

SPACEWATCH

AFRICA

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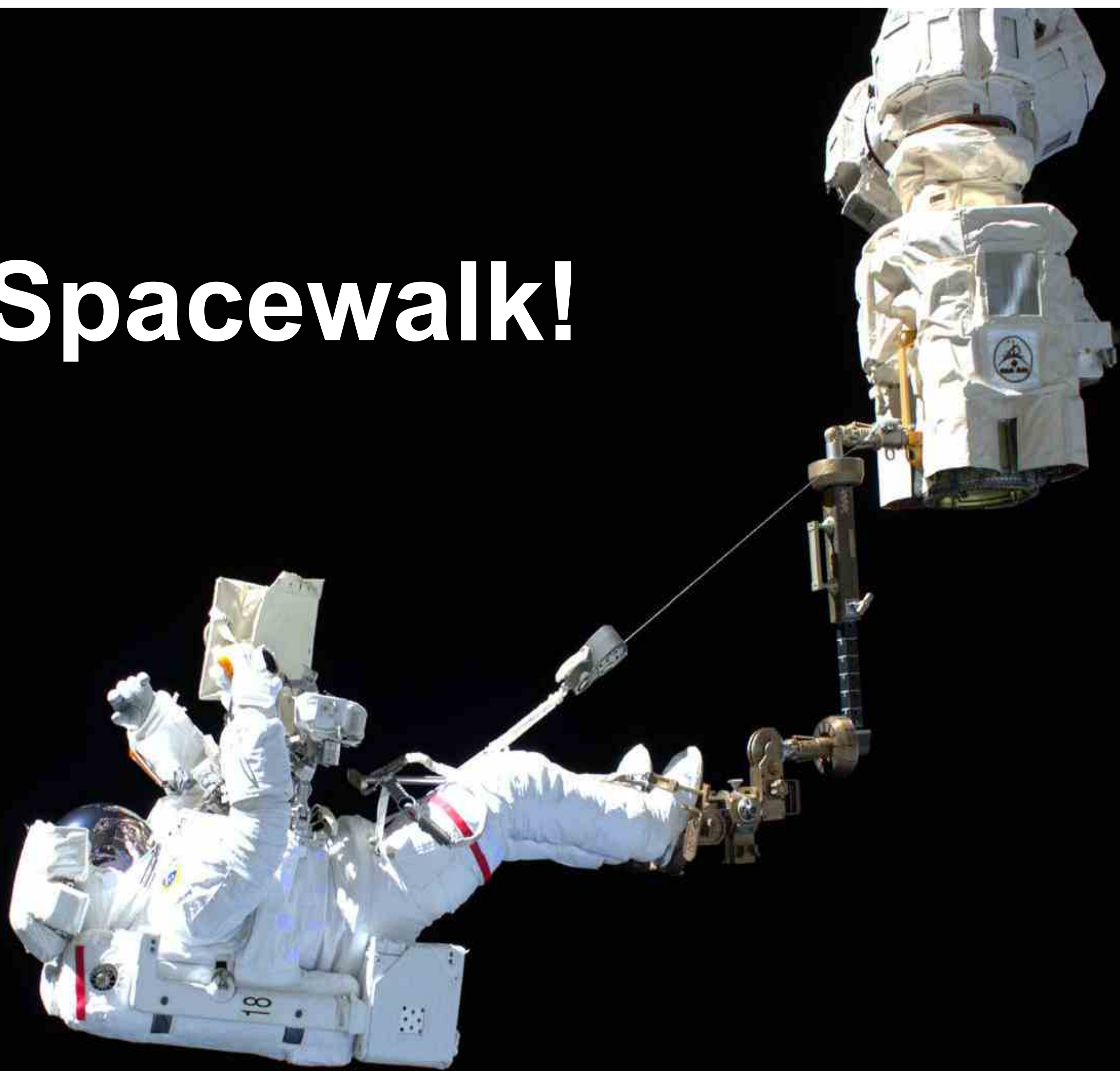
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rockets in 2025

Morocco's deep pockets yielding
results



Spacewalk!





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SPACEWATCH AFRICA

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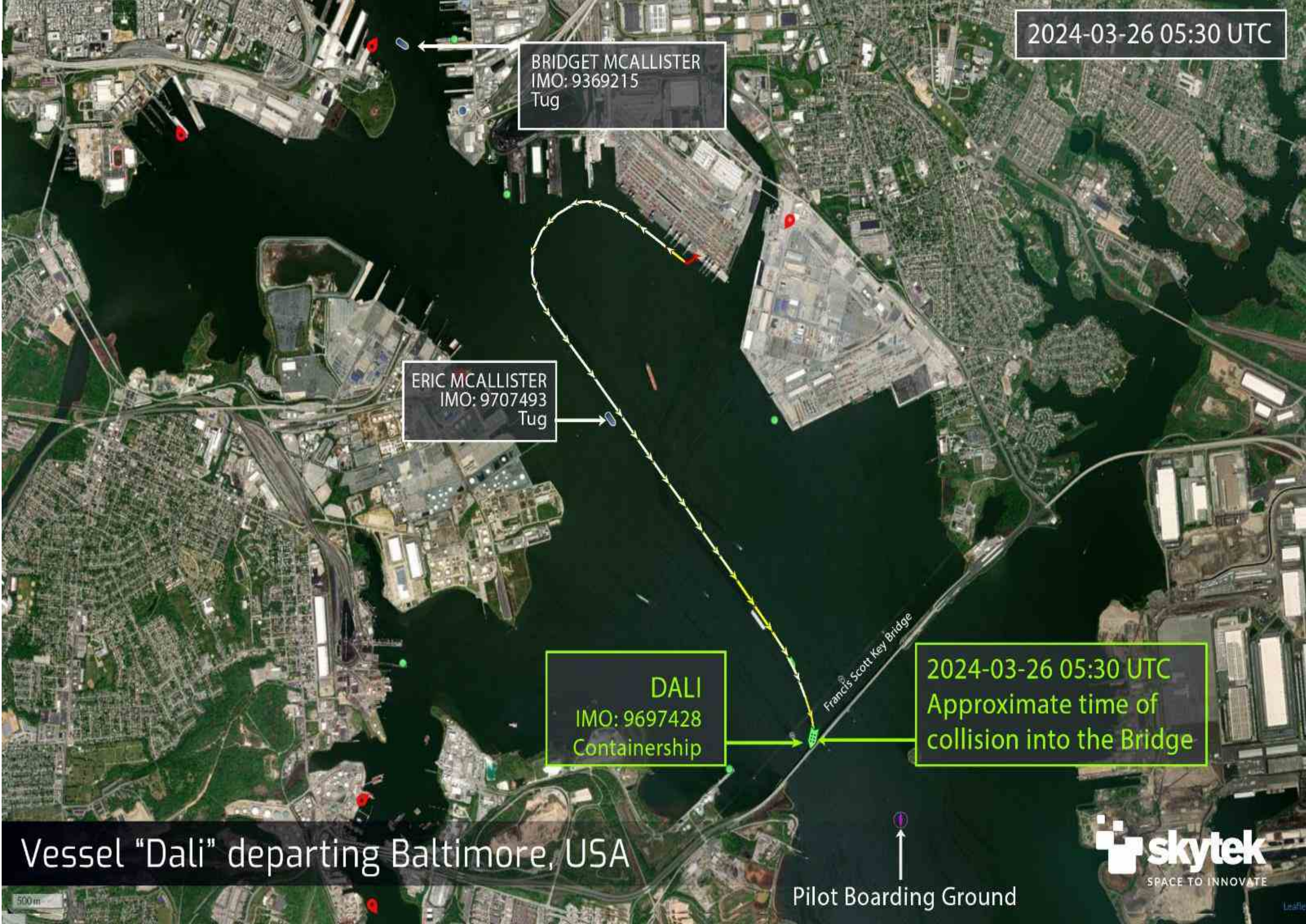
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Pilot Boarding Ground



SPECIAL FEATURE

Sputnik: 67 Years Later



Guess who turned 67? Sputnik II! On Oct. 4, 1957, the Soviet Union made history when it launched the world's first artificial satellite from the Baikonur Cosmodrome in what is now present-day Kazakhstan. Merely the size of a medicine ball and weighing approximately 189 pounds, it took 98 minutes for Sputnik to complete one orbit of Earth. The satellite lasted 21 days in orbit and burned up in the atmosphere three months later.

Plans for the Sputnik launch date back to 1952, when the International Council of Scientific Unions determined an 18-month period between July 1957 and December 1958 as the International Geophysical Year (IGY) the ideal time to launch artificial satellites to map the Earth's surface. In 1955, the U.S. decided to launch its 3.5-pound Vanguard satellite as part of the IGY during 1958. But, the U.S., and frankly the entire world, was caught off guard when the U.S.S.R. was the first to launch with Sputnik I, which was 10 times the size of Vanguard. Sputnik was visible with binoculars before sunrise or after sunset. It also transmitted radio signals back to Earth strong enough to be picked up by amateur radio operators. While admired

for its technical achievement, though, the public feared the successful Sputnik launch signaled the country's ability to also launch ballistic missiles that could carry nuclear weapons from Europe to the U.S. While first seen as a Cold War tactic, Sputnik ushered in the dawn of something much bigger the Space Age. This 60-year period has spawned rapid technology development, scientific advancements and international collaboration ... all in the name of space exploration.

The Race Is On

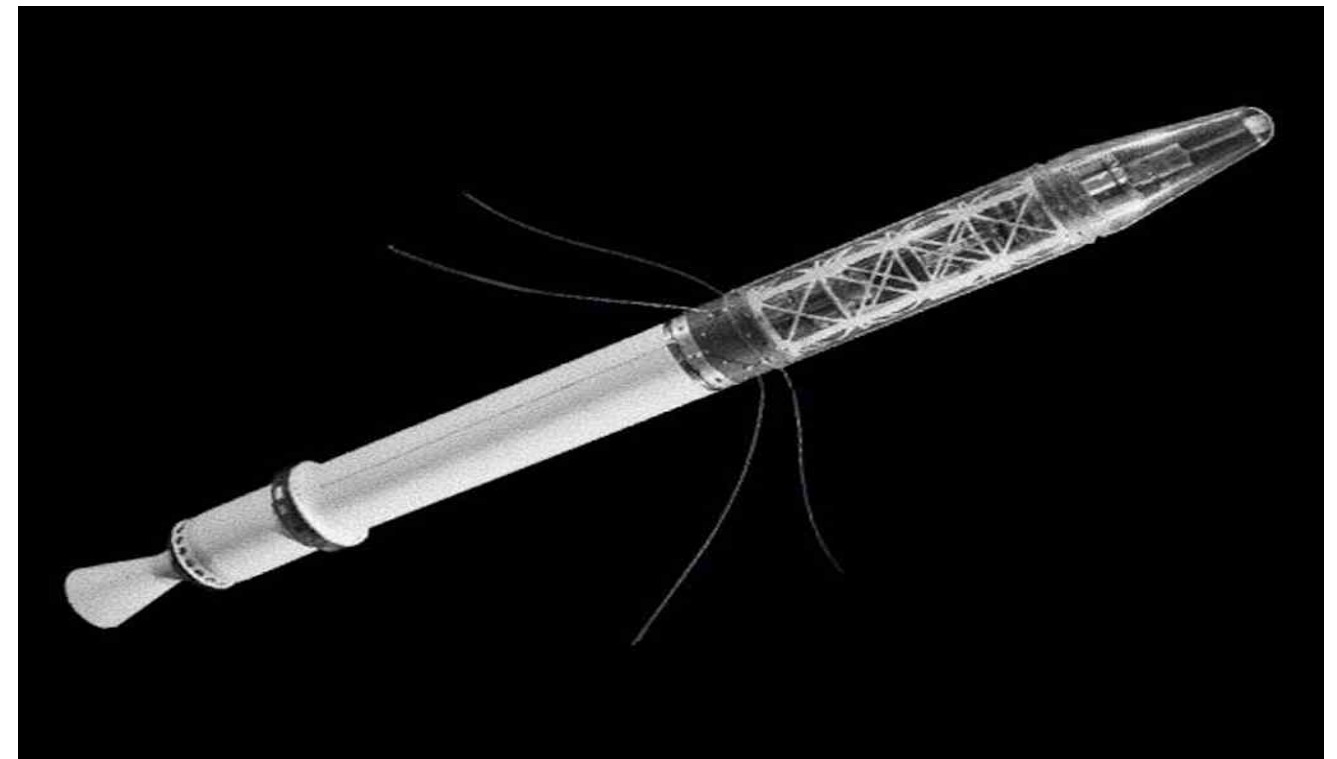
Nearly four months after Sputnik, the U.S. launched its first satellite, Explorer I, and officially established the National Aeronautics and Space Administration (NASA) in July 1958. And so, launched the space race between the U.S. and the U.S.S.R. In April 1961, Soviet cosmonaut, Yuri Gagarin, became the first man in space. The U.S. countered one month later when it sent Alan Shepard into space as part of Project Mercury, which was later followed by John

Glenn's first orbital flight aboard Friendship 7. NASA then moved on to Project Gemini, aimed at developing capabilities to accomplish longer-duration flight.

While successful, the U.S. still trailed the U.S.S.R. in terms of technology development. However, that changed with the launched of the Apollo program. Boasting the largest rocket ever made, the Saturn V, NASA's Apollo program put 12 American astronauts on the Moon, inspired a generation and finally established the U.S. as the world leader in space technology and development.

Joining Forces

Recognizing the possibilities when two powerhouses join forces, the U.S. and the U.S.S.R. set their sights on a collaborative manned mission. In 1975, the Apollo-Soyuz Test Project became the first spaceflight in which spacecraft from different nations docked in space. This mission included scientific



experiments and engineering analysis between the two countries that served as a launch pad for future joint projects, most notably the Shuttle-Mir program and the International Space Station (ISS), the beacon of international collaboration.

Six Decades of Space Technology Benefits

Since Sputnik, more than 6,600 satellites of all sizes have been launched into space, providing key support to humans on Earth, including ability to highlight and monitor the intensity of storms; GPS tracking for military and personal use; using imagery from satellite programs such as Landsat to benefit wildlife and track environmental impact of natural disasters; Global connectivity through internet and mobile broadband services; and interplanetary exploration to yield a deeper scientific understanding of our solar system, over the past 40 years, the Voyager 1 and 2 satellites have explored Jupiter, Saturn, Uranus and Neptune, along with 48 of these planets' moons and the unique system of rings and magnetic fields these planets possess)

The most famous satellite is the ISS. The orbiting facility serves as a platform for testing new technology to enable deep space exploration. It also hosts valuable scientific research that unveil additional benefits to life on Earth and help us better prepare humans for the impact of long-duration spaceflight.

Beyond satellites, though, overall general advancement within space exploration has led to numerous technology spin-offs with worldwide impact – from medicine, transportation and public safety to the environment, information technology and industrial productivity, and many more in between.

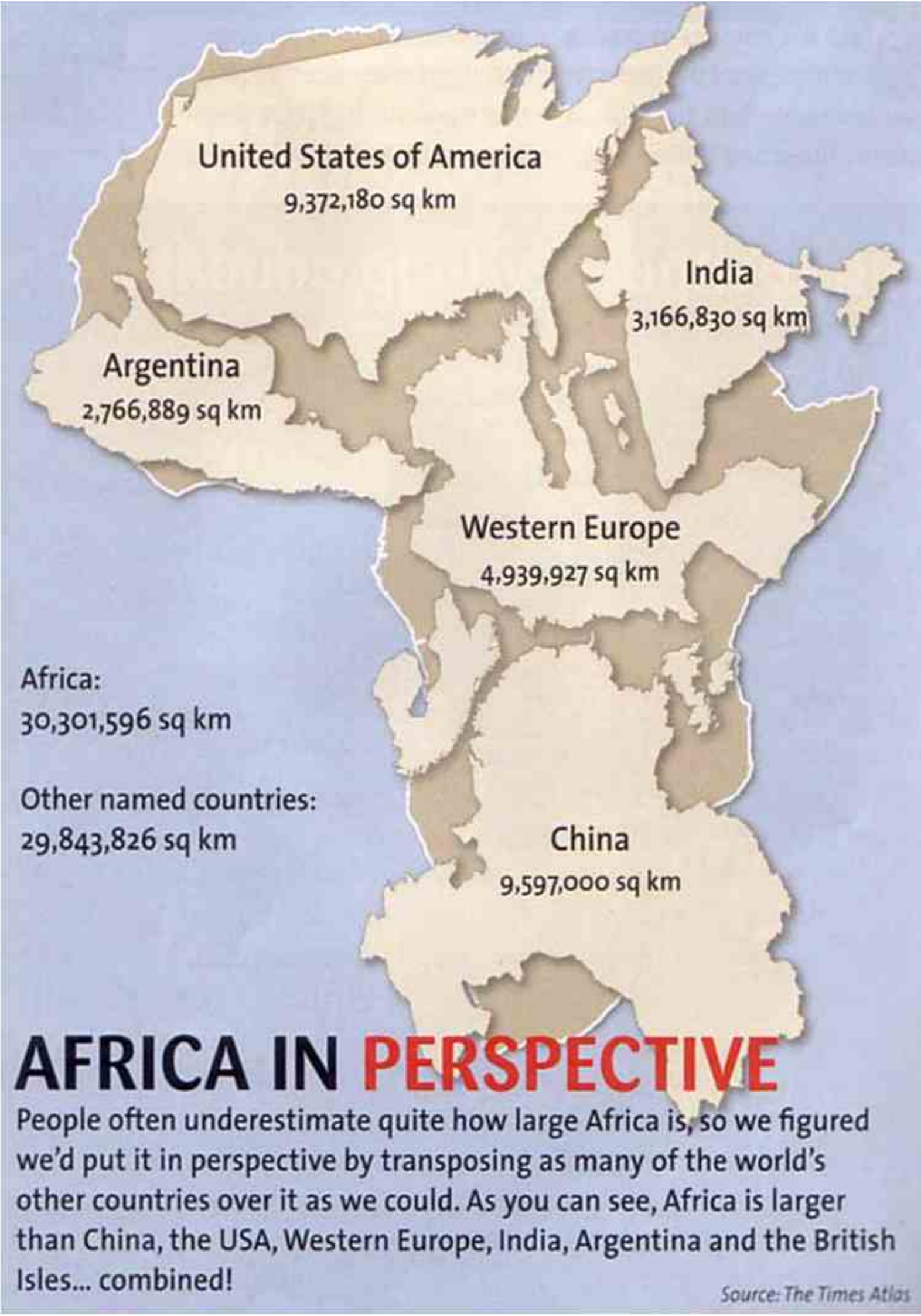
It's Only the Beginning

While we have made significant progress in space technology and development since Sputnik, there is still so much more to uncover. Each year, more commercial companies are bringing cost-effective and innovative solutions, for accessing

space to the table. For example, satellite constellations are on the horizon with companies planning to launch a family of satellites to ensure global connectivity.

This would provide critical support to those who need it most, including rural communities, impoverished countries, first responders and those impacted by natural disasters. NASA's GSFC is developing satellite technologies, such as the Restore-L project, to inspect and service other satellites currently in orbit. On-orbit manufacturing could be one of the next innovations to come online, thereby lowering the cost to access space.

The world is a different place than it was 60 years ago when Sputnik catapulted into space. The advancements we've made and knowledge we've gained by exploring space are incredible. Imagine what the next 60 years of space technology and collaboration have in store for life on Earth and beyond.



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Vessel "Dali" departing Baltimore, USA

Key industry trends highlighted at the SATELLITE 2024

With a rich history dating back to 1981, SATELLITE Conference and Exhibition is renowned as the premier destination for those seeking to stay at the forefront of the satellite industry. Over four immersive days, the event creates an unrivaled program of executive-level discussions, financial insights, technical content, and visionary keynotes delivered by industry luminaries and trailblazers.

The 43rd annual SATELLITE Conference and Exhibition recently concluded its highly anticipated event in Washington DC, from March 18-21. The event had an impressive attendance of 14,768 individuals from 113 different countries making the foremost gathering for professionals in the satellite and space industry. Notably, this year's conference reflected the increasing mainstream adoption of satellite technologies and warmly welcomed diverse end-user communities.

SATELLITE 2024 showcased a remarkable growth in its exhibitor numbers, with 450 companies from over 30 countries participating. The exhibition space spanned 88,000 net square feet, marking a substantial 24 percent increase from the previous year and setting a new record as the largest show floor in its 40+ year history.

SATELLITE 2024 hosted more attendees and exhibitors than any other year. In just three years after having to close our doors early due to the COVID-19 pandemic, we have broken our attendance record two years in a row," said Lindsey Fuller, Senior Vice President of SATELLITE 2024. "The most exciting statistic for us was discovering that one-third of attendees were attending the event for the first time. Many of these first-time attendees were coming from industries outside of satellite and space technology, which speaks to the growth of our community."

During the event, Intelsat CEO Dave Wajsgas delivered a fireside keynote shedding light on the company's transition from solely providing media networks capacity to becoming a comprehensive, end-to-end solutions provider. He also hinted at several potential deals in progress, including ventures into medium-earth orbit and land mobility services.

Another standout fireside session featured Glenn Latta from Delta Air Lines and Paul Gaske, COO of Hughes, stressing the critical importance of inflight connectivity (IFC) for commercial airlines. They emphasized the necessity for IFC to not only be accessible and scalable but also equipped with cutting-edge technology to meet the increasing demand for seamless internet connections.

The Opening General Sessions, sponsored respectively by Thales Alenia Space and Maxar, provided platforms for lively discussions among satellite industry leaders. Topics

ranged from global broadband connectivity and technological advancements to the challenges faced by legacy operators amidst competition from emerging players like Starlink. Gwynne Shotwell, president and COO of SpaceX, touched on several developments — including updates with Starlink, the recent John Deere deal, and Starship's test flight — in addition to announcing SpaceX's next frontier: plug-and-play lasers. During the Wednesday Opening General Session, sponsored by Maxar, executives from Comtech, Viasat, EchoStar, Iridium, Globalstar and John Deere discussed about the practical challenges of satellite and cellular convergence.

The conference also honored notable figures and innovations within the industry. MDA Space CEO Mike Greenley and 3GPP NTN Standards were recognized with the 2023 Satellite Executive and Technology of the Year awards, announced by Via Satellite during the Awards Luncheon on Wednesday, March 20.

SATELLITE 2024 featured its strongest-ever conference program offering to attendees," said Jeffrey Hill, Executive Chairman for SATELLITE 2024. "All-access pass-holders enjoyed access to more than 400 high-level speakers and nearly a dozen keynote presentations from industry thought leaders at U.S. Space Force, the NRO, Space Development Agency, Delta Airlines, John Deere, the ITU, the FCC, SpaceX, T-Mobile, Carnival Cruise Lines and more."

Exhibition Highlights

During the 8th Annual Startup Space pitch competition, ten entrepreneurs had the opportunity to showcase their ideas in front of a panel of judges. The participants vied for the chance to secure private pitch meetings with a select group of influential space investors. This year's winner, Trust Point, is developing a commercial next-generation GNSS to provide performance, security and reliability improvements for GPS users.

A notable addition to the event was the debut of the Via Satellite Theater, which brought a glimpse of conference content directly to the show floor. Across nine sessions held throughout the week, attendees were given various presentations that consistently drew in eager crowds, often resulting in standing-room-only situations. Topics explored ranged from the integration of AI in space ventures to discussions on the future space economy, addressing connectivity requirements for both air and sea end-users, exploring direct-to-device connections, leveraging earth observation data, etc.

Moreover, attendees were given exclusive access to firsthand insights into the latest technological advancements from industry leaders. Through live demonstrations, engaging presentations, and new product launches, companies such as SEAKR Engineering, ST Engineering iDirect, Viasat, and Nanoavionics showcased their innovative offerings. This showcase also featured contributions from Constellations

Podcast by Kratos, SpaceBridge, Keysight Technologies, Blue Canyon Technologies, Globalstar, SatixFy, Capgemini America, and Beyond Gravity, providing attendees with an overview of the cutting-edge developments shaping the future of the satellite and space industry.

Satellite versus Telcos

Leaders representing Orange, Telstra, and Space Compass offered a variety of marriage advice from terrestrial network operators and new hybrid telcos to satellite providers, while echoing Vuillemin's commitment to stick with the relationship. Satellite connectivity is "existentially important for us in Asia," said Paul Abfalter, head of North Asia & Global Wholesale at Australian MNO Telstra. Because Telstra serves markets like the remote rural areas of Australia and the Pacific Islands, which don't have fiber connections, satellite-provided cellular backhaul is sometimes the only way to get mobile connectivity, he said. The telco representatives take a realistic view of the developments in the satellite industry like Low-Earth Orbit (LEO) satellites.

While the satellite industry is excited about LEO, Vuillemin said, "If you want to have the best connectivity at the lowest possible cost, nothing is better than a big traditional GEO [Geostationary] satellite."

The biggest problem in the marriage of satellite and telco partners Vuillemin suggested, is how fractured the satellite landscape is. "Satellite is not an industry — it is a set of industries," he said, adding that it functions as if each operator is its own industry and they don't know how to work with each other.

"It's exactly the same situation that mobile operators were in 60 years ago, when you had one program in each country and it was not possible to interoperate," he said. Vuillemin suggested some operators are "continuing to use a lack of standards as a protection of their own business."

Satellite operators "don't really understand the needs" of their users, he added, explaining how different the Starlink customer experience was. "I ordered it on the internet," he said. Three days later, the terminal arrived. He set it up in his garden and was on the internet five minutes later. "Compare that with a traditional satellite provider," he said. Starlink terminals are priced much cheaper than traditional "very big, very proprietary, and very expensive" terminals, said Shigehiro Hori, co-CEO of Space Compass.

In the relationship between telcos and satellite providers, Space Compass is in a unique position. The company is a joint venture between Japan's largest terrestrial network operator NTT and national satellite provider Sky Perfect JSAT Co-owned by its two parents, Space Compass is staffed by a joint team drawn from both companies, and represents a whole greater than the sum of its parts, explained Hori.

JSAT "understands the [satellite] technology, but they don't know much about the cell network businesses and vice versa. NTT doesn't know much about satellites," he said.

As befits its lineage as the offspring of satellite and telco, Space Compass has a "futuristic vision, fusing terrestrial and non-terrestrial networks" to provide seamless connectivity in hard-to-



reach markets.

Space Compass also plans to invest in high altitude platform stations, or HAPS, with plans to enter service in Japanese fiscal year 2025. HAPS function as a "cell tower in the sky," said Hori, with a much greater reach than a terrestrial cell tower, and more bandwidth than a ground-based local station could offer.

The effort to develop direct-to-device capability underlines why satellite operators need telcos to go to market, said Abfalter.

"I think telcos are needed a lot more than what they were 10 years ago. Just partly because the volume and reach needed now is so much bigger for those B2C use cases, and even for the B2B ones. Volume means telcos have become a much more important channel for the satellite industry than what they were 10 years ago," he said.

In the past two years, Telstra's corporate customers have been demanding broadband connectivity "in some weird and wonderful places." He said large multinational corporations are "really ahead of the game, wanting to see LEO use cases come in as quickly as possible."

Both sides of the marriage need each other. While satellite operators need telcos for distribution, telcos need satellite to connect in places no one else can, said Abfalter. Most of the bid tenders coming from large multinational enterprises required global wireless connectivity that only satellite could guarantee.

But telcos don't always feel the love in return, he said. "I don't think we've necessarily felt like a marriage partner for most satellite providers — more like an ad hoc girlfriend that gets lots of urgent calls when there's a problem. It feels like that most of the time."

Milbank Partner Dara Panahy Moderated Panel on New Satellite

and Space Business Models

Milbank LLP partner Dara Panahy will moderate "The Renaissance of Satellite: New Business Models Across the Value Chain" panel, in partnership with Global Satellite Operators Association (GSOA), at the SATELLITE 2024 conference on March 19, 2024 in Washington, DC. Mr. Panahy will be joined by speakers from NigComSat, Sateliot, SpaceBridge, Arianespace and Terran Orbital Corporation.

The satellite industry is going through an unprecedented phase of growth and innovation, with new entrepreneurial settings, leapfrogging of well-established technologies, vertical integration and multiorbit operations driving the industry ecosystem into a constant state of re-invention. Panelists will discuss how this is leading to increased pressure on investment and the need to define new business models as well as the current evolution of products, services and the overall market. Mr. Panahy, who leads the firm's Transportation and Space practice in Washington DC, focuses on the representation of satellite and space infrastructure operators, aerospace manufacturers, launch services providers, communications, earth observation and data services companies, banks, private equity firms, hedge funds and other investors in debt and equity offerings, project, structured and vendor financings, mergers & acquisitions, financial restructurings and in negotiating commercial contracts. Milbank's Space Business Group distributes a roundup of space industry developments in Milbank's monthly Space Business Review newsletter.

SATELLITE 2024, which runs March 18–21, 2024 has remained at the epicenter of innovation in the satellite and space community, with an expansive program of executive-level discussions, financial insights, technical content and visionary keynotes delivered by industry luminaries and trailblazers.

APPOINTMENTS

Frédéric Texier appointed Head of Media Relations and Digital Influence of the Orange Group

Frédéric Texier has joined the Orange group as Head of Media Relations and Digital Influence. He will report to Caroline Guillaumin, Executive Vice President of Group Communications and member of the Group's Executive Committee.

Frédéric Texier was previously director of corporate communications at Renault Group, which he joined in 2016 as Head of the press office. Prior to that, he spent seven years at Total, first in the Group's press department and then as Head of Communications for the New Energies Division. From 2006 to 2009, he worked in Eurotunnel's operational communication department. He started his career in journalism contributing to science magazines for the general public. Frédéric Texier holds a degree in environmental sciences and geotechnology from the University of Poitiers and a Master's degree in Science Journalism from the University of Montpellier.

World-leading flat panel satellite antenna company Kymeta announced Rick Bergman as the President and CEO

Rick Bergman has been named President and CEO of Kymeta, bringing a wealth of experience from his most recent role as Executive Vice President, Computing and Graphics at AMD. Bergman also served as President and CEO of Synaptics (SYNA) during their high growth phase from 2011 to 2019. His distinguished career includes steering organizations towards capitalizing on market opportunities with innovative technologies, leading to sustained market growth.

"Kymeta stands as a technology and market leader supported by the strength of a highly capable global team" says Rick. "Guided by a dedication to customers, innovation, and the delivery of top-notch products, Kymeta is well-positioned for advancing global broadband communications."

In addition, Nicole Piasecki was appointed Chair of the Board, succeeding Doug Hutcheson. Nicole, who joined the board in May 2022, brings an extensive background from the aerospace and defense sector. Commenting on Rick's appointment, Piasecki says, "I am excited about Rick joining our outstanding team. Kymeta is at the forefront of connecting the world through its hybrid communication solutions. With Rick Bergman's track record of driving value-led growth in the technology sector bolstered by disciplined execution, we eagerly anticipate the next phase of growth for Kymeta."

Kymeta recently completed its Series D round. These additional funds will be used for ramping up production of the recently announced Osprey™ u8 Hybrid-GEO-LEO and future product generations.

Ericsson appoints Andres Vicente Head of Market Area South East Asia, Oceania & India

Ericsson announces the appointment of Andres Vicente as its new Head of Market Area South East Asia, Oceania & India and Senior Vice President. Mr. Vicente who is currently Head of Ericsson's Customer Unit Iberia within Market Area Europe & Latin America, will replace Nunzio Mirtillo whose retirement was announced in October 2023. Mr. Vicente will take up his new position on May 1, 2024, and will be based in Singapore. Andres Vicente has extensive experience from the telecommunications industry and joined Ericsson in 2021. He has previously worked for Vodafone for 25 years in commercial roles where he headed marketing and sales and different market segments.

Börje Ekholm, President and CEO of Ericsson, said: "I'm very pleased that Andres has accepted to take on this role. His knowledge of our industry and deep understanding of the commercial aspects that are vital to our continued success, will prove themselves very valuable to me and to his colleagues in the Market Area."

Space Partnership Board appoints new independent Chair

The Space Partnership Board announce the appointment of Tim Bestwick as its new Independent Chair. Tim brings a wealth of commercialisation experience from chairing the Harwell Campus Joint Venture and at UK Atomic Energy Authority, where he is both Deputy CEO and Chief Development Officer. The Space Partnership brings together industry, academia and government to identify shared priorities and agree collective action to realise the ambition in the National Space Strategy. The non-voting Independent Chair ensures that the Space Partnership Board operates in a fair and transparent way. The appointment was made following a selection process led by a representative from each stakeholder group.

At the Space Partnership Board meeting on 27 February, the outgoing Chair, Graham Peters, handed over to the new Chair, Professor Katharine Robson Brown, Co-Chair of Space Academic Network (SPAN), thanked the outgoing Chair. "On behalf of the whole of the Space Partnership Board, I would like to thank you for your energy and enthusiasm in bringing stakeholders together

to establish the Space Partnership. You have expertly guided the Board through the initial phases as it evolved from the Space Growth Partnership."

Simon van den Dries joins EnduroSat as a Head of Space Service

EnduroSat has appointed Simon van den Dries as the Head of its Space Services sales team as per March 1, 2024.

Simon brings over 24 years of experience in the space industry, having worked with Spire as VP of Business Development Space Services, as well as SES, GE, and Honeywell.

EnduroSat is a highly driven company with a strong vision to streamline commercial access to space for the global market. The company has made the traditionally complex and protracted process of sending a satellite in space into a straightforward and rapid experience for international customers. I'm excited to join the team and usher EnduroSat's in-space capabilities into the next era of Space Services, says Simon Van Den Dries.

EnduroSat kicked its Space Services into high gear last year, raising capital to scale, securing Vyoma as a new customer in situational awareness missions and signing cutting-edge missions for space exploration and remote sensing.

Tom Everitt joins 2excel aviation as operations manager

Tom Everitt has joined 2Excel Aviation as Operations Manager, with responsibility for overseeing day-to-day operations, including managing the Operations Team and supporting the Company's flying programme.

Bringing more than 20 years' experience in commercial aviation operations to the role, Tom, who began his career in Dispatch & Load Control at Manchester, first moved into Operations with Air Atlantique at Coventry, working with the Atlantic Reconnaissance fleet on coastguard operations and disaster response alongside the ATR42/72 fleet on ACMI and charter work. A later role as Operations Manager also saw him looking after an extensive fleet of historic aircraft.

Tom then moved back to regular aviation at Gama Aviation, eventually becoming Head of Ground Operations with responsibility for a team of more than 20 people in the UK and Poland. During his 16 years with Gama, a key role was working with the Scottish & Channel Islands Air Ambulance services.

Tom said: "Joining 2Excel at such a critical time in the Company's growth is an exciting prospect for anyone in the aviation world, whether experienced like me, or new to the sector with a keen interest.

Nigeria's STI Expo 2024



One of Africa's leading event, eighth edition of the Technology and Innovation Expo organised by Nigeria's Federal Ministry of Innovation, Science and Technology came to an end recently in the country's capital of Abuja.

The expo was hosted at the expansive Eagles Square, in the heart of Abuja offers opportunities for agencies and institutions under the ministry and others in the field of science and technology to showcase some of their innovations, especially the homegrown ones.

In a statement to highlight the importance of the expo which ends on March 15th, Nigeria's Minister of Innovation, Science and Technology, Geoffrey Nnaji said Innovation, Science and Technology (IST) is the vital solution to the national challenges and engine room for transformation and acceleration of the nation's economic advancement, generation, create employment opportunities and improve the standard of living of Nigerians.

According to him, the objective of the Technology Expo is to promote locally made goods and services which will reduce the high cost of importation, enhance revenue generation, create employment opportunities and improve the standard of living of Nigerians.

"The administration of President Bola Tinubu is fully committed to ensuring that its Renewed Hope Agenda of accelerating economic diversification, through industrialization, digitization, creative arts, manufacturing is achieved through the application of Innovation,

Science and Technology," Nnaji said.

The Minister, in optimism said, "With our collective and unrelenting efforts, our quest to achieve a service driven economy that is competitive in terms of culture, socio-economic and political independence, the future of our country will be great."

The technology and innovation EXPO, 2024 which lasted for five days highlights activities like the exhibition of research, development, and innovative results, an investor and researcher forum, technical sessions, the assessment of research and development results, and the award of prizes. Speaking earlier in her welcome address, the Permanent Secretary, Federal Ministry of Innovation, Science, and Technology, Mrs. Esuabana Nko-Asanye, said that the numerous challenges confronting the global system have their solutions encapsulated in innovation, science, and technology. She called on the government, MDA's, experts, and relevant stakeholders to map out strategies in unison that are geared towards accelerating the pace of development of Innovation, Science and technology in the country.

He called on the Nigerian Technopreneurs in the Organized Public Sector (OPS) to be patriotic and look inward with a view to partner with the Ministry in developing the Country's Innovation, Science and Technology sector for economic growth and national development.

It was a groundbreaking event that brought together experts, innovators, inventors,

developers, and leaders of thought in science, technology, and innovation.

Exhibitors showcased innovative ideas and research projects to visitors audience comprising potential investors, customers, and strategic partners. This forum presents opportunities to garner the support necessary to propel your projects.

By championing the Made-in-Nigeria agenda and fostering STEM education, the Expo plays an instrumental role in advancing our national development objectives. Through collaborative efforts, we endeavor to stimulate economic growth, generate employment opportunities and more.

Irrespective of your level of expertise, the Expo offers a diverse array of workshops, seminars, and demonstrations tailored to enhance proficiency and expand knowledge within various disciplines especially to encourage students within our educational institutions.

The Honourable Minister of Innovation, Science, and Technology, FMIST, Chief Uche Nnaji, stressed the need for result oriented collaboration between researchers and inventors to facilitate the commercialization of research outcomes for the development of the science and technology ecosystem.

According to him, the primary objective of the event is to unite innovators, inventors, research institutions, experts, and relevant stakeholders in promoting locally made goods and services, which will reduce the high cost of importation as well as boost the revenue generation drive of the present administration.

The Minister, who highlighted some of the key objectives of the annual event, further stated that the initiative is pivotal in advancing the 'made in Nigeria' agenda, which is fuelled by indigenous inventions and innovations showcased during the event. He said the objectives underscore the EXPO's commitment to fostering innovation, driving economic growth, and nurturing a generation of forward thinking individuals poised to tackle global challenges.

In his vote of thanks, the Director, Science and Technology Promotion, FMSTI, Mr. Ronald Ukpog, commended the efforts of the Honourable Minister and the chief Executive Officer of all the Agencies and parastatals under the supervision of the Federal Ministry of Innovation Science and Technology.

He charged them to think outside the box by bringing up research projects that would help in actualizing the renewed hope agenda of Mr. President.

The Science and Technology EXPO is an annual event organised by the Federal Ministry of Innovation, Science and Technology. The EXPO is aimed at promoting indigenous products and showcasing the potentials of our indigenous innovators, inventors, engineers and scientists.

AFRICA

Morocco's deep pockets yielding results



Recently Morocco ups its space game with the launch of 'Mohammed VI-A' from French Guiana giving the North African country's a major breakthrough in mastering space technology, according to an official statement.

With technological advancement on their side, many countries around the world have contributed to space research by sending their satellites in orbit. Now, Morocco has become a part of the list, joining a select group of countries in Africa that have a satellite in orbit with the launch on November 8 of its earth observation satellite.

The Mohammed VI-A satellite is an Earth observation satellite built for the Kingdom of Morocco by Thales Alenia Space as system prime contractor and Airbus as co-prime. The satellite will be in particular used for mapping and land surveying activities, regional development, agricultural monitoring, the prevention and management of natural disasters, monitoring changes in the environment and desertification, as well as border and coastal surveillance, said an Arianespace statement.

A three-axis stabilized satellite, the Mohammed VI-A will weigh approximately 1,110 kg.

The space imagery, operated from Morocco, will play

a key role in the implementation of national strategies for socio-economic development, especially those relating to the agricultural sector which constitutes one of the main pillars of the Moroccan economy.

The satellite will help in land management, through effective control of housing and buildings, as well as tighter monitoring of slum eradication, the statement said. It will also help Morocco better manage water resources and prospect underground water. In order to position Morocco as a leading space powerhouse, and complementing its Mohammed VI/A and Mohammed VI/B satellites already in operation, Morocco again ordered two Ofek-13-type surveillance satellites from Israel to strengthen surveillance in its territory, news outlet Nztic reported earlier this month, quoting a report by the Stockholm International Peace Research Institute (SIPRI).

Ofek-13 satellites, known for their advanced intelligence and security capabilities, can capture images with a resolution of up to 0.5 meter. Designed by Israel Aerospace Industries (IAI) for the Israeli Ministry of Defense and the IDF, these satellites are operated by a control unit known as

9900.

The first Ofek-13 satellite was launched into space on March 29, 2023, using a Shavit launcher from the Palmachim air base in Israel. These satellites utilize Synthetic Aperture Radar (SAR) technology to generate high-resolution images from a limited-resolution radar system by sending microwave radar signals to the Earth's surface. Morocco had previously acquired two Airbus and Thalès-designed satellites pursuant to an agreement in 2013.

With the acquisition and launch of the Ofek satellite, Morocco aims to achieve several objectives: to strengthen its space capabilities, which would make it the leading power on the African continent in this sector, and to increase its security and surveillance. Morocco's Mohammed VI/A satellite was launched in November 2017 from the Kourou base in French Guiana, using a Vega-type rocket. Its counterpart, the Mohammed VI/B, was launched the following year.

Moroccan scientist leads NASA's launch of spacecraft

to upgrade Cold Atom Lab

Space is one of the most important areas, as evidenced by agreements with Israel Aerospace Industries (IAI) to upgrade two observation satellites. Compared to its main competitors, Egypt, Nigeria, South Africa and Algeria, Morocco has enjoyed the greatest growth.

The United States' space agency, NASA, has recently announced the launch of a spacecraft carrying essential equipment for upgrading the pioneering space-based quantum physics laboratory, known as Cold Atom Lab, supervised by Moroccan scientist Kamal Oudrhiri. Resembling a small refrigerator in size, the laboratory is located aboard the International Space Station (ISS) and possesses the capability to cool atoms to nearly absolute zero.

This breakthrough enables dozens of scientists on Earth to conduct experiments in quantum physics, studying the fundamental behaviors of atoms and particles that comprise the world around us. "We hope that Cold Atom Lab marks the beginning of an era where quantum tools are regularly employed in space," stated Kamal Oudrhiri, the project director for Cold Atom Lab, as quoted in a NASA press release.

He further added, "Through Cold Atom Lab, we have demonstrated that these delicate quantum tools are not only reliable but also adaptable in space. We anticipate the Cold Atom Lab to be the first of many quantum space missions to come." The realm of quantum physics has led to the development of crucial technologies, including lasers, transistors, GPS satellites, and medical devices.

Ongoing advancements in this field hold the potential to enhance space navigation and communication. "The experiments we conduct on Cold Atom Lab will one day allow us to measure gravity with unprecedented precision, which is an invaluable tool to have in space," said Jason Williams, a scientist at the Jet Propulsion Laboratory, which oversees Cold Atom Lab for NASA.

Launch of AMAZE Space Camp

The U.S. Embassy in Rabat, in partnership with the Moroccan Initiative for Space Industry (MISI), is pleased to announce the launch of AMAZE Space Camp. This immersive, hands-on experience is designed to spark passion for space exploration and technology among Moroccan students aged 15-18 years.

The week-long residential camp took place at the 1337 School & UM6P venue in Khouribga, Morocco. It offered fantastic opportunity for 30 shortlisted students to immerse themselves in a wealth of activities, including rocketry, space history, robotics, analog mission, space technology, team building, and astronomy. Inclusivity and accessibility are central to AMAZE Space Camp, and students with physical disabilities are strongly encouraged to apply.

Traditional teaching methods can often limit the expansive canvas of technology and space exploration to textbook confines, remarks El Hassan BOUAGHAD, co-founder of MISI. «Our belief is that we should not be spoon-feeding STEM to our students. Hence, the TEAMS (Technology, Engineering, Art, Mathematics, Science) and Teamwork approach focuses on hands-on activities that encourage curiosity, active learning, and shared knowledge within their communities. El Hassan further adds, "Our aim is to nurture these students not just as learners, but as ambassadors of science and technology. We believe that when they share their experiences and newfound passion, they inspire their peers and foster a space-focused mindset in the generations to come"

Two Moroccan researchers join The World Academy of Sciences as fellows

Yahya Tayalati and Youssef Ouknine, two of Morocco's top scientific researchers, have been made fellows of The World Academy of Sciences for the advancement of science in developing countries that has more than 1,400 scientists in around 100 countries.

Tayalti from Rabat-based Université Mohammed V and Ouknine from Marrakech-located Université Cadi Ayyad are members of a new cohort of 47 members joining the prestigious organization. The cohort also includes 2021 Nobel laureate, Italian researcher Giorgio Parisi who won the prize in physics. Tayalti, hailing from the eastern city of Jerada, is a global icon in Physics, astronomy and space science. He is reckoned with his contributions to the TLAS academy. The full Prof. made contributions to the construction and operation of the Liquid Argon Presampler and the observation of light-by-light scattering, 'TWAS' notes.

"He also played a crucial role in the field of neutrino physics, where his involvement in the preparation and deployment of the ANTARES telescope led to the establishment of competitive limits on exotic particles. Additionally, he collaborated with the Cubic Kilometer Neutrino Telescope KM3NeT to establish advanced production lines for optical modules and electro-optics routers in Morocco", the Academy says on its website.

Ouknine on his part is joining the organization for scientific compliments chiefly in stochastic analysis and probability theory and their applications, focusing on stochastic calculus, optimal stopping, Malliavin's calculus, stochastic differential equations (forward and backward) and fractional

stochastic calculus. Stochastic finance is currently one of his research concerns, 'TWAS' notes.

Prof. Ouknine published more than 160 scientific papers in reputed international peer-reviewed journals such as Annals of Applied Probability, Stochastic Processes and their Applications, Electronic Journal of Probability, Electronic Communications in Probability, Bulletin des Sciences Mathématiques, Journal of Theoretical Probability. The Moroccan researcher is also referee and co-editor of several scientific journals of high international repute.

Self-driving rovers tested in Mars-like Morocco

Robots invaded the Sahara Desert for Europe's largest rover field test, taking place in a Mars-like part of Morocco. For two weeks three rovers and more than 40 engineers tested automated navigation systems at up to five different sites.

This marked the end of the first phase of the strategic research cluster on space robotics technologies, a scheme funded by the European Union's Horizon 2020 programme.

The cluster is coordinated by the PERASPERA Ad Astra project, which is a partnership of Italy's ASI space agency, France's CNES space agency, the DLR German Aerospace Center, Spain's CDTI technology agency and the UK Space Agency, UKSA, coordinated by ESA. The venue for the field test – organised by Germany's DFKI Robotic Innovation Centre – was a site served by the Ibn Battuta Centre, near Erfoud on the northern edge of the Sahara Desert.

Pratt & Whitney announces new manufacturing affiliate in Morocco

Pratt & Whitney, an RTX business, announced that it will launch an affiliate, Pratt & Whitney Maroc, in Casablanca, to manufacture detailed static and structural machined parts for various engine models.

This investment is key to Pratt & Whitney's strategy to develop cost-effective sourcing capabilities for competitiveness and to optimize operations footprint and asset utilization. Morocco was selected after a global benchmarking exercise due to its growing hub of aerospace companies, cost of business and trained, available talent.

"Morocco offers many benefits for aerospace manufacturing," said Maria Della Posta, president, Pratt & Whitney Canada. "The growing aerospace community in Casablanca ensures a highly valuable talent pool, a positive economic environment, and the support from Morocco's government. Pratt & Whitney Maroc, as an independent affiliate, will create 200 jobs by 2030, and we look forward to joining the business community in Casablanca's MidParc Free Zone."

NIGERIA: What will be different in 20 years?

Globally, technological advancements will boom. Most thing will be based on electronics and computers. For transactions, electronic money still remains the way to go and instead of swiping a card, quick scan using some smaller item will be done. For transportation, every vehicle will be magnetic like bullet trains, but with more freedom in direction. And trash won't be a hard thing to dispose of, just zap it away!!

Alternate energy will be big, and possibly certain energy will be utilized better to get most power. Oil will become thing of the past, but our pollution problem will still persist of what has happened and is happening. UV rays may pose as a huge problem and sunglasses may become a typical thing to wear everyday. And several buildings will have tinted windows. There will be several big changes in the world in the next 20 years at the rate that is right now. The biggest change will be in computers where instead of a computer being considered old in 6 months after it comes out, it will old in 2 hours or so. Life will be quite fast paced.

As The world is rapidly changing and as a society, organisations too are struggling to adapt to change. In twenty years, the world's focus will be on technology. In Nigeria, NASRDA has taken the initiative to map out an action plan spanning a period of 25 years. The plans are guided by need to stay its course in the advancement of space technology in Nigeria. So far, The National Space Research and Development Agency, NASRDA said, it action plans include launching a satellite manufactured in Nigeria from a Nigeria's launch site on a launch vehicle made in Nigeria.

In addition, it said, NASRDA's action plans include a capability to produce a Nigerian Astronaut. Nigeria has announced plans to send an astronaut into space by 2030, as part of its drive to develop a world-class space industry.

Forecasting the next 20 years, NASRDA has said it would possess satellite and launch vehicle assembly, integration and test AIT infrastructures- Thermo-Vacuum chambers, Vibration Test Equipment, Electrical Ground Support Equipment, Mechanical Ground Support Equipment, among others. Other projects include specialized Centres for the development of satellite components and subsystems incusing antenna systems, attitude and control systems, propellant tank systems, and thermal control system.

The implicit objective for the program has been to aid in the socioeconomic development of the Nigerian people through investment in science,

technology, engineering, and mathematics (STEM) education and earth observation technology. Nigeria intends to utilize these future technologies to help fight climate change, aid in agriculture, oppose Boko Haram, and combat the issue of piracy in the Gulf of Guinea. The goals of NASRDA align well with the stated goals of the Nigerian government to work towards attaining the United Nations' Sustainable Development Goals (SDGs).

Nigeria aims to benefit its populace through investments in space, and space is an integral part of the plan for Nigerian technological independence. Felix Ale, NASRDA Communications Chief, believes that because of the benefits Nigeria and Africa would receive, such as increased security in the fight against Boko Haram, climate monitoring of desertification in the North, or agricultural planning in the Niger Delta, investment in space technology is worth further financial consideration.

NASRDA has also announced plans to develop specialized Centres for development of rocketry and launch systems and components, such as propellants, boosters, thrusters, rocket launch infrastructures such the launch site and rocketry harnesses, and Astronaut training infrastructures While this plan may seem daunting and ambitious, NASRDA is fully determined and focused on achieving each one.

However, building indigenous space capacity in Africa will require partnership with nations that possess capacity and capabilities in advanced space technology infrastructure development and know-how technology training. It is essential for individual countries to identify priorities and design programs that fit into their national needs. Technical cooperation, including that related to technology transfer and know-how acquisition, is effective only when it is derived from and related to the country's own strategies and priorities on development.

In 20 years, the use of technology becomes more and more present with every upcoming day. Engineers have models, programs, and other tools that do many different calculations in many different situations. The need for someone who can think outside of the box becomes very important in the future because these models will surely fail. No matter how accurate a theory may be, there will always be errors that an engineer will need to find. The amount of engineers needed to do a certain task may be reduced however because of new technology.

"We are not just interested in launching satellites, we are also interested in building capacities and that is why we always include capacity building components in all our projects." Felix Ale, Director

of Media and Corporate Communications at NASDRA, stated this recently.

Challenges

The Nigerian space capacity development plans have suffered some challenges since inception. These include but not limited to funding limitations and unfavorable international policies and regulations

According to the agency, building the needed capacities for space ventures is capital intensive. The Nigerian space capacity building programs have largely suffered over the years due to inadequate funding, which is provided for by appropriation, and the untimely release of funds meant for such training programs.

The agency said, "NASRDA currently suffers funding challenges which is directly linked to the paucity of funds within government coffers. Nonetheless, at this juncture, we do hope, suggest and encourage, that in the event of improvement in the government coffers, that this should also translate to improvement in funding of space-related programs.

Despite this, NASRDA it will continue to take advantage of funding support programs available to third-world countries for the training of its technical personnel, especially in technologies that will not draw unnecessary attention to it capacity building efforts or create friction between Nigeria and the advanced space economies who may be overly sensitive to regulations on such technologies.

"We must state however, that regardless of this funding challenge, NASRDA is fully committed to implementing the Nigerian space policy" says the Space Agency's director. Therefore, to address the myriad of needs confronting the Nigerian space venture, the NASRDA management has made the judicious administration of available resources topmost on the list of priorities. It has been able to build research infrastructures such as the Advanced.

In 20 years, actualizing hands-on and know-how capacity development programs demand more than financial investments. Space ventures have global security and legal implications. Thus, an understanding of these security and legal implications backed by a strong political will and a committed leadership remains a foremost requirement for the success of any national space program. Consequently, even in the event that adequate funding is made available, there is the prerequisite of a strong and trusted diplomatic relation and cooperation between space-intending nations and nations that possess

advanced space know-how. Recognizing this, Nigeria through NASRDA engages in continuous space technological expansion and development of its citizens through various training and higher academic programmes. It is an unquestionable fact that a continual investment in space capacity building is a costly venture, nonetheless it is a necessary one. The immediate and long-term benefits are immense and the spin-offs have transgenerational impacts.

Nigeria's venture into space science and technology and at acquiring capacity in space technology has spanned almost two decades. Despite the challenges encountered, progress has been steady though gradual. Hence, there is strong optimism that as the Nigerian government improves on the investment in space technology, acquired capacity and technical capabilities will also improve proportionately.

Technological advancement and security of Nigeria

Chief Geoffrey Uche Nnaji, the Honourable Minister of Innovation, Science, and Technology, recently visited the Centre for Space Transport and Propulsion CSTP, Epe, Lagos, one of the six activity centers of the National Space Research and Development Agency NASRDA, Abuja.

During the visit, he was shown around the facility by the Director General and the Chief Executive Officer, Dr. Halilu Ahmad Shaba, and the Director of CSTP. The facilities inspected include Propulsion & Engine Systems (PES), Structural Integration Systems (SIS), Electronics & Simulation Systems (ESS), and Manufacturing and Launch Services.

After the facility inspection, the Director of CSTP, Epe, highlights the activities, milestones, and challenges facing the centre as the director appeals for more funding both from the government and the private sector to enable them to build more facilities and advance research on space transport and propulsion.

In response, Chief Uche Nnaji, said President Bola Ahmed Tinubu is committed to the development of our dear nation and to creating an enabling environment for Nigerians to enjoy the dividends of democracy. "Nigeria is changing; with a president from the private sector, there is a serious commitment to creating a research and development fund," he assured the agency of his commitment to ensuring access to more funds. This R&D Fund is aimed at supporting agencies, institutes, experts, and individuals excelling in technology to advance their research. Funding is fundamental and a crucial element for research and



development. The CSTP is strategically situated along the Lagos Lagoon in Epe and near the Lagos State University (LASU) Epe Engineering campus. The Center is charged with the responsibility of conducting fundamental research and development R&D in space transport vehicles and propulsion systems.

Launch of Nigerian satellite not feasible in 2025, says NASRDA

Dr Halilu Shaba, the Director-General, National Space Research and Development Agency (NASRDA), says the agency's plan to launch a satellite from Nigeria in 2025 is no longer feasible. Media reports quote Dr. Shaba saying this at the NASRDA Day presentation at the 8th Science, Technology and Innovation (STI) Expo, with theme *STI: Solutions to National Economic Challenges* in Abuja.

The director-general focused his presentation on *New Space: Aligning with the Renewed Hope Agenda*. According to him, while launching of satellite is capital intensive, the agency is not financially ready, but it is developing the needed capacity.

"Presently, we don't have the window to send an astronaut to space, because it is very expensive. It is when we have the slot and make plans within the five years that we can launch an astronaut. We cannot advise the government to train an astronaut now when we don't have the slot, the

person may probably get older and not fit for space by the time we get a slot. For the launch of a satellite, you don't design a big satellite in one year, it takes up to two years. We have all the manpower, but the resources are not here yet, and I doubt if we can achieve that even in 2027," director-general said.

According to him, the agency already has the design of a desired satellite and with the improvement of budgetary allocations, it can build and launch a satellite from Nigeria in the near future. On the need to review the roadmap expected to have its benchmark in 2025, the director-general said the agency constantly updates it according to current realities, which include exchange rates.

Space technology was initiated in Nigeria for socio-economic development. According to the agency's 25-year roadmap, part of its targets was to launch a Nigerian astronaut in space and an indigenous satellite from Nigerian soil by 2025.

According to him, Nigeria still has an operational satellite, NigeriaSat-2 in the orbit and still providing imagery for the country, Africa and countries across the globe. The director-general said other achievements of the agency included developing rocketry programme in collaboration with the military, geo-visualisation of terrorists' activities in the North East and crime mapping. *"We recently estimated the population of the Abuja Municipal Area Council, using the NigeriaSat-2's High Resolution Satellite Imagery. This is because we have not had a census in over 10 years which is overdue. So, the estimation*

S-band: a new age in mobile communication services

Omnispace, the company redefining mobile connectivity for the 21st century, recently announced a collaboration with MTN, the largest mobile network operator in Africa. MTN provides voice, data, fintech, digital, enterprise, wholesale and API services to over 290 million customers in 19 countries. This partnership will explore the use of S-band for satellite services to expand MTN's portfolio of wireless service in their markets.

This initiative underscores Omnispace and MTN's joint commitment to developing cost-effective global connectivity solutions beyond existing cellular, land-based networks. The companies will explore the integration of MTN's terrestrial mobile networks with the Omnispace non-terrestrial (NTN) network, leveraging 3GPP standards, to serve consumer mobile and enterprise IoT services. Furthermore, the companies will also explore how they may collaborate on the development and growth of an ecosystem of devices and software.

"This collaborative effort would offer access to secure, cost-effective, ubiquitous 5G mobile connectivity by seamlessly integrating our respective satellite and terrestrial networks," said Ram Viswanathan, CEO of Omnispace. "Omnispace is pleased to work together with MTN to deliver this first-of-its-kind, 3GPP standards-based solution to add non-terrestrial network connectivity to a large ecosystem of compatible devices, products and applications."

In early 2009, the W2A satellite launched into orbit was the first commercial S-band payload serving Europe, ordered by Solaris Mobile, a joint venture between Eutelsat and SES ASTRA. The S-band arrival opened a whole new space for telecommunications in Europe, optimized for content delivery and two-way communications for small mobile terminals.

The W2A satellite reached its position in the geostationary arc in the first quarter of 2009, and became the first satellite offering S-band coverage over Europe. Its arrival was the consequence of a long process, both in the technology and business fields, which started much earlier. On the technology side, one of the key elements of W2A, and that enables its use for broadcast towards small terminals, is its large deployable antenna of 12 meters.

The S-band provided strong platform for a wide range of industrial sectors: manufacturers of

terminals and network infrastructure equipment, content editors, distributors, network operators and broadcasters. Several features render its arrival truly innovative, starting with its ability to enable terrestrial and satellite networks to operate together for the first time in Europe by using a common frequency band in hybrid networks.

The S-band frequencies enable the use of very small omni-directional antennas, also exploiting the advantages of diversity reception. Whether installed in mobile phones, PDAs or in the bodywork of cars or in rail or in-flight equipment, these antennas will be embedded and almost invisible. Another key feature is the substantial amount of bandwidth and its wide availability to end users. These significant assets provided by the S-Band offer the advantage of being able to support broadcasting services towards large audiences and as well ensuring two-way links for data exchange from mobile terminals to processing centres.

The S-band remains a powerful catalyst for opening consumer access to tens of Mobile TV and digital radio channels per country and associated data broadcasting services anytime and anywhere. While the flexibility and power of the S-band open up a wide range of applications for the general public, they also presents important development opportunities for business and automotive applications.

The technology can be used for issuing distress beacons in the event of an accident and delivering access to real-time information on road traffic delays or weather conditions. These services, interfaced with navigation devices which are increasingly present in every new vehicle will enable drivers to access in real-time local information providing invaluable add-ons.

As vehicles become increasingly intelligent, they will also become permanently connected via return channels that the S-band is able to provide. Cars will as well represent invaluable sources of information for institutional authorities as well as civil protection and surveillance services. For example, it will be possible to monitor traffic flows by collecting travel speeds, weather conditions or pollution indexes.

In extreme conditions when terrestrial networks have been destroyed or in isolated regions with no infrastructure, the S-band could also represent an attractive alternative for surveillance and rescue teams, enabling a standalone and fully secure communications network everywhere and in all weather conditions via small and virtually ubiquitous mobile terminals.

The S-band antennas are quite difficult to build and still now they are available only from a restricted set of manufacturers. First antennas of comparable size were used on commercial satellites by Thuraya (L-band), in the Korean MBSat satellite (S-band) and on Inmarsat IV satellites (L-band), all systems launched in the early years of this decade.

More recently the Japanese ETS-8 satellite has proposed a new concept of deployable antenna, paving the way to the extension in the use of large deployable reflectors even for frequencies beyond 3GHz. In April 2008 the first ICO (US) satellite using a similar technology has been launched while the Terrestar (US) satellite is expected to be launched by the end of 2008. In China, the CMMB project has taken some delay. Today we can affirm that the technology for large deployable antennas is mature enough and that by leveraging on this technology a new family of services will be deployed all over the world.

Today this market represents by far the core of Eutelsat and SES Astra businesses, with thousands of TV channels broadcasted worldwide and with hundreds of millions viewers every day. It is interesting to underline how the arrival of S-band satellites with large deployable antennas and the emergence of hybrid MSS services in Europe, US and Asia, are once again offering to the satellite service industry the opportunity of a new successful growth in the consumer market – this time at the crossroad of the broadcasting market, the mobile telecom market and the automotive market. Those markets together represent a potential of several hundred million customers worldwide.

"Through this collaboration, the mobile technology company said, "It aims to methodically extend the reach of our services, understanding the profound role connectivity plays in shaping societies and supporting growth. Our partnership with Omnispace is a strategic step towards ensuring consistent, reliable access to our network, contributing to the foundational infrastructure that supports a digitally inclusive future, enabling the benefits of a modern connected life for all," said



Mazen Mroué, MTN Group Chief Technology and Information Officer.

Two-way applications

The launch of new mobile services in S-band is an occasion to adjust or reinvent established business and role models. This is visible for broadcast services, where established but contrasting models exist, and is particularly true for two-way applications, where new models may find their route to the market.

The range of applications possible in S-band goes from a limited interactivity for broadcast services, to more sustained messaging services, to full two-way communications. The co-existence with broadcast applications, that make an asymmetric use of the bandwidth, makes probable a mixed use of the different service types. The presence of a single or

many business actors for the operation and provision of such services is still to be determined.

The operation of satellite systems in orbit is governed by international agreements between sovereign countries aimed at managing the interference between such satellite systems and, where applicable, terrestrial systems. The rules for managing such interference and resolving any conflicts are set at the level of the International Telecommunications Union (ITU), an institution of the United Nations. The ITU rules for coordination between satellite systems are generally based on the "first-come, first-served" principle. ITU level coordination for S-Band is indeed based on this principle.

According to ITU rules, the S-band can be used for

both mobile satellite services (MSS) and terrestrial mobile services. The rights of use of spectrum in a given country including the rights to communicate with a satellite system or with a terrestrial network are granted by the national regulatory authorities of those individual countries. Such authority may grant licenses to use spectrum, subject to a number of constraints (for instance related to the operation of the satellite system) and following its own national procedures.

"We look forward to providing MSS and IoT services in Brazil, which is at the forefront of the global stage for creating a harmonized S-band MSS ecosystem," said Ram Viswanathan, President and CEO for Omnispace LLC after announcing partnership between Omnispace and the , Brazil's National Telecommunications Agency ANATEL

AFRICA

Kenya lift-off locally made rockets in 2025



Jomo Kenyatta University of Agriculture and Technology JKUAT engineering students have hit new milestones in their bid to launch a rocket into space.

Recently, Kenya Space Agency Acting Director General Col Hillary Kipkosgey hosted Dr Shohei Aoki, JICA Expert Africa -ai- Japan Project based at Jomo Kenyatta University of Agriculture and Technology who are developing a launch rocket.

Dr Aoki informed the Director General that the project team has developed Nakuja-1 which uses solid propellant which was test launched and rose to 32 metres. The team is currently working on Nakuja-2, also using solid propellant, before embarking on the development of a rocket using liquid propellant. These rockets, according to plans will be developed locally using local available materials. KSA promised to work together with the

team to make this a reality.

During a courtesy visit to Kenya Space Agency Acting Director-General, Col Hillary Kipkosgey, Dr Shohei Aoki announced that the JICA Expert Africa -ai- Japan Project team are currently working on the Nakuja-2.

In May 2021, six Jomo Kenyatta University Of Agriculture And Technology Mechatronic students presented the Nakuja-1 rocket launch for their external industrial attachment. They had been working on the project since January 2021, developing a solid motor-fueled rocket model. The students, Ian Kibandi, Felix Gateru, Sammy Oina, Jeff Mboya, Rodney Osodo, and Mike Kimani, were under the guidance of Dr Shohei Aoki, Dr Bernard Owiti, and Mr Ben Maniafu.

Furthermore, according to Dr Aoki, the project

started in 2019 with the overall aim of launching the liquid rocket that can bring Nano-satellite into low earth orbit by 2024.

Dr Shohei Aoki leads the JICA Expert Africa -ai- Japan Project team developing the launch rockets. The Nakuja-1 uses solid propellant. During test-launch, it rose to 32 metres, similar to a 10-storey building. Additionally, the team is currently working on Nakuja-2, which also uses solid propellant. The Nakuja-2 rocket launch was scheduled for September 2021. The KSA has promised to work with the team to make this a reality. After completing this project, the team would begin working on developing a rocket using liquid propellant. These rockets will be developed locally, using locally available materials.

Nakuja project is a student based technological project, with the aim of building and taking a liquid fuel rocket to space. The project begun in June 2019, where it was divided into two; Control group (headed by Willy) and Mechanical group (headed by Dr. Shohei Aoki). Also, Dr. Shohei Aoki is the project leader and coordinator.

At the beginning of the year 2020, Dr. Shohei Aoki went to the Portland State University to benchmark on what they are doing in the field of rocketry and upon coming back, the whole team was restructured into four teams; Propulsion, Avionics, Telemetry and Airframe.

The Airframe team is tasked with making the body of the rocket and designing its aerodynamic structures. Avionics deals with the flight controller, Telemetry deals with the communication between the rocket and

the ground station while Propulsion focuses on the rocket engine. Avionics is headed by Willy Stephen Tounsi from PAUSTI, Telemetry by Smith Jilks from JKUAT, Propulsion by Washington Kamadi from JKUAT and Airframe by Destine from PAUSTI.

The project started to host the internship in January 2021. There were six interns in 2021, 23 interns in 2022, and 41 interns in 2023. The interns are split into four groups including the Airframe, Recovery, Solid Propulsion, and Liquid Propulsion and work to achieve the specific objectives. There have also been many JKUAT students working on our rocket's research and development as their final year project. More than 100 students have already been involved in the project since the beginning.

Student Exchange Program: Tokyo City University and JKUAT

On February 23rd, the Africa-ai-Japan Project and the College of Engineering and Technology welcomed exchange students and staff from Tokyo City University to Jomo Kenyatta University of Agriculture and Technology (JKUAT).

The team, consisting of eight students and one staff member, visited JKUAT to engage in knowledge exchanges primarily focused on Material Engineering.

The overarching goal was to identify areas of collaboration while providing an opportunity for both staff and students to experience academic and research environments beyond their home country. Additionally, the visit aimed to facilitate the integration of foreign faculty members to teach at the university, both virtually and in person.

Prof. Ai Momozawa, the head of the delegation and an expert in Medical Engineering from Tokyo City University, expressed satisfaction with the collaboration, highlighting Tokyo City University's commitment to working with JKUAT to enhance capacity building and foster achievements.

According to report released by KSA, the joint efforts with the Nakuja project team from Jomo Kenyatta University of Agriculture and Technology (JKUAT) and Japan International Cooperation Agency (JICA) have led to the third launch of the N-3 rockets, named Kabura, Kifaru, Simba, and Tembo. The feat underscored the strides the project team took and emphasised the dedication to advancing rocket technology in the region, aligning with the long-term objectives of the initiative.

Furthermore, the initiative focuses on scientific breakthroughs and serves as a source of inspiration for future aerospace professionals. The initiative aims to cultivate a new wave of talent in space exploration by offering a platform for hands-on experience and applied theoretical understanding.

The Kenya Space Agency (KSA) joined forces with the Nakuja project team from JKUAT to jointly build rockets, aiming to deploy satellites into orbit in 2025 ultimately. Subsequently, the Nakuja team achieved a significant milestone by successfully creating two solid model rockets, N-1 and N-2. This accomplishment marked a crucial step in the collaborative efforts involving the university, the Japan International Cooperation Agency (JICA), and KSA.

Junn, Ruth and Jones in the Recovery Team explains what is going on their team right now. "In this generation of rockets, we want the rocket to land intact, with a parachute. That's what the Recovery Team is responsible for. Today, we're trying to resolve an error in our coding. The coding is needed to manipulate the rocket, so that it won't just crash into the ground."

Jones says although he can build on the coursework at his faculty, still a lot of reading, googling, and asking were done to bridge the gap between basic theories and application.

The team has learned from past Nakuja Project members as well. "It's not *rocket science*, but there's still lots of work," laughs Junn and Ruth. This is the second rocket launch at Nakuja for Junn. She came back to make improvements from the last launch.

At the Airframe Team, Anne, Francis, and Lawrence are working on optimizing the design of the rocket. Moving around a 3D model in the software, the team can determine the specifications of each rocket part, and how the parts all fit in. This week, Lawrence is running multiple simulations with different fin sizes to minimize the quivering of the rocket after launch.

Francis explains that one of the major challenges is accurate calculation. The team has done a lot of reading to ensure the right formulas are used in the designing process.

Anne has always had a passion for creation, and that's why she chose engineering as her major. Francis says he was always fascinated with aviation, but never thought there would come a time he would actually fabricate a rocket. Nakuja Project is a chance for them to use their creativity forwards concrete and tangible results.

Reporting on the innovations progress, the projects lead Dr Shohei Aoki of Africa-ai-Japan (pictured) said 'Nakuja' project has managed to develop and launch two rockets namely the N-1, which rose to an altitude of 32 meters, and the N-2 that was launched recently with a target altitude of 500 meters.

He added that further plans were underway to launch another rocket known as N-3, with the aim to achieve a much higher target altitude. "Jibebe project aims to deliver both a production ready electric tricycle and the first fully autonomous electric tractor with self-tilling capabilities," he said.

MIDDLE EAST

Can SatRevolution delivers Oman 2040?

In 2021, Wrocław's SatRevolution and the Polish company TUATARA have signed a strategic cooperation agreement with ETCO, a technology leader in Oman. The inhabitants of Wrocław will participate in the development of solutions for the analysis of satellite images used in the national digitization strategy "Oman 2040".

The two Polish companies SatRevolution and TATURA have been invited to strategic cooperation in the implementation of the Middle East space program, which is in line with the assumptions of the national strategy for digitization and the development of science "Oman 2040".

However, the most important element of the cooperation will be the CubeSat solution, i.e. a miniature artificial satellite. This technology creates new opportunities for industries such as agriculture, insurance, disaster management or infrastructure planning and management. The contract was signed during the International Astronautical Congress in Dubai.

As one of the few companies in the world, the NASA report "State of the Art Small Spacecraft Technology" lists SatRevolution as one of 12 companies in the world - it comprehensively designs, manufactures and places observational nanosatellites in orbits, collecting optical data.

In March 2024, SatRev commences a groundbreaking 4-day training program in collaboration with the Space Agency of Oman. Titled "Fundamentals of Nanosatellite Earth Observation Space Systems," this initiative represents the third phase of our ongoing contract, dedicated to enhancing knowledge and expertise in satellite technology, particularly focusing on the delivery of Satellite and Ground Station infrastructure in Oman.

Throughout the 4-day program, participants will engage in a combination of lectures, practical demonstrations, and interactive sessions facilitated by industry experts

and seasoned professionals from SatRev. By the end of the training, participants will have gained a comprehensive understanding of nanosatellite technology and its applications in Earth observation, positioning them as key contributors to the advancement of satellite technology in Oman.

SatRevolution is a Polish company that specializes in the design and production of nanosatellites. SatRevolution strives to meet the challenge of reducing costs while also promoting sustainability in space technology.

SatRevolution has recently joined forces with SteamJet Space Systems, to create an eco-friendly and cost-effective space technology that will expand current space mission capabilities.

"Commercial satellites are just a part of SatRevolution's business activity. In 2020 the company launched four satellites in total, including two for commercial customers (SteamSat and SW1FT) and two as a part of the research and development projects. During the first day of the training program, SatRev experts' covers delivers an introduction to Space Engineering sets the stage for the training program, providing participants with a comprehensive overview of space technology, its applications, and the significance of nanosatellites in Earth observation.

It also present CubeSat System diving deeper into the technical aspects of CubeSat technology, exploring its design, functionality, and integration into Earth observation missions. At the day 2 of the training course, the program covers space engineering fundamentals for LEO. It also delves into how space engineering fundamentals for Low Earth Orbit (LEO) equips participants with essential knowledge about the unique challenges and opportunities associated with satellite operations in LEO, including orbital dynamics and propulsion systems.

However, experts also cover mission planning and systems engineering delving into the intricacies of mission planning, emphasizing the importance of

systems engineering in ensuring the success of satellite missions.

The training experts deliver lectures on key topic such as Ground Segment Fundamentals focusing on the critical role of ground stations in satellite communication and data acquisition, covering topics such as antenna systems, signal processing, and data management.

During the fourth day of the programme, SatRev experts explained how launch and transfer segment provides insights into the launch and transfer phases of satellite missions, highlighting the key considerations and challenges involved in getting satellites into their designated orbits.

However, the mission operations concludes the training program by discussing the operational aspects of satellite missions, including command and control, telemetry, and data analysis.

Satrevolution and tuatara join forces to support oman's space program

On October 28, at the International Astronaut Congress in Dubai, SatRevolution and TUATARA signed a strategic cooperation agreement with ETCO – a technology leader in Oman. Space projects with SatRevolution are the next stage of Tuatara and ETCO's strategic partnership.

Continuing its idea of partnerships of the future, TUATARA and SatRevolution entered strategic cooperation, supporting the Middle East space program, as a part of the national strategy for digitization and the development of science "Oman 2040". **As a result, the first Oman satellite CubeSat was sent into space, kickstarting an innovative project that will strengthen the country's position on the map of the global space industry.**

Oman's cooperation with ETCO and SatRevolution was aimed to provide technology and solutions that will contribute to the development of the local space market and enable a qualitative analysis of changes caused by climatic situations, natural disasters or other adverse events. The project's value is estimated at several million dollars.

The key element of the cooperation will be the development of a miniature artificial nanosatellite CubeSat. This affordable technology helps create new opportunities

for various industries such as agriculture, insurance, disaster management or infrastructure planning and management.

We are proud of the given possibility to use our experience to support Oman's digital transformation. We want the technological achievements resulting from our work to be applied in various fields. Participation in this venture and the opportunity to cooperate with new players to create innovative solutions is another step in the process of democratization of the space market. **Grzegorz Zwoliński, CEO, SATREV**

Oman's first satellite will collect and process data that will support technological development and contribute to the country's economic growth. Satellite images can be used to monitor agriculture, renewable energy, oil fields, mining, weather forecasting, border monitoring and national security within Oman. The project will also help engineers, university researchers and the founders of new companies in acquiring knowledge and gaining experience, as well as a comparative advantage to accelerate the space

industry in the Sultanate.

Oman And SatRevolution International Consortium

As part of the historic deep space mission, the group plans to launch a satellite designed by SatRevolution aboard a Virgin Orbit rocket, sending it to deep space with the mission of conducting cutting-edge scientific research and capturing high-resolution imagery. All collected data and images, both from the Low Earth Orbit and deep space missions, will be further analyzed digitally using computer vision, machine learning, and AI solutions developed by TUATARA in strategic partnership with ETCO.

This mission will collect valuable data regarding the hidden patterns that underlie climate change, and the aftereffects of natural disasters. In addition, it could provide scientists with essential information needed to understand what occurs on the surface of Earth's neighbors.

The final mission parameters and scientific objectives will be determined in a study conducted by the parties to the

mission, and thereafter the parties expect to sign a definitive binding agreement to conduct the mission. The mission is the follow-on to the Memorandum of Understanding signed during International Astronautical Congress held in October 2021 in Dubai, which established the cooperation of the Parties to design, manufacture and launch the first Omani satellite, manufactured by SatRevolution and onboard Virgin Orbit's LauncherOne, on the first ever launch from the United Kingdom out of Spaceport Cornwall in 2022. The launch from Cornwall and subsequent missions to deep space will be enabled through Virgin Orbit's versatile air launched system. The Cornwall mission providing the first Oman Satellite in Space sets the foundation for allowing previously non-space faring nations the ability to launch satellites from their own soil, which is a key element of the Oman strategy for Space.

As an emerging space-faring nation with plans to launch small satellites into Low Earth Orbit and foster a local, sustainable space ecosystem and industrial base, the Sultanate of Oman further plans on expanding its ambitious space endeavors and engaging the Omani public and students through STEM activities.

Both missions are in line with the Royal Directives of His Majesty Sultan Qaboos bin Said and will directly correspond with the "Oman Vision 2040", being part of a broader educational outreach initiative with the goal of stimulating long-term growth in the sector. The activities specified in the Agreements are intended to generate and seize opportunities to foster economic competitiveness and social well-being, stimulate growth, and build confidence in economic, social, and developmental relations nationwide.

"Only a few nations have been bold enough to venture into deep space, but with Oman's strong vision supported by cutting edge launch and spacecraft technology another spacefaring nation is about to join those ranks," said Virgin Orbit's CEO Dan Hart. "We are proud to have been entrusted by the Sultanate of Oman as their exclusive launch partner in helping to fulfill the goals of bringing sustainable space solutions to Oman. Beginning with the launch of the first Omani satellites out of the first UK launch this year, the progression has been set for a myriad of space missions to expand technology, science and exploration."



REPORT

What are Space Ground Systems?



3-2-1 Liftoff! We are all familiar with rockets launching commercial, civil, and military satellites into space and placing them into orbit but, how does this occur and what happens after the much-awaited spacecraft separation?

Nearly all missions, whether commercial, military or scientific, use space ground systems for both launch and on-orbit operations. Space ground systems are the workhorse for all satellites and manned spacecraft missions. According to the Delft University of Technology, space ground systems contribute over 5% of the total cost (more than \$25M for one small satellite) of the entire space system.

Component of space ground systems

Space ground systems are made up of several primary components including Ground Stations, Mission Control Centers, Ground Networks, Remote Infrastructure, and Launch Facilities. These components work together to enable management of spacecraft, payload data, and telemetry. They may be located together in one area or expanded across the globe.

Ground stations

Ground stations act as the central nerve

center for the entire space system. Ground stations consist largely of an antenna that physically communicates data from orbiting spacecraft and processes it into actionable reports for satellite and human spaceflight operators.

For example, a spacecraft transmits its telemetry data, which can contain information about its current position or state, to ground stations. Ground stations also transmit data, such as command and control instructions, to the spacecraft to perform actions like orbit corrections or conjunction assessment maneuvers. Ground stations operate 24 hours a day, 7 days a week and may be monitored and

controlled remotely. A single ground station can support multiple spacecraft, repositioning to communicate with each one.

Mission control centers

Mission control centers often called MCCs manage satellite and manned spacecraft missions. Once a spacecraft clears the tower during the launch process, the MCC takes over operations from the launch control center LCC. MCCs are responsible for determining how to process data received from the spacecraft and what data is transmitted to the spacecraft.

MCCs command spacecraft that are on-orbit. After receiving telemetry data (or spacecraft state data) from ground stations, commands are formatted according to the spacecraft system, and are validated prior

to being transmitted to the satellite. Commands may be manually issued in real-time or automatically as a part of a list of procedures. Both commands and procedures are often developed and validated against flight dynamics simulators before being performed on the actual satellites.

For instance, a spacecraft reports the



momentum of its reaction control wheels in telemetry data that is received by the Ground Station and transmitted to the MCC. The flight dynamics team within the MCC analyses the change in momentum over time and determines that, if left unchecked, the momentum will grow to an unsafe level in the next few days.

A momentum unload maneuver is planned, indicating a specific thruster (or thruster set), time and number of pulses for the maneuver. The MCC uses the Ground Station to relay the maneuver plan to the spacecraft, and the spacecraft will execute the maneuver at the specific time. In the same way the MCC will then analyze the resulting momentum values to determine the effectiveness of the maneuver

Ground networks and remote infrastructure

Ground networks handle all communications and data transfers to and from the different components of the space ground system. They provide the bandwidth, reliability, and security needed for complex processes and computations on a day-to-day basis. These networks must remain operational 24/7 and have redundancy built in to maintain continuity of operations.

Remote infrastructures are hardware elements that are tied into the ground networks. These hardware elements can be end-user terminals that are separate from the MCCs. These can be accessed by any team on the mission either as a "receive-data-only" or can transfer data to the ground network.

For instance, the Hubble Space Telescope takes beautiful pictures of the depths of space. The image data the HST captures is received on the ground by the Ground

Station. It is then processed by the MCC and routed to other institutions, such as, the Space Telescope Science Institute STScI for further analysis.

Launch facilities

Launch facilities make up the entire infrastructure needed to erect a rocket, together with its spacecraft, for launch. Launch facilities are often referred to as a spaceport where the area provides for one or more launch pads.

Launch facilities include many components such as the launch platform and services structure that will support the vehicle with electrical, fluid, propellants, telemetry and communications. These services are connected to the launch vehicle through umbilicals that are accessible to launch and mission control centers, ground stations, and remote devices for controlling launch operations. Space ground systems make up a large part of enabling access to space. Each component of the system is vital for a spacecraft's continued mission success. As new technologies are developed for complex spacecraft missions, ground systems must be able to support these developments.

There is a greater need for updating existing space ground systems with new technology to remain cost effective for the entire mission. Space ground systems are currently the center focus for modernization; adding new capabilities to legacy systems and developing new ground systems that can handle future space missions.

by Shannon Terry

SPECIAL REPORT

Cloud, IP and 5G: Three themes shaping live sports production in 2024 according to LiveU



After disrupting the broadcasting industry decades ago, LiveU redefining the industry. LiveU offers an array of Broadcast, Production, and Online Solutions while also producing some of the most effective products for comprehensive live video coverage of and broadcast to virtually anywhere on the globe. With over 5,000 customers in 150 countries and world-class customer support, LiveU's technology is the solution of choice for global broadcasters, sports, production houses, public safety and other organizations.

Live streaming is now becoming increasingly popular. The advent of fast internet is now

enabling anyone with a stable, and moderately fast connection to create live broadcasts to a worldwide audience. Their field units allow for ultra-portable and quick transmission of video in high definition using WiFi, cellular, or satellite services even including a feature where connectivity can be automatically and dynamically routed between cellular or satellite services depending on cost efficiency, ensuring high quality transmission from remote areas of the globe.

The field of live sports production and broadcasting is entering a pivotal phase, confronted by challenges arising from

changing viewer preferences, continued economic uncertainty and evolving societal expectations. This is further complicated (and enriched) by the continued advancement of cloud-based workflows and IP video transmission technologies, and the widespread implementation of 5G.

In a landscape dominated by the likes of TikTok, YouTube and Instagram, sports rights owners and broadcasters are in a race to capture and retain younger viewers who favour short-form, instantly accessible content. This shift in consumption patterns has triggered a demand for bite-sized highlights, social media-friendly graphics and an emphasis on immediacy. Driven by the goal of

engaging younger audiences, Paris Saint Germain (PSG), Free Ligue 1 and the FIA World Rally Championship (WRC) stand as examples of rights owners that are demonstrating innovative approaches to this challenge, while managing costs. PSG's Qatar tour involves broadcasting its match against the Riyadh XI team and pre-match content to a global fan base in multiple languages and across various platforms. To ensure top quality and a seamless viewing experience, it has evolved to transmit live feeds (one main and one backup for each language) to a cloud-native live video production solution using multiple IP bonding field units and all at a fraction of the cost of using a

traditional on-premise workflow.

Free Ligue 1, the top soccer league in France, leverages a flexible and cost-efficient IP video transmission and cloud production workflow to deliver a rich array of content to fans via their app, including match highlights, pitch-side interviews and more. Monetisation has been increased with fans looking for additional football content signing up for Free Ligue 1's Premium Account.

WRC Promoter, the company that's responsible for all commercial aspects of the WRC, has recognised the need for continuous innovation to engage existing viewers across different platforms and attract new and younger audiences. It is using IP video workflows in conjunction with its traditional radio frequency RF and satellite workflows, allowing it to significantly expand coverage.

Balancing cost efficiency and quality

Cost efficiency exercises inevitably come with concerns about compromises in quality. This need not be the case with live sports production and the sector is already reaping the benefits of embracing cloud and IP video transmission technologies, as well as 5G. For example, the European League of Football ELF, a professional American football league based in Europe, leverages affordable IP video solutions for full cloud production, streaming up to six live games per game day on its digital platform.

Premium sports rights owners are not immune to budgetary pressure. Those that have not already done so will increasingly be forced to explore the potential of new technologies and reduce their dependence on traditional methods.

Sky Deutschland's 2023 Special Olympics World Games coverage highlighted the efficiency and ease of use of 5G, together with IP bonding, as a mode of live video transmission. Sky Deutschland worked with both the Local Organising Committee and a 5G service provider to create a private 5G network and deliver a successful proof of concept (POC) that perfectly highlighted the future of contribution and production.

Live news production, known for its demands, is an important source of innovation for the live sports production and broadcast sector and there are fewer news events that attract more interest than the coronation of a British monarch. The coronation of HM King Charles III marked the first time that a network slice was created on a public 5G standalone (SA) network in the UK by Vodafone. Live IP video feeds were transmitted over the network slice helping ensure dedicated bandwidth and the delivery of low latency and high video quality with the rest of the bandwidth remaining

available for public use.

Coverage of the coronation benefited from the world's largest single-use private 5GSA network. The private network enabled broadcasters to reliably deliver live wireless contribution pieces and the scalability of the network architecture meant that portable encoders could easily and swiftly be added in different locations.

Meeting ESG standards

The emphasis on environmental, social and governance ESG standards in the sports industry is a welcome development. In the past, ESG compliance may have been perceived as a mere tick-box exercise, but the landscape is changing.

At the 2022 International Ski Mountaineering Federation World Cup Finals in France, Eurovision Sport delivered a POC to test innovative contribution, production and distribution solutions through the cloud. The POC demonstrated that even in remote locations with unstable local internet networks, reliable IP distribution is achievable. Eurovision Sport can now deliver production solutions in the world's most beautiful and fragile alpine landscapes, in an environmentally sustainable way. While the environmental aspects of ESG frameworks often tend to capture the headlines, sports industry players committed to creating a diverse and inclusive workplace, supporting social initiatives and upholding high standards of corporate governance are set to gain an edge in 2024.

The outlook for 2024 and beyond

As the live sports production and broadcast sector navigates the challenges of engaging younger audiences, optimising budgets and meeting ESG standards, three key questions will shape its strategies in the coming years: Firstly, adapting younger audience preferences and control costs, while aligning content production and distribution with the preferences of younger generations, and leverage the latest technologies for convenience and immediacy and cost efficiency. Secondly, leveraging innovation for greater cost efficiency, which include innovation with cloud-based production, IP transmission technologies and 5G networks for more efficient content creation and distribution, and reduce reliance on traditional broadcasting methods.

And lastly, meeting the rising ESG standards will depend on strong focus on environmental sustainability, social inclusion and corporate governance, and contribute to a positive industry image through reduced carbon footprints, diverse workplaces and support for community initiatives. By proactively addressing these themes, sports rights owners and their broadcast and production partners can ensure the longevity and success of live sports production and broadcasting in 2024 and beyond.

Last year, the space sector restarted an arms race for technology dominance in mobile phones.

Dr Maureen Haverty, Vice President, Seraphim Space



A convergence of new technology, regulatory changes, global partnerships, and new standards means that standard mobile phones will be able to communicate with satellites, improving satellite connectivity everywhere..

Keen hikers have used satellite-to-cell technology for well over a decade: Globalstar's Spot emergency beacon, for example, can be used to call in a rescue from anywhere. But the high cost of satellite connectivity data and phones means that satellite-to-cell has, until now, remained a niche market.

In recent years, however, several innovative startups, including AST Mobile and Lynk, have been working to revolutionise the satellite-to-cell industry. Their ambitious goal is to deliver broadband to mobile phones. This will take quite

some time to deliver. Meanwhile, large swathes of relatively well-connected countries, such as the UK, still lack basic messaging coverage. But that seems likely to change very rapidly in 2023.

How has mobile technology evolved over the years?

The foundation for the development of universal messaging via satellite connectivity was laid with the ratification of the Third Generation Partnership Project – known as 3GPP Release 17' in March 2022. This seemingly mundane document forms the backbone of most mobile phone operations. 3GPP standards were introduced to enhance interoperability when 3G was first launched, allowing mobile phones to

operate across various networks.

As technology has evolved (we are now on 5G!), the name has remained the same. Stakeholders ranging from chip and phone manufacturers to mobile network operators have collaborated on each release of these standards to implement new technology.

The latest focus has been on allowing satellites to integrate into terrestrial networks, essentially functioning as cell towers in space. Mobile phone chips are built to this standard. This means that the next generation of smartphones released in 2023 and 2024 will be able to message anywhere across the globe, no matter the terrain, thanks to the use of satellites.

The race to develop satellite connectivity technology

Therefore, over the last year, the race has been on to see who would leverage satellite connectivity technology the fastest. As is often the case, Elon Musk jumped first. His company, SpaceX acquired satellite IoT provider Swarm in 2021 to help build its capabilities. Then in August 2022, SpaceX announced their partnership with T-Mobile, promising an end to coverage blackspots for T-Mobile customers using Starlink's Gen 2 satellites. Messaging would come first, with higher data rates allowing voice and more coming later. SpaceX is also rolling this out internationally, with messaging promised on the Swiss network Salt by 2024..

In March of this year, SpaceX took the next steps towards deployment. The US Federal

Communications Commission FCC announced that mobile phones operators, such as T-Mobile, could allow satellite operators, like SpaceX, to use their spectrum. Spectrum is the means by which satellites talk to devices on Earth and represents the key enabler for the satellite industry. Radiofrequency spectrum is the range of electromagnetic waves used to transmit data, and the amount of data that can be transmitted is directly related to the amount of spectrum you can use. Simply put, if a satellite connectivity operator does not have a spectrum allocation, it cannot communicate with Earth or any devices on it. Spectrum is limited, and, in the case of the mobile services spectrum used to talk to mobile devices, most of the spectrum was often allocated in the 1990s.

Therefore, it would be extremely difficult, if not impossible, to be allocated a meaningful amount of spectrum now. In addition to spectrum, satellite operators also need landing rights, i.e. permissions from each country to allow service and connection in that country. That is why Starlink, for example, is not available yet in every country. Partnering with someone that has both spectrum and landing rights, as SpaceX did with T-Mobile, could be the fastest route to deployment.

Apple also took the partnering route, this time working with a satellite connectivity operator that has spectrum and international landing rights. Apple announced their partnership with GlobeStar in September 2022. Arguably, they are ahead of SpaceX after quickly deploying iPhone emergency beacon capability in November. This is the first time such a feature has been available via satellite without a specialised device, like Globalstar's Spot. Messaging will come next as Globalstar launches more satellites.

Rapid rollouts highlight the potential of the satellite technology industry

The rapid rollouts are the result of years of work and prescient predictions about the potential of the sector. For example, Globalstar filed to launch 3,000 satellite constellations in December 2020. Clearly, the race is on, with announcements of satellite-to-cell capability already coming thick and fast in 2023.

First, in January, we had Qualcomm, promising that its new Snapdragon Satellite chips would connect with Iridium, one of the original LEO constellations. News of these chips being used in Chinese phones such as Honor, Oppo, and Xiaomi came in February. Mediatek, another chip manufacturer, announced its partnership with Skylo in the same month. Skylo allows its customers to connect to existing GEO satellites using the 3GPP standards, again leveraging their spectrum, landing rights, and existing satellites.

These developments, which are becoming more

and more rapid, are incredibly exciting for consumers and investors alike. It's clear with all these developments that phone manufacturers, chip manufacturers and telcos that don't offer satellite connectivity are going to be increasingly left out. Phone manufacturers are terrified of being the next Nokia, *the* classic example of what happens when your competitors start to pull ahead.

Apple, T-Mobile, and Qualcomm are mobile phone industry players that have thrown down the gauntlet. What will the likes of Android, Samsung, and Telefonica do to respond? There are two schools of thought. Industry experts suggest that matching performance won't be enough: they will have to leapfrog Apple's emergency beacon. But incremental improvements sooner have their benefits they prevent your device from appearing totally obsolete. Ultimately, I believe we'll see at least one company announce messaging rollout in 2023 or early 2024 as the first phones with 3GPP Release 17 chips roll out.

The flurry of announcements we saw this year is the culmination of years of work from Apple and SpaceX. Is there any hope for companies that have not been making similar investments? Yes, and this is where the opportunities for investors start to emerge.

How can companies adapt to these growing changes?

To respond quickly, companies don't have time to deploy their own constellations – for most, that would take two to three years at least, even if they had the spectrum. Technology that leverages existing satellite connectivity technology will be increasingly attractive, and startups like Skylo and ESat Global are working to do just that. Phone manufacturers and network operators are likely to find willing partners too. Heritage GEO operators, like Intelsat, Viasat, and SES, have seen their business models squeezed by SpaceX and OneWeb.

Providing connectivity to mobile phones is a whole new market with a different way of doing business. It will be interesting to see who innovates in this space.

Ultimately, the last few months have presented a masterclass in the competitive arms race for new satellite connectivity technologies. Everyone outside the industry ignores the announcement of a new technology or standard.

A competitor pre-empts another's announcement. Suddenly, in the space of a few short months, the pressure is clearly on for every single player in the market to innovate or fall by the wayside. Some of these companies could ultimately be fighting for their survival in this market, and the innovation that drives their survival will be exciting to watch.

SPECIAL REPORT

Why startups are investing millions to make drugs and semiconductors in space



In-space manufacturing may sound like science fiction but it's happening already, albeit on a very small scale. It's a fledgling market that analysts and several startups are projecting will take off.

"If you look at pharma, semiconductors, beauty and health products and potentially food in the sense of like new crops, we estimated the market to be above \$10 billion at some point in 2030, depending on the speed of maturation," said Ilan Rozenkopf, a partner at McKinsey.

Space offers a unique environment for research and development because its higher levels of radiation, microgravity and near vacuumless state allows companies to

come up with new manufacturing methods or materials that are not possible on Earth.

The practice is not entirely new. The International Space Station has hosted several experiments from academics, government agencies and commercial customers for things such as growing human tissue, making purer semiconductors and developing new or better drugs. In the 2024 fiscal-year budget, President Joe Biden even set aside \$5 million for NASA to pursue cancer-related research on the ISS.

But access to the ISS has always been competitive and interest continues to grow. Now, several space startups see an opportunity to satisfy in-space manufacturing

demand using compact space factories. One company is Varda Space Industries in Southern California. Varda's mission is to help pharmaceutical companies improve their drugs or come up with new drug therapies by taking advantage of the unique properties of space, and then return those materials back to Earth.

Key to Varda's business proposition is a phenomenon known as protein crystallization. This occurs when super-saturated protein solutions are essentially evaporated to form a solid so scientists can study a protein's structure. Understanding the crystal structure of a protein can help scientists get a better idea of disease mechanisms, identify drug targets and optimize drug design.

Think drugs that have less side effects, are more effective or can withstand a greater array of

conditions such as not needing to be refrigerated. Years of research have shown that protein crystals grown in space are much higher quality than those grown on Earth. The plan is not to make the entire drug in outer space, just what is known as the primary active pharmaceutical ingredient, or the portion responsible for the therapeutic effects of a drug.

"You're not going to see us making penicillin or ibuprofen or these types of very generic mass consumption targets, given the amount of crystalline you need to create is far beyond our current capabilities," said Delian Asparouhov, co-founder and president of Varda Space Industries. "But there is a wide set of drugs that do billions and billions of dollars a year of revenue that actively fit within the manufacturing size that we can do even

on our current manufacturing facility."

Asparouhov said that in the U.S. in 2021 and 2022, of the hundreds and millions of doses of the Pfizer Covid vaccine administered, "the actual total amount of consumable primary pharmaceutical ingredient of the actual crystalline mRNA, it effectively was less than two milk gallon jugs."

Across the Atlantic in Cardiff, Wales, Space Forge is working on designing its own in-space factory to manufacture next-generation semiconductors. Space Forge's goal is to make semiconductor substrates using materials other than silicon to manufacture more efficient, higher performing chips.

"This next generation of materials is going to allow us to create an efficiency that we've never seen before," said Andrew Parlock, managing director of Space Forge's U.S. operations. "We're talking about 10 to 100 X improvement in semiconductor performance."

Just like with pharmaceuticals, the secret sauce to achieving this type of performance improvement in semiconductors lies in creating the perfect crystals in space. These types of advanced chips are important for industries such as 5G and electric vehicles. Similar to Varda, Space Forge plans to manufacture only part of the chips in space.

"Once we've created these crystals in space, we can bring them back down to the ground and we can effectively replicate that growth on Earth," said Josh Western, CEO and co-founder of Space Forge. "So we don't need to go to space countless times to build up pretty good scale operating with our FAB partners and customers on the ground."

Space race

In 1957, the Soviet Union launched Sputnik, the first artificial satellite to orbit the earth. The Soviets struck again four years later, sending the first human, cosmonaut Yuri Gagarin, into space, where he orbited for 108 minutes on April 12, 1961 aboard the Vostok 1. Gagarin joined a small but growing number of satellites in low earth orbit (LEO), those little green dots.

The Soviets' space supremacy spurred their Cold War rivals into action. In 1962, President John F. Kennedy "chose to go to the moon in this decade" and in under seven years, NASA fulfilled his promise when Neil Armstrong took "one small step for man, one giant leap for mankind."

The Americans had won the Space Race, but the Soviets continued on. In 1971, they launched the first space station, the Salyut 1, into orbit, marking the first time that humans could live and work in space for extended periods. They joined a growing number of LEO satellites (the green dots) and newer satellites further out in geostationary orbit (GEO, the purple dots) in their journeys around the earth.

NASA's funding plummeted after the Space Race wrapped up, but it didn't completely stop innovating. In 1981, the US launched the Space Shuttle, the first partially reusable spacecraft. The rocket itself couldn't be reused, but the Orbiter, the plane-looking thing strapped to it, carried astronauts back down to earth in relative comfort compared to splash-landing in capsules.

The Space Shuttle would come in handy when, in 1998, construction began on the International Space Station, a cooperative effort between the US, Russia, Japan, Europe, and Canada. Humans have continuously inhabited the ISS since its completion in 2000, where they've conducted scientific research in microgravity spanning biology, physics, astronomy, and meteorology.

While commercial enterprises launched communications satellites, space remained largely the domain of the governments who monopolized launch capabilities until 2003, when Elon Musk founded SpaceX with the goal of building reusable rockets in an effort to dramatically lower the cost of getting things and people into orbit and beyond. In 2015, SpaceX successfully landed its Falcon 9 rocket for the first time, effectively firing the starting gun on the commercialization of space.

Just seven years after the first successful landing, the number of objects launched into space annually has increased 10x, from 222 in 2015 to 2,163 in 2022. The ramp has been particularly steep since 2018, when SpaceX launched the Falcon Heavy, bringing launch costs down from 10x from the turn of the millennia, to \$1,500/kg. On April 20 of this year, SpaceX launched its first orbital test flight of the tallest and most powerful rocket ever flown: Starship. While the rocket exploded, getting that behemoth off the ground was another giant leap towards a future in which launch costs on Starship reach less than \$100/kg.

The existence of SpaceX and the dramatically cheaper and more frequent launches it offers makes space businesses not only possible, but economically viable.

Satellites were the first step. Thousands of satellites, used primarily for earth observation and communication, dot the skies. SpaceX's Starlink satellites make up a huge chunk of the objects in space, and their number is set to grow dramatically with Starship. In the coming years, cheap satellite internet will blanket the earth.

SpaceX is one of only two private companies to successfully re-enter from orbit, and when they re-enter, they do it in the Dragon capsule on which Will led hardware engineering. In March, four SpaceX astronauts splashed down in the Gulf of Mexico inside of a Dragon capsule.

MIDDLE EAST

Saudi Arabia's tallest building Rising to the cloud with confidence



"On a clear day, you can see forever," the old song says. From the windows of Saudi Arabia's Jeddah Tower, eventually more than 1000 meters 3,281 feet above the port city for which it is named, the old song will no longer be poetic hyperbole. The spectacular views are easy to imagine. However, suppose the tune changes to "Stormy Weather." It is much less romantic to picture a windstorm roaring outside your window when you are standing on the 167th floor.

In this situation, what will matter to occupants is the structure's capacity relative to the demands such weather imposes. The task of characterizing windstorms for the structural engineering design of the Jeddah Tower was in the hands of the wind engineers of Rowan Williams Davies & Irwin Inc. The challenge the firm faced was that nobody had actually studied, in detail, what a windstorm does at such extreme heights above the earth's surface. At over 1,000 meters (3,280 feet) and a total built area of 530,000 square meters (5.7 million square feet), **Jeddah Tower**, formerly known as Kingdom Tower will be the centerpiece and first construction phase of the \$20

billion Kingdom City development in Jeddah, Saudi Arabia, near the Red Sea.

Expected to cost \$1.2 billion to construct, Jeddah Tower, which is now under construction, will be a mixed-use building featuring a luxury hotel, office space, serviced apartments, luxury condominiums and the world's highest observatory. Jeddah Tower's height will be at least 173 meters (568 feet) taller than Burj Khalifa, which was designed by Adrian Smith while at Skidmore, Owings & Merrill.

AS+GG's design for Jeddah Tower is both highly technological and distinctly organic. With its slender, subtly asymmetrical massing, the tower evokes a bundle of leaves shooting up from the ground—a burst of new life that heralds more growth all around it. This symbolizes the tower as a catalyst for increased development around it.

The sleek, streamlined form of the tower can be interpreted as a reference to the folded fronds of young desert plant growth. The way the fronds sprout

upward from the ground as a single form, then start separating from each other at the top, is an analogy of new growth fused with technology.

While the design is contextual to Saudi Arabia, it also represents an evolution and a refinement of an architectural continuum of skyscraper design. The three-petal footprint is ideal for residential units, and the tapering wings produce an aerodynamic shape that helps reduce structural loading due to wind vortex shedding. Jeddah Tower's design embraces its architectural pedigree, taking full advantage of the proven design strategies and technological strategies of its lineage, refining, and advancing them to achieve new heights.

The result is an elegant, cost-efficient, and highly constructible design that is at once grounded in built tradition and aggressively forward-looking, taking advantage of new and innovative thinking about technology, building materials, life-cycle

considerations, and energy conservation. For example, the project will feature a high-performance exterior wall system that will minimize energy consumption by reducing thermal loads. In addition, each of Jeddah Tower's three sides features a series of notches that create pockets of shadow that shield areas of the building from the sun and provide outdoor terraces with stunning views of Jeddah and the Red Sea.

The great height of Jeddah Tower necessitates one of the world's most sophisticated elevator systems. The Jeddah Tower complex will contain 59 elevators, including 54 single-deck and five double-deck elevators, along with 12 escalators. Elevators serving the observatory will travel at a rate of 10 meters per second in both directions.

Another unique feature of the design is a sky terrace, roughly 30 meters (98 feet) in diameter, at level 157. The sky terrace will be open to the public and will be considered the world's highest observatory once opened.

Beyond Surface Models

The first step in any wind engineering analysis is to develop an engineering model of the wind characteristics at the building site. The typical approach adopted for most buildings is to start with design wind speeds—provided in building codes or generated from statistical models derived from historical wind measurements—and then extrapolate up to the height of the building by using simplified engineering models of the planetary boundary layer. This layer is the portion of the atmosphere closest to the earth's surface, where the wind speeds depend on the roughness of the surface terrain.

A consensus in the wind engineering consulting community is to rely on the standard engineering model of the planetary boundary layer developed by Deaves and Harris. Although a simplified model for very complex physical phenomena, it has proven effective for the design of many tall buildings. For a structure of such an extreme height as the Jeddah Tower, the wind loads and wind-induced motions depend primarily on wind conditions near its top. However, it was recognized that the project might push the limits of the Deaves and Harris model.

Most structures sit entirely within the planetary boundary layer, the layer of the earth's atmosphere closest to the ground that is most heavily affected by the properties of the underlying surface, such as terrain, urban surfaces, and interfaces between the land and water bodies. At its upper reaches, the tower enters a region above the boundary layer sometimes referred to as the free troposphere. This region is where the effects of larger masses of air called synoptic

systems determine the weather with very little influence from boundary layer features. These systems include features familiar from television weather maps, such as major storm fronts and low-pressure regions.

Ideally, wind engineers would develop and validate a new engineering model specific to this situation, but such an approach is not practical over the course of the design of a single project, even one so extreme as the Jeddah Tower. Instead, RWDI engineers had to find ways to determine the usefulness and limits of the standard model of the planetary boundary layer to ensure the safety and performance of the building. Their solution was to exploit additional data sources and advanced simulation techniques.

A First Approximation

Weather balloons reach heights comparable to the Jeddah Tower, and beyond. They, therefore, provide a source of wind speed data that could be used to augment historical surface measurements. About 17 years' worth of good-quality wind data were available from balloons released at the Jeddah International Airport. By interpolating measurements taken at various heights, data sets for the surface and 350, 600, and 1000 meters (1,148, 1,968 and 3,281 feet, respectively) were created. From these data, RWDI could develop a statistical model to predict the frequency of wind speeds at each of these four heights.

The difficulty with this approach is that balloon measurements tend to underrepresent extreme wind events. Typically, balloons are launched only twice a day. If high winds occur between balloon ascensions, the peak wind speeds associated with that event are non-existent in the collected data. Furthermore, balloons are rarely released in high winds, so entire events may also be missed. An example is shown in Figure 2, where a day-long high-wind event prevented a release, causing a 24-hour gap in the data. Also, further uncertainty to the analysis of balloon data is introduced due to the measurement duration of the wind speed. Rather than taking a long enough sample to determine the mean wind speed at each elevation as the balloon ascends, the wind speed is instead instantaneously measured and thus may reflect a localized gust. To get the hourly resolution needed to model the wind climate at the upper reaches of the Jeddah Tower with greater confidence, the firm, RWDI adopted a second strategy: mesoscale modeling.

A Bigger Picture for Finer Detail

To get the necessary wind climate detail, the constructing firm, RWDI turned to the

Weather Research and Forecast Model (WRF, pronounced "worf"), which draws on the expertise and data of many governmental and academic institutions. This state-of-the-art weather model simulates atmospheric circulation at the mesoscale, that is, on scales ranging from hundreds of meters (feet) to thousands of kilometers (miles).

However, WRF could not pull historical data out of thin air. Thus, initial and boundary conditions for RWDI's WRF model were set by using the Global Forecast System (GFS) reanalysis data, developed by the U.S. National Ocean and Atmospheric Administration (NOAA). This dataset is based on "reanalyzed" historical archives from a worldwide meteorological observation network. In the reanalysis, a mesoscale model is run in "hind-cast" mode on the archival data to retroactively simulate the weather, thus generating a fully detailed meteorological dataset (with a resolution of 1.0 degree everywhere on the planet) calibrated against measured values.

RWDI ran their WRF model in a "nested" approach, using three iterations on progressively finer grids (36, 12, and 4 km; 22, 7.5, 2.5 miles) centered on Jeddah. The model was also configured with a total of 35 vertical levels from the ground surface to 100 millibars (about 16,000 meters or nearly 10 miles above sea level). The vertical resolution was higher within the region of most interest, with 20 layers representing the region from ground level up to about 2000 meters (2,187 yards). This numerical strategy of nesting and vertical discretization offered a balance between computing requirements and detailed output specific to the project location.

The WRF simulations generated 87,000 records for each grid cell, giving hourly resolution for the period 2001 to 2010, inclusive. For each record, a vertical profile of wind speed and direction was extracted at the Jeddah Tower site and used in the subsequent analysis.

The wind engineers extracted records of strong windstorms from both WRF model and airport data, and plotted the time series for comparison. As an illustration, a strong wind event from the prevailing wind direction (north-south) is given in Figure 4. While there are some differences, the correlation between the WRF and, in general, surface data is very good. Wind events from east-west directions did show some differences between the datasets in wind speed and temporal shifts. These differences can be attributed to differences in site exposure, as mentioned earlier.

Additional report by Jon Galsworthy, PhD

FEATURE

Connecting shipping for a more sustainable future



The International Maritime Organisation's (IMO) 40% emission reduction target by 2030 has put sustainability firmly at the forefront of the shipping industry's minds. Actionable change must be taken and taken seriously, and it's no surprise that the theme for this year's World Maritime Day echoes that: 'New technologies for greener shipping'.

There is a wide range of technologies and innovations being deployed and developed to reduce the environmental impact of the maritime sector which are all underpinned by connectivity and communications. The ability to communicate ship to shore and back again from shore to ship empowers efficiency and ensures impeccable safety worldwide, which all play a role in maintaining ESG (Environmental, Social, and

Governance) targets and goals.

Sustainability now means more than emissions targets and carbon neutrality, sustainability has adapted to encompass the three Ps: planet, people, and profit. This signifies a more holistic way of looking at sustainability in all industries, including shipping by considering overall impact. Innovation around sustainability often positively impacts more than one element and leads to better practices in the long term.

Planet

The maritime industry is now under increased pressure to hit sustainability targets, not only for themselves but also for their partners. This is because organisations are now measuring sustainability across the entire supply chain, including shipping. This means that shipping

companies must now be accountable and consistently hit targets in order to stay ahead of competitors.

In addition to this, the maritime industry is looking to adhere to the Poseidon principles which have been set by financial institutions to promote sustainability. This framework is in line with the IMO's targets and can impact funding or insurance for shipping vessels.

As ships have a working lifespan of around 20 years, designs are already being drawn up with the IMO's 20250 target in mind. This target is to cut emissions by 70% and will rely on technologies which have not yet been developed such as alternative fuel. In the meantime, shipping companies are looking

to reduce emissions in their current fleet. To reduce environmental impact, shipping companies are now using Internet of Things (IoT) technology to measure the operations of a vessel. This data is then transmitted to the shore where it is analysed, driving the decision-making process in future voyages. This data transmission between the shore and ship is only made possible by the latest satellite communication technologies. Digital analysis is also used for fuel optimisation which can vastly reduce emissions from ships.

Innovators in the industry are now looking to create products that are future-proof and have longevity in order to reduce waste and emissions in the production process. Intellian's latest NX series fulfils this demand for durable and useful



tech. These antennas can be converted to track LEO, MEO and GEO so can be used in different contexts without the need to replace the device for various uses.

People

During the pandemic, 400,000 seafarers were reported to be stuck at sea due to lockdown restrictions. This created a major human rights issue as crews are often expected to work extremely long hours, even working seven days a week. This issue has shone a light on crew welfare issues and put people at the forefront of the discussion around sustainability, particularly crews spending months at sea.

Connectivity is a major factor in the drive to promote welfare on vessels. To reduce mental strain on crews, staying in touch with friends and family at home is extremely important. With advancements in satellite technology, crew members can now communicate with their family more easily, even in the remotest locations. This reduces mental health problems and boosts morale onboard. In a similar way, satellite televisions now provide seafarers with a better choice of entertainment which helps to make their days more balanced and enjoyable. In a digitally connected society, the next generation will expect a high level of connectivity no matter where they are on the globe. As connectivity is so important in modern life, the maritime industry must adapt to keep attracting talent into the industry and improve the conditions of crews already at sea.

Health and safety on board can also be supported through new developments in satellite communications. This is essential in flagging potential hazards and crisis situations in order to signal for assistance. Satcoms can also be used to monitor extreme weather conditions and reroute as needed to avoid danger. There are even methods for remote assistance such as telemedicine which can be used to outsource expertise from individuals onshore to crew

needing support.

Profit

Although sustainability is often considered in altruistic terms, profit margins are essential to keep businesses afloat. Even in times of economic downturns, sustainability must continue to be prioritised. This is because the market now sees sustainable practices as equally important to other factors such as cost. To stay ahead, shipping companies must implement a watertight sustainability policy which utilises all tech nology available to have the best outcome.

Profit is also intrinsically linked to people. 90% of the world's traded goods travels by sea, and in order to keep the shipping industry profitable, skilled crews are necessary to maintain routes. IoT technology on board can also give shipping companies a clearer idea of how to spend effectively to promote crew welfare based on how onboard technology is used. Fuel optimisation, as well as reducing emissions, can also lead to reduced cost for shipping companies. Digital decarbonisation can also lower cost in energy as the vessel is working more efficiently and waste is being reduced.

Satellites connect ships to the shore in order to guarantee the best possible use of a vessel, route and fuel available. By monitoring all aspects of a vessel's activity and analysing it onshore, companies can achieve the best results financially and in terms of emissions. Without satellite technology, this level of communication would not be possible.

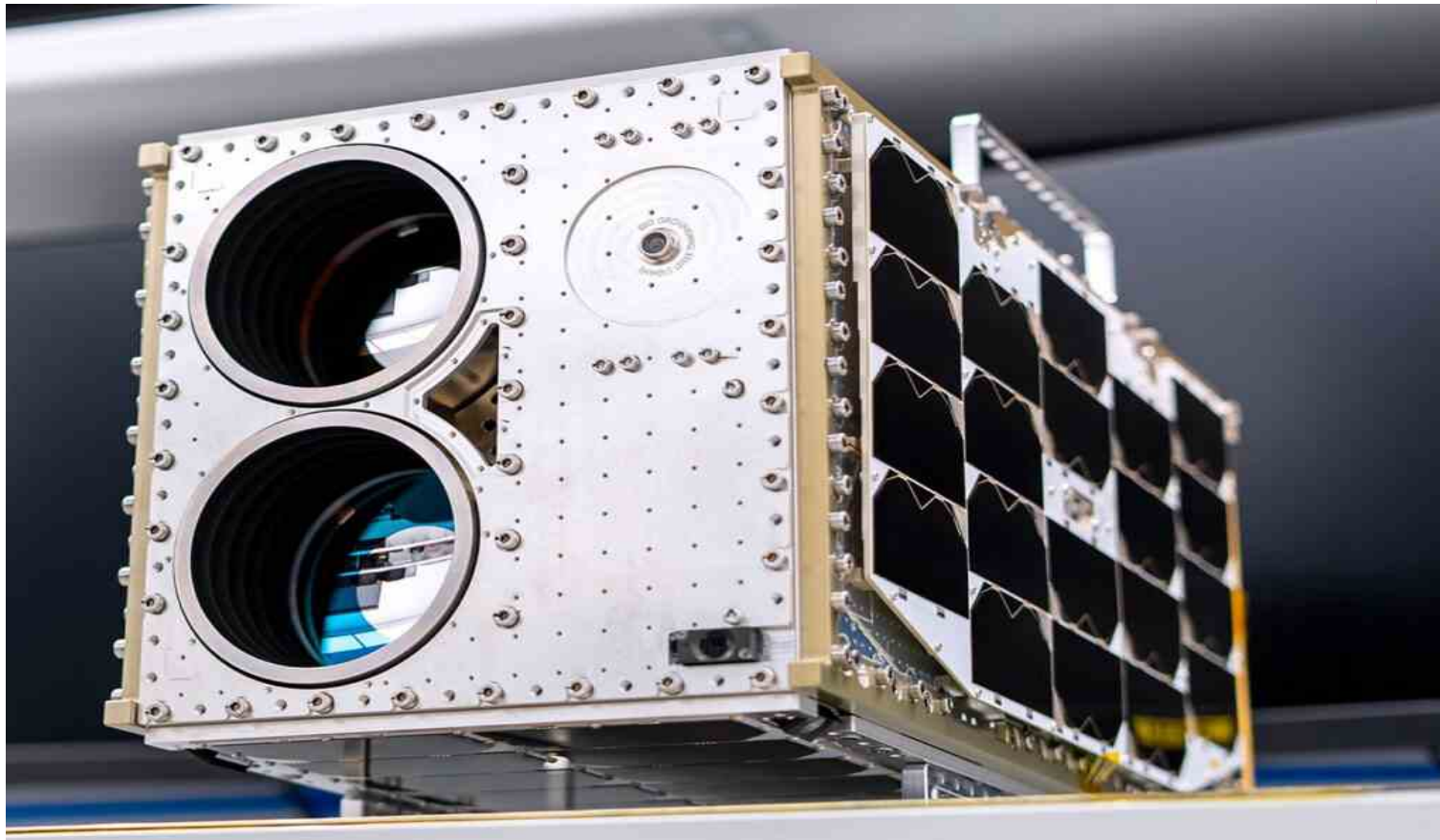
Looking forward

As the industry looks to a greener future, technology empowers shipping to be better in many respects, reducing its carbon footprint and allowing for better conditions onboard. ESG and sustainable practices rely on more than just reduced carbon and must consider the industry as a whole. Connectivity and satellite communications is at the heart of this change and will continue to be central going forward.

By Dana Jongsens

INTERNATIONAL

Across the world, space race continues...



The satellite industry is currently in the midst of a formative era comparable to the 1950's Space Race. Driven by the ever-increasing need for high speed communication, top tech companies are locked in high-stakes competition to establish a worldwide network of low earth orbit (LEO) satellites, the prize being the lucrative prospect of delivering next generation internet access on a global scale. Considerable wealth and resources have been invested in the development of cost-effective launch vehicles and systems capable of reaching LEO, laying the groundwork to vastly expand the commercial utilization of space.

This commitment to the potential of satellite communications can be seen in the contributions of industry visionaries such as Elon Musk and Jeff Bezos. Musk's SpaceX is lowering cost per flight by rapidly building and turning around launch vehicles for reuse. This has allowed him to put more than 600

LEO satellites in orbit, with plans to establish a constellation of between 12,000 and 30,000 to deliver global low-latency high-bandwidth internet access. In like fashion,

Bezos started Blue Origin to enable his e-commerce and cloud computing company Amazon to put over 3,200 satellites in orbit. Making the establishment of such large-scale LEO infrastructure both efficient and profitable requires constant innovation, particularly in the design of the essential components these systems rely upon. The space economy was worth at least USD464bn in 2022 and it is likely to reach USD737bn within a decade, according to estimates from Euroconsult. North America and Asia currently dominate the sector, with Europe not far behind in terms of revenue share. However, India has placed the space sector as a key pillar of its aim to become a world technology superpower, based on a report by A report by HSBC Global Research.

While the cost of space travel has fallen significantly. SpaceX's Falcon Heavy rocket launched in 2018 at a cost of USD1,500 per kilogram, compared with USD5,400 per kilogram for NASA's Saturn V rocket used between 1967 and 1973. SpaceX's Starship rocket could lead to a further significant drop in costs by lowering the cost per kilogram to below USD100 by 2030.

In 2021 the European Space Agency estimated there were 130m pieces of debris larger than 1mm in orbit and this figure is even higher when considering debris that is too small to track. Even relatively small pieces of debris can cause LEO satellites serious damage when travelling at many kilometres per second.

The future of space

The OECD defines the space economy as any activity that involves exploring, researching, understanding, managing, and utilising space. The European Space Agency has claimed that space infrastructure has benefited a number of sectors, particularly: meteorology, energy, telecommunications, insurance, transport, maritime, aviation, and urban development¹.

In October 2021, Amazon announced a partnership with Verizon to use its Kuiper constellation to expand rural broadband access in the US; In June 2023, OneWeb partnered with Telstra, the agreement will see up to 25Gbit/s of LEO capacity being delivered to the most remote areas in Australia³; In August 2022, SpaceX announced a partnership with T-Mobile to enable satellites-to-cell connectivity which would help to close gaps in cell networks in rural and remote regions.

According to Euroconsult, the space market for instance, commercial space revenue and government procurement was USD424bn in 2022 and the space economy, also including government organisations spending to conduct space activities was USD464bn. Euroconsult also expect the space economy to reach USD737bn within a decade. And moreover, 86% of the market is made up of space-based end-user applications, for example telecommunications or satellite navigation. North America and Asia dominate the sector making up USD131bn and USD102bn, respectively. With Europe just behind at USD94bn.

Why LEO?

Satellites operating in low earth orbit between 300 and 1200 miles above ground enable a round trip for radio signals of less than 20 milliseconds, whereas signals going to and from a satellite in geostationary orbit require closer to 250 milliseconds, a more than 12-fold improvement. While geostationary satellites are well-suited for the "one to many" delivery of broadcast applications, they are not well suited to the high speed, two-way interactive data flows of modern internet-based applications. By placing a large number of satellites in low earth orbits, Bezos and Musk hope to have true competitors rivalling the performance of forthcoming cellular technology known as 5G. Verizon, AT&T and other wireless carriers are targeting 5G network latencies of one to ten (1-10) milliseconds once their ground-based infrastructure is fully deployed. The difficulty for these carriers is that they are going to have to rely on microwave frequencies well above 6 GHz, potentially going as high as 60 GHz, in order to meet the stated latency and bandwidth goals of 5G. Due to the propagation characteristics at the extreme high frequency (EHF) and millimeter wavelengths licensed to them, the carriers are going to have to deploy a greater amount of infrastructure in much greater density than today's macro cell tower-based networks. This presents a window of opportunity for the building and operation of

LEO satellites to deliver "direct to satellite" two-way communications and internet access.

Regional breakdown

We have previously discussed India's growing ambitions in the space race. We have also covered the setbacks the UK has had in its aim to become a global space player, for instance, the failed Virgin Orbit launch in January 2023.

For now, the big players are the US and China making up 47.6% and 27% of orbital launches, respectively. SpaceX makes up the bulk of the US launches and in 2022 SpaceX launched 61 orbital missions (approximately, a launch every six days). This cadence, doubled the company's previous record of 31 launches in 2021. In 2022 34 of these 61 launches were for the purpose of expanding SpaceX's megaconstellation. The remaining 27 were on behalf of its clients (e.g. NASA, International Space Station). The company has suggested that the aim is for up to 100 launches in 2023 (around 2 launches per week)

In May 2023, it was announced that SpaceX now had over 4,000 Starlink satellites in low orbit. Since 2019 the company has launched 4,340 Starlinks with 4,023 still in orbit and 3,988 of those operational. SpaceX has permission from the Federal Communications Commission (FCC) to deploy 4,408 Ku-band satellites and 7,500 V-band Gen2 satellites, with pending approval for 22,488 next-gen satellites in the future⁷

The Union of Concerned Scientists, who advocate for multinational cooperation in space said that as of May 2022 the US accounted for 3,433 of the 5,465 operating satellites in space (68.5%), with China on 541 (10.7%), UK on 486 (9.7%), and Multinational satellites with 180 (3.6%, where 60 of which are European Space Agency run). Of the 5,465 satellites in space, 4,700 were LEO satellites (86%), 565 Geostationary (10.3%), 140 MEO (2.6%), and 60 elliptical satellites (1.1%). Of all the satellites, commercial satellites make up 74% of all satellites (4,047), government 10% (527), military 8% (424), mixed uses 5% (306), and civil 3% (152). Of the US satellites in space 87% of them were commercial satellites (2,992), 7% were for military purposes (237), 5% for government (172), 31 civil satellites (<1%), and 2 were mixed use (c.0.05%).

The cost of space travel

The cost of space launches into low orbit has dropped significantly since the 1960s. NASA's Saturn V used between 1967-1973 cost USD5,400 per kilogram and the Space Shuttle used between 1981-2011 first cost USD65,400 per kilogram. In 2010 SpaceX's Falcon 9 rocket cost just USD2,600 per kilogram and the Falcon Heavy launched in 2018 cost USD1,500 per kilogram⁹. This amounts to a greater than 95% drop in the cost of a US space launch.

As we discussed previously, SpaceX recently conducted its first test launch of its Starship.

The goal of the Starship is to launch daily with the ability to carry over 100 tons into orbit per launch. This would amount to a launch cost as low as USD100 per kilogram, though this is unlikely before 2030. According to Indxx, the current launch costs are USD 1,500 per kg. By 2040 Indxx estimates the cost to drop to USD100. Largely brought about by sizeable costs savings from a reusable second stage (reducing costs 48%) and reusable faring/payloads (reducing costs 24%).

What is in space, where is it and debris dangers ahead?

We mentioned in a report published on January that in the 1990s there were three major players (Iridium, Teledesic, and Globalstar) who aimed to bring about LEO constellations for mobile phone communications. However, the market was too immature to succeed at that time and all three companies entered bankruptcy at some point.

LEO constellations made a comeback in the 2010s with new constellations such as OneWeb, SpaceX, and Amazon. Improved technology, miniaturisation, and terrestrial broadband adoption has made these newer projects viable; as well as the large rise in demand for telecommunications and digital divide which LEOs seek to close.

We can see in chart below the uptick in activity in LEO that begins in the late 2010s as these constellations (particularly SpaceX) ramp up their launches. Before these constellations began being launched there was still a lot of activity in low Earth orbit, with most artificial objects in outer space existing in low Earth orbit. Some famous examples of human activity in low Earth orbit include the International Space Station and the Hubble Space Telescope.

Debris left in low orbit has caused concern amongst scientists that this debris could cause issues such as collisions with other satellites and also lead to environmental concerns such as ozone depletion. In 2021, the European Space Agency estimated that there were >130m pieces of debris objects larger than 1mm.

And there are many more times more debris in low Earth orbit that are not being tracked, with some scientists claiming up to 100trn pieces of debris are circling the Earth untracked which could render low Earth orbit unusable. According to the European Space Agency, there are also 900k space fragments between 1-10cm in size, 34,000 fragments larger than 10cm, 21,000 unidentified debris objects and fragments, 2,850 defunct satellites, and 1,950 discarded rocket stages. Even the smaller pieces of debris can cause serious damage to satellites because they are travelling at many km/second.

SPECIAL REPORT

Is Australia and its military forces prepared for drone warfare?

By Matt Jones



As Hamas completed final preparations for its assault against Israel, small drones approached the many watchtowers that encircle Gaza, placing or dropping explosives onto the remote-controlled weapon platforms that provide Israel's first line of defence.

With these obstacles removed, Hamas fighters stormed the fortified locations in a co-ordinated ground assault aided by a barrage of rocket fire. As these assaults unfolded, larger and faster drones were used to attack Israeli ground forces, inflicting damage to even a mighty Merkava 4 tank.

This attack marked another chapter in the growing use of drones by unconventional forces to unhinge standard military capabilities. The use of drones is now a major feature in conflicts from Israel, Syria, Sudan, and Ukraine where drone operations can number in the thousands of events daily.

Recently, even the Sinaloa cartel has used drones to surveil and attack Mexican government forces. Drones and

their sister technology of loitering munitions represent what a US Air Force general described as a "democratisation of air power" that favours the agile and innovative, challenging many conventional technological approaches to war.

Countering the threat from drones is no easy task. Threats range from the small, nimble, and cheap, to platforms that have been hardened against jamming carrying very large payloads and moving at speeds up to 300km/h.

Detecting and tracking drones at low altitudes among battlefield clutter and then safely defeating them is a challenge for conventional air defence capabilities optimised to defeat helicopters, low-flying aircraft or cruise missiles. This task is complicated by "cost asymmetry" where an air defence missile can cost up to 20 times more than a commercial drone or loitering

munition valued at just a few thousand dollars. Even the standard programmable anti-aircraft cannon shells cost more than \$1500 per round and are fired at rates of 600-1000 rounds per minute. Opponents, like Russia, effectively exploit this asymmetry, stretching Western supply chains using Iranian supplied drones, challenging Ukraine to use their limited stocks of munitions or risk losing critical infrastructure.

If the drones get through, the impact is substantial, but if they don't then they have consumed a resource that the West cannot resupply at the same rate. It's a highly effective war of attrition.

Any effective counter-drone solution needs three basic elements: the ability to detect; the ability to understand, categorise and co-ordinate a response; and the ability to interdict. Australia has many companies with strong capabilities that address each of these elements.

Silentium Defence in South Australia has a portfolio of passive radars that can provide target detection without allowing an opponent to identify your position, and CEA Technologies in Canberra produces some of the best air defence radars in the world. Acacia Systems has evolved its submarine combat system technology to produce a command-and-control capability that can co-ordinate many sensors and effectors simultaneously to defeat drone swarms, and companies such as DroneShield have developed globally competitive jamming solutions capable of safely defeating many types of commercial drones.

Electro Optic Systems has evolved its 30-year expertise in precision targeting and engagement to deliver a range of direct fire solutions that can defeat drones using directed energy lasers, cheap laser-guided rockets or even direct fire by chain guns and machine guns. These options all contribute to one overarching objective: to choose and conduct drone kill operations for less than the cost of the drone itself – rebalancing the asymmetric advantage in favour of the drone defender.

A number of these Australian solutions are now appearing in Ukraine and other theatres of conflict as crucial capabilities for Australia's allies.

Today, drone warfare is a rapidly evolving element of modern warfare, not only a future threat. Every day new operational methods are being explored on battlefields, requiring the rapid development of counter-drone technology.

While the ADF is yet to fully commit to new counter-drone capabilities, Australian industry and research centres are already working hard to stay ahead of these developments and in many ways, we already play a leading role in this global battle. For Australian industry to best support this national security need, a dialogue between government and industry on the threat of armed drones is needed, and together a comprehensive strategy developed.

Leveraging the space domain

Australia is one of just two countries with the capabilities to neutralise large numbers of satellites passing over its territory, said Dr Ben Greene, founder of defence company Electro Optic Systems, at the ADM Space Summit in Canberra.

Dr Greene, now EOS chief innovations officer, told the forum that a central issue was what Australia could do to deter others from attacking Australian space assets.

"Most people in this room mightn't know it, and it's not classified, but Australia is only one of two countries in the world that has the technology and the capability to neutralise satellites in number rapidly," he said. "The key thing to do would be to say to them, if you degrade or diminish capability of any of our satellites, we'll take out 50 of yours. That's all you have to do." Dr Greene didn't spell out how that would be achieved.

Australia has no anti-satellite missiles, but it does have advanced capabilities for precise tracking of satellites and high-powered lasers for attacking drones, both developed by EOS.

Even though a high energy laser might not obliterate a satellite, it could dazzle or damage its sensors.

Dr Greene told the conference that the essential precursor for any counter-space activity was superior space intelligence, what is now referred to as Space Domain Awareness (SDA).

This refers to the detection, tracking and identification of satellites and other orbiting objects, for which Australia has advanced capabilities.

Dr Greene said Australian SDA covered around one sixth of the sky, delivered by, among others, EOS with its laser tracking facility in Canberra, the RAAF's space telescope in WA and the new LeoLabs Australia space radar, also in WA.

"There's not a low orbiting satellite that's focused on ISR or any activity around the world that doesn't overfly Australia," he said. "We have the ability to conduct intelligence and interdiction operations from Australian territory on any satellite at all that's of importance going forward into the coming decades.

"We are one of only two countries in the world that could do that. Russia is a little bit too far north but could make a reasonable attempt. The US and Australia are the only two countries in the world that could do that. We could do it independently." Dr Greene said he had done the math.

"We could intercept and interdict the satellite operations of any country on earth, if we chose to. That's a really powerful platform for us," he said.

"It's quite feasible now to talk about taking out hundreds of satellites a day if that was necessary."

While Australia has made good progress in its space journey, the panellists were asked what Australia really needs to advance national space capabilities.

"Policy and strategy. We won't actually have the correct policy and strategy until we have national leadership that gets what we are all talking about," said Terry van Haren, president and managing director of LeoLabs

Australia.

"We actually need ministerial type leadership to set the policy and strategy to do everything we are talking about and it's unfortunately not happening yet."

Bec Shrimpton, director of defence strategy and national security at the Australian Strategic Policy Institute said the story of space and its importance to Australians' daily lives was not told well enough or well understood.

"Neither its opportunities or its risks are really being addressed adequately in policy and strategy. That's not for lack of trying from parts of our space system," she said.

Ms Shrimpton said there were pockets of genuine excellence with dedicated individuals, parts of government departments that really got this and interested investors who wanted to see the sector take off.

But all these actors seemed to be operating in silos, dispersed and their effect diffused.

"They are less than the sum of their parts. That is because the capstone of getting space right in this country is a national bipartisan commitment and a vision and that is lacking," she said.

Ms Shrimpton said defence and foreign policy enjoyed general bipartisanship, a joined-up approach, a mature means of interaction between departments and certainty in organisation and funding.

"That that must be the goal for space as well," she said.

"A strategy can help because it just tells people what it is we are trying to do, which also attracts investment, attracts business and deals to allow exports which in credibly important."

ASPI senior analyst Dr Malcolm Davis said he would like to see a minister for space, and that moving the Australian Space Agency from the industry department to Prime Minister and Cabinet was a good idea.

"I would like to see Australian astronauts standing on the lunar surface with Australian flags on their spacesuits. That to me would be the most inspiring thing that could imagine for young men and women looking at a future in space," he said.

"We need a much more ambitious approach to how we think about defence and space. It can't just be for communications provision. It's got to be about space control.

"It's got to be how we respond to a contested space domain when China is rapidly developing counter-space capabilities and fully intends to use them in the next war. Space will quickly become a warfighting environment, not because of our own actions but because of decisions in Beijing."

Korea opens new era of space economy



The Republic of Korea is a remarkable country. In 1960, seven years after the Korean War ceasefire, it was a corrupt dictatorship with a per capita GDP of US\$82, about US\$400 in 2022 moneyless than Haiti. Today, through incredible drive, it has transformed itself into vibrant modern democracy with a per capita GDP of \$30,000, roughly equal to the EU average, and a total GDP greater than Russia's. This is an absolutely unique achievement, making the ROK the only country that has gone from being a foreign aid recipient to a foreign aid donor.

It has also become a cultural superpower, with Korean TV shows, for example, penetrating global media markets to a much greater extent than those of many much larger countries. Its electronics and automotive sectors are top notch, with companies like Samsung and KIA competing aggressively on the global market against Apple and Toyota. It also has a first-rate nuclear industry, capable of building a 1000 MW pressurized water reactor power plant in less than four years compared to the sixteen-year average now prevailing in the US, making it, alongside France, one of the two free-world nations capable of competing against Russia and China in the global nuclear power export market.

Korea is set to launch a new space agency, the Korea Space Administration KASA, following the passing of a special act for its establishment at the National Assembly. The agency, which will be responsible for all aspects of space, including setting a vision, technology development and global cooperation, is expected to play a pivotal role in propelling Korea toward becoming an emerging space power, according to industry officials and experts.

Korean President Yoon Suk-yeol recently declared that South Korea will open the era of the "space economy," aiming to develop a lunar lander by 2031 and expand its participation in the Artemis program to the Korea Aerospace Research Institute in Daejeon to congratulate the second successful launch of the Nuri.

The OECD defines the space economy as the full range of activities and the use of resources that create value and benefit to human beings in exploring, researching, understanding, managing and utilizing space. "With the successful launch of the Nuri-ho, we have become one of the world's seven largest

space powers with satellite technology and projectile technology," Yoon said at the event, speaking to the researchers, industry officials, and graduate students who had developed the rocket. He called the attendees "heroes of the Nuri." "The government will also invest boldly to open an era of the space economy," he added. Yoon said the nation's future depends on the space industry, which is a key area of national competitiveness, and that the government will invest boldly to establish the Korea Aerospace Administration to systematically support the aerospace industry

"Beyond the development of satellites and projectiles, we will actively support the development of necessary technologies in space, such as exploration robots, space transportation rights and space experiment equipment," he said.

The president vowed to strengthen industrial competitiveness by transferring the satellite technologies and projectile technologies proven by the success of the Nuri to companies, and support space resource mining, exploration and space traffic control.

Korea's new space agency propel

The Korea Space Administration KASA, the Korean version of NASA would focus on ensuring that space development is very well interconnected with the development of related industries, thereby benefiting the national economy.

While the agency will be launched with high expectations, there are also issues to be resolved beforehand, they added. One of the issues is how to secure enough personnel to begin the full operation of the agency. The fact that Sacheon in South Gyeongsang Province, where the agency will be located, is about 300 kilometers away from Seoul, makes it difficult to attract skilled workers to the aerospace sector.

Paul Yun, NASA's solar system ambassador, said that the newly launched space agency will focus on coordinating Korea's space industry and technology development, coordination among government ministries and international cooperation.

"The space agency needs to establish regular

strategies for space exploration, space science and space technology related to the Korean space sector and organically connect with various government ministries, companies, research institutes and universities," he said. "It also needs to create and execute a collaboration structure with space agencies of each country and international cooperation organizations and coordinate them."

The NASA ambassador noted that the current trend in space development is to move away from the era when space development was conducted with national security in mind during the Cold War. Instead, it is now being carried out for national economic development. Therefore, he advised KASA to steer toward rejuvenating the national economy through the space industry.

"Korea and its companies have been conducting economic activities mainly based on Earth. With the expansion of the space economy, KASA should establish a long-term strategy to expand and develop into space," the NASA ambassador said.

The Korean government is well aware of this and has declared that KASA will foster 500,000 jobs and 2,000 related companies in the space industry by 2045. They also aim to dramatically increase investments in the space aviation industry to achieve a 10 percent share in the global space market.

The minister said that the budget for the space agency this year is expected to be around 800 billion won about \$600 million, and the head of the space agency will be appointed by President Yoon Suk Yeol as KASA is an external agency of the science ministry.

Kang Goo-young, CEO of Korea Aerospace Industries (KAI), has consistently argued for the necessity of establishing a space agency, which will play the role of a control tower for the development of Korea's aerospace industry. After the special act for the establishment of KASA passed on Jan. 9, he said, "I congratulate the establishment of a control tower that can promote a new aerospace led by the private sector."

Kang, who also serves as chairman of the Korea Aerospace Industries Association (KAIA), said, "The association will also contribute to the urgently needed policy promotion, budget securing and system improvement for the development of the Korean aerospace industry."

Securing adequate workforce

One of the urgent issues that experts point out that KASA needs to resolve as it launch the Korean Space Agency is securing enough workers. The government has stated that KASA will be an organization composed of 300 personnel.

However, experts noted that the pool of aerospace industry-related experts in the country is not large, and that the agency needs to come up with more inducements to attract

workers, especially young researchers since the headquarters of KASA is far away from major cities.

The science ministry said that the KASA personnel will consist of 200 researchers and 100 administrative public officials, totaling 300 people. The researchers will be composed of domestic and foreign experts. The government's decision to locate KASA's headquarters in Sacheon was due to the industrial location of the city. KAI, which manufactures fighter jets and multipurpose satellites, already has its headquarters and factory located there, and to the west of Sacheon is Goheung, where the Naro Space Center — which launched Korea's first space launch vehicle is located.

"There doesn't seem to be a lot of aerospace-related researchers in Korea, so it seems that KASA may have difficulty in recruiting related personnel," a researcher of a local space-related institute said on condition of anonymity.

The researcher said that while KASA may recruit researchers from state-run aerospace agencies like the Korea Aerospace Research Institute (KARI) or the Korea Astronomy and Space Science Institute (KASI) in preparation for its launch, he questioned whether there would be any factors to make those working at state-run agencies, mostly located in Daejeon which is one of Korea's major cities, go all the way to Sacheon.

Data from the Korea Association for Space Technology Promotion shows that as of 2022, there were 10,125 space-related personnel in Korea, but 7,501 of them, or about 75 percent, were employed in companies. It is also questionable whether KASA can offer better incentives than companies that offer relatively high salaries.

"Securing 200 researchers for KASA is not an easy task," Lee Sang-ryool, president of KASA, said during a press conference on Jan. 18. "Rather than perfectly matching the launch of KASA in May, it is necessary to proceed with a plan to gradually gather excellent professionals."

In regards to cooperation with global space agencies, Korea has been especially increasing cooperation efforts with NASA as the U.S. space agency's ShadowCam equipment is installed on the Danuri lunar orbiter and they have been collaborating on observing permanently shadowed areas on the moon's south pole.

Experts also pointed out that the government needs to put efforts into expanding the pool of professionals in the aerospace sector in the long run.

The science ministry said the new space agency will continue to cooperate with NASA after its establishment.

SPECIAL REPORT

Start-up space: what's next?

A report by Bryce Space and Technology has revealed three significant trends shaping the start-up space environment in the 2020s. Firstly, the report said, investors continue to pour large amounts of capital into start-up space ventures, shattering previous records as increasing numbers of investors fund more recipients. Each one of them plays different role such as funding source, including the stage of involvement; preferred funding instrument for instance debt, equity, or hybrid debt/equity instruments; and general objectives in investing.

Over the 20-year period, Venture capital firms represent the largest number of investors in start-up space companies, followed by angel investors. Together, these two investor groups comprise about 73% of the investors in start-up space ventures. Corporations, private equity firms, and banks make up the remaining 28%. There is small participation by a few altruists, who have provided grants or prizes, such as Thiel Foundation, Knight Foundation, XPRIZE Foundation, and Space Frontier Foundation, primarily through business plan pitch contests or other competitions.

In 2017 the early stage-focused angel syndicate Space Angels announced a \$50 million inaugural fund, Space Capital, which has invested in 9 start-up space ventures as of the end of 2019.

In 2015, Bessemer Venture Partners announced the creation of its \$1.6 billion fund, BVP IX, to invest in innovative companies, including those in the space sector. In addition to VC funds, governments and sovereign wealth funds have emerged as investors in start-up space companies. For example, in 2016, Luxembourg opened a \$227 million fund, SpaceResources.lu, to provide “early stage investments in innovative start-ups as well as in more mature companies, with a focus both on Luxembourg-based enterprises in the space resources industry, and companies developing substantial space resources related technologies in the Grand Duchy among several others.

According to the report, start-up space companies themselves are primarily based in the United States. These 180 companies make up 55% of the global total of 330. California is home to 71 of these companies,

which represents 39% of the U.S. total and 22% of the overall global total. Start-up space companies headquartered outside of the United States of 150 make up 45% of the global total. Overall, 31 space start-ups are headquartered in China, comprising roughly 21% of all non-U.S. space start-ups. The United Kingdom has the second most start-up space companies made up of 24 companies, followed by Canada (10), Japan (8), India (8), Singapore (7), and Israel (7) respectively. Seventy-nine start-up space companies based outside the United States received funding in 2019.

Since 2000, nearly 500 VC firms have invested in start-ups. VCs generally invest in start-ups and early stage companies with high growth potential, and accept a significant degree of risk. These investors frequently invest in syndicates, pooling investment with other VCs, but they can also include angel investors, corporations, private equity firms, and banks in their transactions. The number of venture capital firms investing in start-up space increased to 190 in 2019 from 142 firms in 2018. Of the 190 VCs that invested in start-up space companies in 2019, 63 had previously reported investment in start-up space companies, while 127 appear to be new additions to the start-up space ecosystem.

From 2000 to 2004, the average number of VCs per year is four. Over the next five years between 2005 and 2009, the average doubled. From 2010 to 2014, the average nearly tripled before increasing by a factor of more than five to 122 in 2015–2019 periods. However, the report revealed that years into start-up space investment, many ventures still have yet to demonstrate profitability and sustainability; creating expectations for rationalization and consolidation. Finally, government stakeholders are becoming an increasingly important element of the potential success of venture-funded space start-ups as many firms turn towards the government as a potential customer.

Overview of start-up space ventures

Over 310 new angel- and venture-backed space companies have been founded and funded in the period from 2000 to 2019. In the early 2000s, an average of four funded space companies were started per year; today the figure is nearly eight times higher. (In the last five years, the number of funded new

companies has averaged 29 per year.) That average excludes new firms that have not yet secured investment.

From 2009 to 2010, the number of new space start-ups more than doubled and venture capital investment increased 55%. Three of the newly founded companies were lunar exploration start-ups, which competed in the Google Lunar XPRIZE competition (Moon Express, ispace, and Team Indus). Other companies founded in 2010 attracted \$1+ billion of venture capital in later years, including Planet, Satellogic, ispace, and Mapbox. The more than tripling of new start-up space companies from 2009 (8) to 2012 (26) coincides with a near quadrupling (to \$198 million) of venture capital invested in space start-ups during that span.

There is generally a multi-year lag from a company's founding to when it receives external investment. Therefore, recently founded companies have not had a chance to raise (and announce) external funding and are not included in Figure 1. Potential reasons for not announcing funding include actively pursuing further funding rounds, or the protection of a competitive advantage while in “stealth” mode. The total number of reported start-up ventures has increased compared to Bryce's *Start-Up Space 2019* report, reflecting new announcements by existing companies, new companies, and enhanced data sets. Based on the recent trend, Bryce anticipates that the 2019 number will increase in the next 1 to 2 years.

Record-Setting Investment in Start-up Space

Start-up space ventures attracted \$5.7 billion in financing of all types during 2019, shattering the \$3.5 billion record set the previous year. This was largely driven by investors continuing to pour large amounts of capital into a handful of the industry's largest companies.

SpaceX and Blue Origin drew an estimated \$1.9 billion in combined investment during the year, while low-Earth orbit (LEO) broadband venture OneWeb attracted another \$1.25 billion. Sir Richard Branson's space tourism start-up Virgin Galactic raised more than \$682 million in 2019. A reverse merger with special purpose acquisition company Social Capital Hedosophia, raised \$500 million and paved the way for public trading of Virgin Galactic shares, one of the year's more notable transactions. Together these four companies accounted for



nearly 70% of the 2019 total. The continued ability of sector heavyweights like SpaceX to raise capital is one of the major storylines of Start-up Space 2020.

Other companies attracting large infusions of venture capital during 2019 included U.S. small rocket maker Relativity Space and China's Qianxun Spatial Intelligence, a Beidou-enabled (Chinese GNSS) high-precision location service provider, each raising \$140 million.

In addition to the six companies mentioned above, another 129 start-up space ventures received investment in 2019. In total, 135 startup space ventures received investment in 2019, a 34% increase over 2018, the previous record. Observers have speculated about a possible investment slowdown in start-up space, but 2019 brought no clear evidence of lost momentum. 2019 was a record setting year for the number of start-up ventures raising investment (+34% from 2018), investors (+46%), deals (+36%), and investment (+61%). Excluding SpaceX, OneWeb, Blue Origin,

and Virgin Galactic, total investment in start-up space was \$1.8 billion in 2019, down slightly from the \$1.9 billion excluding those companies the year before. However, a sharp increase in the number of rounds with undisclosed investment (based on publicly available data)—38 in 2019 compared to 15 in 2018— suggests that the actual total for the year is above \$1.8 billion.

Growth in start-up space was in part due to the growing international presence. The year saw a surge in the number of non-U.S. start-ups obtaining financing: 79 in 2019, compared to 47 in 2018. The number of U.S. firms, meanwhile, appears to be leveling off, with 56 in 2019 compared to 53 the year before. This is the first year where the number of non-U.S. companies receiving investment exceed the number of U.S. companies.

The largest single start-up space investment category continues to be venture capital, with some \$4.0 billion raised during the year. About

68% of that, or about \$2.7 billion, is attributable to SpaceX, OneWeb, and Virgin Galactic. The \$1.3 billion raised by the other companies represents a 17% drop from \$1.6 billion in 2018, although, again, the number of rounds with undisclosed magnitude invested was substantially higher in 2019.

The seed investment category, meanwhile, continued to be dominated by Blue Origin, bankrolled by Amazon.com founder Jeff Bezos. Blue Origin's estimated \$1 billion in 2019 accounted for 76% of the total for the category, which also includes prize and grant money. Another 12% (\$162 million) comes from Virgin Group internal seed investment into Virgin Galactic as reported in fourth quarter earnings reports.

Yet even with all of this record-breaking investment in start-up space ventures, financial sponsors report that, from their standpoint, there's an enormous amount of



available capital looking for opportunities. John Stack, managing director and head of U.S. aerospace and defense investment banking at Canaccord Genuity LLC said that with an investment capital pool of some \$1.6 trillion available, “investors continue to seek companies with strong growth potential. Furthermore, despite industry consolidation over the past few years, the publicly traded aerospace and defense companies also have meaningful capacity to acquire other businesses.”

Long term state of the start-up Space

To date, according to the report, only a small percentage of the hundreds of space start-ups financed since 2015 are drawing revenue on business operations, and fewer still—if any—have reached profitability. However, the leveling off of the number of United States start-up space ventures receiving investment in 2019 indicates that many prospective investors are waiting to see how companies that have raised capital in the recent past perform in the months and years ahead.

“The ideas from a few years ago raised a lot of money,

and the companies have turned those ideas into new technology,” said Sunil Nagaraj, founder and managing partner with the Silicon Valley-based investment firm Ubiquity Ventures. Nagaraj, whose previous firm, Bessemer Venture Partners, was an early investor in several well-known start-up space companies, including launch services provider Rocket Lab and imaging satellite operator Skybox. “The reckoning is: Does that result in business value?”

Silicon Valley capital emerged as a major catalyst five or six years ago as tech investors recognized the potential for satellite data to drive information-centric business applications. This, in turn, has fueled efforts to reduce the cost of building and launching satellites. Whether these new price points will ultimately translate into sustainable profits remains to be seen.

“In certain areas investors will take a pause to let business models evolve and see how performance shakes out,” Stack said. “Where companies are not proving themselves, there will be rationalization and consolidation, while successful companies will become prime acquisition targets.”

There are indications that the rationalization is beginning, as 2019 saw three high-profile casualties in the sector: broadband hopeful LeoSat, small rocket maker Vector, and satellite data-relay provider Audacy Space. Failure is par for the course in any venture capital-funded sector. About three-quarters of venture-backed firms in the U.S. don't return investors' capital. More such failures are to be expected in the coming years as the availability of capital tightens for companies that are behind on their performance milestones or cannot realize sufficient demand for their products and services. This can be expected to lead to a rationalization and consolidation of the industry in the years ahead.

While start-up space remains unquestionably dynamic as a sector, investors have noted the dearth to date of lucrative exits. “Every venture capitalist considering a space investment is eager to see more liquidity in the sector...” Nagaraj said. “At the moment we're in this wait-and-see phase and as startup space companies hit more business milestones, more liquidity will emerge.”

Government's Increasing Role in Start-up Space

The report said, “An increasingly important feature of the start-up space investment landscape is the enabling role played by the government, both as a source of direct funding and a perceived stamp of approval that builds confidence among private investors”.

However, the creation of the U.S. Space Force and an increase in study contracts awarded by government agencies are making government business more attractive to start-ups. Lucrative government contracts could offset sluggish development of commercial markets for some of these companies.

“In dealing with investors, if you have customers willing to pay and take this risk, that's transformative,” said Pamela Melroy, a former NASA astronaut who subsequently served as deputy director of tactical technology at the Defense Advanced Research Projects Agency (DARPA).

Since 2000, 164 corporations have reported investing in start-up space companies. The number of corporations investing in start-up space ventures increased by 19% from 2018 (42) to 2019 (50). Participation from corporations was low in the first fifteen years of the study with the average number of corporations investing rising from two in 2000–2004 to three in 2005–2009, before increasing slightly to five in 2010–2014. From 2015 to 2019, the average is 40. This represents more than an eight-fold increase in the average number of corporations investing in start-up space ventures (see Figure 23 on the following page).

Of the corporations investing in start-up space ventures, 38% are headquartered in the United States, about a third of which are based in California (12% of the global total). The remaining U.S. portion of the global total is distributed across the United States, with New York, Illinois, Maryland, Texas, and Virginia leading. Non-U.S. corporate investors comprise 62% of the global total, 33% of which are based in Japan, 14% in China, and 10% in the United Kingdom.

In March 2019, SpaceX successfully launched the Demo-1 mission of an autonomous, uncrewed flight of the Crew Dragon spacecraft to the International Space Station (ISS), where the vehicle docked and later splashed down to Earth. This was followed by SpaceX's successful in-flight abort test in January 2020. These tests paved the way for Dragon's first crewed flight to ISS, marking NASA's first human spaceflight from U.S. soil since 2011 and a significant start-up space milestone. Though not a start-up, Boeing also a contractor for commercial crew program, conducted an uncrewed test flight of its CST-100 Starliner vehicle December 2019, though it was unable to rendezvous with the ISS.

The start-up space industry is becoming an important source of innovation for the

government, Melroy said. “The pressure on defense, particularly in space acquisition, to move faster has forced a marriage with start-up space companies who are more comfortable with 'other transactions' and other types of rapid contracting mechanisms,” she said. The government has an opportunity to leverage emerging start-up space companies to help it to do more while spending less.

Governments have an opportunity to leverage emerging start-up space companies to do more while spending less—at the same appropriately managing the additional uncertainty created by this venture-backed, dynamic innovation. As start-up space activity moves into the 2020s, government stakeholders will be an increasingly important element of the potential success of venture-funded space start-ups.

China's evolving commercial space sector

China's government has historically engaged in comparatively high oversight of the country's industrial capacity, including its space technology industrial base. However, in recent years, China has prioritized its ability to adapt to the changing global economy. In 1999, China began major managerial reforms to state-operated enterprises (SOE) impacting space. More recently, China's space industry has included more diversified investment—much of it allegedly private targeted at the development of dedicated small satellite launch vehicles and constellations of small satellites, which support the provision of communication and Earth observation services. Investment in non-governmental Chinese space ventures has particularly expanded following the 2014 government decision to incentivize private capital's participation in China's space sector.

In the context of this report, the term “non-governmental” refers to what are commonly regarded as “commercial” space ventures in capitalist economies, as opposed to Chinese government space activities and SOEs. A small network of “frontrunner” Chinese venture capital firms investing in non-governmental space has emerged. Key players will likely continue to shift as more firms add space ventures to their portfolios.

In keeping with global start-up space trends, many of the Chinese ventures that have emerged since 2014 are focused on launch services. Although a majority of the start-ups are likely receiving undisclosed financial support from the Chinese government directly, investment activity from Chinese venture capital firms continues to grow, and new ventures are emerging each year. Note that many Chinese venture capital firms have access to government funding and therefore do not operate on an entirely private basis.

Some sources have indicated upwards of 100 independent space start-ups have surfaced in China, but that number is much lower for start-ups that have publicly announced funding.

Counting only those companies that have announced funding, China is now the leader of non-U.S. space ventures. Of the 79 non-U.S. space ventures receiving investment in 2019, 22—more than a quarter—were located in China, up from 10 the year before. Three countries—the United Kingdom, Japan and India—were tied for second, with six each (see Figure 26).

Investors, most if not all based in China, invested \$314.2 million into Chinese ventures during 2019, up from \$288 million in 2018. These investment totals far exceeded those for other non-U.S. countries, with Japan placing second at \$130.6 million. There were 24 financing deals in Chinese start-up space during 2019, double the 2018 number. The number of Chinese investors investing in space also nearly doubled from 2018 to 62, the most of any non-U.S. country. Venture capital firms made up 65% of these investors.

The biggest Chinese investment during the year was a \$141 million infusion into Qianxun Spatial Intelligence, a positioning services venture that will use data from the government's Beidou satellite positioning system. Another significant round in 2019 was Chinese launch service start-up LandSpace, which received \$85 million in two tranches.

China's space industry has evolved rapidly to meet a dynamic globalized market. Chinese policy and investment in space activities are encouraging greater commercial activity and technological innovation in the country. Consequently, new actors are emerging within China to address a growing demand in space-based services. The future of these ventures and their business case success remains uncertain.

Finally, NASA's Artemis program, which seeks to return humans to the moon by 2024, creates significant opportunities for start-up companies. Fourteen companies, including start-ups like Astrobotic, are engaging in NASA's Commercial Lunar Payload Services program, competing for task orders to fly specific research payloads or instruments to the moon.

In 2019 alone, NASA awarded \$253 million in task orders on that contract to Astrobotic, Intuitive Machines, and Orbit Beyond to fly NASA's first science and technology payloads to the lunar surface. Start-up companies can also increase readiness of their technologies through lunar-focused Small Business Innovation Research awards and other initiatives. NASA's Artemis program will continue to provide on-ramps and opportunities throughout the decade as NASA aims to create a sustainable lunar presence. Governments, particularly NASA, are likely to remain the primary source of demand for these activities.

ADVERTORIAL

ICEYE: Making better decisions for the planet.



As the escalating effects of global climate change become more pronounced, the need for monitoring and understanding extreme weather events has never been more critical. Enter ICEYE, a Finnish Earth observation company that stands as the world's first global and continuous data utility.

ICEYE is at the forefront of climate change solutions with its unique synthetic-aperture radar (SAR) satellite technology. SAR technology, which involves creating high-resolution images or three-dimensional reconstructions of objects like landscapes, is a pivotal tool in ICEYE's mission. ICEYE currently owns and operates the world's largest constellation of SAR satellites.

ICEYE's technology is a practical tool used by various customers in sectors such as insurance, natural catastrophe response and recovery, security, maritime monitoring, and finance. Governments and large multinational corporations can purchase radar imaging

satellites from ICEYE and operate them independently or arrange for ICEYE to manage the spacecraft exclusively on their behalf. All these sectors require reliable, repeatable, precision data that can't be hidden, and ICEYE's technology delivers just that.

ICEYE stipulates that the world currently faces three key problems around Earth Observation Data: reliability, timeliness, and access. The ICEYE radar satellite constellation addresses these challenges directly in the following ways.

ICEYE's SAR satellites can capture high-resolution images of the Earth's surface, regardless of weather conditions or light, allowing for continuous monitoring of various environmental changes.

These images can be used to track deforestation, land use changes, ice melting, and other climate-related phenomena. This is highly valuable for climate research as it enables an unprecedented

understanding of climate patterns, changes in ice cover, sea-level rise, and other critical climate-related factors. This further helps to improve climate models and predictions. In the US, for example, the intensity and frequency of wildfires have increased significantly. In 2020, the wildfire season burned 10.2 million acres of land, costing the economy \$19 billion, of which \$16.5 billion was property damages. The events showcased the intricate challenges that insurers and disaster response teams encounter when dealing with wildfires of such magnitude. Particularly when assessing damage caused by heavy smoke and ash and restricting access to those affected.

ICEYE's SAR technology is not just about data collection; it's about action. It enables more effective disaster management and response by providing rapid and accurate mapping of areas affected by natural disasters such as wildfires, hurricanes, earthquakes, and floods. This technology minimises the impact on affected communities and the environment by significantly

improving disaster response and recovery efforts. In a data-driven era, insurers are always looking for innovative information to streamline their claims procedures, aiming to reduce claim expenses while delivering top-notch service to policyholders. In this context, radar remote sensing data is a game-changing tool for managing catastrophic events.

Furthermore, ICEYE's SAR satellites can assist in assessing the progress of sustainable development projects, such as those related to renewable energy, forestry, and urban planning. By monitoring these project's effectiveness, decision-makers can make data-driven decisions to further sustainable initiatives. To this end, ICEYE has already assisted Ukraine's global security efforts. ICEYE signed a deal with the Serhiy Prytula Charity Foundation to use ICEYE's satellite constellation to provide objective data and technological support to Ukraine. This agreement has significantly aided the government of Ukraine's urgent request for critical Earth Observation data and greatly benefited their armed forces.

Additionally, this data can be used to combat illegal activities that adversely affect the environment, such as illegal deforestation, mining, and fishing. By providing reliable and frequent monitoring, efforts to enforce environmental regulations and protect vulnerable ecosystems are supported.

With ICEYE's monitoring capabilities, insurers and governments can stay on top of increasing economic and insured losses as these monitoring solutions provide near real-time hazard and damage data across the globe. If we take oil spills as an example, 150,000 tons of crude oil is unintentionally deposited into our oceans every year. These events have disastrous environmental and economic implications; identifying where and when they happen is significantly difficult, yet necessary. Doing so requires persistent monitoring, which is only possible from space.

Companies like ICEYE are just at the beginning of what is possible. They are a shining example of how space can help our climate action and sustainable development. Investment in SpaceTech companies like ICEYE and the growth of the new space economy are new frontiers for solving humanity's most significant challenges. Reaching net zero is seemingly impossible without space. Thus, utilising the technology and data analysis from space,

delivered by companies like ICEYE, reduces waste and enables regeneration. ICEYE's ability to monitor any location persistently and flexibly is a game-changer, providing insight and response capabilities that have never been seen before.

ICEYE partners with WWF to protect 'blue corridors'

ICEYE's journey started ten years ago with an idea to monitor the movements of the Arctic ice that is where the company name comes from. Combined with our vision to improve life on Earth by becoming a global source of truth, the protection of Arctic nature is close to ICEYE's hearts. That's why the WWF's Arctic Programme was the clear choice when we asked our people to cast their vote on the target of our nature conservation work.

As of 2024, ICEYE is partnering with WWF Finland and the global Arctic Programme to protect whale migration routes in the Arctic region. Every year, tens of thousands of whales migrate long distances to and from the Arctic Ocean in search of the right conditions for feeding, mating, and giving birth. These underwater migration routes, also known as blue corridors, are vital for almost a third of the world's whale species.

Blue corridors are threatened by the warming of the Arctic

Whales follow the sea ice, traveling thousands of kilometers on their underwater migration routes. They use signs of the changing of seasons to make sure they are in the right place at the right time of year. But with the intense warming of the Arctic region, whales' navigation is becoming increasingly difficult. Sea ice loss is bringing more ships to the region, extending shipping seasons, and opening new routes. Increased maritime traffic means more underwater noise and a higher risk of oil spills and lethal collisions.

Whales are vital for the health of the oceans. At the top of the marine food chain, they are fundamental to the survival of other species and entire ecosystems. They also contribute to the fight against climate change by sequestering carbon from the atmosphere – one whale can capture an average of 30 tons of carbon dioxide over its lifespan.

According to WWF, seven out of the 13 great

whale species are endangered or vulnerable. The urgency to protect their natural environments has never been greater.

Piloting innovative solutions to monitor and manage blue corridors

WWF's Arctic Programme is working to safeguard migrating whales in line with the UN Global Biodiversity Framework (GBF). The Arctic Blue Corridors project increases information about the migration routes, pilots innovative solutions for monitoring, and advocates for conservation measures in cooperation with the shipping sector.

As part of the partnership, ICEYE will explore how synthetic aperture radar (SAR) satellite images could be used to identify and protect the migration routes of whales. ICEYE operates the world's largest fleet of SAR satellites that enable constant observation of the Earth – day and night, in all weather conditions, and both on the ground and in marine environments.

ICEYE's solutions are widely used to monitor natural disasters like floods and wildfires, enabling faster response and recovery. SAR data from the ICEYE constellation can be produced over wide areas, such as glacial regions or coastlines, to effectively detect oil spills and mitigate threats in marine environments. Read more about the applications of SAR data and solutions.

Earth observation data enables sustainable decision-making

ICEYE aims to transform decision-making with reliable and timely information about the events on Earth. Data is also the key to tackling complex sustainability challenges. Monitoring climate-related issues such as deforestation in the Amazon or melting of the Arctic sea ice will help us understand how our actions affect natural resources and living conditions on Earth.

"Through the partnership with WWF Finland and the Arctic Programme, ICEYE can contribute to the preservation of biodiversity and the natural environment beyond our own operations and value chain," said **Milla**

INSIDE PAPER

How satellite IoT will offer reliable connectivity to almost any location on the planet.



The meaning of the word “Smart” has changed dramatically over time. As the capabilities of technology have evolved, so too have our lives, allowing us to achieve far more with less input.

The Internet of Things (IoT) is the enabler of “smart” in today’s world, and this technology is having an impact on nearly all facets of society. Usually when referring to IoT, we think of technology designed for consumer convenience: smart speakers such as an Amazon Echo, smart light bulbs, thermostats and home security. However, IoT is much more than just a collection of smart devices that help us with our domestic lives, it also covers the rapidly expanding ways that businesses are using the technology.

Businesses across most industries, such as Agriculture, Energy & Utilities, Aviation and Maritime have embraced or are embracing Industrial IoT (IIoT) technologies to help improve operations, and efficiency and enhance productivity. One of the challenges when you take IoT out of the home, and indeed out of the city, is connectivity becomes more problematic. With only 10% of the world’s landmass connected by cellular or fiber connectivity, satellite becomes a critical connectivity method for enabling Industrial IoT. By using satellite connectivity to connect IoT

technology, new complex capabilities and solutions become available to businesses and industry.

Between IoT and IIoT

At its core, IoT refers to a network of physical devices, vehicles, appliances and other objects embedded with sensors, software and connectivity that enables them to collect and exchange data. Because these devices are all connected through the internet, they can communicate and interact with each other without the need for human intervention. The emergence of IoT can be attributed to the convergence of several key factors, including:

IIoT simply refers to the integration of IoT devices and technologies such as interconnected sensors, devices, machines and systems in an industrial environment, for the collection, analysis and exchange of data. Organizations can go on to use this data-driven approach to enable real-time monitoring, automation, data analytics and much more to streamline processes, reduce downtime, improve overall productivity and unlock new

opportunities.

Satellite connectivity and IoT work

Satellite IoT refers to the integration of satellite networks and IoT devices to enable seamless connectivity and data exchange. Firstly, IIoT-enabled devices such as sensors, trackers and monitoring devices need to be equipped with satellite communication {modules/terminals}. This allows the given device to be directly connected with a satellite in space, bypassing the need for a complete terrestrial infrastructure. The IoT device then collects data from its surroundings, such as environmental conditions, equipment performance, or asset tracking. This is then processed and packaged for transmission. Using selected frequencies and protocols, the device transmits the packaged data to the satellites above. Once received by the satellite, this data is then relayed back down to ground stations located on Earth. It is then forwarded to the intended recipient such as farmers, energy operators or fleet managers to be processed, analyzed and visualized through cloud-based or local systems.



The agriculture sector, for instance, is facing several challenges globally, a rapidly growing population, unpredictable climates, international conflicts, and supply chain issues to name a few. In order to meet these demands and address these issues, the way in which we cultivate land and supply food across the world needs to change. This is where the integration of satellite communications and IIoT can support the industry to help meet those challenges head on.

By utilizing IIoT, farmers and agricultural companies can achieve much higher levels of precision, efficiency and sustainability in their practices, in real time. This is especially the case across large farms and plantations, where it can be difficult to constantly monitor crops over hectares of land in remote locations.

The IoT devices farmers use are equipped with sensors that can collect data on a number of environmental factors, such as soil moisture, temperature, humidity, and other crucial parameters.

This ability to monitor crops with greater accuracy allows farmers to optimize resource allocation, reduce waste, improve crop yield, minimize environmental impact and ultimately maximize profitability.

With the emergence of wearable IoT devices, farmers can monitor the location, health and behavior of livestock in real-time, tracking loose livestock and their vital health signs, as well as detecting anomalies and receiving early warnings of potential diseases.

Satellite-enabled IoT devices also enable

farmers to remotely monitor their livestock’s well-being, optimize feed management, and ensure timely intervention when necessary. As a result, livestock health is enhanced, productivity is increased, and operational costs are reduced.

As the global production and supply challenges, along with an international push to become more sustainable, energy companies need to reassess how energy output and consumption can be efficient, green, and economical.

The energy industry has embraced satellite communications and IoT to change the way energy is generated, transmitted, and consumed. This integration can bring forth numerous benefits, including enhanced operational efficiency, grid management and renewable energy integration.

In addition, assets such as solar farms, wind turbines and oil rigs can be effectively monitored remotely through satellite-connected IoT technology, collating data on equipment performance, energy output, and environmental conditions, as well as controlling these assets from a central operational base.

With utility companies increasingly moving towards smart grids, where electricity distribution and consumption can be effectively managed, companies are looking to monitor and automate reclosers, manage advanced metering infrastructure and address other aspects of the smart grid. Satellite connectivity can power this as well as aid workforce safety.

Connecting remote workers’ wearable smart cameras with reliable and secure satellite communications optimizes the performance and safety of the workforce in the field. For security surveillance, video over satellite can validate any

alarms that are triggered and provide additional information via high-quality video. It also empowers energy providers to manage and monitor their grids more effectively. Real-time visibility into energy consumption patterns, voltage levels and demand fluctuations allow energy providers to balance supply and demand, detect faults or outages, and improve energy distribution.

Satellite communications and IoT in Transport

The transport industry is undergoing a transformative shift with the adoption of satellite communications and IoT, redefining logistics, fleet management, and passenger safety to make transportation more efficient, secure and sustainable.

However, real-time visibility significantly enhances safety and fleet management by accurately identifying where transport assets are at any time, understanding fuel usage, and providing feedback on whether drivers are adhering to safety procedures, as well as broader driver behavior.

With an increasingly complex global supply chain, the extra visibility IoT offers – tracking items in real-time – allows organizations to understand and manage optimal transport conditions so quality can be tracked for even the most perishable items, such as foodstuffs or medicine cold chains.

Safety is the number one priority for public modes of transport and satellite connectivity allows for enhanced safety measures, such as remote monitoring of vehicle conditions, driver behavior analysis, and emergency response systems.

FEATURE

Digital solutions for agriculture 4.0.



By 2050 the world population will reach 9 billion and the demand for food is expected to increase by 70%. Arable land will only increase by 15%, water is not easily accessible and the weather is increasingly less predictable. Hence, a more effective and efficient food production is essential. Providing the right information at the right time to food producers like farmers, pastoralists and fishermen can help to improve and increase food production in a sustainable manner, thus ensuring food

security on a global scale.

Consequently, a combination of improved mobile connectivity, new satellite services and private investments offers new opportunity for scaling up innovations to large-scale implementation and operation. A growing fleet of earth observation satellites encircling our planet guarantee a continuing global coverage and provision of free data.

Recent studies¹ show that information from satellites and other geodata can be translated

into agricultural advice, which enables higher crop yields and a more efficient use of seeds, water and fertilizers. Also, food producers will be able to receive early warnings for drought, flooding and/or diseases. Mobile phone based services providing up-to-date market prices have already been proven successful in Africa and India. Increasing the quantity and quality of communication networks enables millions of food producers in remote areas to benefit from relevant agricultural information, empowering them to

make better decisions. Also, micro-insurances and/or micro loans combined with information services can help guarantee the continuity of food production.

HiSky and Zoko Enterprises Group

hiSky, an Israeli Satellite Communications Company and Caterpillar's Israeli Dealer, Israel Tractors & Equipment ITE Ltd, Part of Zoko

Enterprises Group, are Embarking on a Joint Pilot of hiSky's Satellite Terminal on Cat Machines. The Israeli satellite communications company, HiSly and Caterpillar's Israeli dealer, Tractors & Equipment ITE Ltd., a part of Zoko Enterprises Group are carrying out a joint pilot program to integrate hiSky's satellite terminal also the Smartellite, with the machines and vehicle platforms of the manufacturers represented by the Zoko Enterprises group in Israel.

The program, according to the partners will explore the integration of the satellite terminal into the company's platforms, to enable transmitting and receiving of data to control centers, location and data analysis, diagnostics, fuel consumption, data collection and processing, designation of assignments to platforms, remote data transmission and computer updates, via hiSky's satellite communication system.

Once integrated, these functions will assist end-user and enable efficient fleet management. In addition, the system integration will enable the platform operator to make satellite phone calls and send messages.

One of the goals of the pilot program is to give Cat machines complete management capabilities, even in locations where there is no mobile coverage or in areas with limited mobile connectivity, says a Machine operator.

Cat machines are often operated at emergency situation sites, such as earthquakes and disaster-stricken areas, increasing the need for continuous communication, independent of wired or wireless infrastructure.

A company official said: "Integrating hiSky's satellite communication systems may be the solution for Cat customers and dealers around the world, who can generate significant added value in fleet management tools for use in areas where there is no cellular network, or in emergency situations, and maybe even in other scenarios where there is a technological or commercial advantage in using a satellite communications platform."

hiSky's CEO, Shahar Kravitz, added: "We are excited to start working with Zoko and explore the integration of our system into Cat products, and are certain that there will be significant added value in connecting our unique satellite communication system with machines and other vehicles. We are delighted that Zoko is participating in such forward-thinking and innovative pilot together with our team of experts, in order to explore the opportunity to better serve their customers."

hiSky has developed a portable satellite terminal that enables smartphones to interface with voice and data communications, via geostationary High Throughput Satellites. Working with these satellites enables a significant reduction in voice and data transfer rates. The hiSky Smartellite device will also meet the needs of the growing IoT market.

Tabula and Topcon announce solutions integration

Two leaders in agricultural services, Tabula and Topcon Positioning Systems, Inc. are collaborating on the integration of their respective solutions to create a combined solution for ground-based fertiliser and spray application.

Tabula and Topcon bring proven technology to the table and are committed to supporting the sector by driving great outcomes for farmers. Tabula's strengths of job management, health and safety, compliance processes and reporting will join with Topcon's highly accurate placement, sophisticated spraying and spreading equipment and auto steering capabilities. Together, the integration of these solutions gives farmers and contractors the right tool for the right job. John Enlow, Tabula CEO says the company is very pleased to work with Topcon.

"We are always looking for ways to provide additional support to farmers and contractors who work the land, and this collaboration is a natural next step and fit for our businesses. "Our strategy of relationships with highly regarded integration partners such as with Topcon demonstrate our commitment to the farming sector."

Tabula provides precision guidance, proof of application and job management solutions to give landowners and their contractors certainty. At the core of our offer is easy and seamless mapping and tracking of fertiliser and spray application. But it's not all about spreading and spraying. Tabula manages a whole range of other tasks on the land as well. For landowners, the information recorded that can be mined for insights to keep improving efficiency and yield, protecting and growing the value of the land. Tabula solutions make it simple for landowners and contractors to work together, thanks to an easy, intuitive user interface and world class support.

Phillip Hubbard, Topcon Director of Sales ANZ, says the relationship brings together complementary technology.

"It is great to come together with a solution that we know will really make a difference to farmers and contractors. Together our companies have an offering that suits all operators from small to large. We know that both New Zealand and Australian ground application customers are very interested in the field proven auto steering and product control capabilities of Topcon. This collaboration will deliver real benefits for landowners and contractors and we are excited to initially launch this in New Zealand and Australia," says Hubbard.

Rising energy costs and more reasonably priced auto-guidance systems have made a clearer cost justification for investment in this new technology. As many of the benefits of auto-guidance technology become increasingly evident, early adopters continue discovering additional advantages.

REPORT

Artificial Intelligence and the Future of Space Exploration



On February 18, 2021, NASA successfully landed its Perseverance rover on the surface of Mars after a 203-day journey to the Red Planet. Perseverance began its descent shortly after arriving, which required NASA to rely on the highly complex landing systems aboard the spacecraft to guide it to its final resting spot within Jezero Crater during a period known as the “seven minutes of terror.” Because the distance between Earth and Mars does not allow for real-time hand-steering of the rover to the surface, NASA utilized artificial intelligence AI to scan the landing site prior to landing the rover and safely guide Perseverance to its destination.

In addition to the landing process, NASA also equipped the rover with scientific instruments that use AI to perform guidance maneuvers and rock and sediment chemistry studies during its mission. The

Planetary Instrument for X-ray Lithochemistry is attached to Perseverance's robotic arm using a hexapod and is guided by AI to get the most accurate aim for its X-ray beam to determine rock textures and structures. The rover is also equipped with a SuperCam that uses AI to identify, zap, and vaporize rock targets with a pulsed laser to study their chemical makeup.

What is AI & Machine Learning?

AI refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. This also extends to any machine that perceives its environment, takes actions, and mimics cognitive functions associated with a human mind such as learning

and problem-solving. AI aims to solve traditional problems like reasoning, knowledge representation, planning, learning, perception, and the ability to move and manipulate objects based on a given situation.

One of the most commonly cited benefits of AI is automation, which has significant impacts across multiple industries. Automation is used to improve productivity and increase production and allows for more efficient use of materials and reduced lead times. AI in automation helps streamline resources to provide availability for more critical or complex tasks.

We use AI to make smarter decisions. With technology that can be used to coordinate data delivery, analyze trends, develop data consistency, provide forecasts, and quantify

uncertainties, AI technology can help us make the best unbiased decisions for a specific scenario. AI systems eliminate human emotion, drawing patterns in data and delivering accurate results faster than human capabilities.

We also utilize AI and machine learning technology to understand the potential outcomes of different scenarios and trends. Machine learning algorithms build predictive models based on sample data to create patterns and can make conclusive decisions

without being explicitly programmed to do so. We further use a form of machine learning, called deep learning, to mimic human capabilities of performing classification tasks directly from image, text, and sound data. We train these algorithms with big data and artificial neural network architectures that contain many layers, which is particularly important for safety-critical applications.

We benefit from AI and machine learning by using these technologies to reduce human error, handle repetitive jobs, and maintain business continuity. Similarly, AI and machine learning technologies positively impact our support to the complex missions that define the future of exploration and national security operations in space.

AI & Machine Learning in Space Operations

Current space exploration missions use AI and machine learning capabilities in many areas of space operations including mission planning and operations, data collection, autonomous navigation and maneuvering, and spacecraft maintenance. Future missions will need to rely on the same.

Mission Planning

The Entry, Descent and Landing flight dynamics team had to rely heavily on AI for mission planning and complex scheduling systems to get through the “seven minutes of terror” during the Perseverance mission. Mission scientists and engineers consider scheduling to be a domain where we can apply AI techniques due to the intricate planning involved with these systems. Without the use of AI, scheduling for a mission requires large teams to work many hours to meet the requirements of the mission. By using AI, we can alleviate the need for these human resources by programming the spacecraft to determine for itself how to intelligently execute a command given a specific function based on past experiences and its environment.

Realistic scheduling problems typically involve many constraints. Offsetting conflicting constraints and performing trade-offs greatly increases the complexity of scheduling. We can use AI to address key scientific and engineering mission constraints and optimize the schedule accordingly to satisfy all needs.

Mission Operations

AI is used for autonomous operations for space

missions. Through the European Space Agency's ESA technology transfer program, the Italian start-up company, AIKO, developed a software library called MIRAGE that is used to enable autonomous operations for space missions. Using these operations, the spacecraft itself can perform autonomous replanning, detect events (both internal and external), and react accordingly, ensuring fulfillment of mission objectives without the delays introduced by the decision-making process on the ground.

We can also use AI and machine learning to assess safety-critical missions and evaluate operational risk analysis. These technologies allow for risk mitigation systems to process large amounts of information based on indicators from nominal operations and past performance where anomalies occurred. However, without deep learning using ANNs, we could not confidently assign a risk level to events and would require expert supervision as a result. Once we have trained a model to identify risk categorization, it can use the knowledge to evaluate real-time risk assessments.

Data Collection

Over the past decade, the volume of data we have collected from Earth-observing spacecraft, deep space probes, and planetary rovers has increased significantly for ground infrastructures used to distribute and deliver the data to multiple end users. Having the ability to optimize the vast amount of data collected from scientific missions and analyze the data using AI automation positively impacts how data is processed and transmitted to the end user.

AI used aboard spacecraft can autonomously detect and characterize features that are nominal, such as typical weather patterns, and differentiate them from unusual patterns like smoke plumes from volcanic activity to create maps and data sets. We can use AI to determine which data sets are important to send to ground segments for processing. We can also use AI technologies to remove data that provides little to no significance. This can ease burdens or constraints the space-to-ground networks experience with the transmission of large-volume data.

Autonomous Navigation and Maneuvering

As we saw during Perseverance's arrival to Mars, ground operation communication capabilities do not always allow for continuous human monitoring and operations of the spacecraft. Autonomy in navigation allows for spacecraft to travel through interstellar space and perform complex maneuvers for arriving at and landing on distant celestial objects. Human intervention to control a spacecraft cannot occur in real-time from the ground due to the lag in communications in deep space. Since spacecraft cannot wait for commands in given situations that require immediate determinations, using AI and machine learning facilitates guiding and maneuvering a spacecraft while freeing up human resources for other mission activities.

The risk of collisions between man-made objects

in space is growing. With the increase in space debris and the launch of mega-constellations, the situation is expected to get worse. Therefore, another area where machine learning is being tested is in space situational awareness and conjunction events, where two or more spacecraft arrive at the same point and time. Ideally, by identifying conjunction events requiring maneuver action, we can capture specific data for events and operator responses to feed into a machine learning algorithm in order to determine and mitigate future events. However, edge-case scenarios or scenarios that occur only at an extreme operating parameter, can be difficult for training since they can be unique and hard to capture.

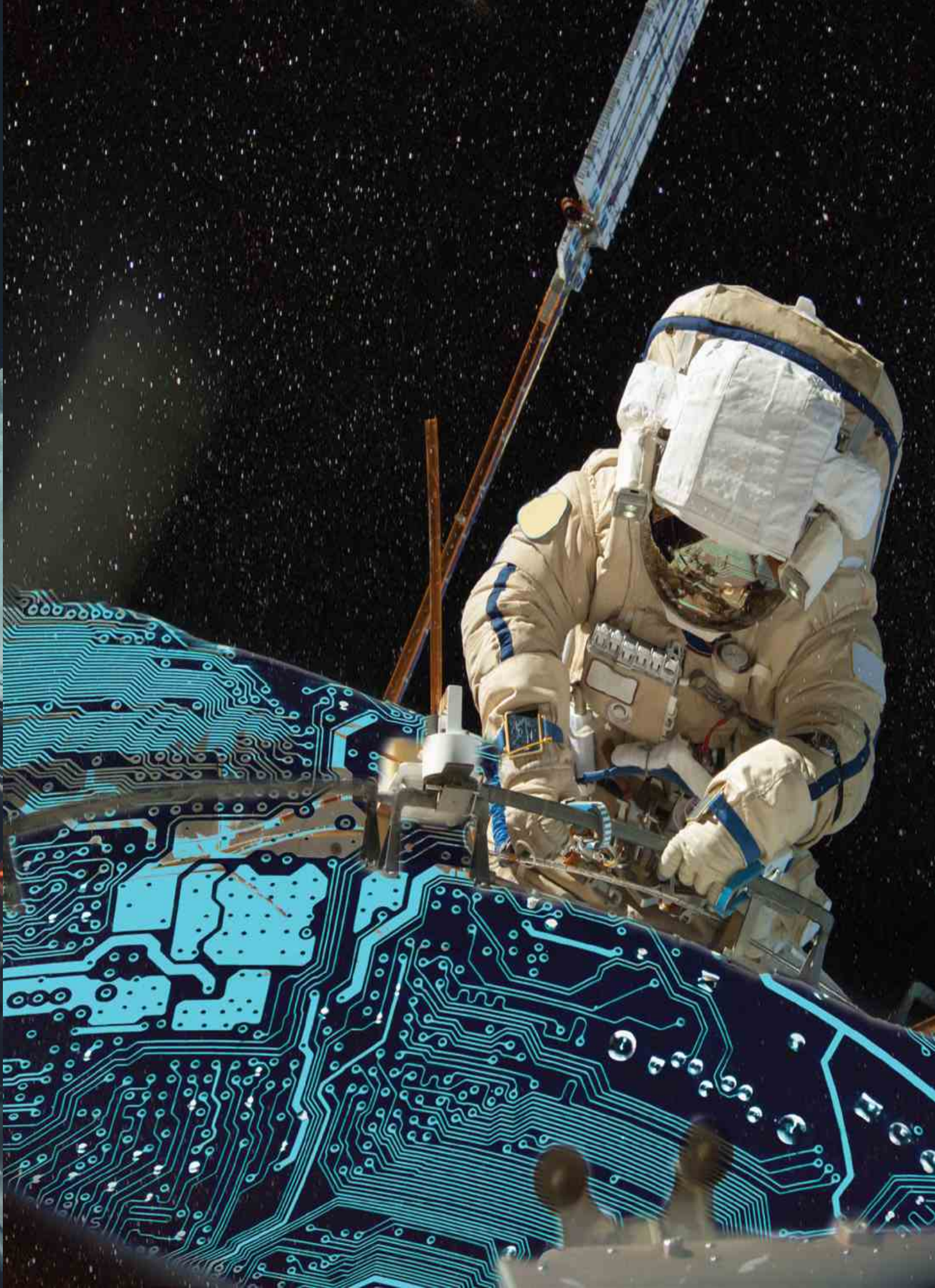
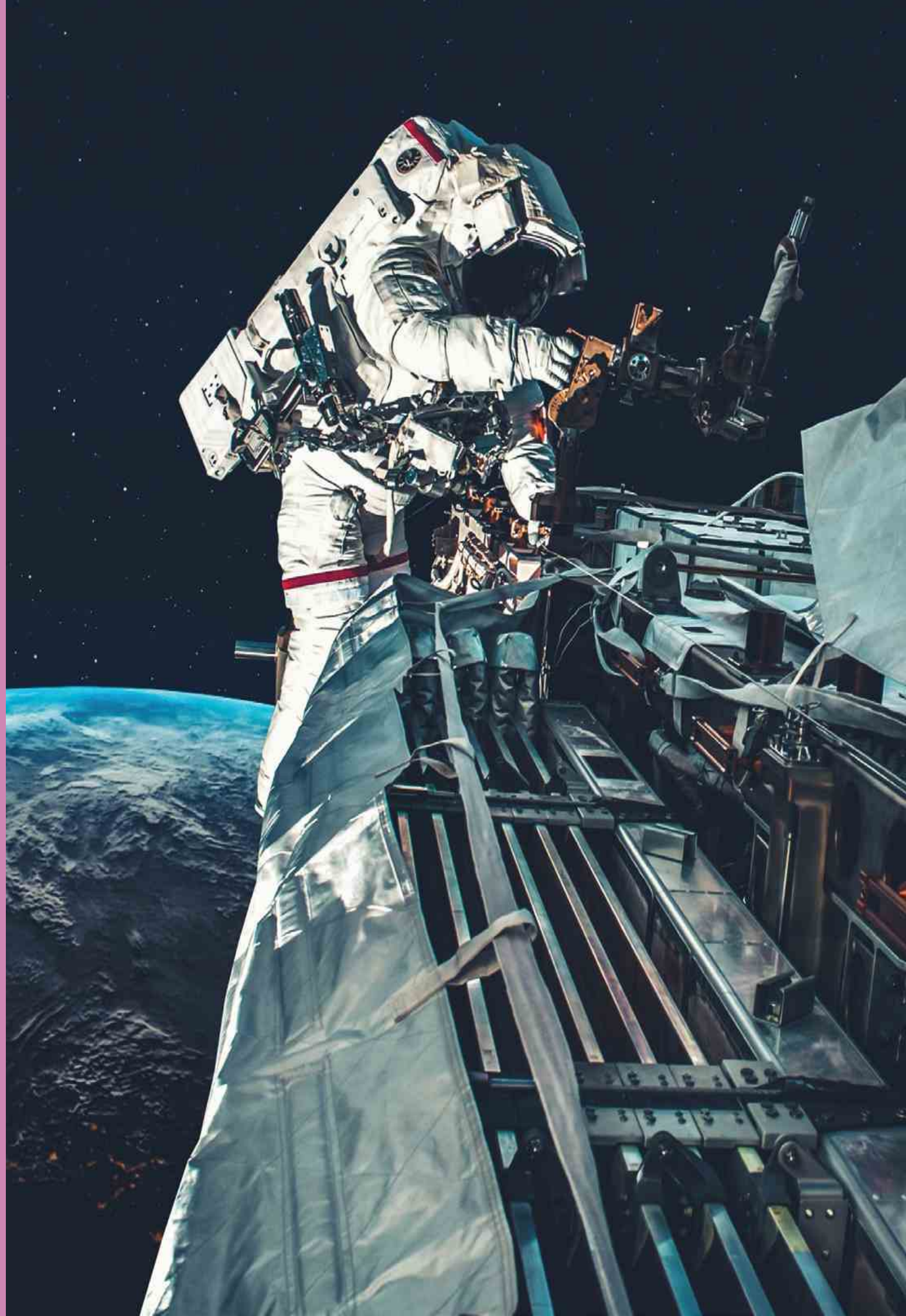
On-Orbit Spacecraft Maintenance

As we investigate the future of space exploration, we cannot overlook the need for spacecraft maintenance missions. The spacecraft we are launching today are designed for routine assisted and self-maintenance including hardware upgrades, refueling, and service for jammed systems like solar arrays.

NASA's On-orbit Servicing, Assembly, and Manufacturing 1 OSAM-1, formerly called Restore-L, is a robotic spacecraft equipped with the tools, technologies, and techniques needed to extend the life of satellites, even if they were not designed for servicing. During its mission, the OSAM-1 spacecraft will rendezvous, grasp, refuel, and relocate a U.S. Government-owned satellite to extend its life. Using the attached payload called Space Infrastructure Dexterous Robot, OSAM-1 can assemble and install a 9-foot communications antenna and add a 32-foot beam to the government satellite.⁷ The maintenance mission technology supported by AI and machine learning technologies includes autonomous, real-time relative navigation systems, dexterous robotic arms that precisely execute assignments, and advanced tools to execute servicing tasks.

Conclusion

AI and machine learning capabilities are making significant impacts in the space industry by creating efficiencies in mission planning and operations and providing scientists with the ability to explore the far reaches of space. While automation of tasks paves the way for the use of AI, the ability for spacecraft to become fully cognitive machines, capable of making critical decisions based on their current environment, without reliance on ground systems to perform essential functions will create more time for humans to spend on valued and more complex research activities.



REPORT

The Middle East space race



Iran launched the dummy satellite into space taking an important step in its quest for an autonomous satellite program. In an earlier test, the indigenously fabricated Safir launch vehicle did not reach orbital velocity in what was apparently the second apparent launcher systems test ahead of this month's launch.

Analysts' responses to this month's launch have been mixed with some viewing it as an important indicator of progress. Others sought to present the test as a further indicator of the perceived dangers posed by Iranian ballistic missile and nuclear programs, while some have cast doubts on Iranian claims that the launch was successful. Stockholm International Peace Research Center researcher Shannon Kile told ISN Security Watch that there is "no doubt" that Iran has made significant progress in space R&D in recent years, adding, "There was a launch a few days ago of something and it is not quite clear what it was."

Initial Defense Ministry claims that the country's first domestically produced telecommunications satellite, Omid, had been launched with the vehicle were quickly refuted by government officials.

President Mahmoud Ahmadinejad confirmed that Omid had not been launched in a speech last Saturday in Arak in which he was quoted as

saying that Iran now had the "advanced technology to launch its first remote-sensing telecommunication satellite into space."

The speech came shortly after the head of the Iranian Space Agency announced plans for Iran's first manned space flight within 10 years. Iranian officials have repeatedly made statements regarding the development and capacity of space systems and related plans that have turned out to be grossly overoptimistic.

Last year, Iranian leader presided over the opening of Iran's space center and second launch site at Emamshahr in a remote northern desert region. He retains at least titular authority over the Iranian space program as head of the governing Iran Space Council, which has authority over Iranian Space Agency activities.

Seeking autonomy

While the paucity of reliable, independent, extant information on the Iranian space program makes it all but impossible to ascertain actual progress, this month's Safir launch appeared to constitute a significant step on the path to an independent satellite imaging capacity which, if achieved, would be seen as a major strategic threat by western and allied Arab powers and Israel.

"I think their Iran's intentions are very, very

broad," Yiftah Shapir, of the Institute for National Security Studies in Tel Aviv, told ISN Security Watch. "They want to be able to build their own satellites; they want to be able to launch their own satellites."

Iran is reportedly working on five satellite programs, though little information is available on the development status of several of these. Iranian claims in January 2006 that the Mesbah research satellite - developed with Italian assistance - would be launched within three months came to nothing and no launch further launch date has been announced.

Iran does have a presence in space through the Russian-made Sinah-1, launched from Plesetsk cosmodrome in Russia on 28 October 2005.

Asked if Iran now enjoys a significant imaging capacity through the Sinah-1, Shapir said, "No. the satellite that was launched has a camera, but it is not a camera that can bring you pictures good enough for any other purpose not a resolution that would allow you any military significance."

The fact that Iran was forced to turn to Russia's Polyot company both for the launch vehicle and satellite fabrication points to developmental problems with Iran's launcher and satellite fabrication which may, or may not, have been overcome in intervening years.

The Zohre (Venus), a telecommunications satellite, is being produced for Iran under the terms of a 2005 deal with Russia, but the launch date has reportedly been put off until next year at the earliest with the delay apparently caused by contractual issues.

Asked if there had been launch vehicle progress through the three Iranian launcher tests, Kile said, "Yes, they are definitely making technical progress." He cautioned that the Iranians were not necessarily going to have a system that was "able to deploy immediately."

"I think one of the issues people are looking at is: Is the technology Iran is developing now purely indigenous or are they getting outside assistance," he said. "The most likely source of outside assistance would be possibly North Korea but more likely Pakistan. The recent [ballistic] missile that the Iranians launched, the so-called Ashoura missile, may be a derivative of a Pakistani design."

Dual use potential

While the specter of an independent Iranian satellite program raises concerns in the west, the identity of the launch vehicle is itself a potentially important indicator of progress in Iranian ballistic missile development.

Kile notes that the launcher is "where everyone is concerned because that technology is dual use and could also be used directly in military applications with warheads."

According to some reports, the rocket used in this month's test is a derivative of the Shahab-3 medium range ballistic missile, for which the Israeli Arrows anti-missile system is being developed as a direct counter, with US funding.

Referring to the second launch, Shapir said: "What they showed on television in February was definitely a Shahab-3. However at least one of the sources I read said that what was actually launched or tested in February was not a Shahab and that the footage that they released did not belong to the vehicle actually tested."

The use of a Shahab-3 derivation for this purpose can be seen as confirmation of the shelving of the Shahab-4 - an impression bolstered by the reported extension of the range of the Shahab-3B to encompass the initial intended range of the Shahab-4. Again, speculation abounds.

"It looks like the Iranians are moving away from liquid fuel missiles to solid fuel missiles and that is a big technological leap," Kile said.

"If you are looking to have a military program solid fuel rockets are the way to go because you don't have to have all the fuelling trucks, you don't have to have all the associated infrastructure, you can fire them on much shorter notice," he said. "So if it is the case that Iran is indeed moving towards solid propellant ballistic missiles that would have important military implications."

It is important to note that there does not appear to be significant credible evidence of the militarization of Iranian Space Agency activities, which appear clearly aimed at this point at civil scientific R&D and

the related deposit of space vehicles into Low Earth Orbit (160km-2000km).

The Iranian Defense Ministry was involved in the fabrication of the rocket launched in February 2007, which carried research created material created by the ministries of science and defense. The Defense Ministry has also made it clear that it sees the development of a satellite capacity as an important national priority.

With the potential relationship of Iranian missile programs to the country's nuclear intentions a key source of concern in western capitals, the utilization of the Iranian space program as a potential driver of ballistic missile development may attract unwanted international attention to the space program. Asked what the strategic import of Iran developing a satellite capacity would be, Kile said: "It is not so much the satellite capability per se but if Iran were to eventually develop the capability to launch satellites into medium and high earth orbit, to have that capability means that you are also going to have the capability to manufacture ballistic missiles that can deliver a military payload to quite some distance, well in excess of 2,000km."

Developing programs

"Most countries in the Middle East have their own communication satellite which they bought, Egypt has one; Turkey has several; Saudi Arabia has too; the UAE has the most advanced communication satellite in the world." Shapir said, adding, "The Iranians have been trying to do the same for the past 30 years and the project is not getting off the ground."

Egypt launched its first imaging satellite, EgyptSat1, in April 2007 in a cooperative venture with a Ukrainian firm. The planned launch of a second reconnaissance satellite, Desertsat, by the end of 2007, has come and gone without further statements of intent. According to reports, EgyptSat's multi-spectral camera is the first of its kind deployed by a Middle East state, transmitting black-and-white, color and infrared images. Some Israeli analysts believe the launch caused a significant shift in the strategic balance between the countries and in the wider Middle East.

Shapir disagrees: "It has a camera but I don't think it has any military significance. It is a research satellite with the goal of training engineers to be able to build satellites, to be able to conduct experiments in space." The Saudis also appear to have long-term plans for achieving a significant presence in space with Saudisat 3, launched in April 2007, utilizing imaging technology provided by a South African firm.

Asked how advanced the Saudis are in satellite R&D, Shapir said, "They are building, with the help of some western companies, their own research satellite but this is very, very rudimentary."

Israel: building capacity

Israel is seeking to maintain its strategic edge in space, launching the Eros B in April 2007, whose imaging system is said to be capable of pinpointing objects as small as 70cm across, as opposed to EgyptSat1's estimated 4m across, and highly advanced TecSAR this January.

"Israel is much, much more advanced than any other countries in the Middle East with the Ofeq and EROS military imaging satellites," Shapir said.

Israel has far greater indigenous development capacities than its Middle East competitors and a clear preference for autonomous development of highly sophisticated imaging and satellite systems.

The Shavit launcher utilized by the Israeli program has encountered significant problems in the past leading to two launcher failures - including the loss of the multimillion dollar Ofeq 4 and 6 reconnaissance satellites.

In response, Israel's January launch of the TecSAR spy satellite was conducted from an Indian facility utilizing an Indian rocket. Shapir explained that the heavier weight of the Indian launcher allowed for the deposit of a far larger satellite payload than the Shavit is capable of deploying through the latter's retrograde westward launch.

The decision provoked significant discord in the Israeli space industry where opponents reportedly saw it as directly undercutting Israel's autonomous development model. This, despite the prior launch of the Eros A and B from a Russia cosmodrome, utilizing Russian Start-1 rockets.

Shapir went on to explain that space program cooperation appealed as an important way to cement warming relations with New Delhi in light of the Israeli military's refusal to buy proffered Indian helicopters and UAVs. The TecSAR's synthetic aperture radar is reportedly capable of capturing and transmitting images of 10cm across and can operate in darkness and penetrate thick clouds. Israel's Defense Ministry plans to launch a further highly sophisticated imaging satellite, Opsat, by the end of 2009, details of which remain under wraps.

It is clear that the small Israeli reconnaissance satellite array provides Israel with a clear strategic advantage that the Iranian space program looks unlikely to bridge in coming years, including the capacity to intercept Iranian military and civil communications, potentially crucial in the event of an outbreak of hostilities.

With the world's focus understandably on regional flashpoints and conflicts and prospects for the Iranian nuclear program, the extension of regional tensions to space has largely been ignored, mired in a welter of competing claims and counter-claims.

The rising potential of emerging space nations



What was once a “space race” between the United States and the Soviet Union has rapidly expanded worldwide for both commercial and government-funded projects. With a current global space economy at an estimated \$360 billion as of 2018 and the commercial sector contributing \$277 billion of that to various space technology companies, there is a clear socioeconomic as well as technological benefit for countries developing space programs.

What are emerging space nations?

The global space economy is experiencing rapid growth from countries engaging in space activities for the first time, as well as a revival from those who once were active in the industry. New trends have resulted in the emergence of these nations as viable space entities. Government support is critical to the success of

these developing space programs, which often lack socioeconomic investment, access to space, and aeronautic-related partnerships with other nations. Commercial companies also are navigating the space sector among these countries and adding to their success by creating innovative, low cost technologies and providing essential resources in support of these economies. Four such emerging space nations are South Korea, Ethiopia, Australia, and India.

South Korea

Established in 1989, the Korea Aerospace Research Institute KARI has grown in project size, scope and investment over the last 15 years. Currently, KARI is developing Unmanned Aerial Vehicles UAVs and high-altitude airships in addition to next-generation multipurpose helicopters. The organization has also established the Korean Multipurpose Satellite KOMPSAT program and the Communication, Ocean and Meteorological

Satellite COMS program, founded in 1995 and 2002 respectively. Originally, these programs were used to develop and launch satellites in partnership with foreign nations and companies. However, one of KARI's more recent milestones is launching a satellite on its own soil for the first time in 2013.

In 2016, KARI announced a partnership with NASA and created the Korean Lunar Exploration Program, a two-phase program with the goal to launch a lunar orbiter in 2022 aboard a Falcon 9 rocket and a lunar orbiter, lander and rover together from South Korea's Naro Space Center by 2030.

The country's emerging space program demonstrates the need for strategic international partnerships and commercial groups to enable growth. South Korea's funding for the space industry is significantly lower than other nations. However, the Republic of Korea government is committed to space development as a means to foster the expansion of

high-tech firms that will create more high-paying jobs and will, in turn improve the Korean quality of life. **Ethiopia**

The African continent struggled to establish a lasting space program in its countries. However, with assistance from China, Ethiopia launched its first observatory satellite into space in December 2019 marking a major milestone for the country and for East Africa.

Like other African nations, Ethiopia's government instability, supply shortages and civil unrest took priority, resulting in less available resources for aerospace engineering. The foundations for a space program were only finalized in recent years, with the Ethiopian space science and technology institute ESSTI founded October 14, 2016 to “enable the country to be a robust contributor for the development of aerospace science and technology.

Ethiopia's use of space technology for its sustainable developments showcases the agricultural benefits of investing in its space program. Researchers in Addis Ababa hope the satellite will allow Ethiopia to observe the northern and southern hemisphere and monitor weather patterns to predict its effects on crops and livestock.

Australia

Australia has engaged in the space industry since the 1980s, including oversight of its National Space Program by the Australian Space Office ASO prior to the disbandment of the office in 1996. The dissolution of the ASO diminished the coordinated efforts and government support for the Australian space program.

In 2019, Australia's government reestablished a space program with renewed vigor and founded the Australian Civil Space Strategy, outlining a plan to triple the size of Australia's space sector within the next ten years, increasing its current market size of \$3.9 billion to \$12 billion by 2030. The strategic goals include increasing national capabilities, promoting safe practices, and building a space workforce that supports a thriving aerospace industry. The Strategy is driven by four Strategic Space Pillars -open the door internationally, develop national capability with competitive advantage, ensure responsible regulation, and inspire the lives of all Australians.

India

The Indian Space Research Organization (ISRO) was founded in 1969, but unlike NASA and the Soviet space programs, which prioritized putting humans in space, India focused on launching satellites. With launch assistance from the Soviet Union, India launched its first satellite called Aryabhata in 1975. In 2008, India launched 11

satellites nine of them foreign – and became the first nation to launch 10 satellites in one rocket.

India's key goal for its space program is economic progress rather than the pursuit of record-breaking feats. Vikram Sarabhai, father of the Indian space program, laid out India's space goals in 1969, stating: “We do not have the fantasy of competing with the economically advanced nations in the exploration of the Moon or the planets or manned space-flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society,” as stated on Indian Space Research Organisation' website.

Nigeria

Nigeria, among other developing nations also followed suit, directing their substantial resources to exploit outer space programmes for socioeconomic gains, as well as national pride among the committee of nations.

Few people know or remember that the National Aeronautics and Space Administration (NASA) built the first satellite earth station in Nigeria the NASA Tracking Station 5, in 1961 in Kano to monitor the Gemini and Apollo space missions. But the station was closed in 1963 before both missions were concluded in 1966 and 1972, respectively. In 1976, at an ECOWAS meeting in Addis Ababa, Nigeria first declared its space ambition, and it took about 23 years to set up a space agency. In May 1999, the National Space Research and Development Agency (NASRDA) was established. Currently, Nigeria's space programme is managed by NASRDA. And in 2000, the National Space Policy (NSP) was approved, and a 25-year roadmap for its implementation was endorsed in 2005.

Several benefits can be derived from a well-managed space programme of a country. Space technology with all that comes with it is a national asset that can be reused to develop new products and processes, to the benefit of economic growth in new companies, new jobs, and the resulting contribution to the Gross Domestic Product.

While the Nigerian space program has stated its goal to launch a Nigerian built satellite on a Nigerian-built and located vehicle, perhaps a more useful goal is to leverage space for the

socio-economic development of the country through observation and security technologies. Nigeria, in particular, could benefit from Earth-observation data to track crop production, monitor desertification of the northernmost part of the country, or assist with the fight against Boko Haram. If the government of Nigeria chooses to continue the development of a Nigerian launch vehicle, it should consider expanding its capacity by building programs to include rocket design and manufacturing.

South Africa

In the 1980s, South Africa kicked off its first space program. The programme centred around the development of an Earth observation satellite, Greensat, as well as the supporting facilities and launch capability. Following the historical changes in South Africa in 1994, due to large scale government and defence industry strategic realignment with critical immediate social and economic priorities, the Greensat satellite program and a significant portion of its associated programs were discontinued.

All was not lost, and a critical subset of the satellite integration and testing capability was transferred to the academic environment. This transfer leads to the SunSAT (Stellenbosch University Satellite) mission, which led to the launch of the first South African satellite, SunSAT-1, in 1999. The activity in the academic environment grew into a university spinoff company, Sunspace, which eventually absorbed back into the state-owned defence conglomerate Denel, with the creation of a new entity, SpaceTeq.

After SunSAT, more South African satellites were launched such as Sumbandillasat in 2009, ZACUBE-1 in 2013, nSight-1 and ZA-AEROSAT in 2017 and ZACUBE-2 in 2018. The Department of Science and Technology, DST, established the South African National Space Agency (SANS) in 2010, who has been heading up EOSAT-1 program as part of the Africa Resource Management Constellation (ARMC).

Currently, South Africa is very active in radio astronomy, with large projects such as the MeerKAT project and the Square Kilometre Array (SKA). The South African Large Telescope (SALT), located in Sutherland, South Africa, is a 10-meter optical telescope mainly used for spectroscopy. Operation of SALT is led by the SALT Foundation, made up of academic and government institutions from all over the world.

MIDDLE EAST

Why Iran's satellite launch does not amount to an ICBM test

by Michael Elleman

Iran attempted and failed to lift the Payam-e Amirkabir satellite into orbit using a Simorgh rocket on 15 January. Israel's Prime Minister Benjamin Netanyahu responded to the news by stating that the purportedly 'innocent satellite' launched by Iran was in reality 'the first stage of an intercontinental missile', which he claims is in violation of international agreements. Not to be outdone, US Secretary of State Mike Pompeo tweeted, 'In defiance of the international community & UNSCR 2231, #Iran's regime fired off a space launch vehicle today. The launch yet again shows that Iran is pursuing enhanced missile capabilities that threaten Europe and the Middle East.'

Iran's failed launch was neither a violation of United Nations Security Council Resolution 2231, nor was it an intercontinental ballistic missile (ICBM) being tested under the guise of a satellite launch.

Iran's space programme

Iran's interest in space research dates back to 1967, long before the Islamic Revolution of 1979. Active research and development aimed at creating satellite-launch vehicles (SLVs) did not begin until around 2000, and Iran's first attempt at orbiting a small satellite took place in February 2008, with the two-stage Safir SLV. The launch failed, although Iran finally succeeded on its third attempt a year later.

Iran unveiled a mock-up of the Simorgh in 2010. After a series of delays, the first two launches of the Simorgh took place in April 2016 and again in July 2017, with each ending in disappointment. The third attempt on 15 January also failed. Iran's Minister of Information and Communications Technology, Mohammad Javad Azari Jahromi, indicated that the first and second stages of the space mission were completed successfully, but that the Simorgh's third stage failed to accelerate the Payam satellite to orbital speed.

The Simorgh is a three-stage rocket. Its first stage weighs about 75 tonnes, and is powered by a cluster of four Nodong engines and four small steering engines. The second stage relies on four low-thrust engines originally designed for steering the now-obsolete Soviet submarine-launched missile, known as the R-7 or SS-N-6. The third stage consists of a newly designed, Iranian-

produced solid-fuel motor weighing less than a tonne. Apparently, this new motor either failed to separate from the second stage and ignite, or it malfunctioned during operation.

Differences between SLVs and long-range ballistic missiles

The technologies and components employed by satellite launchers, including the *Simorgh*, and long-range ballistic missiles are similar. Both use powerful rocket engines, high-strength and lightweight airframes, inertial navigation and guidance units, stage- and payload-separation mechanisms, as well as tracking and telemetry systems to support development and operations. Despite these similarities, accusations that Iran's use of *Simorgh* to launch satellites is a cover for ICBM development are misguided.

For example, ballistic-missile carry payloads must survive the rigours of re-entry into the Earth's atmosphere, requiring development of robust thermal- and mechanical-protection systems. SLVs, including the *Simorgh*, carry payloads that operate in space, and that are not subjected to challenging re-entry dynamics. Satellite-launch vehicles and long-range ballistic missiles employ distinctly different trajectory to fulfil their respective missions. SLVs perform well when using low-thrust, long-action time engines, whereas ICBMs must climb to higher altitudes to maximise achievable range. This requires upper stages equipped with high-thrust engines. The *Simorgh's* configuration, featuring low-thrust engines in the second and third stages, is consistent with a rocket optimised for satellite launches, not ballistic missile trajectories.

Perhaps the least obvious difference between the two systems lies in their operational requirements. Prior to lift-off, SLVs including the *Simorgh* are prepared over a period of many days, if not weeks. Components and subsystems can be checked and rechecked. If a technical glitch emerges during the countdown, the launch can be delayed until it is fixed. Similarly, SLV launches can wait for ideal weather conditions. Whereas ballistic missiles, like any weapons system, must be poised to operate without delay and under all conditions. A missile's operational demands impose a more rigorous validation scheme

that includes an extensive test-flight programme consisting of at least a dozen launches before being declared combat ready.

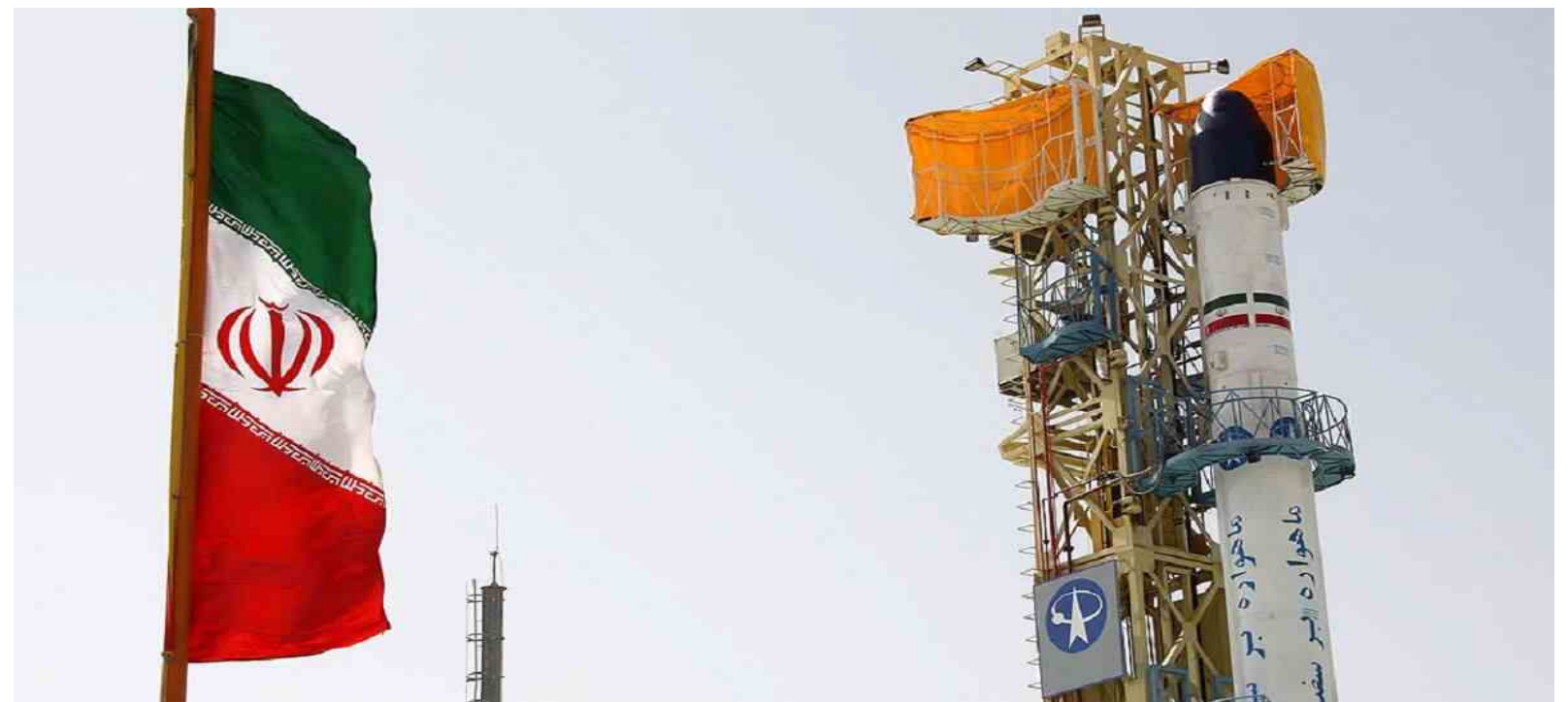
Finally, the *Simorgh*, like other SLVs, can be prepared for launch over an extended period, at a fixed and known location without fear of being interdicted by an adversary. Ballistic missiles, on the other hand, are expected to be targeted by foes so must rely on mobility, concealment and prompt preparations to avoid pre-launch destruction. Reducing the size and weight of an SLV is not a critical design parameter, as they need not be deployed on mobile-launch platforms. The *Simorgh's* first stage, which is more than 17m long, 2.4m wide and weighs more than 75 tonnes, is ill-suited for mobile deployment as required by most ICBMs.

Satellite-launch activities do offer Iran's engineers an opportunity to accumulate experience and generate data that could aid efforts to develop long-range ballistic missiles. However, the results have limited application to ballistic missiles. Only a fraction of the overall missile development challenges can be addressed when operating an SLV. Other criteria – most notably re-entry technologies, operational requirements and launch-crew training – cannot be adequately addressed while operating the *Simorgh*.

If Iran seeks to transform the *Simorgh* into a long-range missile, engineers would still need to flight test it as a ballistic missile a dozen or more times before it could be deemed a dependable, operationally viable and accurate weapon. For these reasons and others, the trend of other countries has been to convert ballistic missiles into satellite launchers, not the reverse. Further, satellite-launch activities have not decisively contributed to the development of a long-range missile. The *Simorgh* is no exception.

Purpose over capability

Adopted in July 2015, UNSCSCR 2231 endorses the controversial Joint Comprehensive Plan of Action (JCPOA), or nuclear deal with Iran. Unlike the



JCPOA, Resolution 2231 addresses Iran's missiles and their potential role in delivering nuclear weapons to distant targets. The resolution states: 'Iran is called upon not to undertake any activity related to ballistic missiles designed to be capable of delivering nuclear weapons.'

As argued in a new IISS book, *Uncertain Future: The JCPOA and Iran's nuclear and missile programme*, the resolution proscribes Iranian missiles based on their intended purpose – those designed to carry nuclear weapons – rather than their inherent capability.

Some of Iran's current arsenal of ballistic missiles are indeed designed for nuclear delivery. The design heritage, performance characteristics, including throw-weight capacity, and the size of the payload compartments (i.e. re-entry vehicle or nosecone) of the *Shahab-3* and *Khorramshahr* medium-range missiles exhibit clear signs of nuclear intent.

Other missiles, such as the *Shahab-1* and -2, are based on the export versions of the Soviet-era *Scud-B* (R-17E) and *Scud-C* (R-17M) respectively. The export versions of the *Scud* missiles were specifically designed for conventional warheads. The nuclear version of the *Scud-B* (R-17) has measurably different external dimensions than the export versions. The *Scud*-based missiles imported by Iran from North Korea are clones of the R-17E and, therefore, are presumed to be designed for non-nuclear use.

Finally, Iran's *Qiam*, *Sajjil* and variants of the *Ghadr* missiles are all equipped with a tri-conic nosecone that is too small to house Iran's prospective nuclear-implosion device described in documents captured and presented by Israel, rendering them designed to be non-nuclear capable.

The *Simorgh*, as discussed above, is designed and optimised for use as an SLV, not as a ballistic missile, let alone

one for delivering nuclear weapons. It could certainly be transformed to perform as a ballistic missile, but this would require a new design and configuration, and then it would have to be subjected to a flight-trial programme to validate its military utility. Clearly, the *Simorgh* SLV does not violate the word or intent of UNSCR 2231.

Saving diplomatic capital

While they do not violate UN resolutions, continued satellite launches using the *Simorgh* do pose some risks. Successive launches provide training and experience to Iran's missile experts that could contribute to a future ICBM development effort. The potential contributions, however, will not significantly shorten the time or reduce the expenses needed to create a militarily viable long-range missile. The US and its allies should prioritise their non-proliferation policies to address

Iranian activities that could most directly lead to the creation of long-range missiles.

To this end, the Khorramshahr missile – which uses propellants that are more energetic than those employed by Scud and Nodong systems – is of much greater concern. The higher energy propellant combination allows engineers to reduce significantly missile size and mass, which in turn could form a basis for a road-mobile, nuclear-capable ICBM.

Similarly, if Iran restarts development of the two-stage, solid-fuel *Sajjil* missile, which has not been flight tested in eight years, and begins employing large, solid-fuel boosters on its SLVs or missiles, the international community would be right to protest, as such developments could be exploited to fashion a nuclear-tipped ICBM.

In short, diplomatic capital should not be diluted by protesting Iran's use of the *Simorgh* SLV, but should instead focus on Iranian actions that pose the greatest risk to international security.





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