to grow more with fewer resources and do so in an environmentally sustainable manner. Yield monitoring and mapping uses a combination of GPS technology and on-site sensors to track crop yields. Yield maps display the spatial and temporal variability in crop yields. The data can be collected for either a specific load or field, thus enabling farmers to compare yield performance across different test plots or crop varieties. Smallholder farmers can use yield data to get insurance and loans at a lower price since the banking companies would have reliable farm data to back their loans and insurances.

Today, as the payload capacity of unmanned aerial vehicles increase substantially, it has allowed them to carry variety of payloads such as sensors, cameras, spray equipment for various precision agriculture applications. Drones allow much higher resolutions than satellites in remote sensing. In addition, they can also be used for the precise application of pesticides and herbicides. In combination with other technologies such as various sensors and variable rate technology, drones are used in multiple stages of the crop growth cycle from soil analysis, seed sowing or crop spraying to deciding the right moment for harvesting.

When equipped with cameras and sensors, drones enable real-time aerial monitoring and provide a bird's eye view of the farm. Drone payloads, like spraying systems, can reduce the physical labour involved in farm activities such as scouting and applying fertilisers, pesticides and herbicides.

However, a complete drone solution including the analytics software, training modules and charging equipment could amount to $5,000, which is unaffordable for most farmers in low- and lower middle-income countries. In developing countries, drones are being made available for smallholder farmers at affordable prices through business models that support their use. The high initial investment cost of drones makes them an expensive technology to use.

In fact, the use of drones for cotton spraying in China by the company DJI is reported to be 40 times more efficient than manual spraying. This means that after accounting for their cost savings, drone services can be more competitive than traditional farming methods.
Precision spraying is carried out using drone technology and robotics, are usually leveraged by spray contractors, often times the drone service providers who help carry out such services at a marginal cost. For instance, in Myanmar, a drone spray service provider would charge $10–12 per hectare for a 20 kg payload capacity.

A study of Ghanaian farmers showed that 80 percent of the farmers surveyed were willing to pay between $1.50 and $7 for drone application of pesticides. Satellites and drones are often compared because they are both a form of remote sensing technology. The following table highlights the considerations for choosing one over another.

In addition, IoT for agriculture revolves around on-site sensors that can monitor farm-level parameters such as soil moisture, pH and temperature, complementing data from other sources for informing farmers' decisions. The agricultural IoT market has strong growth momentum with an expected annual growth rate of 15.2 percent until 2027, when the market is expected to be worth $32.75 billion.

This is driven by multiple trends, including the growing availability of low-cost sensors, increasing broadband penetration that enables devices to transmit data to the cloud for aggregation and analysis, and reducing installation costs as sensor providers offer easier assembling of IoT equipment. For example, the IoT sensor array by Fasal, an agritech start-up in India, can be installed in less than 15 minutes.

Connectivity and affordability issues hinder adoption of IoT technology. On-site sensors require Internet connectivity, which can be a challenge in rural areas. Also, while the cost of sensors is falling, data transmission networks and protocols powering these technologies use significant power and bandwidth, thus causing the overall price to be high for smallholder farmers.

Some companies are also investing in local production of sensors to avoid paying high prices for imported components from developed markets. Overall, sensors are less scalable because multiple farms would require multiple sensors, which may not be economically favourable. Small farms often do not have much variability in soil parameters, such sensors may not provide significant insights. Given this, the benefits of sensors do not currently justify the cost for the smallholder farmers.

A smart irrigation system can help substantially improve water-use efficiency. It involves using technology to assess and cater to the needs of the farm. This system requires an irrigation controller, which is typically an electronic device. A smart irrigation system can be either weather-based or soil sensor-based. Soil sensors placed in the farm can be used to monitor soil moisture levels. The number and location of sensors in the farm can be varied for precision and can be connected through wired or wireless networks.

When the soil moisture level falls below a certain threshold, an alert can be generated through a mobile phone app. The farmer can then decide the optimal time to irrigate the farm and the amount of water to apply. Alternatively, a weather-based system depends on the phenomenon of evapotranspiration, through which water evaporates from soil and plants. Local weather stations can calculate evapotranspiration based on factors including temperature, sunlight, wind and humidity. An irrigation controller can provide appropriate amounts of water to the farm based on evapotranspiration rates. Smart irrigation may involve on-site sensors and irrigation controllers, which can make it expensive for smallholder



farmers.

Farmers around the world are also using robotics in varied forms such as autonomous tractors, weeding robots, harvesting robots, and crop monitoring bots to reduce multiple trips for farm monitoring, reduce crop damage and losses, improve farm yield and reduce fuel consumption. The biggest constraint to adopting agricultural robots in developing countries is their high cost.

Market status of precision agriculture

Despite the relevance of technology in farming, industry reports that many farmers are unaware of the benefits of satellite-enabled agri-tech. This is a particular problem, according to analysts, because agri-tech normally requires a large upfront investment from often finance constrained farmers. In this situation, investments in agri-tech become very difficult to justify.

Similarly, a survey by London Economics found from a survey of 50 farmers that one of the biggest difficulties relating to Agri-tech came from cost and reliability of mobile internet, lending support to the conclusion that technology costs remains the largest barrier to the adoption of agri-tech.

Beyond cost, the technical capabilities of aging farming community and the lack of compatibility of equipment are the next most reported barriers to the adoption of agriculture technology.

However, current business models for agri-tech also limit the attractiveness of agri-tech to farmers. This is because farmers, who are sometime financially constrained, are expected to make large upfront investments and bare all the risk in sector that is characterised by volatility. Business models that can limit this risk especially leasing arrangement where payment is performance dependent and ensure that technologies fit within the existing investment strategy of farmers are likely to be more sustainable.



Another problem concerns the nature of agri-tech relative to other cost-saving technologies that end users in the agriculture sector are used to adopting. For example, agri-tech is characterised by the provision and utilisation of satellite data to enhance agricultural productivity. This is, especially in comparison to farm machinery, a soft product and one that delivers environmental benefits that are not tangible to the farmer. Attempts to demonstrate the power of data driven agri-tech and that create a mechanism for rewarding environmental savings, through government pricing for example, would certainly encourage the penetration of agri-tech within the farming community.

Though farmers account for most private end-users for agri-tech, but the cost of agri-tech is still high for all but the largest farms. This means that the addressable market is limited by the size of farms. Industry players, for example, suggest that GNSS applications to agriculture are viable for farms above 50 ha. To put this in perspective, globally 84% of farms are smaller than 2 ha, and operate about 12% of the world's farmland. In Sub-Saharan Africa, the proportion of farms smaller than 2 ha stands at about 70–80% of farms and accounts for a larger proportion of total agricultural land at about 30–40%.

Nigeria alone has a land area of 98.3 million hectares, with 74 million hectares good for farming; yet half of its arable land has not been exploited to produce crops and livestock to stem the threat of hunger and poverty through efficient production system.

Global precision agriculture market

The total size of the agri-tech market is difficult to estimate because it encompasses a number of different satellite technologies such as GNSS, EO, satcoms, sensors and covers several distinct market segments as detailed in the agri-tech value chain.

However, the total worldwide market for precision agriculture devices was estimated to worth £1.2bn in 2016. This estimate include the device price of automatic steering technologies means that it accounts for half of these projected revenues estimated at £653m, with about 100,000 device shipped over that period, while tractor guidance technologies follow with 27% of total precision agriculture revenues valued at £357m for about 155,000 shipped devices. This is followed by Variable Rate Technologies (VRTs) which reached 67,000 shipments in 2016 for a 20% share of total market revenues (£262m) in this market.

According to a projection, in 2025, the total precision agriculture device market is expected to grow by an average CAGR of 11% to £3.3bn. in particular, Variable Rate Technologies revenues will grow at a comparatively faster 17% CAGR to reach £1.0bn, while tractor guidance technology revenues will grow relatively more slowly at 6% CAGR over the 2016-2025 period. Asset management technologies are also expected to grow significantly over this period, but the low device price means that they will still only constitute 4% of total PA revenues.

According to report, North America is currently the most technologically advanced region and the centre of precision agriculture, with the highest installed base, followed by Asia-Pacific. The shipments in North America increased more than two fold between 2015 and 2025, proving that precision agriculture is becoming increasingly prominent among farmers from this region and that the industry is committed to technological innovation.

Based on the report, US companies dominate device sales in this market, and while companies like John Deere maintain a strong international footprint, there is still an opportunity for the UK to develop a presence in regions where the penetration of precision agriculture is comparatively lower.

Asia-Pacific, for instance, has continue to expand its installed base, reaching 330,000 shipments in 2025. Countries such as China, India and Australia are the main adopters of precision agriculture in Asia-Pacific, driven by rising human populations and economic growth which has fuelled new dietary aspirations. The smallest farms, which is the case of most farms in the Asia-Pacific region, have the smallest capacity to purchase and indeed benefits from precision agriculture.

This is because of difficulties in obtaining investment finance and the fact that the benefits of precision agriculture are often proportional to farm size. The challenges faced by precision agriculture in Africa, Latin America and Middle East concern the size and diversity of the agricultural market. For example, these markets are dominated by holdings of less than 5 hectares and the average utilised agricultural area per holding is around 80 hectares. The benefits from agri-tech are low at this scale.

Despite this, the Middle East and Africa, together with South America and the Caribbean are projected to see the highest growth, partly due to the currently low levels of adoption and the fact that technologies from the developed world is becoming more accessible.
In the MEA, for example, shipments grow from 14,000 in 2015 to 239,000 in 2025. Affordable and smart technology solutions are gaining ground in Africa, a region with much untapped potential. Maize and rice are amongst the crops that have benefitted from advanced technologies.

Farm management solution providers

Across the agri-tech market there a several companies which dominate over multiple segments of the value chain, integrating both hardware manufacturing and applications service provision as farm management solution providers. In most cases they are large navigational service providers such as Trimble and Topcon, but there are also other smaller but well established players such as AgSpace, SOYL Precision Farming, and GEOSYS. However, agricultural companies have been found in early stages of the value chain. Deere & CO are the largest agricultural machinery company in the world and appear at all points in the value chain, including as augmentation service providers and component manufactures. Trimble and Hexagon, Leica Geosystems are large navigational service providers and are also active in all parts of the value chain except for agricultural equipment.

Similarly, guidance systems such as automatic steering are one of the oldest Precision Agriculture techniques, however, the market for these technologies is very mature and dominated by a few well established players, including John Deere, Topcon, Trimble, and Agco.

Similarly, precision livestock tracking and virtual fencing are still in the early stages of development, but wider adoption is possible as the technology develops. However, it appears that many satellite-technology companies struggle to find a route into market.

As system integrators of farming machinery, equipment manufacturers and farm management solution providers appear to be an obvious customer for agri-tech software and value-added services. However, this part of the supply chain is characterised by a small number of very large manufacturers and early evidence from stakeholder consultations suggests that they are likely to block new market players as they have an incentive to protect their existing market share. Independent agronomists and other agricultural advisors are an option but the most successful products that have come into market have come through collaborations between agricultural experts that understand end-users and technology companies.

The alternatives to satellite-enabled agri-tech include manual techniques for mapping land, detecting irrigation and soil erosion, agronomy etc. These techniques are, however, time consuming and labour intensive so cannot be done at a frequency that allows it to be an adequate input into the farm management process. It is also very difficult to replicate the efficiency offered by GNSS precision steering systems for agricultural vehicles so all alternatives to agri-tech imply higher inputs costs to the farmer.



Farmers account for the majority of private end users for agri-tech. However, the viability of farmers as a route to market depends on their scale of operations because of differing levels of investment capacity and the fact that benefits are often proportional to farming scale.

The willingness and indeed capacity to pay for agri-tech also varies significantly by region. The willingness to pay for agri-tech is likely to be highest in Europe and North America were labour shortages incentivise investments in cost-saving technologies, however, farmers in these countries have often already achieved high-levels of productivity so the scope for growth is likely to smaller. On the other hand, the willingness to pay for agri-tech is likely to be lower in developing countries. As such, the potential for growth is likely to be higher since agri-tech penetration is much lower and the scope for productivity gains much higher than in the developed world. The developing world is also characterised by a cheap and plentiful supply of labour so the value proposition for agri-tech is linked more the promise of increased resilience and lower crop risk and less to cost saving.

On this basis, governmental authorities and agencies, large scale farmers, agricultural corporations, agricultural commodity traders and agricultural investors are likely to represent the core addressable market for agri-tech firms.

It is clear that a combination of pressures including climate change, a growing population with rising incomes will continue to place considerable pressure on global food supply in the coming decades. These pressures have encouraged considerable investment in satellite enhanced agri-tech applications which can help increase yield and reduce input and environmental costs.

Farmers account for the majority of potential end users, but the cost of agri-tech is high for all but the largest farms. This means that the addressable market for precision agriculture companies is limited by the size of farms. However, this presents a potentially large and untapped opportunity for companies that can develop low-cost agri-tech that can deliver benefits for small holdings.

However, the successful exploitation of this opportunity will depend on a number of factors. Firstly, farmers face a number of challenges to adoption. Agri-tech firms will need to address concerns relating to cost, understanding of the value proposition, usability and the compatibility in order to penetrate this market. Secondly, partnerships with the dominant agricultural equipment manufacturers will be key to expanding market share for potential agri-tech service providers and operators.

LEO satcom for railway communications



The satellite industry is in the midst of the largest transformation since the inception of satellite communications over five decades ago. There is an interesting parallel between today's drive for change and that of the “Space Race” era that unfolded in the late 50's between the United States and the Soviet Union. Starting with the successful launch of Sputnik-1, the first artificial satellite put into orbit in 1957, and peaking in 1969 with the landing of a Man on the Moon, this period gave birth to the satellite industry.

Today, we are transiting into a new space race era, a “21st-Century Space Race”6 that shares common goals with the old race, space exploration and launch of artificial satellites, however, it's taken to a much higher level. This modern Space Race involves the launch of thousands of satellites across different types of orbits, deep space exploration, space travel, asteroid mining, and ultimately Mars colonialization and a multi-planet civilization.

Aside from the magnitude of today's projects and ambitions, a key difference is the 21st-century space race is largely driven and funded by the private sector, attracting an enormous inflow of capital, fueling innovation.
The ongoing, unprecedented launch cadence of thousands of satellites placed into non-geostationary LEO and MEO orbits must be observed in the context of this new space race. The commercial sector is in the driver's seat of innovation, and the push for new paradigms in network economics have implications spanning across all users of space-based applications or programs – public or private, civil or military.

The game-changing characteristics of the so-called “mega-constellations” cannot be under-stated. Launch of thousands of satellites by SpaceX's Starlink, OneWeb -and potentially Amazon Kuiper, Telesat Lightspeed and other LEO initiatives in a future- not only promise to intensify competition in satellite HTS7, but also foster new business paradigms with impacts in the broader telecommunications industry. Times of disruption drive the need to assess impacts in new ways.

Today, communications for safety-critical railway applications have become an essential area within the railway domain, given that, under the current legal framework, new trains operate under the supervision of an Automatic Train Protection System. These systems are critical since they provide movement authorizations and are able to stop the train by applying brakes when required to avoid exceeding the speed limit.

However, Global System for Mobile Communications Railway is the current communication technology used in railways and is used as communication support for: safety-critical applications, such as data transmission between train and Radio Block Centre and voice communication, such as driver transmissions, maintenance and shunting personnel.

Although the use of this channel for new services and applications is limited due to its reduced bandwidth and the absence of high-capacity-demanding applications, the technology will have to be replaced in the future mainly motivated by Global System for Mobile Communications Railway 's obsolescence, which is expected around 2030, rather than changes in functional and/or performance requirements.

Wireless technology is continuously evolving and the need to replace Global System for Mobile Communications Railway can be regarded as an opportunity to increase the number of applications supported not only safety-critical applications, but also mission-critical and even those for maintenance or passenger entertainment. This opportunity can also be useful for separating railway safety application requirements from the communication system, to ensure that future changes to the communication system are made smoothly.

The LEO architecture “blessing and curse”

An often-overlooked aspect of LEO satellite constellations is that, while operators deploy terabits of global capacity, orbits' low altitude limits satellite visibility of the Earth's surface, so constellation players are unable to steer most of the globally deployed capacity to the areas with the largest target population. The lower the altitude, the smaller the satellite's field of view, limiting opportunities for capacity steering.

This visibility limitation is compounded by the fact that addressable markets for connectivity are confined within a small portion of LEOs global footprint. Sir Arthur C. Clarke9, an English science-fiction writer who conceptualized the geostationary (GEO) communications satellite, once made a wise comment that paradoxically, today applies to the LEO addressability dilemma: “How inappropriate to call this planet Earth when its quite clearly Ocean”.

Several constellations are usually used for SATCOM systems depending on the services to be offered and the required coverage. Most of these systems are based on geostationary orbits especially GEO, which provide important advantages with respect to non-geostationary orbits particularly LEO, MEO and HEO, since ground antenna tracking is not required and with only up to 3 satellites it can provide worldwide coverage (except for polar regions). However, due to the distance from the earth surface (~36.000 Km), big delays are encountered and conversational voice services are not too much satisfactory from user QoE point of view.

Furthermore, lower orbits like LEO or MEO are achieving worldwide coverage, including Polar Regions especially Iridium, Globalstar and enabling the use of the handhelds. On the contrary, these constellations are requiring complex ground antenna tracking and in some cases inter-satellite links with regenerative payloads.

In the railway domain, tunnels and shadowing zones due to buildings, trees, etc.



provide an obstacle to satellite coverage. To solve this issue, the use of gap fillers and/or additional (terrestrial) communications systems is required. Therefore, the introduction of SATCOM within the railway domain also requires the use of terrestrial solutions.

Therefore, this network trend, where several systems of different natures can coexist to provide service to independent applications, facilitates the introduction of satellite communications within the railway domain. SATCOM can thus be used as a bearer (main or backup) to cover (for example) remote areas with small number of users where terrestrial communication system deployment could be complex and too much expensive.

Since LEO satellites may not use full power throughout each orbital period, scaling back the LEO satellite power to what will be effectively used may drive design efficiencies at a CAPEX level lower satellite weight and launch cost. When this is supplemented by a good choice of orbits, frequency bands and antenna elevation, well-designed LEO constellations may ultimately achieve decent global fill rates relative to their designed power balance but regardless of choice low altitude inevitably limits addressability.

Orbital inclination is another design factor affecting both coverage latitude reach and supply density. Over 75% of the globally addressable rural population for LEOs resides within 35 degrees of latitude north and south of the Equator. Yet, leading LEO-HTS operators deploy the highest capacity density with Gbps proportionally overhead above 35 degrees N/S to be able to serve high-ARPU11 regions in the northern hemisphere. This, in turn, creates supply-demand imbalances in other regions or latitudes that satellite operators and educated users or distributors could attempt to leverage with various degrees of bargaining power.

Therefore, constellations low altitude can be considered a blessing for latency and for spectrum reuse but also a curse for addressability. The addressability limitation of low altitude is the main reason why LEO players must target not just fixed data applications in terms of consumer, enterprise broadband, backhaul, but also energy and mining distant locations and mobility routes maritime, aero, rail, and eventually “connected cars”. Maximizing addressability is vital for constellation players to drive the lowest possible marginal cost per Mbps in order to be progressively more competitive.

The satellite industry is in the midst of a major transformation with LEO constellations under the spotlight but supply-demand imbalances and interference avoidance complexities may foster GEO-LEO and GEO-MEO complementation to Capabilities ultimately become the end game. Commercial distribution partnerships and hybrid technologies for distribution will also come into play to drive both technical and commercial pipeline efficiencies. It is hard to anticipate how much of complementation will be modulated by the various applications, but there is no doubt that such complementation will occur sooner or later, via either private-level coordination, provider partnerships, mergers and acquisitions or all.

Satcom constellations beaming tens of Tbps are impacting the space sector and the broader telecom industry. While LEO constellations continue blanketing the globe, GEOs and MEOs, being further away from Earth, can direct HTS spot-beam capacity more easily towards “hot spot” areas without wasting spectral resources and by leveraging low-cost VSATs. GEO-HTS systems large to small GEOs are thus ideally suited for capacity augmentation or complementation, not only around hot spots such as airports but also in low-ARPU populated regions within +/- 35 degrees of the Equator, where LEOs simultaneously exhibit lower density of overhead capacity and tighter interference-avoidance constraints on top of expensive terminals.

Today's fast-paced environment brings unprecedented opportunities for the telecommunications industry as a whole to make the most out of disruptive innovations and investments in space networks, both Non-GEO and GEO. However, orbital dynamics of LEO satellites drive the need to assess impacts differently, as not all LEO satellite capacity is either usable or uniformly distributed across the coverage regions.

Cyber security: raising the red flag



In the 1890s, traditional seafaring relied on paper charts, manual steering, and visual communication methods, such as signal flags and lights. Port operations, too, were labor-intensive, with minimal technological intervention. The advent of digitalization has revolutionized maritime operations, leading to the development of smart ships and automated ports. The integration of electronic navigation systems, such as the Electronic Chart Display and Information System and the Global Positioning System (GPS), has significantly improved the accuracy and safety of maritime navigation.

Furthermore, the introduction of the Automatic Identification System AIS has enhanced maritime situational awareness by enabling ships to automatically share their positions and other vital information with nearby vessels and shore-based authorities. Ports have also embraced digitalization, with the adoption of automated systems for cargo handling, logistics, and communication.

With the advent of digitalization, the operating system can be attacked through the network used for updating electronic files or via USB memory for the same purpose.

Originating Port

Once cargo is ready to begin its journey, it goes from the initial storage location to its port of departure via train, truck, or some other form of transportation. Firstly, after some level of inspection and verification, information about the container is entered usually automatically into the port's computers. The container then gets directed to a staging area, where it stays until the proper time to be moved to the designated berth and loaded onboard a ship.

A container ship typically carries hundreds or thousands at the loading bay requiring complex set of algorithms to optimize loading and unloading sequences and exact ship locations, as well as managing the ship's ballast. These algorithms need to determine a container's placement based upon the entire voyage of the vessel and knowing at which stop on the trip the container will be offloaded, ensuring that a container is placed in a powered bay, and the load balancing needs of the ship. This complexity is the root cause of insecurity at this stage. Additionally, depending on the type of cargo, the loading process looks different; nonstandard containers and other types of goods may go through a slightly different process.

The choreography of loading and unloading containers is a result of messages exchanged between the shipping agents, stevedores, tonnage centers, and ship's master/cargo officer. The cybersecurity risk here can be huge. Attacks on the loading and unloading software, IP theft, cargo manifest, bay plan and stowage information, Information systems controllers, and more at ports can cause a misloaded vessel and harm to cargo or the ship itself, as well as other potential affects.

A misloaded ship could be particularly vulnerable to rough seas, leading to the loss of containers overboard or other negative effects. Such attacks can also damage or disable gantries, cranes, containers, port vehicles, and vessels.

Once loaded up, containers and other types of cargo are then transported from the origination port to the destination port on a route that could include intermediate ports, where other containers have scheduled offloads and added cargo that needs loading.

The cybersecurity threat for cargo at sea is minimal, but not nonexistent, and it often aligns with the cyber threats discussed for ships above. A cyberattack on a cargo vessel can directly impact the cargo in transit. A refrigerated container, for example, might lose power, thus causing spoilage of the contents. Safety and monitoring devices on a bulk oil carrier might be turned off, affecting the stability of the
vessel and putting lives and cargo at risk.

A cyberattack on the loading and offloading systems of an LNG carrier could cause a catastrophic failure of the cooling mechanisms necessary to maintain the safe transport of the fuel. A cyberattack on the shipboard system that causes an electrical cutoff at powered bays could allow a flash-point increase near a container with flammable vapors.

A malicious actor could introduce a rogue communications device in a container to launch a cyberattack on a ship's or port's network. With some major liners exploring IoT-enabled containers, which customers can access remotely, the container itself may become a target vector. In most cases, ship operators do their best to ensure proper cybersecurity practices are followed, including network segmentation. However, the connectivity of these new smart containers, if accessed while onboard, could widen
the attack surface for ships. This could lead to compounding effects in the operation of a ship's navigation or communications systems or, in a worst-case scenario, connect to networks at the ports to which the ship visits, leading to even more lateral movement.

Destination Port

Once the cargo reaches its final destination port, the trip at sea is complete and it is time to unload. The process at the destination port is like that at the originating port, but in reverse. Containers to be unloaded from a vessel need to be accurately identified, and unloading algorithms control container removal and staging. The process looks slightly different depending on the cargo, but in all cases there is a critical reliance on technology to do so.

As before, messages exchanged between shipping agents, stevedores, tonnage centers, and the ship's master and cargo officer dictate the choreography to unload the containers. Information about each container must be entered usually automatically into the port's computers. Customs inspections need to be managed and bills of lading need to be reviewed and inspected. Although the attack vectors look similar for unloading ships and loading them, the potential uses for adversaries can look distinctly different.
Between 2011 and 2013, a criminal group reportedly gained access to the Port of Antwerp's IT systems, capitalizing on this access by using it to identify and intercept the containers their international partners had filled with illicit drugs. When their access was eventually discovered and mitigated, the criminals physically broke into the facility and downloaded malware that allowed them to continue their operation unmonitored.
Not only does this illustrate how cyber and physical activity can intersect in the maritime domain, but it also shows how comparable risks to the cargo transportation process can manifest in diverse ways for malicious actors throughout the life cycle.

Ultimately, containers and other goods are placed onto appropriate intermodal transport to be taken off-site and transported back to a shipper or warehouse. The cybersecurity threat during this stage can be significant as well. Attacks on the loading/unloading software and the controllers can cause a shift in the balance of a vessel or harm to cargo or the ship. Again, falsified or altered bills of lading can also cover up smuggling of illegal or contraband goods, or theft of cargo.

Similarly, ports and terminals are vital nodes in the global supply chain, handling the majority of the world's cargo. These complex infrastructures are increasingly reliant on digital systems for managing logistics, communications, and cargo handling operations. However, this reliance on technology introduces significant cybersecurity vulnerabilities. Many ports operate with outdated or unpatched software, making them susceptible to cyberattacks.
The integration of various systems, such as Terminal Operating Systems, Port Community Systems, and Industrial Control Systems, creates numerous entry points for attackers. Moreover, the connectivity of ports with external stakeholders, such as shipping companies, customs authorities, and logistics providers, further complicates cybersecurity. The exchange of data across these interconnected systems can be intercepted or manipulated by cybercriminals. Insider threats, whether from

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disgruntled employees or unwitting staff, also pose a significant risk, as they can exploit their access to sensitive systems. The lack of uniform cybersecurity standards across global ports exacerbates these vulnerabilities, as ports with weaker security measures can become gateways for broader cyber disruptions.

The consequences of such an attack are the same as for a personal computer, especially, operating system failure, encryption and deletion of data, placement of malicious scripts, and the spread of malware within the connected network. As a result, Electronic Chart Display and Information System becomes unusable, and other instruments are infected. In such a scenario, a second ship should be equipped with Electronic Chart Display and Information System as a backup or with a chart for the intended voyage. Another form of attack involves GPS signal disruption or falsification of the Electronic Chart Display and Information System location.

The issue can be easily detected when the system loses the entered position data and switches to dead reckoning mode. The GPS spoofing scenario is significantly worse. Electronic Chart Display and Information System then, plots a false location on the electronic chart from the GPS receiver, which is harder for the operator to detect and take appropriate action.

One of the most notorious cyber incidents in the maritime sector occurred in June 2017 when the global shipping giant Maersk was hit by the NotPetya ransomware attack. The malware spread rapidly through Maersk's network, disrupting operations across multiple terminals and affecting the company's ability to process shipments and manage cargo.

The incident forced Maersk to temporarily shut down its IT systems, causing significant delays and financial losses estimated at up to $300 million, according to report. The attack highlighted the vulnerabilities in the interconnected systems used by major shipping companies and underscored the need for robust cybersecurity measures in the maritime industry.

In July 2018, China's COSCO Shipping Lines experienced a cyberattack that targeted its American operations. The attack disrupted email and network communications, forcing the company to revert to manual processes for several days. While the incident did not significantly affect cargo operations, it demonstrated the potential for cyberattacks to disrupt communications and operations on a large scale. The COSCO attack emphasized the importance of having effective incident response plans and the ability to maintain business continuity during a cyber-crisis.

Similarly, in September 2018, the Port of San Diego was targeted by a ransomware attack, which impacted the port's information technology systems, including business services such as payroll and email. Although the attack did not affect port operations directly, it raised concerns about the vulnerability of critical infrastructure to cyber threats. This incident highlighted the importance of cybersecurity for ports, which are essential nodes in the global supply chain, and the need for robust defenses to protect against such attacks.

In another incident, in 2019, a cargo ship en route to New York suffered a GPS spoofing attack that caused its navigation system to display incorrect coordinates. Fortunately, the crew noticed the anomaly in time to correct the ship's course, but the incident underscored the potential dangers of cyberattacks on navigation systems.

In times of increased digital dominance, the maritime sector finds itself in crisis. As dependency on technology grows, so does the risk of cyberattacks, creating unprecedented challenges for global trade. In recent years, the impact of digitization has been unparalleled, beginning with the replacement of legacy systems with smart devices and the connection of nearly everything to the Internet, from massive data centers to personal wearable devices.

Ships and vessels, the primary carriers of global trade, have become increasingly digitalized, making them vulnerable to cyber threats. Modern ships are equipped with sophisticated electronic systems such as the Electronic Chart Display and Information System ECDIS, the Automatic Identification System AIS, and Global Navigation Satellite Systems GNSS, all of which are critical for navigation and communication. However, these systems can be compromised if not properly secured.

The Electronic Chart Display and Information System, for instance, is responsible for displaying navigational charts and providing real-time positioning information. A cyberattack that alters the data within system could mislead a vessel's crew, potentially causing the ship to run aground or collide with other vessels. Similarly, AIS, which broadcasts a ship's location and identification information, can be spoofed, leading to the misrepresentation of a vessel's position or identity. This can result in collisions, illegal activities such as smuggling, or even piracy

Also, the increasing use of Internet of Things IoT devices on ships, such as sensors for monitoring cargo conditions and engine performance, also presents new vulnerabilities. These devices often lack robust security features, making them susceptible to hacking. Once compromised, these systems can be used to disrupt operations, steal data, or gain control over critical ship functions.

Managing the maritime security

Shipping is frequently described as a conservative industry that is slow to embrace new technologies. In fact, this is not true especially when it comes to the matter of ship communications. Ships were communicating with the shore via radio from 1899 although initially messages were sent using morse code rather than voice. By the late 1970s, satellite systems and networks were being used by a small number of commercial vessels and many more military ships.

Obviously technological change is only adopted once it has reached a stage where it can meet the unique demands of the maritime industry and in particular prove its reliability and robustness under the harshest of conditions. If shipping has been slower to embrace some aspects of modern technology, it is often because the difficulties and high cost of ship communications across vast distances has meant that ship operators devised ways of minimising the amount of communications needed for commercial purposes.

Shipping is a truly global industry, as one researcher has stated: “A Greek owned vessel, built in Korea, may be chartered to a Danish operator, who employs Philippine seafarers via a Cypriot crewing agent, is registered in Panama, insured in the UK, and transports German made cargo in the name of a Swiss freight forwarder from a Dutch port to Argentina, through terminals that are concessioned to port operators from Hong Kong and Australia”.

The offshore industry is one of the fastest-growing sectors of the maritime economy. It contributes to the creation of thousands of jobs for highly skilled specialists. According to estimates, wind energy contractors may require approximately 100,000 people over the next 20 years.

Maritime revenues have always played a key role in the economies of many countries. Today, in the era of globalization, it has become a crucial element of the supply chain, handling approximately 80% of global trade. As a driving force of the global economy, it requires constant protection against threats such as piracy, natural disasters, and cyberattacks.

However, the maritime economy is changing rapidly. The number of embedded and interconnected systems, as well as those accessible and operable from land, is growing quickly. The term "marine" refers to ships, hulls, extraction structures, other floating objects, infrastructure, and everything that connects and integrates all of these elements into a business. Many organizations are currently migrating to the cloud for convenience.

Therefore, managing cybersecurity, particularly in terms of securing information and the systems that process it, has become one of the fundamental challenges of our times. Complex IT systems process massive amounts of data, making them attractive targets for criminals, ranging from intellectual criminals and amateur hackers to organized crime groups manipulated and trained by the military and police forces of various countries.

In times of increased digital dominance, the maritime sector finds itself in crisis. As dependency on technology grows, so does the risk of cyberattacks, creating unprecedented challenges for global trade. In recent years, the impact of digitization has been unparalleled: the replacement of legacy systems with smart devices and the connection of nearly everything to the Internet, from massive data centers to personal wearable devices. Energy infrastructure is also undergoing these changes, becoming increasingly interconnected. The use of smart devices, such as intelligent electronic devices IEDs, IoT-enabled systems, and cyber-physical systems, along with the widespread adoption of Industry 4.0, has resulted in efficient resource utilization, reduced intervention, and increased convenience

The rapid digitization and automation of devices and systems on ships, in ports, and in remote equipment make maritime transport enterprises increasingly vulnerable to threats such as data theft, modification, or destruction.

Marine assets such as ships, containers, port infrastructure, offshore wind farms, and drilling platforms can be connected to sensors and the Internet to collect and monitor data in real time. The Internet of Things IoT enables remote asset tracking, predictive maintenance, and improved operational efficiency. Again, cyber-physical systems facilitate real-time remote command and control over on-site systems and equipment. Autonomous ships and smart port facilities, such as automated quay cranes, automated guided vehicles for moving vessels, and automated gate systems for efficient cargo clearance using technologies like machine learning, computer vision, and advanced navigation systems, allow for reduced human intervention and enhanced outcomes, resulting in increased profits.

Cybersecurity measures adopted by maritime industry

As the maritime industry has embraced digitalization, the need for robust cybersecurity measures has become increasingly critical. Recognizing the rising threat of cyberattacks, many maritime organizations have implemented various cybersecurity practices to protect their assets and operations. These measures typically involve a combination of technological solutions, organizational policies, and personnel training.

On the technological front, many maritime companies have adopted firewalls, intrusion detection systems, and encryption techniques to safeguard their networks and communications. These technologies help prevent unauthorized access to critical systems and ensure that data transmitted across networks is secure. Additionally, shipboard systems are increasingly being equipped with cybersecurity software that can detect and mitigate malware and other forms of cyber threats in real time.

Many companies have developed cybersecurity protocols and incident response plans to guide their actions in the event of a cyber-incident. These policies often include guidelines for access control, system updates, and regular security audits. Moreover, maritime companies are increasingly conducting cybersecurity risk assessments to identify potential vulnerabilities and implement targeted countermeasures.

Also, personnel training is another vital component of cybersecurity in the maritime industry. Since human error is a significant factor in many cyber incidents, training programs are designed to raise awareness among employees about common cyber threats, such as phishing and social engineering, and to educate them on best practices for maintaining cybersecurity. Regular drills and exercises are also conducted to ensure that personnel are prepared to respond effectively to cyber incidents. Despite these efforts, the effectiveness of these measures can vary widely across the industry, depending on factors such as company size, resources, and the complexity of operations.

Why space tech companies eye President Trump's Golden Dome project



On May 20, 2025, President Donald Trump announced that the Golden Dome, an initiative to provide a missile defense shield for the U.S. homeland, would cost $175 billion and take three years to build. Since it was first described in an executive order on January 27, 2025, a number of U.S. companies have expressed interest in contributing to the project, including a consortium reportedly proposing a space-based solution, which would, at least in part, be sold as a service using a subscription model.

The Golden Dome initiative would include, among other elements, a space-based component that would provide detection, tracking, and boost-phase missile intercept capabilities. In late May 2025, the president announced that Gen. Michael A. Guetlein, currently the vice chief of space operations of the U.S. Space Force, would lead the initiative, serving in a role that will likely report directly to Deputy Secretary of Defense Stephen Feinberg.
While a number of current military systems aim to defeat ballistic missiles in their midcourse and terminal phases of flight, especially the Ground-Based Midcourse Defense and Aegis systems that target missiles in their midcourse phase and the Patriot, Aegis, and Terminal High Altitude Area Defense systems target missiles in their terminal phases, the Golden Dome would include space-based interceptors aimed at hostile missiles in their boost phase, which is a short three-to-five-minute period after missile launch.
The Golden Dome, like the current U.S. ballistic missile warning architecture, would also lean heavily on space-based components for missile launch detection and missile flight tracking data, which would be used to help steer interceptors to their targets. Essentially, the Golden Dome as a service could include either satellites performing missile launch detection and tracking (e.g., satellites with cameras and thermal sensors), satellites performing the missile intercept function, or both.

The idea of a Golden Dome is not new. In the 1980s, President Ronald Reagan tried building a missile defense system known as “Star Wars.” The project failed.
“Ronald Reagan wanted it many years ago, but they didn't have the technology,” Mr. Trump said in May. “But it's something we're going to have. We're going to have it at the highest level.”

“The space-based interceptor is by far the most technically complex element,” said Charles Beames, a retired colonel and former director of space systems at the Pentagon who is chairman of York Space Systems, a defense tech company. Golden Dome needs the “strengths of traditional space and defense companies with the innovation of today's leading defense technology firms,” he said.

Iron Dome's radar, is an Active Electronically Scanned Array multirole radar that locates the launch origin of incoming rockets and mortars, tracks the projectiles in flight, calculates an intercept solution, and directs the interceptor to the interception point.
The target acquisition process is reportedly performed in anywhere from less than one second to seven seconds, with the interceptor launch taking place just one second after that. It can locate the source of artillery and rocket fire with a circular error probable of 150m at 50km, according to Military Periscope, an online weapons database. Each battery is estimated to be able to protect a 58mi2/150km2 area.

Using the information gathered by the radar, soldiers at the battle management and fire-control center determine if the rocket is on a trajectory to hit a populated area or areas of strategic importance such as industrial sites or military bases that the state would want to defend. If the rocket is on target to land in an open field or the desert, no further action is taken the rocket is ignored and left to explode in the open where it will not cause any damage. If the rocket is on target to land in a populated or important area, the battle management and fire-control center will take appropriate action.

The Israel Iron Dome is not without its limitation. Given the volume of rocket fire targeting Israel, the Israel Defense Forces would run out of interceptors if it had to engage all incoming rockets as opposed the smaller percentage of rockets whose trajectories indicate they will land in the protected envelope. Providing coverage for the entire country is also a costly endeavor.

According to most estimates, Israel has nine Iron Dome batteries, and Israeli officials estimate it would take 13 batteries to cover the entire country, which they plan to do. While Israel developed Iron Dome on its own, the United States provided Israel with monetary assistance to the tune of around $1 billion for production and procurement, greatly offsetting the cost that Israel's much smaller defense budget would have to allocate.

Further, the hypersonic missiles the US Golden Dome system would be tasked with intercepting travel many times faster than the short-range missiles and rockets Israel's Iron Dome has to deal with. And even in the case of Iron Dome, the recent fusillade from Iran included some medium-range ballistic missiles, which got past Iron Dome.
However, intercepting a missile from space requires systems that can reliably track an object moving at hypersonic speeds and predict its trajectory, as well as decide when and how to intercept that object and which objects to intercept, two defense officials said.

Defense experts have said Mr. Trump's plan could cost more than $1 trillion, adding that it is unclear if even the most advanced technology could create an impenetrable barrier around the United States.

But tech companies are not waiting. Many have flocked to defense conferences and conducted exercises to display everything from sonars that monitor incoming threats to lasers that shoot missiles from space. Companies chosen for Golden Dome are likely to become the new cornerstones of U.S. defense, military officials involved in the project said.

Palantir has discussed building an A.I.-backed platform to analyze threats and control the different systems needed to follow a missile's trajectory, while Anduril has discussed using experimental interceptors such as lasers to take down missiles, they said. SpaceX, Elon Musk's rocket company, is likely to help build infrastructure and get satellites into orbit, they added.
The military has long used contractors and commercial services to accomplish military functions, including space missions for which the U.S. Space Force has articulated a “buy before build” commercial preference. This predisposition for commercial options supporting military space functions aligns with overall U.S. government policies that have attempted to remove barriers for using commercial services to support the government's mission and space missions specifically.

The commercial space companies
In the US, commercial satellite services companies have also played an important role providing capabilities for joint operations. Since the 1960s, the DOD has obtained satellite communications services from commercial operators for military use. Starting more recently, the DOD has acquired both geospatial intelligence as a service and analytical insights used to support operations from companies operating satellites that collect electro-optical, radar, and RF sensing data.

The Space Force also contracts with companies to obtain space domain awareness data and surveillance, reconnaissance, and tracking products using an as-a-service model, providing functions that directly support the space control mission and space superiority objective. Additionally, all military space launches are purchased as a commercial service.
In January 2015, SpaceX announced the opening of a Seattle office to begin work on Starlink and predicted that it could begin offering global service after about five years. The prototype Starlink satellites were launched in 2018 and first operational satellites were launched in 2019. Starlink began offering beta service in July 2020 essentially matching SpaceX's timeline announced five years earlier—and today has nearly 8,000 satellites in orbit.

Earlier, York Space Systems, the Denver-based aerospace company announced its selection by the U.S. Space Force for a $237 million defense mission contract to procure small satellites supporting national security missions. The contract award is designed to enable faster and more flexible acquisition of spacecraft, integration, and launch support.

The award highlights York's role as a trusted partner for defense space programs and builds on the company's launch of its Space Systems Service offering, designed to provide mission-ready space capabilities under a commercial framework. This new contract vehicle provides a streamlined path for the Space Force to access York's rapidly scalable production model and operational spacecraft services.

"This award is another important step forward in how our national security partners are leveraging proven commercial providers to meet urgent and evolving mission requirements," said Melanie Preisser, GM and Executive VP of York. "York has been demonstrating for years that we can deliver high-performance, affordable satellites fast and at scale. We're thrilled to be selected and ready to respond at the speed of need as these missions are conceived and then activated under this contract.”

York Space Systems was founded on and is dedicated to achieving increasingly rapid delivery of reliable and affordable spacecraft. The Denver-based aerospace company is a beacon in the industry, enabling and spearheading next-generation space mission operations globally. Specializing in the swift production of mission-ready spacecraft platforms, York integrates commercial methodologies to deliver across a spectrum of government and commercial missions.

This new contract supports a range of future missions, including remote proximity operations, space situational awareness, and Golden Dome demonstrations. York satellites performing these missions, and several others have all been built, integrated, and tested in Denver, Colorado, leveraging a now fully scaled domestic supply chain that continues to operate at high throughput.

"This contract opens the door for the Space Force to field resilient capabilities with the speed and agility the moment demands," said Michael Lajczok, CTO of York. "We're proud to be a part of this exciting new procurement framework and look forward to supporting a wide range of mission types that strengthen our nation's security.”
The president's ambitious plans to increase national security through a defense system similar to Israel's Iron Dome have also caught the attention of Denver-based York Space Systems.

"York is really well positioned, uniquely suited to support the Golden Dome," said Melanie Preisser, the company's executive vice president and general manager.

Preisser believes they have the quick production capabilities to keep up with President Trump's 3-year timeline and the innovative abilities to deliver.
"We've been able to make a laser communication link between our satellites and satellites that were developed by another company," said Preisser. That's kind of a first heard, and we're very proud of that accomplishment.”

"We are executing programs for the government and our commercial customers." The company just launched satellites into space in June and July.

"Within a few weeks, we're going to launch yet another set of satellites, actually 21 of them all at the same time for the Space Development Agency," Preisser. "We actually have a pretty large backlog of over 100 satellites that we are building for various customers. “

Established in March 2019, the Space Development Agency (SDA) was set up to operate much faster than traditional DOD space acquisition organizations. In April 2023, SDA launched its first transport layer satellites. Though SDA expected to have around 170 satellites in orbit by October 2025, including an initial warfighting capability, it is well short of that goal. As of May 2025, SDA had only 19 transport layer and 8 tracking layer satellites in orbit—all part of an initial testing and evaluation group of satellites.
Start-ups including Varda have also jumped in. The company was founded in January 2021 to design and fly spacecraft for making pharmaceuticals in space. The company launches into orbit reusable capsules, which take advantage of microgravity to create specialized molecules that are hard to produce on Earth. Varda has raised more than $329 million from venture capital firms including Founders Fund and Khosla Ventures.

After Mr. Trump signed his executive order for a missile shield in January, Mr. Bruey saw an opportunity, he said, to use Varda's technology to “support national security needs.”

He met with executives at Anduril and LeoLabs, with whom he is friendly, and broached the idea of working together. Their combined technologies could track an object moving at hypersonic speeds to Earth, the way a missile would potentially move, he said.

“We wanted to lean in and demonstrate how existing technology could be applied to new missions,” said Tony Frazier, the chief executive of LeoLabs.

At Varda's headquarters during the test, employees watched screens in a NASA-like control room that tracked the capsule. The capsule, which had already been in orbit for a few weeks, began its descent to Earth at 6:37 p.m. Just after 6:55 p.m., applause broke out as the capsule's parachute deployed.

Twelve minutes later, the capsule was confirmed to have landed in a remote part of Australia. The demonstration was declared a success. “No one is going to forget this day ever,” Mr. Bruey said. “We've already started planning the next demonstration of what we can do.”

Iron Dome Israel's miracle weapon faces reliability tests



As Israel picks up pieces from powerful missile strikes from Iran, Israeli compensation fund announced that it has received 30,735 claims for compensation since the beginning of the conflict for damage to homes, cars and equipment following Iranian missile attacks.

The cost of property damages from Iranian missile and drone attacks on Israel after 12 days was estimated to be around double the sum of claims stemming from the October 7 attack and all 615 days since, the head of the Tax Authority's compensation department said.

After Israeli homeowners filed more than 45,000 claims for some $1.47 billion of property damage sustained during Israel's 12-day war with Iran in June, a government initiative called “Renovating in Unity” was designed to bring together private contractors, local authorities, and government officials to manage the large-scale restoration effort.

The likely $1.47 billion price tag calculated by Amir Dahan underlined the destructive power of the few Iranian missiles to make it through Israel's air defense shield, carrying massive warheads that reduced whole apartment buildings to rubble and sent out blast waves that shattered windows and caused other damage over a wide area.

“These are figures we have never seen for direct property damage,” Dahan told the Knesset Finance Committee. According to Dahan, damage claims resulting from ballistic missile attacks from Iran had already reached $1.32 billion, and were expected to climb by another NIS 500 million. By comparison, Israeli property owners had incurred some $735 million in damage resulting from the October 7 attack and since, including months of heavy fighting in the north.

Some 40,000 property claims over the war have already been filed, a figure that Dahan predicted would likely reach 50,000 or more, including claims from factories still assessing the extent of damage. It was not clear if the forecast was based on a longer timeline for the war, which appeared to end abruptly Tuesday morning following a US-brokered ceasefire. Direct hits from Iran on the Weizmann Institute of Science in Rehovot and the Bazan oil refinery in Haifa were particularly destructive, Dahan said, without providing specific values.

Of 38,700 claims filed before the rocket barrage Tuesday morning, which destroyed a building in Beersheba and killed four people, some 31,000 claims were made for damage to buildings, 3,700 for vehicle damage, and 4,000 for other property, including furniture and appliances, according to the Tax Authority. These included some 25,000 claims made in Tel Aviv, 10,800 in Ashkelon, 2,600 in Haifa and Acre, and 94 in Jerusalem, among other districts, according to incomplete Tax Authority data.
Regarding damages to the contents of a home, Israeli law provides that owners can be compensated up to a certain value for different objects. For example, families can be compensated up to $7,400 for damaged furniture and up to $9,084 for electronics and appliances. The Tax Authority offers insurance for higher payout, at a premium of 0.3 percent of the additional value. While only 600 Israelis had signed up for this additional coverage before the war, more than 50,000 have joined since the beginning of the Rising Lion operation, according to a report in the Hebrew daily Calcalist.

During the 12-day war, the sheer quantity of rockets, fired in such massive salvos, have become so large that Iron Dome's radar was overwhelmed, according to one analyst. The radar works by scanning for rockets and, once it finds one, dwelling on it for a certain amount of time before moving on to scan for other rockets. It then returns to the first rocket again in order to track its trajectory, and repeats this process for all the rockets it finds. As the radar is forced to dwell on more rockets in this cycle, it has less time to scan for new objects and has to wait longer before returning to each rocket, which lessens the quality of the trajectory calculation.

In addition, the Iranian arsenals also include guided projectiles, therefore, the percentage of total rockets that Iron Dome will have to intercept increased. Analyst believes guided projectiles have a better than one-fourth chance of landing in a protected area.
Analysts argued that, a guided rocket may require Iron Dome to fire more than one Tamir in order to successfully intercept it. This is because the course corrections of the guided rocket will complicate the radars' tracking and provide less time to calculate an intercept point.

Any terminal guidance on the projectile can also interfere with the Tamir's ability to detonate in close enough proximity to the incoming warhead in order to destroy it. Therefore, equipping short-range rockets with cheap GPS guidance systems is relatively easy. It would increase the cost of each rocket substantially but would still be far cheaper than each Tamir interceptor.

The question is, “What effect might Iron Dome's degraded performance have on the perception of victory in both Israel and the Arab world”? Iron Dome helped Israelis conceptualize the outcome of the last two wars as victories for Israel because Hamas's main threat had been neutralized. Because Israelis place so much pride and faith in Iron Dome, if the system performs below expectations, Israelis might have a harder time believing they achieved victory during a future war.

Iron Dome's Performance

Before the war, complacency about the rocket threat under the belief that Iron Dome works exceptionally well have caused reckless behavior, including ignoring the sirens alerting people to seek shelter. This has already happened, as some Israelis remained outside during rocket attacks in attempts to take pictures of Iron Dome in action. The benefit of feeling protected, which allows for some degree of normalcy during wartime, is a good thing, but if taken too far it can degrade the civil defense necessary to save lives.

After Iron Dome's debut on April 7, 2011, it was put to the test in two major military conflicts between Israel and Hamas in the Gaza Strip. Israel's Operation Pillar of Defense, a week-long mini-war between Israel and Hamas, took place from November 14 to November 21 in 2012.
Another much longer and bloodier war followed two years later, called Operation Protective Edge by Israel. From July 8 to August 26, 2014, Hamas and other Islamist groups in Gaza launched thousands of rockets into Israel while the Israel Defense Forces IDF conducted thousands of airstrikes in Gaza along with limited ground incursions.

Iron Dome was the darling of Israeli’s operations, both in Israel and around the world. Commentators touted the success of the system, often using phrases like “game changer” and “stunningly effective.” In Israel, Iron Dome became something of a cultural icon, inspiring songs, skits, and even tattoos.

The data for Operation Protective Edge has even more variance than the data for Pillar of Defense. According to an Israeli defense expert who received an oral briefing by an Israel Defense Forces IDF Spokesman, 4,591 rockets and mortars were fired at Israel during the 50-day war. One hundred and ninety-seven of those exploded or landed in Gaza, leaving 4,394 that actually landed in Israel. Of those, 3,434 landed in “open spaces,” areas not in Iron Dome's envelope. That means that 960 rockets were judged by Iron Dome to pose a threat to defended areas.

Of these 960 threatening rockets, Iron Dome successfully intercepted 735, leaving 225 that hit within the protective envelope. Of those 225, Iron Dome engaged 70 but the engagements were unsuccessful, according to a report from Aviation Week. No explanation is given for why Iron Dome did not attempt to intercept the remaining 155 rockets that hit within the defended envelope, though it may be possible that some of these were actually mortars with ranges of under 4km, which Iron Dome is not designed to defend against.

Other estimates for the total number of rockets fired vary slightly, while other estimates for the number of rockets that landed in open areas vary by a few hundred. The main explanation for this wide variance is that some estimates include mortar attacks while others only include rocket attacks.

The Israeli government sees Iron Dome as an instrument of political and military flexibility. Because Iron Dome gives the Israeli population a sense of security and shows the public that the government is “doing something” to protect them, there is less public pressure on the government for military action.

This gives the Israeli government more political maneuvering room and enables decisions about the use of force to be made with less political considerations.
According to many Israeli officials and commentators, if it weren't for Iron Dome, Israel would have been forced to invade Gaza to stop the rockets or the government would have paid a political price. Since the cost of a single day of IDF ground operations in Gaza is estimated to cost around $260 million, and the cost in Palestinian civilian lives and the lives of Israeli soldiers would be catastrophic, anything that gives the Israeli government more options short of invading Gaza is beneficial.

In addition to saving lives and providing decision makers with greater flexibility, Iron Dome was a massive propaganda victory for Israel and helped Israelis view the 2012 and 2014 wars as successes even though Hamas was not defeated and the rocket fire continued throughout both operations. Israeli researchers even found that confidence in Iron Dome helped reduce Post-Traumatic Stress Disorder among those affected by Operation Protective Edge.

Iron Dome a Hoax?

Just months after Operation Pillar of Defense, Theodore Postol, a missile expert and professor of Science, Technology, and National Security Policy at the Massachusetts Institute of Technology, wrote that Iron Dome could not have performed as well as the Israeli government claimed. Postol's analysis immediately gained attention among academics in the United States due to his past success in exposing the failure of the Patriot PAC-2 batteries during the Persian Gulf War. A handful of other skeptics also emerged, but since Postol's analysis is the most well-known and comprehensive, this paper will focus on evaluating his claims.

Postol analyzed footage of Iron Dome interceptions, mostly videos uploaded to the internet by Israelis who captured the event on their cellphones, and concluded that Iron Dome's Tamir interceptors were not engaging the target rockets in a way that would lead to a high success rate.64 In fact, Postol estimates that Iron Dome's true interception rate is closer to 5 percent.
In order to understand how Postol came to this conclusion, it is important to understand the basic physics of rocket defense. The objective of rocket defense is to explode or otherwise disable the warhead of the incoming projectile. This must be done either by slamming an interceptor's kill vehicle into the warhead of the incoming projectile known as a hit-to-kill interception, likened to “hitting a bullet with a bullet”, or by exploding an interceptor's warhead near the incoming projectile and spraying it with shrapnel that explodes or disables it known as a fragmentation or explosive detonation interception.

For fragmentation interceptions, which is the method Iron Dome reportedly uses, engagements between the interceptor and the incoming rocket need to be head-on, or antiparallel. If the interceptor approaches the target projectile from the side or from behind, it will explode and spray its shrapnel into the rocket motor, not the warhead at the tip of the descending rocket.
During the descent phase of a ballistic projectile, the rocket motor will have already expended its fuel, meaning it is essentially an empty tube. Because the descending front-end of the rocket is the heavy end, blowing holes in the empty motor tube most likely will not cause the rocket to tumble or otherwise alter its stable trajectory. The only way to explode the interceptor warhead in a way that will send shrapnel into the target warhead is by approaching the target warhead head-on

This confrontation angle allows the Tamir's radar seeker to detect the incoming projectile, estimate where the front of the projectile is, and calculate how long it will take the front of the projectile to line up with the Tamir's warhead located behind the radar seeker. Approaching the target projectile from behind will cause the radar seeker to think the end of the target projectile is in fact the front of it. Side engagements are also extremely unlikely to line up such that the shrapnel from the interceptor hits the warhead of the incoming rocket.

By looking at dozens of Iron Dome interception videos, Postol concluded that fewer than 20 percent of the engagements were antiparallel. He determined this by looking at the contrails of the interceptors as they approached their targets and by looking for asymmetric explosions as a sign that the target warhead had actually detonated. According to his analysis of the footage from both Pillar of Defense and Protective Edge, the Tamirs appear to be maneuvering wildly and chasing the rocket instead of meeting it head-on as it descends on a steep trajectory.

Maneuvering at the end of the engagement to chase the rocket indicates the interception is not antiparallel. Richard Lloyd, a former Raytheon employee and consultant for Tesla Laboratories, agrees that the contrails show the Tamirs engaging in maneuvers that indicate interceptions from the side. Postol also saw no evidence of asymmetrical explosions. If only the interceptor warhead detonates, a spherical explosion would be seen; however, if the interceptor successfully causes the target warhead to detonate, an asymmetric fireball should be seen as both warheads explode next to each other.

Israel has also signaled recently that it wishes to expedite production of additional Iron Dome batteries to meet the evolving threat. But against enemy rockets in the hands of a wealthier and more capable enemy, which faces no blockade from Israel, upgrades to Iron Dome are unlikely to keep up. Therefore, it is possible that Israel has reached “peak Iron Dome,” wherein the system's performance may increase or decrease slightly in future engagements. The Israeli government must begin the process of explaining to the population the conditions of a future war that will make protection of the country impossible. Either the IDF will need the batteries for the war effort or the system will simply be overwhelmed by the larger raid sizes fired into Israel.

If Israelis understand that Iron Dome will not provide such coverage, they will take the civil defense measures more seriously and will be less likely to see any of Iron Dome's failures as a failure of the war effort overall.
If Israel goes into the next war with its current mindset about Iron Dome, the disparity between Israel's expectations and reality may result in a perception of failure after the fighting stops.

Hopefully, these theoretical questions about Iron Dome's performance in another war was never answered and deterrence between Israel and its adversaries will hold for the foreseeable future. The tragic consequences of deterrence failure for the innocent were very painful following Israeli war with Iran. But in an unstable region, the possibility of another war between Israel and its adversaries is a real, and growing, possibility. Israel, and Iron Dome's advocates around the world, would be wise to temper their expectations about the system's performance given the very real chance that the next war produces conditions so unfavorable for rocket defense that Iron Dome becomes viewed as a failure.

By Ari Kattan, with agency reports

SouthPAN, Australia's 'next-generation SBAS'



As part of the Positioning Australia program, Geoscience Australia is progressing with the delivery and operations of SouthPAN, the Southern Positioning Augmentation Network. SouthPAN is a Satellite-Based Augmentation System (SBAS), which includes a system of space and ground infrastructure that augments positioning signals provided by the Global Positioning System GPS and other Global Navigation Satellite Systems (GNSS) to significantly improve positioning accuracy and reliability. SouthPAN delivers positioning data to users via satellite and is a partnership between Geoscience Australia and Toitū Te Whenua Land Information New Zealand under the Australia New Zealand Science, Research and Innovation Cooperation Agreement.

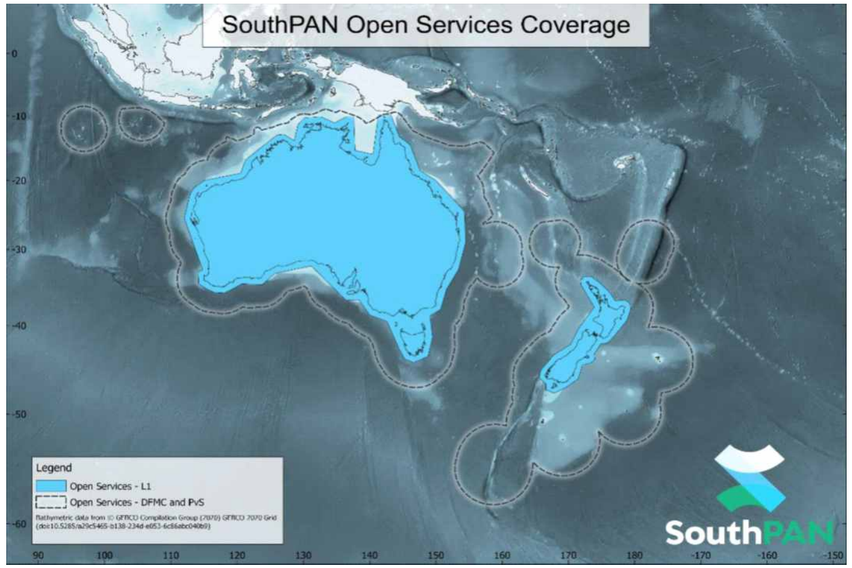
Australia and New Zealand's operational Satellite Based Augmentation System (SBAS) has officially been named the Southern Positioning Augmentation Network, or SouthPAN. SouthPAN will be the first SBAS in the Southern
Hemisphere, led by Geoscience Australia and Land Information New Zealand under the Australia New Zealand Science, Research and Innovation Cooperation.
The Southern Positioning Augmentation Network (SouthPAN) is the first satellite-based augmentation system (SBAS) in the Southern Hemisphere. Improvements to Global Navigation Satellite System (GNSS) positioning across New Zealand and Australia, including from new SouthPAN ground stations, enables compatible devices to achieve less than a metre accuracy.

Scion field crews are utilising SouthPAN in handheld GNSS kits to accurately collect data, manage forest inventory, and monitor pests and diseases. Handheld GNSS devices have been used in forestry for years, however, the positioning accuracy in these challenging conditions is often limited to 15 metres. By enabling the SouthPAN L1 SBAS satellite signal in the configuration, these GNSS devices are now working at sub-metre positioning accuracy.

The SouthPAN broadcast signals went live on 26 September 2022 and will operate for 19 years with Safety of Life SBAS services commencing in 2028. We are providing Australia and New Zealand world-class access to positioning services that will improve accuracy from 5-10 metres to as little as 10 centimetres on land and sea without the need for mobile or internet coverage. SouthPAN is the first SBAS service in the southern hemisphere and estimated to generate at least $7.6 billion in benefits to the Australian and New Zealand economies over 30 years. This presentation provides an introduction to SouthPAN, along with a progress update of project and service delivery and the benefits to users.

The Southern Positioning Augmentation Network (SouthPAN) is an open access positioning system, delivering improved accuracy, integrity and availability of global navigation satellite system (GNSS) positioning corrections across New Zealand and Australia via satellite and the internet, benefiting a wide range of sectors.
SouthPAN is the first SBAS in the Southern Hemisphere, with early Open services now available. SouthPAN is empowering industries across New Zealand and Australia to optimise operations, improve productivity and efficiency, maintain high health and safety standards, and drive innovation at scale to compete with global capabilities.

SouthPAN is a joint satellite-based augmentation system designed to deliver highly accurate positioning and navigation services across the region. It underpins applications in aviation, maritime transport, agriculture, surveying, mining and emergency response.
By correcting signals from global navigation satellites, SouthPAN enables positioning accuracy down to a few centimetres far more precise than the standard GPS service available to the public.
Geoscience Australia chief executive Melissa Harris said the deal would provide a secure and reliable foundation for critical industries: “This agreement secures a reliable satellite service and ground infrastructure, delivering precise positioning across Australia and its maritime zones – enabling industries to innovate where accuracy is critical.”
Harris added, “From farms to freight, users will be able to access free services that are accurate and timely.”
In agriculture, SouthPAN supports advanced practices such as controlled traffic farming, inter-row seeding, yield mapping, precision spraying and livestock monitoring. In resources and construction, it can enhance worker safety through smart geofencing technologies that track the movement of personnel and heavy machinery in real time.
The latest award follows the 2023 contract originally granted to Inmarsat before its merger with Viasat to deliver a satellite payload for SouthPAN. The new agreement extends services from Viasat's in-orbit satellites and adds a fresh payload, strengthening its role as a long-term partner in the program.
Viasat International Government president Todd McDonell said the company was proud to expand its collaboration with both governments.
“SouthPAN represents extraordinary potential for the region: it can save lives by enabling precision safety tracking, help farmers improve productivity through automated device tracking, and even support transport management systems of the future,” he said.
Once fully operational, SouthPAN is expected to transform sectors where pinpoint accuracy is essential, delivering productivity gains, boosting safety and opening the door to new technologies across Australia, New Zealand and surrounding maritime zones.



SouthPAN serves growing end market use cases, including in agriculture to increase productivity through applications like precision spraying, yield mapping, controlled traffic farming, inter-row seeding and livestock management. It is also capable of improving personnel safety on mine and construction sites through smart geo-fencing technologies to accurately identify the location of workers operating vehicles and heavy machinery.

This marks the second such award for the company, after Inmarsat which has since combined with Viasat was awarded a contract in May 2023 to deliver a satellite payload for SouthPAN. The new agreement, which amends the previous award and comes under Viasat's Communication Services segment, covers the continuation of services from Viasat's existing in-orbit satellites as well as a new payload, marking a significant extension of Viasat's partnership with both Governments.

“This agreement secures a reliable satellite service and ground infrastructure, delivering precise positioning across Australia and its maritime zones – enabling industries to innovate where accuracy is critical,” said Geoscience Australia's Chief Executive Officer, Melissa Harris. “From farms to freight, users will be able to access free services that are accurate and timely.”

Todd McDonell, President, Viasat International Government, said: “Viasat is thrilled to expand its support for SouthPAN and enable improved positioning and navigation services across Australia and New Zealand. SouthPAN represents extraordinary potential for the region: It can save lives by enabling precision safety tracking, help farmers improve productivity through automated device tracking, and even support transport management systems of the future.

“We have a long history providing advanced PNT and safety services across the world, so we are of course excited to be expanding this work and collaboration with GA and LINZ.”
SouthPAN is delivered by Geoscience Australia in partnership with Toitū Te Whenua Land Information New Zealand, with early services available to both countries since 2022.
Minister for Resources and Northern Australia Madeleine King said the $252 million agreement marked significant progress in the delivery of the Southern Positioning Augmentation Network (SouthPAN), which is a satellite-based augmentation system developed jointly by Australia and New Zealand.
“This new agreement ensures we will have a robust, reliable satellite service working with our network of ground infrastructure to provide accurate precise positioning across the country and our maritime zones,” Minister King said.
The Australian Government has committed $1.4 billion towards the establishment and sustainment of SouthPAN over 19 years. The project will provide precise positioning and navigation services to support a number of sectors, including aviation, maritime, agriculture, surveying and emergency response.
Inmarsat Australia, which has since combined with Viasat, won the first contract in 2023 to deliver a satellite payload for SouthPAN.
The new agreement covers the continuation of services from satellites as well as a new payload to be carried on one of Inmarsat's I-8 constellation of satellites.
It is also one step closer to SouthPAN being certified as a safety-of-life service for aviation, which is expected from 2028.
This new capability would mean SouthPAN can be used in safety-critical operations where life could be at risk, such as medivac flights in a wider range of weather conditions. SouthPAN can be used in agriculture through applications like precision spraying, yield mapping, controlled traffic farming, inter-row seeding and livestock management. It can also improve safety on mine and construction sites by accurately identifying the location of workers operating vehicles and heavy machinery.

How BlackSky safeguard lives during deadly evacuation in West Africa

Imagine a scenario where two big local actors are fighting for the control of a country's capital, threatening peace and stability of the country they once lead, closing airspace for international travel, and limiting connectivity. One of the key highlights of this perilous moment is that lives of locales have become disrupted moving from bad to worse as large swath of communities are displaced from their homes, leaving thousand or million looking for safe abode outside their home country.

After several years of maintaining security and delivering humanitarian assistance, international organization whose duty are to also represent their national governments and ensure the protection and safety of their nationals are disrupted as well, afraid of their own safety and their lives as well as that of their national's resident in the country, are in urgent need of evacuation from the country they once considered as their second home forcing them to terminate their diplomatic program.
.
In this scenario, the task of evacuating personnel of international organization from areas infested with conflicts have also become life threatening as security agencies are compromised and many have taken sides with the opposing camps, with several citizens and their international partners losing their lives, as kidnapping for ransoms, and other crimes against humanity are daily rising.

"As part of closure of operations, administrators and personnel began withdrawing from their bases across the country. For the international organization, this presented great dangers, with hundreds of personnel killed during these operations", according to one BlackSky report.

"During evacuations, the risk persisted, local anti-government factions began attacking personnel, causing injuries and damaging vehicles with explosives. To make matters worse, rations, water and fuel ran low due to denied requests for supply transport", said the report.

"Unfortunately, flight and travel permits were denied, and personnel were forced to travel by road in a kilometers-long convoy of almost 150 vehicles", the report said. Consequently, the convoy's leaders need to periodically relay location details to their headquarters, but communications were limited in frequency and value.

In this environment, the international organization was not permitted to fly aircraft to counter threats from armed groups, thereby limiting the scope of their evacuation. "With airspace denied and communications constrained, the operational support team needed a space-based solution to remotely check on the safety of evacuating personnel and evaluate potential threats along the route to their safe destination" the report stated.

With space-based intelligence solution, international organization can raise the situational awareness of their immediate precarious environment to oversee their evacuation from their base of operations. Indeed, by enlisting BlackSky On-demand solution delivered at industry-leading speed, the operations teams monitored kilometers-long convoy of hundreds of people and vehicles until they safely arrived at their destination, says BlackSky report.

BlackSky On-demand solution

In order to help safeguard personnel evacuated from their African base, the international organization's operational support team had chosen BlackSky On-demand, to create routine visual images and help maintain persistent awareness of the precarious environments.

For instance, "On-demand helps organizations act first by providing intelligence at industry-leading speed, with tasking and collection-to-delivery timelines of under 90 minutes on average", says Brain O'Tool, chief executive officer of BlackSky. "With On-demand, organizations can task anywhere in the world at a variety of priority levels and access all BlackSky's imagery and analytic products", he said. While relying on On-demand solution, the convoy team increased their chances of observing the convoy in motion, and at the same time tasking area 2x1 imagery products for greater coverage.





At the peak of the evacuation efforts, BalckSky's On-demand's timely intelligence assisted the team to track the convoy of vehicles on its unpredictable journey out of their base. Running against the tide of the moment, helicopter flights evacuated seriously injured personnel and resupplied the convoy with water, food and vehicle spare parts. Convoy teams had also prepared for armed opposition. In order to track these dangers and effectively support evacuees, support teams couldn't afford to wait days for updates.

According to Brian O'Toole, "BlackSky's frequent revisit capability ensured fresh imagery came quickly, helping operational support personnel verify the position and condition of the international organization's vehicles as they carefully proceeded from the base to their safe destination".

During their journey out of their base, life-threatening hazards and multiple safety incidents have drove the need for fast and accurate intelligence. Unfortunately, improvised explosive devices (IEDs) were mined throughout the route, as several IEDs exploded along the route, injuring nearly tenth of personnel and damaging seven vehicles and posing significant threat to life, because most vehicles had no armor.

As the evacuation was ongoing, the operational support team leverage BlackSky to remotely track active vehicles, confirm when the convoy had missed its schedule and inspect nearby areas for potential hostile combatants. The team personnel also used BlackSky imagery to communicate internally about the status of the evacuation and keep leadership up to date on mission status.

In order to access the most recent location reports from convoy leaders, the operational support team set up to coordinate these efforts used BlackSky Spectra® to evaluate collection feasibility and task multiple types of imagery of the convoy's predicted position. They also utilized multi-frame products to collect burst imagery of the travel route and the destination, according to the report.
Lastly, whenever feasible, the operational support team also tasked twilight collections to observe the convoy at its nightly stopover points.

After eight days of hazardous travel, the evacuating team finally reached their safe destination, reporting no fatalities and limited serious injuries. The intergovernmental organization then continued their successful withdrawal from the West African country by closing remaining bases and handing over sites and equipment to local leaders.

Thanks to the valuable space-based intelligence provided by BlackSky, the intergovernmental organization's operational support team plans to continue using its Ondemand subscription for similar support missions in the future.

Spire Global: Vessels tracking in deep ocean is impossible for land-based stations



InSpire Global, Inc., formerly known as Nanosatisfi Inc., was founded in August 2012 in Delaware. It was co-founded by International Space University former students Joel Sparks, current Spire Global CTO, Jeroen Cappaert, current Spire Global CTO, and Peter Platzer, current Spire Global CEO. It was the latter one who, while at the Singularity University from NASA in 2009 realized that there was a" tremendous amount of change happening in the space industry". He later organized this trend in the sector into a" tri-factor of change".

The first factor of change are the shrinking government budgets. There was a need for other sectors, like the private one, to step in as the government budgets were getting more and more squeezed. The second one is the emergence of billionaires in space. These individuals want to leave a legacy by putting their reputation, network, capabilities and net worth on the line and fill the gap left in the previous point. Finally, the third factor is the emergence of new technologies following the Moore's
law. The Nanosatellites are about 3 orders of magnitude cheaper and lighter than traditional satellites, can carry the most modern technology and are more launched than any other satellite form.

Thus, the industry was changing from a slow and government dominated to a more versatile, innovative and private companies dominated. With little innovation, their technology was getting obsolete and it was taking enormous amounts of time and money to launch satellites.

That sparked him to go to the International Space University to obtain a MSc. in Space Science and Management. There he met the later co-founders of Spire Joel Spark and Jeroen Cappaert. From looking onto the nanosatellites new technology and their business ecosystem they decided to start a company. They based it on some principles that nowadays can be seen as their 3 main pillars; they" collect data where nobody else can", they" collect data not the size of sensor but the number of sensors creating value" and they" collect data where the sensors are programmable and reprogrammable by software to really bring Moore's Law to space".

Nanosatisfi started then with the building of a prototype nanosatellite that was intended to be a platform to approach space to students in terms of accessibility and costs. This was called the ArduSat, as it was based on Arduino technology, and started to be founded thanks to the crowdfunding website Kickstarter.

With an initial goal of USD 35K intended to build the 1U CubeSat, the amount was raised to USD 106.33K by the end of the funding period in July 2012 and supported by 676 backers. Soon after that, Spire raised USD 1.2M from individual angel and venture capital investors on the AngelList platform for start-ups that helped them build the company. They moved to the hardware incubator Lemnos Labs in San Francisco and founded by themselves its launch pad.

Eventually the two ArduSat, 1 and X, were launched on board of the H-2B-304 rocket from the Tanegashima Space Center in Japan to the International Space Station (ISS) on August 3, 2013. They were deployed from there on November 19, 2013 at about 400km from the Earth surface and re-entered the atmosphere on April 15 and 16, 2014 respectively. Due to the success of the program, Nanosatisfi launched the next generation of ArduSat, the ArduSat 2 on board of the Antares-120 to the ISS on January 9, 2014. This 2U CubeSat was then deployed on February 28, 2014 at an altitude of 400 km above the Earth surface and re-entered the atmosphere on July 1 of the same year.

The crowd-funded program of the ArduSat made Platzer gain the recognition by the Obama administration as a" Crowdfunding Champion of Change" in 2013, with the ArduSat 1 and X being the first ever crowd-funded satellites in orbit. However, the main idea Sparks, Cappaert and Platzer had in mind was to develop the most accurate weather forecast and they never lost sight of that. On this direction they launched their 4th satellite on June 19, 2014, the Lemur-1. This is a 3U CubeSat intended for technology demonstration and EO, with an Electro-optical imaging system of 5 m resolution and an IR imaging system of 1 km resolution payloads. It was intended to assess for meteorological, aeronautical and maritime potential commercial markets and had approval from the National Oceanic and Atmospheric Administration (NOAA). The CubeSat orbits with a perigee of 612 km and an apogee of 697 km.
Spire Global has launched 99 CubeSats by January 1, 2019. They can be classified in four different missions, with two of them still being active. The company is specially focused on their most successful project, the Lemur-2 constellation, with a new update of the satellites introduced in March 2018. Spire's operations are explained in this section, being categorized by past, present and future actions. There have been 3 different satellites launched by Spire or NanoSatisfi at the time, that are currently not operating. They are the ArduSats -1, -X and -2. The first two corresponded to the company's first mission, while the third one composed a different mission derived from the previous.

Soon after the launch of the Lemur-1, on July 28, 2014, Nanosatisfi changed its name to Spire claiming that the new name and web presence were" emblematic of the energy and enthusiasm that we put into our technology and into the relationships that we have developed with our customers, and as a team". At the same time Spire communicated that their growth process is doing well with a new USD 25M series A closed funding deal that raised their total fundings up to USD 29M. This investment was led by RRE Ventures and had participation from other investor such as Moose Capital, Quihoo and Mitsui & Co. Global Investment. That same year Spire opened a second office in Singapore, a country which government in the eyes of Platzer" spends a lot of effort to create economic diversity and economic growth, thinking about industries that don't require large amounts of people and land".

The beginning of 2015 came with the announcement of the next generation Spire Global CubeSats, the Lemur-2. This 3U CubeSats will create a constellation that, at that time, was able to collect meteorological data through GPS-RO (Stratos payload) and ship tracking data through AIS. This would help to provide a more accurate and reliable weather prediction and fleet efficiency, safety, voyage and fuel management improvement for shipping companies. With an expected lifetime of about 2 years, the Spire constellation was safe to be constantly technologically updated. The first 4 units of the Lemur-2 were launched and deployed on September 28, 2015 from India at an altitude of 640 km above the Earth surface. Since then until February 1, 2018, 77 Lemur-2 have been launched with this configuration, even though the orbital altitudes have ranged from 400 km to 590 km. However, from May 21, 2018 a new additional payload has been incorporated for airplanes track through AirSafe payload.

During the 2015 summer, Spire opened a third global office in Glasgow, UK, becoming their first European office. It would support the design, development manufacturing and data management of the company CubeSats. The announcement came supported with a GBP 1.9M grant funding from the Scottish Government and the Scottish Enterprise. A few days later, on June 30, 2015 Spire announced a USD 40M Series B investment funding led by Promus Ventures. It also involved already known investors RRE Ventures and Lemnos Labs and new faces like Bessemer Venture Partners and Jump Capital.

The year 2016 stated with the opening of the 4th Spire Global Office in Boulder, Co. While the Lemur-2 was being launched and ground stations were built along the year, the NOAA awarded Spire Global with the first-ever satellite data contract to a private industry company in September. With it, Spire joined the US government to acquire weather data from space in order to improve weather forecast with an award worth USD 370K. It became part of the government's Commercial Weather Data Pilot program.

Spire finished the 2016 year announcing on December 6 the space-based global aircraft tracking service AirSafe. By using ADS-B this new Lemur-2 payload would capture and provide location of most international flights, as they would need to provide updated flight information every 15 minutes. This was an International Civil Aviation Organization ICAO mandate that would be effective by November 2018.

On March 6, 2017 Ball Aerospace and Spire Global announced a collaboration in association with the National Geospatial-Intelligence Agency (NGA) to improve Maritime Domain Awareness in the arctic. Spire's constellation will collect vessel tracking data over the Arctic. This data is integrated into Ball's cloud-based data analytics architecture with other external data to create accurate and near real-time information of maritime activity and vessel behaviour in the Arctic. Later that year, on November 6 Spire Global announced the opening of their fifth office and the closing of a Series C funding worth USD 70M in order to continue their global expansion.

The office would be in Luxembourg and would serve as the company's full-service European headquarters. The financing round was led by the Luxembourg Future Fund, which also became a Spire global shareholder, and included Empiricus Capital. With this Spire aimed to increase access to global talent while establishing in a country that provided support, commitment, and expertise to NewSpace.
February 1, 2018 saw how the UK Space Agency awarded about GBP 4M to Spire Global in order to demonstrate space technology including parallel supercomputing. This particular technology was to serve as a core component for future computationally intensive missions.
During the beginning of March 2018 Spire made big steps towards their satellite-based aircraft surveillance platform with two announcements. Firstly, the signing of a Letter of Intent with INDMEX for the use of the collected ADS-B data for Airport and Airline Collaborative Decision Making.

Secondly, Spire Signed a Memorandum of Understanding with Airbus Defence and Space in order to contribute with Spire's ADS-B data to the Airbus Surveillance Digital Eco-System. Spire saw their quality satellite development recognized and rewarded with a partnership with DHV Technology to offer their solar panels to the rest of the space industry. They would build and sell the double deployable panels.

The company was kept busy with new partnership announcements like, in April 24, 2018, when Spire Global and Esri started a partnership which would integrate the latter's satellite datasets into the former global user ArcGIS platform. However, not everything was a piece of cake. In September 27, 2018 a Congressional Report issued by the NOAA in reference to the Commercial Data Weather Pilot reviewed the contractors of the program in round 1 by 2016 and their delivered data. Spire Global delivered a first dataset with quality issues in background noise, uncertainty in satellite position and clock offsets. Spire was required to fix the issues and delivered new improved data only on the final week of the delivery period. It showed some agreement with weather model outputs but was inconsistent. The data was not enough for NOAA to make statistically significant conclusions, leading to a reduction of Spire contract award amount to USD 87.3K. This meant that the company had to de-obligate the remaining USD 282.7K of the initial contract.

Nevertheless, the NOAA awarded Spire again with a contract for the round 2 of the program a few days before the Congressional Report, on September 17. The new contract aimed one more time to evaluate the quality of the weather data from the GPS-RO satellite companies and readdressed some issues observed in the round 1. Spire had been awarded with USD 1.425M and has time until July 31, 2019 to deliver the data.
On December 11, 2018, Spire announced at The Morgan Stanley Space Summit in NYC that their constellation would be the first ever to use ESA Galileo GNSS satellite constellation signals to perform radio occultation, or GNSS-RO, for weather sensing. The Galileo GNSS system will be fully operational with 30 satellites in 2020. This will enable Spire to harvest about the 25% of the GNSSRO profiles available, making the company unrivalled. It also highlighted Spire's capability and flexibility to product satellites and update their software and hardware.

Company Business and Philosophy

Spire Global Inc. defines its mission as:" Our mission is to uncover data and build systems that fundamentally improve the work and lives of the people on our planet. The things we do may create sweeping shifts but we don't do change for change sake - we do things that truly matter". The Global Trends in Small Satellites defines the organization's missions as to provide" unique data for any point on Earth in near real time to provide competitive advantages for organizations in areas like global trade, air-traffic, weather, shipping, supply chain, illegal fishing, and maritime domain awareness." The same report also states Spire's goals as to" aspire to build and operate the first commercial weather satellite network".

As previously observed, the founder and CEO of Spire Global revealed that nowadays the company is based in three highlighted pillars; to" collect data where nobody else can", to "collect data not the size of sensor but the number of sensors creating value" and to "collect data where the sensorsare programmable and re-programmable by software to really bring Moore's Law to space".

In their web page, Spire Global emphasizes on the value creation and its measurement. Understanding it as the" cash flow per employee times the number of people affected by products", Spire thinks about value in a holistic way. They state that a one-dimensional metric is not enough to measure it, putting examples in their Stratos and Sense products, which reach every part of the economy through weather and shipping respectively. They also state that Spire is" measured by impact" and that it is a" data driven organization" because "if you can't measure it, you can't improve it".

Platzer described Spire's unique company culture as one which differs from a traditional approach and tries to inspire people. He claims that people need have changed thanks to better economic environments and they nowadays seek for autonomy, mastery, and purpose. This has become an anchor principle in the company as they expect employees to drive for excellence through relentless growth, achieving mastery. The area where they master is self-chosen, providing autonomy, which is spurned with resources and evaluated.

Spire website also hosts a section in which the culture of the company is explained. They relate the purpose, mastery and autonomy drives with how they can be found at the company and how they encourage the employees to seek them. They align personal purpose with Spire's missions and vision, measure mastery through reliability of on-time deliveries and encourage autonomy through ownership of the employee's tasks. Instead of traditional managers they implement a system with coaches and captains. The former are great people leaders who mentor their subordinates called" players" through interpersonal skills to achieve others personal grow, while the latter are the technical leaders responsible for the driving results.

Instead of performance reviews Spire caries out quarterly coach's discussions every three months in which they discuss purpose, autonomy and mastery growth with their players. This discussions involve questions such as" how are your autonomy, mastery and purpose doing?", "what do/don't you enjoy how to do more/less of that?" or "where do you see yourself in 5 years?".

Regarding all discussions above, Spire defines its people as self-driven and growth oriented who have a relentless desire for self-improvement, collaborative across boundaries and time zones as the company is decentralized and with a high emotional quotient, able to recognize emotions, communicate effectively and adaptive to social changes.
Connected to this unique culture, Peter Platzer earned a reputation of being the boss who has never fired anyone. However, this wasn't entirely true as the company has a zero tolerance towards employees doing inappropriate, illegal or insubordinate actions. This has led to a few rare dismissals. Nonetheless, the culture of the company encourages them to find a solution to align the company mission with the worker purpose, but if it is not possible they always agree to part ways.
Spire offers its Automatic Identification System, AIS and ADS-B data to public institutions though the Sense and AirSafe products. This intends to help them deal with the illegal fishing, coast guarding and aircraft identification. Moreover, the Stratos product can provide meteorological, in-space TEC and ionospheric characteristics data. The last two sets are highly important for the military sector, as ionospheric space activity like solar flares can cause detrimental effects on GNSS and radio signals, blocking positioning information and reliable communications. Finally, Spire's space-as-a-service provides a reliable space platform for agencies to install their sensor payloads and gather customized data.

VIEW FROM EUROPE

Europe's Iris² initiative aims to rival Elon Musk's Starlink network and spans commercial dilemmas



When Guillermo Guerra Martín started working last year on the Indra Group's planned, purchase of 89.7 per cent of Hispasat, a Spanish satellite operator, he faced formidable obstacles. The €725mn deal required "very specialist due diligence" because of the many legal, competition and national security issues concerned, according to Guerra Martín, a partner in Madrid-based Gómez-Acebo & Pombo. The transaction, to buy the shares owned by Redeia, Spain's electricity grid operator, involved "very tough negotiations", he says.

However, on January 31, Indra was able to announce a deal that should transform its satellite capabilities. The agreement will not only give it control of Hispasat but will also give it 50 per cent of Hisdesat, another satellite owner, which specialises in secure communications for Spain's government. Indra already owns 7 per cent of Hisdesat, while Hispasat holds 43 per cent. The deal is still awaiting competition and other approvals before completing. The transaction is one of a series recently completed or going through the regulatory process in different parts of Europe aimed at giving European countries capability in satellite communications that is independent of the US.

Lawyers have been critical to navigating the multiple complexities of working between different jurisdictions and between the public and private sectors to put deals together. The central role in the push is likely to be played by Iris², a multi-orbit constellation of small communications satellites funded by the European Commission. Of the project's expected €10.6bn cost, 61 per cent will come from the commission. The rest will come from an industrial consortium known as SpaceRise consisting of France's Eutelsat, Luxembourg's SES and Hispasat.

The deals have been complex because they have been conducted in a field that is developing fast and have been motivated in many cases by geostrategic considerations as much as by commercial ones. Indra plans to add its interests in Hispasat and Hisdesat to Deimos, a specialist in small satellites that it acquired in October last year. "Together with the acquisition of Hispasat, we can say that Indra has become really the leading company, the Spanish champion in the satellite sector," Guerra Martín says.

"There are some areas in which each country must have its own presence." European governments are eager to build up their own satellite capabilities to ensure they have an alternative to Starlink, the vast constellation of low-earth-orbit satellites put in place by Elon Musk's SpaceX, says Sash Tusa, aerospace and defence analyst for Agency Partners, a research group. Governments have been alarmed by some of Musk's stances on the war in Ukraine.

There have been claims that Musk ordered the turning off of some Ukrainian army Starlink terminals in 2022 at a point when it was conducting a successful counteroffensive against Russia. Musk has declined to comment on the claims about the company's actions during the counteroffensive and other incidents. Yet in March this year. Musk publicly mused about the effects on Ukraine if he decided to end its access to the system altogether. "Elon Musk has gone from being the destroyer of the European space industry to arguably its saviour," Tusa says.

"In the past six months, comments he has made have fired a massive set of warning shots to Europe. However good Starlink is, however good SpaceX is, you are ultimately really reliant on a single man and a single country, each of which can turn that access off at any stage." Yet it has remained a challenge to build up Europe's capability, according to Benoit Le Bret, managing partner for the Brussels office of French law firm Gide. Elon Musk has gone from being the destroyer of the European space industry to arguably its saviour Sash Tusa, aerospace and defence analyst for Agency Partners Le Bret, who acted for the European Commission in setting up Iris², says the arrangement had to respect EU competition law demanding a competitive tender for such projects. But it also had to accommodate the realities of Europe's space sector — that there were only a handful of companies able to deliver such a project and none would be able to do so alone.

"We needed to organise some kind of contest, while being prepared to allow everybody to work together," Le Bret says. The transaction was further complicated by the involvement of both the EU and commercial partners. The satellites are the first space vehicles owned by the European Commission. "It's a public-private partnership," Le Bret says.

"There's a lot of commercial risk and EU money and so it's a first-of-a-kind PPP." There were similar considerations around Indra's purchase of Hispasat, says Guerra Martín. Spain's government holds a 28 per cent stake in Indra and the involvement of Hisdesat, and its role in handling secure government communications, meant the deal's significance was more than purely commercial. Guerra Martín points out that the civil telecommunications aspects of Hispasat's business are regulated.

But he adds: "We're not dealing just with a regulated sector but a sector because of the defence part of the deal that's considered a national interest. The idea here is to combine the collaboration with the defence ministry that's the one that also regulates Hisdesat with the private initiative of a Spanish listed company." We needed to organise some kind of contest, while being prepared to allow everybody to work together Benoit Le Bret, Gide Le Bret, meanwhile, expresses relief that, whatever the complications, European public bodies and companies have started to build their own alternatives to both Starlink and the Kuiper satellite constellation being assembled by Amazon, the US tech group.

He says that, when the system was first being discussed in 2022, Europeans had few concerns about Musk. The now-departed European internal markets commissioner Thierry Breton, who championed the programme, was simply convinced, according to Le Bret, that European governments should have their own system. Breton's thinking was that Europe could not continue to depend on "one single guy", Le Bret says. He adds: "I think what happened afterwards was really confirming that it was a good idea to have such an EU infrastructure."

Innovation of LEOs

Throughout the history of research in Antarctica, communication has been a challenge. Early explorers were disconnected for months, or years, at a time; by the 1930s, audio broadcasting was possible, and in the 1960s, basic two-way communication via Telex was possible. Expensive, large-scale satellites were installed in the 1980s and 1990s, but a thousand seasonal workers at McMurdo Station shared a 17 Mbps connection. Now, with Starlink, researchers are able to collaborate with remote colleagues by the terabyte, and residents are able to seamlessly stay connected to families at home. Now, the world has a much greater window into Antarctic stories and science.

In 2024, Starlink helped people around the world connect when other means of communication were unavailable. Whether it was the result of flooding, wildfires, earthquakes, hurricanes, cable cuts, or other crises when communication was impacted, the Starlink team worked with governments and key responding organizations to rapidly restore connectivity. These responses spanned North and South America, the Caribbean, Europe, Asia, and Africa.

When Hurricane Helene affected a wide region of the southeast United States, communities were disconnected from transportation and communication. Starlink was used by first responders to facilitate communication, search and rescue teams, hospitals, schools, local

police patrols, and fire trucks. Residents could connect with friends, family, and work, supported by free Starlink service for the rest of the year. In a first, Starlink's Direct to Cell service was activated, allowing people to connect via LTE devices and send and receive more than 300,000 text messages. Hundreds of emergency alerts were also delivered via Direct to Cell to people in the affected areas, messages that otherwise wouldn't have been able to be received. Although the Starlink team responds as rapidly as possible to every crisis, in times of disaster, minutes matter. So the best case scenario is that Starlink is already available and in the hands of responders and individuals. This was the case in Vanuatu, where Starlink became available in October 2024. When an earthquake struck in December, individuals were able to immediately use their Starlinks to support search and rescue efforts, and Starlink worked with our local resellers to send more kits to supplement.

From travelers exploring off-grid locations in RVs to remote workers staying connected while on the move, Starlink ensures customers stay online wherever their journeys take them, bridging the gap between connectivity and freedom of movement.
In 2024, Starlink installed service to 450 aircraft across all aviation customer segments while serving over 4.6 PB of data to passenger devices. Hawaiian Airlines began to offer transcontinental Starlink connectivity with daily flights over the Pacific Ocean, including destinations in Australia and Japan. Qatar Airways began global service on its Boeing 777-300 aircraft. United Airlines and Air France announced their plans to install Starlink on their entire fleets, joining other airlines adopting the service, including Hawaiian Airlines, Qatar Airways, Air New Zealand, Zipair, airBaltic, and JSX. Starlink is now on contract for installation on over 2,000 additional aircraft.

In 2024, Starlink Maritime connected more than 75,000 vessels, including 300+ cruise ships, serving over 10 million cruise passengers annually 30% of the global total. We provide reliable internet for passengers and crew, supporting streaming, video calls, and communication in even the most
remote waters. Shipping companies like Maersk, Hapag-Lloyd, and Mitsui O.S.K. Lines use Starlink to improve operations with real-time data and diagnostics, while cruise operators enhance onboard experiences with high-speed Wi-Fi. Starlink Maritime is transforming connectivity at sea for both travel and industry.

In 2024, Starlink made significant strides in improving internet connectivity for train passengers across various regions. Florida's Brightline became the world's first passenger rail service to implement Starlink, offering free, uninterrupted Wi-Fi on trains between Miami and Orlando. Similarly, ScotRail introduced Starlink on its Far North Line trains in the Scottish Highlands, providing reliable internet on remote routes to Inverness, Thurso, and Wick. These advancements enhance passenger comfort and operational efficiency, addressing long-standing connectivity challenges in underserved areas.

In 2024, Starlink's Direct to Cell technology made it possible for explorers in remote areas to use their mobile phones where they never could before. By linking phones directly to satellites, it removes dead zones, letting adventurers send messages and stay safe in places far from towns or cell towers. With text services already available and more features like data and IoT tools coming, Starlink Direct to Cell is helping people explore with better tools and peace of mind.

The story of Ariane 5

The Ariane 5 rocket is the workhorse of Europe's independent access to space. Its reliability, availability and affordability are based on a strategy where a significant part of the exploitation costs is financed through commercial activity. Ariane 5 is launched six to seven times a year, out of which one or two are launches for institutional customers.

This strategy has proved to be highly successful for more than 30 years. The successive versions of the first generation of rockets Ariane 1, 2,3 and Ariane 4 series, launched half of all the world's commercial satellites at the time. Ariane 5 maintains this impressive record, making it one of the most reliable launchers in the world.
Ariane 5 was a major evolution for the Ariane family. It is more powerful and uses more advanced technologies. Three successive generic version – Ariane 5G, Ariane 5G+ and Ariane 5GS, are now retired from service. The Ariane 5 ES was used for various missions, such as the Automated Transfer Vehicle in low orbit and Galileo in medium orbit. It was retired from service on 25 July 2018.

There is now one operational configuration, Ariane 5 ECA (Evolved Cryogenic, model A). It can launch one, two or three very large satellites. A dual launch configuration is the most commonly used. Ariane 5 mainly delivers communications satellites to Geostationary Transfer Orbit (GTO) but has also proved itself on non-GTO missions for institutional customers.

Arianespace's Ariane 5 is the world reference for heavy-lift launchers, capable of carry payloads weighing more than 10 metric tons to geostationary transfer orbit and over 20 metric tons into low-Earth orbit with a high degree of accuracy mission after mission. Developed by under management of the European Space Agency (ESA), Ariane 5 is able to loft the heaviest spacecraft either in production or on the drawing boards, and enables Arianespace to match up most telecommunications satellites for highly efficient dual launches a capability that has been proven by the company in Ariane-series missions since the 1980s.

The launcher's predecessor was Ariane 4, a rocket that flew from 1988 to 2003 and was noted for its efficiency in putting telecommunications satellites into orbit.

With Ariane 5, they managed to carry up to two large orbiters and take heavy payloads into deep space.

ESA commissioned EADS SPACE Transportation and Arianespace to build this rocket in 1984. Its development took more than 10 years to complete and cost Europe €6 billion. Its first flight attempt was on June 4, 1996 and ended in failure with an explosion at the European base in French Guiana. Its self-destruction occurred at an altitude of 3,400 meters and was due to a software error in the inertial reference system, intended for control and guidance.

However, its history has been fraught with many more successes than failures, as already mentioned. That has made it a star rocket of ESA, coming to be defined as "the workhorse" of the agency. Its model has evolved with Ariane 5G, Ariane 5G+ and Ariane 5GS, Ariane 5 ES and Ariane 5 ECA, each with better and more powerful

PROFILE

How Planet Labs is pushing boundaries of Earth observation, navigation, and space exploration

Planet Labs was officially founded in December 2010 under the name of Cosmogia Inc. But its history begins some years before when the founders, three young NASA scientists, met at the United Nations trying to find a way to use space to help people around the planet, protect biospheres and stop deforestation.

They were Robbie Schingler, MBA from Georgetown University, Master of Space Studies from the International Space University and BSC in Engineering Physics from Santa Clara University, Will Marshall, PhD in Physics from the University of Oxford, MSc in Physics with Space Science and Technology from the University of Leicester and Chris Boshuizen, PhD in Physics from the University of Sydney.
They came from three different continents, but they realised they shared a feeling of disillusionment with the established space industry. Specifically, with how it had become trapped in a tradition of requirements-driven approaches to design and testing, because that was leading to increasingly unaffordable spacecraft in terms of cost, mass and schedule.

Marshall, Boshuizen and Schingler had long wanted to change the space industry. They just had not found how to do it yet, and probably needed to find whom to do it with. It was the early 2000s when they met at an international conference held at the United Nations aimed at young professionals to make policy recommendations on how space could benefit humanity.

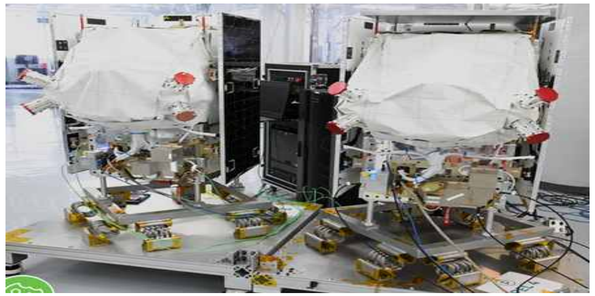
That event would bond them to a global community of scientists and led to a relationship of regular collaboration over the next decade. Together, they wrote a paper for the European Union about space policy. It was a statement that they decided to join efforts to put together a report at a conference where no one was willing to put individual merits aside in the interest of making a higher contribution. That collaboration across different time zones required many phone calls at inconvenient hours but gained them a valuable experience in making big, international projects happen.

Two of the three co-founders remain today in the company: Will Marshall and Robbie Schingler. Will Marshall is the Chief Executive Officer, leading the overall company strategy and direction. Robbie Schingler, who spent 9 years at NASA, is now Planet's Chief Strategy Officer. In November 2015 the third co-founder, Chris Boshuizen, who at that time was responsible for satellite production and the leadership of the engineering team as Chief Technology Officer, announced via Twitter he was
leaving the company.
Along with Schingler and Marshall, there are seven more people in management positions in Planet Labs these days providing their lengthy experiences. Among them, Tom Barton is responsible for the company's business operations and Ryan Johnson the President, whereas Karthik Govindhasamy leads the engineering section and David Oppenheimer oversaw the financial aspects.

Sometime afterwards the three of them were working on small scientific satellites at NASA Ames Research Centre. There, Engineering Director Pete Klupar would often hold his Blackberry in his hand and ask his staff why satellites were so expensive and carried outdated technology. “My smartphone is better than your spacecraft”, he used to say. After hearing this a few times, Chris Boshuizen and Will Marshall realised how smart that thought was.
This was exactly the idea behind PhoneSat, a NASA project devised by Boshuizen and Marshall that put a mobile phone with extra batteries aboard three CubeSats launched in 2013. Again, at the time of launch, the two of them, together with Schingler, already left NASA to found their own startup.
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In 2005 they started living in a house together and, in what today would be considered a typical Silicon-Valley style, turned their garage into a workshop where they spent the weekends playing with satellite technology. When it got more serious, they started hiring friends. Eventually, they decided to leave the space agency. It was in that garage that they built their first satellite, called Dove. While it has become quite standard now for start-ups to start in a Silicon Valley garage, they proudly claim to
be the first ones to literally build a satellite in such place
.
In February 2012 the start-up moved into the SoMa coworking space in the trendy South of Market neighbourhood in San Francisco, where it remains today. Other than its premises in the US at the San Francisco and Mountain View in California, and Seattle in Washington, it has offices in Amsterdam and Berlin. From there, its imagery is delivered to an International network of customers and partners in over 100 countries.
Reinventing space business is not easy, but Planet Labs has been quite consistent in its announced launch program. It launched its first satellites in 2013. Two years later, in July 2015, the company announced its future acquisition of BlackBridge and its RapidEye 5-satellite constellation, together with an archive of 6 billion square kilometres of imagery captured over the previous years. By the time that acquisition was complete in October 2015, five years after being founded
Planet Labs was already operating the largest constellation of Earth-imaging satellites ever.

Only months after, the corporation signed an introductory contract with the National Geospatial-Intelligence Agency,, the largest of geospatial customers. The business has kept expanding at a fast pace since early 2017. After hitting the headlines with their record-breaking launch of 88 nanosatellites on February 15 and bringing the constellation of Doves to 144, on April 19, 2017 the company announced it had completed the acquisition of Terra Bella, a rival satellite imaging company. It also confirmed that, as part of the deal, Google was now a noteworthy shareholder in the firm.

Google had previously purchased Terra Bella, formerly named Skybox Imaging in 2014 for an estimated price of $500 million. In 2017 both Planet and Google were declining to disclose any other details about the deal other than the fact that Google had then a deal for some years to buy imagery from Planet. Though Planet acquired Terra Bella business and satellites, the search engine giant would keep on



licensing the satellite imagery for its mapping products such as Google Maps, so it would still keep control over the satellite imaging company.

By the end of 2017, Planet announced the accomplishment of its Mission 1 phase, which consisted in assembling a solid constellation of satellites with its owned Doves and the acquired TerraBella and RapidEye constellations ensuring daily global imagery coverage, at a wide range of resolutions. After completing this first phase, Planet announced that it was entering its Mission 2 phase, which will expand the company towards research fields which involve Machine Learning procedures to process their imagery data, as well as creating the Queryable Earth project, focused on creating a daily updated index of all parameters on Earth's surface by means of satellite imagery and Machine Learning and Artificial Intelligence methods. And finally, expanding the observation tasks towards the observation of the entire Solar System, through a collaboration with SpaceX to develop Megasatellites and Megalaunchers. As part of this second stage in the evolution of the company, in 2018 Planet acquired Boundless, a company devote to the development of Machine Learning methods.

Company Business Statement

and Philosophy

Planet's goal is to use space to help life. The Planet Code of Ethics, a means to put Planet's Company Values into practice, is shared on its website. Planet workers really intend to achieve a breakthrough in the space industry, which they consider stuck in inefficient and unproductive old practices. They believe the current situation of space business calls for a more proactive attitude. From people like them who want to carve out a career in it, but also from everyone in the world. Co-founder and former CTO Chris Boshuizen states: “The space industry has been asleep for 30 years. I kind of feel like we're just waking up right now. I'd love to see more people starting companies in this space or similar spaces, just saying space entrepreneurship is back. I really want this company to not just show people what is changing about the world but show them how they can help”.

This is what Planet's leaders call Global Sensing Revolution or Space 2.0. In a Sales Force conference, Will Marshall, asking for the aforementioned global collaboration, ends his speech posing an open question to his audience: “Imagine you had all these imagery data from the whole planet, then what would you do with them?” That says something quite meaningful to anybody trying to understand Planet's business model: it feels like the space start-up had little concern about having
a clearly identified ultimate use of its products; probably Planet's leaders just believed that they could do something valuable in itself and decided to start doing it, with a firm conviction that applications would come alone.

This is a smart idea, for it is not easy to foresee all the possibilities that could come before you even do that one thing that will change the game. It is interesting to see this approach of assuming risks, accepting possible failure and embracing challenge without guarantees reflected in its overall business approach, because it is the core of Planet's engineering philosophy.
It is undeniable that Planet workers take care of little details they consider meaningful, like the fact that they called their satellites Doves because “they're on a peaceful mission”. That is a statement about their vision, but also a playful gesture when they call their constellations “Flocks”.

Tech writer Kevin Roose, who interviewed Planet's representatives at their headquarters in San Francisco, wrote: “If you haven't heard of them, it's because they've been avoiding most interviews with the media until they're further along in the development process.”. That is very true. When you perform a thorough search on Planet, you notice how, despite being founded in 2010 and successfully launching their first Doves in 2013, a good amount of publications arises in 2014, the year Will Marshall gave a TED talk. While Planet is setting an example of uncertainty tolerance, it really feels like it has quite a lot of things under control.

Satellites designed and built by Planet are called Doves. Planet refers to a group of Doves deployed simultaneously into a single orbit as a Flock. A Dove is a standardised 3U CubeSat usually 10 cm by 10 cm by 30 cm weighing 5 kg. Doves are designed to be frequently updated and replaced, having each an expected operational lifetime of 1 to 3 years, depending on the type of orbit. In order to keep this continuous cadence of launches, Planet uses an agile aerospace approach to technology development.
The complete PlanetScope of Planet's constellation built up of Doves) is designed as a constellation of approximately 120 satellites to be able to image the entire land surface of the Earth every day. This the updated constellation design reported in 2019, whereas the original design included up to 150 spacecraft.
Planet's satellites are deployed into two types of orbits: International Space Station orbits are at a 52-degree inclination at approximately 420 km altitude, and Sun Synchronous Orbits are at 98 degrees' inclination or higher at approximately 475 km altitude. Here too there has been a change in the company's plans. Whereas in 2015 Planet stated that “Large constellations of satellites will be operated in both orbit types”. In whatever orbit, Planet' satellites operate in a constant monitoring mode. Doves are not tasked; instead, they continuously capture imagery of the sunlit portion of the earth's surface.

EO Market Segment

Planet focuses on the market segment of very-high temporal resolution with daily revisit time and medium spatial resolution especially 3 to 5m. Its primary product offering is Earth imagery and imagery-derived data products. The company states that the key differentiators of its dataset are: one, complete coverage of the entire Earth's land area at a resolution not currently available, and two, daily revisit of this sampled land area.

Planet's satellites are not tasked with searching for images; their Mission 1 is to scan the whole Earth every day. Customers can then search for the images they want using GPS coordinates. A spatial resolution of 3–5 m and a daily revisit time, along with the global scanning mission, make possible for Planet's imagery to track everything from crop yields to the evolution of Syrian refugee camps.

The company does remark, however, that its products can be especially helpful for climate change monitoring. Fighting deforestation has always been the founders' favourite application: “The use case that inspires me the most is deforestation”, Marshall specified.

One of the objectives of the constant monitoring mission is to be able to report changes on the Earth mass land. A probably unforeseen application of this took place around the 2015 earthquake in Nepal. Planet Lab images, taken before and after the tragedy, revealed two remote towns no one was counting with. Aid workers could send in medical assistance and supplies. CEO Will Marshall considers this a success in his original mission to use space remote sensing to help people on Earth:
"It was the first time our data actually helped people in the real world. Not just some sort of Silicon Valley bubble of hypothetical, you know", he said.
Another of Planet's ambitions has always been to democratise access to data. When an earthquake struck Ecuador and a wildfire erupted in Alberta, the start-up made their high-resolution imagery of those regions available under an open usage license.

Recently, Planet has also expanded the target of its value proposition to a wider number of customer segments, starting to be a provider of intelligence to entities such as the NGA or NASA, providing them with daily updated imagery from any spot of the Earth's surface. In the future, and after the development of Mission 2 is accomplished, Planet is expecting to expand its customer segments to an even wider spectrum.

Production System

Planet is fully vertically integrated; it operates all aspects of its business except launch. The company uses an agile aerospace approach for the design of its satellites, mission control and operations systems, as well as the development of its web-based platform for imagery processing and delivery.

Planet designed and manufactured satellites do not contain a single component directly sourced from the space industry. Instead, they use commercial, off-the-shelf COTS components. Planet found out that efforts made by the consumer electronics industry to reduce price and schedule had resulted in an extraordinary component catalogue available to everybody. The start-up is convinced that it is no longer required to develop a specialised Application Specific Integrated Circuit when nearly
all electronic functionality is already available in catalogue parts.

For instance, Planet takes advantage of the tools developed to perform the heat transfer analysis on the latest Ford Diesel engine, the electronic design tools used for the PlayStation 4, or some of the electronic testing houses present in Northern California available to perform environmental tests for the consumer electronic industry.

Traditionally, the space industry has been proudly acting like a global R&D department, pushing the technology limits and enabling advanced technologies to be developed and then adapted to everyday usage. At some point though this seems to have been inverted. Today, it is the consumer electronics industry who is behind the massive miniaturisation of electronics and technology that is enabling Planet to produce remarkable capability in a 5-kg satellite.

Planet Labs reports investing significantly in the packaging and the miniaturisation of satellite capability. Aiming to compress most of the capability of a traditional small satellite, its engineers accepted the challenge to create an ultra-high-density microsatellite. To do that, they drew lessons from laptop Personal Computer, tablet and smartphone industries. Putting some inevitably large components like reaction wheels aside, a Dove looks like those state-of-the-art consumer devices:
printed circuit boards with a lot of layers, outstanding high density of surface mounted electronics components, and hardly any internal cabling.

Planet remarks a trend not only towards further miniaturisation but also towards higher levels of integration, inspired by the levels of hyper-integration or shared resources in the automotive and electronics industries. Knowing that an effective integration or sharing resources among single components in a spacecraft is key to increasing the system's functionality and density, Planet has adopted this no-boxes approach: power supplies and other resources are shared by all instruments, radios or consuming elements.

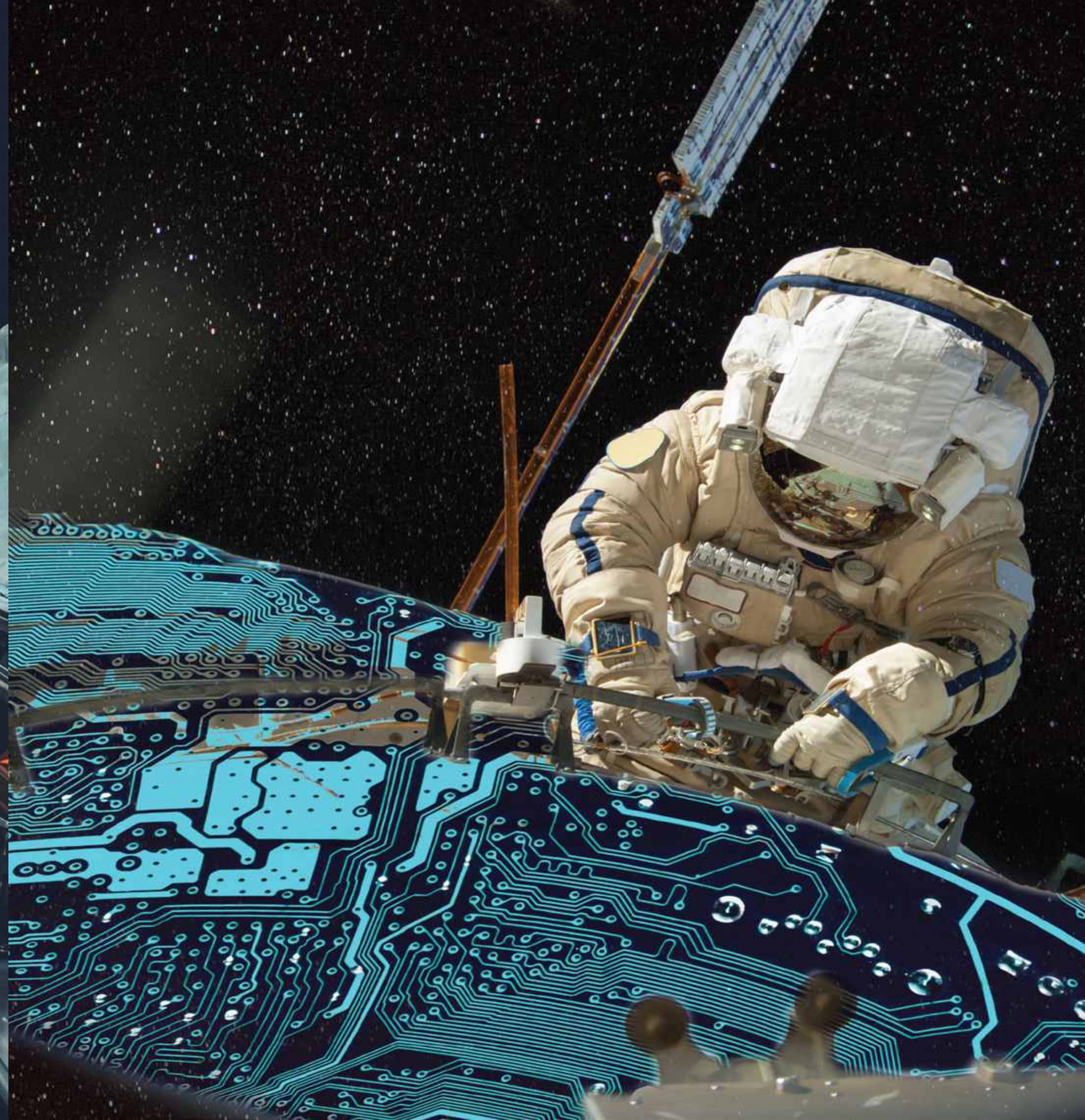
As Planet Labs puts it, “Small parts make tough systems!”. This summarises an additional benefit of this ultra-dense architecture: fundamental modes become higher outside the operating regime and stiffness is increased. Likewise, smaller busses lead to smaller, less complex payloads, which in turn reduce the team sizes, materials, costs and development timelines.

Planet follows the software team management motto “release early, release often”. This means small iterative steps and early customer engaging. And, in this case, is literally reflected in the start-up's continuous cadence of launches. One complete iteration of a Dove satellite takes 8 to 12 weeks from design to manufacturing. Most importantly, this prevents obsolescence by continuously integrating the latest technology improvements. Chester Gillmore, Planet's director of manufacturing, explains,
“We're building satellites with computers that are six months old. Lots of satellites have 10-year-old computers”. Also, the iterative process is continuously improved: Gillmore estimated version no. 9 of Doves cost around 35 percent less than the no. 7 and was completed four times faster.
Even if the satellites you build are the size of a loaf of bread, "It's a risky business going into space, which we've experienced. We've had 10 launches, two of which exploded. One was the Antares rocket and one was the SpaceX rocket. We had 26 satellites on one and six satellites on the other and yeah, that sent our satellites to smithereens”, CEO Will Marshall admitted.

However, as Marshall points out, the start-up was smart enough to put just a limited amount of its satellites in each of those launches. Planet fosters a culture of risk tolerance and failure acceptance. Embracing risk means managing risk, which is basically done by distributing it. “Rather than building redundant systems into a single satellite, which requires a larger team and more materials, thus higher costs, we build redundancy into the overall constellation. This puts the cost burden on the production rather than R&D, which is proportionally less expensive”.

The company allows for a part of its satellites to fail, and designs the constellation taking that into account. In my opinion, the engine-out design rule in aeronautics: engineers design each aircraft as if one engine was to fail during takeoff. In Planet's case, this approach provides reduced development times and results in an overall risk reduction. And it has the additional benefit of allowing A/B testing. Putting different satellite variants across the constellation is a good practice to keep
improving the technology used without risking the whole mission , and it enhances adaptability to change. This capability to respond to market shifts helps Planet amortise its satellites over shorter lifetimes, which is the reason why it is economically feasible for the start-up to build its constellation in





Satellogic, a leader in satellite earth imagery



IWhile Emiliano Kargieman, founder of *Satellogic*, was in a summer course in NASA's California base, in 2010 he was surprised that the technology used for the satellite's development was almost the exact same one which existed in the Apollo mission's era. Due to this fact, he started thinking about how to impulse the space technology as well as it happened with mobile phones or personal computers, and he got the idea of developing a new kind of small satellites, which would be 20 cm length and 10 cm width, with the main objective to democratize the access to space related information and the intelligence it can provide. To do so, he returned to his motherland, Argentine, to start developing this first project idea.
After the creation of Satellogic, the argentine company dedicated its main activities to applied investigation, which granted them a NASA qualification. This relation helped him with the process of obtaining the knowledge for the development of *Satellogic*'s first satellite, called Capitan Beto, which was launched in a Chinese shuttle in April 2013.
In November 2013, after finishing their second satellite production, *Satellogic* published the technical code and the details for the mechanical and electrical engineering of all the components of the newly developed satellite, in order to democratize the space market which was one of the main objectives the company was aiming to. Despite promising to keep on explaining their developments and achievements, after 2013 no further technical communications were released. However, *Satellogic*
kept on working developing their business model and the satellites that would conform the *Aleph-1 constellation*. Under this purpose, in April 2014 *Satellogic*'s training phase ended, with the launch and operation of the third prototype.

Later, in May the 30th of 2016, as the first operational and commercial satellites of *Satellogic*, *Fresco and Batata*, were launched. Its success lead to the Argentinian government to meet Emiliano Kargieman to congratulate him for the operation and for its company success. In September of the same year, Kargieman was chosen by the Financial Times as one of the Six men and women shaping how the World views Argentina.

In March 2017, NASA's EO-1 satellite was dismantled and Satellogic became the unique provider of hyperspectral imaging. At middle June of the same year, the company got 27 million dollars of investment funds, from a group of companies, the most known of them are Tencent, which is a Chinese technology specialized company, the Brazilian investment fund Pitanga, and CrunchFund, from the U.S. The company stated that those funds were going to be invested in research and development, to have capital for the satellites production and to enhance the sales department of the company.

Also, in the 15th of June 2017, *Satellogic* had another successful launch, this time the third operational satellite, called Milanesat, using a Chinese space shuttle, the same as the two previous commercial satellites. In November the same year, the newspaper Clarin released a stating that Satellogic had reached an agreement with Microsoft in order to use their cloud-based system, Azure. This agreement would provide space to storage the data captured, but above all, a platform where to
analyse and process the information compiled by the satellites. This volume of data was expected to grow exponentially as the company would be launching more satellites into near space. The main aim of the joint venture was to collect the amount of inedit information of the Earth in order to reach higher knowledge about our planet. As it was planned to analyse the data using Big Data and Machine Learning processes, it is expected to be key in the development of some industries such as
agriculture, oil and gas control, or disaster monitoring, among others.

The joint venture with Microsoft did not mean big investments. In fact, Satellogic would have to pay for Microsoft's services. However, Satellogic would take advantage of Microsoft's sales to offer the services of the satellite information.

As it has been stated, one of the main objectives of the organization is to democratize the access to space information. Satellogic wants to achieve it by offering access to their images to the scientific community in order to provide the data for future investigations and allowing the development of improvements in science and humanitarian aspects. To continue with the constellation expansion, two more satellites, Ada and Maryam where launched in February 2018.
Satellogic's main office is located in Buenos Aires, Argentina. The satellites are produced in Uruguay, and the software factory is in Israel. It has business development offices in Palo Alto, and marketing department in Colombia and Canada.
In the department of research and development, the employees work in an environment based on experimentation and innovation. This department concentrates the higher degree of freedom to try new things and ideas which would improve the satellites. Most of the ideas are discarded due to failure in computing tests before the prototype definition, yet the best of them are prototyped and submitted to a process of trial and error starts.
Each new generation of satellites generally takes ten months of development. The instruments are usually developed in three weeks and possess a lifetime limit of three years. However, there are some instruments whose development can take significantly longer.

The Satellogic headquarters located in Uruguay, the innovation is applied and studied in the assembling process and the functionalities of the satellites. There is not the same freedom of creation in Uruguay as in the development centre, nevertheless there is a certain degree of flexibility to improve the serial production, the process improvement and the efficiency utilization of the machinery.
The size and weight of the satellites is a key aspect for the launching phase as one space shuttle can launch the amount of 80 of these smallsats at the same time. However, there is a risk in launching them all at the same shot, because a big amount of loss can happen if a failed launch occurs.

Satellogic has mainly used Chinese launch vehicles to carry its satellites and as it is explained by Satellogic's CEO, Emiliano Kargieman, it creates some complication in the export process due to the U.S. government restrictions on the exports of satellites and related components to China.

Although the Chinese company, Tencent, had made the most important investment in Series B funding round and Satellogic frequent use of the Chinese rockets Long March, the company states that they do not possess exclusivity with any particular Chinese launcher company and that they do not discard to work with other providers which could offer the same service.

Work Environment

The key for the success of this company that provides such a disruptive innovation is the freedom as the way of working. The company looks for very autonomous people as the most important characteristic for the organization. The leading team, states that they know that they are doing something new and better than what already exists, so it is necessary to create new ways to
do it. Kargieman recommends that, in order to ensure innovation, it is requested not to fall in love with the ideas, many problems appear when this happens, and it is the way the traditional companies work, so it is a behaviour to be avoided. To prevent this relationship with the ideas is to have a more fluid relationship with them and to focus on the correct results to be obtained, to analyse objectively the ones gotten and to look for the clearly established objectives.

Market segments and product lines

Satellogic is self-defined as a company focused to unblock the value of the real-time geographical information analysis to improve the daily decision-making process of different companies, sectors of the government and Small-Medium Enterprise. According to the company, this objective is achieved by the combination of different capabilities of Satellogic that include the reduced cost, the high-resolution of the data as well as the hyperspectral data retrieved.

Hyperspectral data are images that collect and process information along the whole electromagnetic range. These vast electromagnetic range permits the division of the spectrum in different bands that offer different types of information. Some objects and materials leave unique trails through the complete hyperspectral spectrum, and these trails allow the identification of those materials that compose the analysed object. The result of the data obtained is a collection of images in which each
of them represents a different spectral band. The set of images combined is known as a hyperspectral cube.

The main device to obtain this type of data was the NASA's satellite EO-1 that integrated the Hyperion sensor, but it was dismantled in March 2017 after spending 17 years in orbit. The dismantling of this satellite translates into the fact that Satellogic became the only provider of high-resolution hyperspectral imaging in the world, offering a 30-meter spatial resolution from orbit and with the ability to discern 30 simultaneous spectral bands. These capabilities are not offered by any other commercial or scientific satellite in the EO market.

The use of hyperspectral images can be applied in different EO markets such as agriculture, mining, construction and environmental mapping. Apart from this, Satellogic, also looks for the commitment to science by offering free hyperspectral data to open scientific research or other humanitarian projects.
The company's intention for the service offered is to provide not only raw data, but also data products derived from that imagery. Satellogic has noticed the importance of the value-added services in the EO market. For that reason, the company is planning to provide a specific solution for each particular EO industry through applications that combine the hyperspectral data with the high-resolution imagery.
After the successful launch of Fresco and Batata satellites, and its progress in the space sector, the company managed to awake the interest of some companies from the agriculture and oil sectors that had seen the advantages that Satellogic could offer with their EO products. Specially, Satellogic EO products are divided in two types of information depending on the final consumer: Smart data and Industry Solutions.

Operational Satellites in Orbit

The ÑuSat Earth observation satellites form the Aleph-1 constellation were developed and operated by Satellogic S.A. This constellation was planned to be formed by 8 small satellites, but nowadays it is expected to include around 300 CubeSats. The constellation formation has been possible after the experience gained through the three first launched prototypes CubeBug-1 and CubeBug-2, which have been nicknamed Capitan Beto and Manolito, respectively. With the knowledge and experience acquired from these satellites, the engineering team of Satellogic developed the BugSat-1, Tita, the third prototype, which was the primary pathfinder for the Aleph constellation. It weighs 22 kg and has a mid-resolution camera and amateur radio equipment.

Once the company has verified the functionality of the integrated system for the data acquisition, data downlink, processing and distribution to users and quick tasking of the satellites, the development of the operational satellites of the constellation started. After the launching of CubeBug-1 & 2 as well as the BugSat-1, the operational satellites would rapidly be designed and developed, trying to include incremental improvements in each of the models. The process used by the organization for the design, testing and development, as well as the materials used, allows the fast manufacturing of the devices. The operational satellites era started with Fresco and Batata, which were both launched in May 2016.

Satellogic developed the sixth nanosatellite and the third operational one named Milanesat, which was launched into orbit in June 2017. Equipped with similar technology than the previous ones, it weighs less than 40 kg and heights less than 80 cm. Placed at the altitude orbit of 500 km, Milanesat spends 93 minutes to go around Earth. With the launch of the third satellite, Satellogic started to be able to offer commercial services to its clients.

In order to continue with the constellation implementation, two more satellites, named Ada and Maryam, were developed. Ada, in honour of Ada Lovelace, considered as the first person to be a computing programmer in history; and Maryam, in honour of the brilliant and well-known Iranian mathematician named Maryam Mirzakhani; conform a pair that make a tribute to important women figures in the world of computing and mathematics. Both satellites were placed into a 500 km altitude orbit in February 2018, to reach the number of 8 satellites in orbit.

Online Platform

In a public interview, the founder of Stellogic, stated that it is a mistake to think about the current Earth Observation market and look for a space into it. As he explained, there a growing number of companies that produce satellites and constellations to provide the service of the Earth Observation. The plan, instead, is by lowering the acquisition data cost by several orders of magnitude, combined with rapid revisit rates and data analysis tools, is what will make the difference with other competitors,
his literal words were: "we'll essentially open up completely new markets for Earth observation data and we'll make this data part of daily decision-making for every industry in the planet". Satellogic's business model has two different phases which are to continue making the low-cost satellites and keep on with adding incremental improvements in each of the launchings, while developing the application platform to allow the future clients to obtain all the information from their images and the parameters gotten by the first satellites. Within the agreement which they reached with Microsoft in November 2017, Satellogic could start counting on Azure, Microsoft's Data Centre, to intelligently process and analyse the information captured. Ezequiel Glinsky, Microsoft's manager of new businesses, stated that the fact that Satellogic worked with open source as it is Linux, had been a challenge for them and have changed their mind about it in the last months. The real problem that Azure had to solve was to cope with the amount of information obtained by the satellites and how to transform this data into useful information to improve the decision-making process of governments, companies or particulars.
From the work performed using artificial intelligence AI as well as Machine Learning, processes can be learned from the collected data and find the best way to use the natural resources, improve the productivity of some industries or monitor the regional economies growth.
The artificial intelligence algorithms are used to identify objects and perform an automated classification. The work is focused on looking for the gradual changes produced in an image to detect changes in a defined area, such as the cut of a group of trees in a zone. Some may think this tools can have military applications, but Kargieman, Satellogic's CEO, states a firm position about that saying that "our company's culture and objective is against this military application, the objective is to improve people's lives and not to learn how to kill each other".

Regarding the Azure Microsoft's platform, in its website is self-defined as an integral service set in the "cloud" used by the professionals and IT developers to create, implement and manage applications through their global network of data centres. The platform offers services of integrated tools, Development and Operations and a marketplace which would help Azure customers to create anything in an efficient way









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