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CAPSTONE: Proving a path to the Moon



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On the rise

Frank Lloyd Wright, noted for designing buildings in harmony with humanity and the environment, once remarked, "Less is more only when more is too much." His sentiment is food for thought when considering the state of the smallsat industry which, according to a recent report from Euroconsult, is expected to generate a market value of US\$84 billion over the next ten years.

The market intelligence report anticipates that 18,500 smallsats weighing up to 500kg will be launched between 2022 and 2031. That equates to one ton per day on average. Too much? Perhaps, since the report goes on to site quite a few challenges facing both manufacturers and launchers. These include "high inflation, limited market addressability, difficult profitability, oversupply risk, and concentration of the market by a handful of established players." Add the growing problems of space debris and overcrowding to the list of challenges and it's easy to see that the way forward is not entirely rosy.

The risk of collisions with other satellites or any one of the millions of pieces of orbital debris is a big concern. According to the Global Risks Report 2022, published by the World Economic Forum, "Collisions could hinder future space development or aggravate international tensions. This is because when objects in space collide, they may break up and produce debris that—even at sizes of 1 to 5 centimeters in diameter—could cause severe damage."

The report cites the Kessler Effect (first identified by NASA scientist, Donald Kessler in 1978) as a cautionary tale: "This describes a scenario where the density of objects (satellites and debris) in LEO is high enough that collisions between objects could cause a cascade in which each collision generates space debris that increases the likelihood of further collisions and an exponential growth of debris. One implication is that the distribution of debris in orbit could render space activities and the use of satellites in specific orbital ranges difficult for many generations."

As catastrophic as this suggestion is, very little has been done by any government to turn the situation around.

Indeed, a recent Global Risks Perception Survey found that 76 percent of respondents characterized the current state of international risk mitigation efforts in space as either "not started" or in "early development." We'd better get a move on.

In this issue of the magazine, we take an in-depth look at NASA's CAPSTONE mission. The 55-pound CubeSat is now making its way to Near Rectilinear Halo Orbit around the Moon supported by a team of mission specialists from Advanced Space, Terran Orbital, Stellar Exploration, and NASA. We also find out how three companies—Pacific Dataport, Inc., Kratos, and Astranis—combined their talents and technologies to deliver broadband to rural and indigenous populations in Alaska.

Laurence Russell shares the highlights of his exchange with KT SAT, Korea's leading satellite operator, which has recently introduced an exciting new service that provides Earth observation imagery, video, and analytics data through an AI-powered geospatial analytic platform. Russell also interviews Vincent Dedieu, COO and Deputy CEO of Sodern, a world leader in star tracker development. The two discuss emerging markets, customized applications, and the need for a space-based surveillance system.



Crispin Littlehales,
Executive Editor ●●●



Photo Astranis Alaska Satellite

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Spire Global announces services deal to scale constellation

EAST ASIA: Spire Global, Inc., has announced an agreement with HANCOM inSPACE, initially a spin-off by Korea Aerospace Research Institute and now a part of HANCOM Group, for a second mission with Spire Space Services. Hancom will host an optical payload on a second Spire 6U satellite, named HANCOM-2, and Spire will manage the payload integration, satellite launch and mission operations. HANCOM-1, a Spire 6U satellite carrying an optical payload for Hancom, launched in May 2022 on the SpaceX Transporter-5 Mission from Cape Canaveral Space Force Station. It was the first commercial satellite deployed for a private South Korean company.

Hancom specializes in commercial and government applications of image analysis, including detection of vehicles, aircraft and ships, changes in roads and buildings, and pine tree death detection. The HANCOM-1 and HANCOM-2 missions are focused on collecting optical imagery for applications in the agriculture sector, including landscaping applications and the expansion of its existing image analysis portfolio offerings. Hancom plans to launch and operate a constellation of up to 50 satellites.

"Hancom is a pioneer in the South Korean space industry as the first private company to deploy satellites, and we're thrilled to work with them to further build out their constellation," said Joel Spark, Co-Founder and General Manager, Space Services, Spire. "I'm extremely proud of the dedication and ingenuity of our Space Services team for delivering an unparalleled experience to our customers that allows us to continue earning their business."

"The satellite data business has been mainly used in areas such as defense, military, disaster and disaster control due to its characteristics, but now it is expanding to the civilian market," said Choi Myungjin, CEO of HANCOM inSPACE. "HANCOM inSPACE plans to provide solutions that observe crops and predict output through satellite observations; initial target countries are in Asia and the Middle East, where demand for satellite image data is high. The company's ultimate goal is to build an image data service belt that covers all space, aviation, and ground. HANCOM inSPACE plans to continue its cooperative relationship with Spire."

Spire Space Services offers fast and scalable access to space through a subscription model that eliminates the high upfront cost of building and maintaining infrastructure in space. Commercial and government organizations can deploy and operate a constellation of satellites, a hosted payload, or a software application in space with Spire's established space, ground, and web infrastructure. Spire handles the end-to-end management, from manufacturing to launch to satellite operations, and the customer operates the system through a web API. ●



Photo courtesy Gilat/IPT ●●●

Internet Para Todos expands services contract with Gilat in Peru, extending 4G cellular backhaul

SOUTH AMERICA: Gilat Satellite Networks has announced that Internet para Todos (IPT) in Peru is expanding its contract with Gilat, for 4G cellular backhaul services over the Internet.

IPT is a global collaborative between Telefónica, Meta (formerly Facebook), IDB Invest, and CAF. The initiative is bridging the digital divide in Latin America and providing internet connectivity to remote regions of Peru.

Gilat provides 4G cellular backhaul services over the internet that are being deployed at more than 100 sites to provide coverage to rural zones through Gilat's access network. The new multi-year contract addresses 4G connectivity to smaller villages and is expected to further grow over time.

"The services from Gilat have been instrumental in helping us to supply the population of Peru with broadband connectivity, even in the most rural regions," said Teresa Gomes, CEO at IPT.

"It's an honour to expand this important, continuing work with IPT, helping them to overcome technical and economic barriers to bridge the digital divide and increase connectivity in rural areas," said Arie Rohrstock, Corporate SVP and General Manager Gilat Peru. ●

Xona's investment from First Spark Ventures and Lockheed Martin to accelerate LEO GPS alternative

NORTH AMERICA: Xona Space Systems have raised an oversubscribed financing round to accelerate the development of their high-performance commercial satellite navigation network, bringing their total funding to



Xona Engineer Nick Manglaviti setting up hardware-in-the-loop testing at Xona's R&D lab in San Mateo, California. (Photo: Xona Space Systems) ●●●

over \$25M. The round was led by First Spark Ventures who is joined by numerous new investors including Lockheed Martin Ventures, SRI Ventures (of SRI International), Velvet Sea Ventures, Gaingels, Airstream Venture Partners, and Space.VC. Existing investors also continue to show firm conviction in Xona's accomplishments and market opportunity with participation from Seraphim Space, Toyota Ventures, 1517 Fund, MaC Venture Capital, and Stellar Ventures.

Xona is focused on the development of Pulsar – a Low Earth Orbit (LEO) satellite navigation system designed to provide resilient and trusted centimeter-level position anywhere on the globe.

Within the past year Xona more than doubled their full-time headcount, launched their first orbital mission, and signed agreements with major players across the GPS/GNSS ecosystem such as Hexagon | NovAtel and Spirent Federal.

"What the team has been able to accomplish in the past year is awe inspiring," said Xona CEO Brian Manning.

"The massive domain expertise of our supporters in everything from scaling global companies to deep technical knowledge of GNSS is both a validation of our team's capabilities as well as a catalyst that has been instrumental in our growth and speed."

The new capital will accelerate the development of Pulsar through several critical design milestones by expanding the team and building out Xona's new R&D and manufacturing facility in Burlingame, CA to enable more rapid design cycles and prepare for production. Xona's first demonstration mission, Huginn, was successfully launched in May 2022, and their second mission, Muninn, is planned to launch in 2023.

"Xona's approach to GNSS is poised to enable a whole new class of robust & reliable solutions in everything from automotive to drones," said

Manish Kothari, Managing Director of First Spark. "This is a technically challenging problem - a problem which the Xona team is uniquely qualified and experienced to address. We are very excited to be part of this journey with them."

Xona's core mission is to enable modern technology to operate safely in any environment, anywhere on Earth. To achieve this in industries such as automotive autonomy, drones, and aerial mobility, precise knowledge of location and time is critical, and it must be robust against sources of potential interference or degradation. This is driving a need for global infrastructure that can support the demands of these applications as they continue to expand in both capability and geography.

"As customer needs evolve, Lockheed Martin Ventures continues to work with companies we believe are on the forefront of emerging technology and that support increasingly resilient, hybrid systems," said Chris Moran, vice president and general manager of Lockheed Martin Ventures. "We invested in Xona so they can continue to develop and build their commercial system to



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complement the greater Global Navigation Satellite System (GNSS) architecture."

Xona has been making rapid progress towards launching their commercial GNSS alternative. In less than a year the company has successfully tested the core technology for Pulsar in both simulation and hardware, designed, built, and flown the world's first ever privately funded satellite navigation mission, and grown to over 30 employees, all for under \$10 million.

"The world would look very different today without GPS," said Xona CTO Dr. Tyler Reid. "The ubiquitous robust precision that Pulsar can provide has potential to make the same level of global impact, not only in present and emerging markets, but we believe this global high precision can also enable entirely new devices and apps that we haven't even thought of yet."

SES completes \$450M acquisition of DRS Global Enterprise Solutions, doubling US Government Business

NORTH AMERICA: SES and its wholly-owned subsidiary SES Government Solutions have announced the completion of the acquisition of DRS Global Enterprise Solutions (GES) from Leonardo DRS for \$450 million after obtaining all the necessary regulatory approvals. The DRS GES business will be combined with SES GS to create a scaled solutions provider serving the multi-orbit satellite communications needs of the US Government and

supporting missions anywhere on land, at sea, or in the air.

With the combined businesses operating as SES Government Solutions, the new organization will comprise a cross-functional workforce with deep technical expertise and a proven ability to integrate and manage multi-orbit geostationary and medium earth orbit (MEO) services as well as multi-operator network solutions. In particular, SES GS will offer highly flexible second-generation MEO services – via SES's soon-to-be launched O3b mPOWER system – with a unique combination of low latency and high throughput per terminal for high-value missions, to an expanded government customer base. SES GS will also leverage essential tools and expertise in cybersecurity operations, customer support, governance and compliance. The combined business will continue to serve US Government customers under the direction of the SES GS Proxy Board of Directors.

The consolidation of DRS GES with SES GS is expected to unlock \$25 million of annualized run-rate synergies, with government becoming SES's largest data business segment in terms of revenue.

The combined business will be led by David Fields, who assumes responsibilities on August 1, 2022 as appointed by the SES GS Proxy Board. Fields has over 30 years of experience in the satellite communications and information technology (IT) services industries, and joins SES GS from DRS GES. He succeeds Brigadier General Pete Hoene, USAF (Retired), who, after 11 years at the helm of SES GS and decades of dedicated service in the satellite communications arena, will take his retirement.

"I am extremely excited about the potential that this combination unleashes, reinforcing our commitment to



SES completes DRS GES acquisition, doubling USG business and significantly expanding services for US DoD ●●●

provide best-in-class satellite network solutions to the US Department of Defense customers," said Brigadier General Billy Bingham, USAF (Retired), Chairman of the SES GS Proxy Board. "We are delighted to welcome Fields, who comes to SES GS with extensive knowledge and expertise in the satellite communications industry and a demonstrated record of achievement in the US Government sector. Well-respected by industry partners and customers, he has developed deep and trusted relationships with many US Government agencies, and we anticipate David to build on his success through his leadership of the combined business. We would also like to take this opportunity to thank Pete Hoene, whose leadership has resulted in SES GS achieving outstanding growth rate of over 30% in just the last five years. We wish him all the best in his well-earned retirement."

"I am excited to join SES GS and honoured to lead the combined team where we will be delivering best-in-class solutions and state-of-the-art multi-orbit satellite networking capabilities," said David Fields, President and CEO of SES GS. "SES GS will be significantly expanding its differentiated value proposition for the US Government, with a trusted multi-operator network integration and service management solutions. The breadth of our capabilities, now spanning both connectivity and integration, allows for building, managing and supporting the most advanced satellite networks solutions for our US Government customers." ●

Intellian launches all new satellite TV antennas to improve live TV on vessels

Intellian Technologies, Inc., has announced new t-Series and s-Series antennas to enhance the live television (TV) experience for those onboard maritime vessels.

With millions of people working at sea every day across commercial maritime markets and even more passengers onboard cruise ships, ferries and yachts, the demand for live TV onboard is as strong as ever.

The new t-Series antennas, available from September onwards, will leverage improved technology to elevate the user and customer experience.

Featuring an upgrade to Intellian's trademarked WorldView™ Technology (WLNB), it enables seamless television viewing onboard anywhere in the world as vessels travel between regional services.

The four new models of the t-Series - t85N, t100N, t130N, t150N - range from 85cm up to 150cm. They join Intellian's extensive portfolio of popular satellite TV antennas designed for vessels ranging from 20ft to over 1,000ft.

The new s-Series range also in development by Intellian, is designed for the US regional market, with an expected launch later this year. The new s100N and s130N, will be a dual Ka-band for the US and Ku-band for the Mediterranean, TV receive only antenna system, which supports DIRECTV and DishNET reception. ●



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● ● A KT SAT engineer by a KT SAT maritime antenna. Photo courtesy KT SAT

Satellite Evolution Global

Q&A

Delivering connectivity across a wide range of sectors ● ●

KT SAT has long been a powerful satellite developer, both in orbit and on the ground. Delivering connectivity across a wide range of sectors, the company has seen the industry from many angles and is well placed to discuss the market's evolution in the Eastern world. We spoke to KT SAT about what they anticipate for the APAC region and their perspective on the West.

Laurence Russell, Associate Editor, Satellite Evolution Group

Question: What were KT SAT's latest achievements, and how were they delivered?

KT SAT: KT SAT aims to be a global provider of multi-orbit satellite connectivity services from GEO to NGSO. KT SAT finished an International Telecommunications Union (ITU) filing for a LEO Constellation along with a technical constellation design. Also, KT SAT made an investment in Mangata Networks, a US-based start-up that plans to provide MEO satellite service. KT SAT expects its service will be more stable and reliable when it does business using multiple orbits.

One of our most recent achievements is the launch of our space data service, providing Earth observation imagery, video, and analytics data through an AI-powered geospatial analytic platform. KT SAT plans to first tap into the domestic market to formulate customer use cases, with the aim to expand its service to the global market by focusing on creating value-added services in data analytics and applications, areas that have great potential for future growth.



KT SAT at CommunicAsia 2022 ● ● ●

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KT SAT technicians pictured at a company ground station. Photo courtesy KT SAT ●●●

Question: You unveiled a new maritime product, XWAVE, earlier this year to target the Southeast Asian region. How did your launch perform, and how has the service performed so far?

KT SAT: Currently our customers using the XWAVE service consist of more than 1,650 vessels globally. Regional MVSAT features allow for expanded coverage of the Asiatic oceans from the Bay of Bengal, Indonesia, and the western seas of Australia to the Indian ocean on an unlimited high-speed network (2Mbps).

To expand its market to Southeast Asia, KT SAT made a contract with Singapore-based partners and proceeded with on-site customer meetings with 13 vessel management companies in May. In June, KT SAT participated in CommunicAsia 2022, the largest global satellite conference in Asia-Pacific Region where we met with customers from Singapore, Malaysia, Indonesia, and the Philippines.

KT SAT's MVSAT offering also includes various value-added services optimized for vessels. KT SAT plans to offer value-added services using ICT technology like CCTV, network management systems, broadcasting services, etc. with a goal to improve work efficiency as well as to provide secure operation in vessels.

Question: Last year, KT SAT's President Song Kyung-min proposed a "LEO Alliance" at the Euroconsult World Satellite Business Week 2021. In your eyes, why is a collaborate-to-compete strategy superior?

KT SAT: Regional GEO operators need to secure enough

satellite capacity through NGSO to enhance business competitiveness. As we've experienced, barriers to entry can be harsh, but a high tide can raise all ships. With effective collaboration, we can all benefit from a more dynamic market.

Question: Western markets have a limited understanding of the East Asian market and the trends and policy directions that inform it. How best can we bridge these gaps to create a more efficient global economy?

KT SAT: Recently, major players in the satellite industry, mostly from the western market, have started to provide their NGSO connectivity service to the East Asian market. To enter that market, they have to solve regulatory issues like licenses, administrative procedures, requirements of regional providers, etc. On the other hand, KT SAT has already secured a wide business share in East Asia along with a strong reputation of trust. It just makes sense to try to establish partnerships with other operators to acquire a broad range of satellite connectivity including GEO, LEO, and MEO, and we welcome global partners becoming a part of that.

Question: You attended CommunicAsia in Singapore this June. What were your impressions of the show, and what did KT SAT showcase at the event?

KT SAT: We resumed our offline showcase after Covid 19 starting from CommunicAsia 2022 and promoted our service and technology including our space data service

which provides high-resolution satellite imagery and AI-powered analytics data. Through KT SAT's space data service, customers can get a clearer picture of activities that give immediate benefits to the defence and intelligence community for security, supply chain, and other critical needs.

The service is also a hybrid solution, a technology that allows more reliable data communication than traditional 5G with flexibility coordinating across different networks. It offers seamless connectivity through satellites which outlasts potential disconnections in terrestrial networks. KT SAT expects this to be a next-generation network solution because it aggregates many means of connection under one service, from satellites to LTE, 5G, Wi-Fi etc. As the so-called NewSpace era continues, we expect the importance of hybrid solutions will grow as they continue to integrate across orbits.

Question: From your perspective, how do you believe the East Asian market will evolve in the next decade? What will be the West's influence on the market, and do you foresee monopolisation or disruption? Do you believe China will begin behaving like the US in economic policy and work towards a larger space start-up segment while being open to collaborating more with its neighbours?

KT SAT: East Asia is a set of continuously growing economies just as mature as those in the West, with a high demand for satellite data like broadband, mobility, and the requirements of government. Before the days of NewSpace, KT SAT saw the growth potential of the East Asian market to expand quite naturally, potentially serving parts of the West, but with the explosive growth of players like SpaceX, which plans to target East Asia with its Starlink service, the picture has become more complex. It will be interesting to see how market share disseminates in the wake of such bold moves.

If providers like SpaceX are serious about tackling Asian markets, there will be many hurdles to overcome ranging from regulatory issues to coordination with regional providers – especially in Indonesia. Another issue is making their satellites compatible with existing connectivity infrastructure. We don't exactly anticipate a SpaceX monopoly, but they are sure to affect the market supply in ways that fly in the face of our economic expectations over the last decade. KT SAT will continue its effort to provide world-leading satellite service through strategic cooperation with regional operators.

With regards to China, space development has typically been considered a national business, but as the NewSpace era dawns, we've seen growing participation from their private sector. The space industry was once exclusive to a small selection of advanced economies, but the connected nature of the world means global-facing start-ups can dive into this industry from anywhere.

China will go on exploring space commerce in the private sector after its initial successes to gain ground that the US has started to claim. China has a strong history in space technology and is a formidable economic competitor. They have the potential to make significant inroads in these new markets. We anticipate that China's progress will be accelerated by a commercial approach,

favouring start-ups, and encouraging greater degrees of collaboration with its neighbours to secure the best conditions for growth.

Question: What can we expect from KT SAT in the year ahead?

KT SAT: KT SAT plans to provide a total satellite service including not only connectivity but also Earth observation, and navigation. For more than 50 years we have delivered incomparable service and technology to the satellite industry. It's that reputation for excellence that has led to the set of government projects we'll be serving. The first is the KASS (Korean Augmentation Satellite System) project, a national business operated by the Korean government for improving the accuracy and reliability of global positioning system (GPS) signals to ensure flight safety.

The second is the KPS (Korean Positioning System) project, another government business developing sovereign GPS for South Korea. KPS will improve the accuracy of Korea's GPS services, which South Korea heavily relies on, and which will be essential to supporting the infrastructure of the nation by paving the way for drone and autonomous vehicle navigation.

Through these prestigious projects, KT SAT will continue growing its capabilities in satellite navigation, and honing its competitive edge, while remaining open to partnerships overseas to strengthen its data analytics and range of applications. ●



KT SAT's President Kyung Min Song proposed a "LEO Alliance" at the Euroconsult World Satellite Business Week 2021 ●●●

CAPSTONE: Proving a path to the Moon

Creating a sustainable presence on the Moon and establishing a Gateway space station is still a work in progress, but the successful launch of the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment, known as CAPSTONE™, takes us one step closer to the finish line. This 55-pound CubeSat will not only test the Near Rectilinear Halo Orbit around the Moon but will also demonstrate spacecraft-to-spacecraft navigation services that don't rely exclusively on tracking from Earth.

Crispin Littlehales, Executive Editor, Satellite Evolution Group

It's been fifty years since Eugene Cernan, Commander of the Apollo 17 mission spoke these words: "As we leave the Moon at Taurus-Littrow, we leave as we came, and God willing, we shall return with peace and hope for all mankind." One might well ask what is taking us so long to return. Besides being a political football with a costly price tag, the game has changed. Instead of landing a few

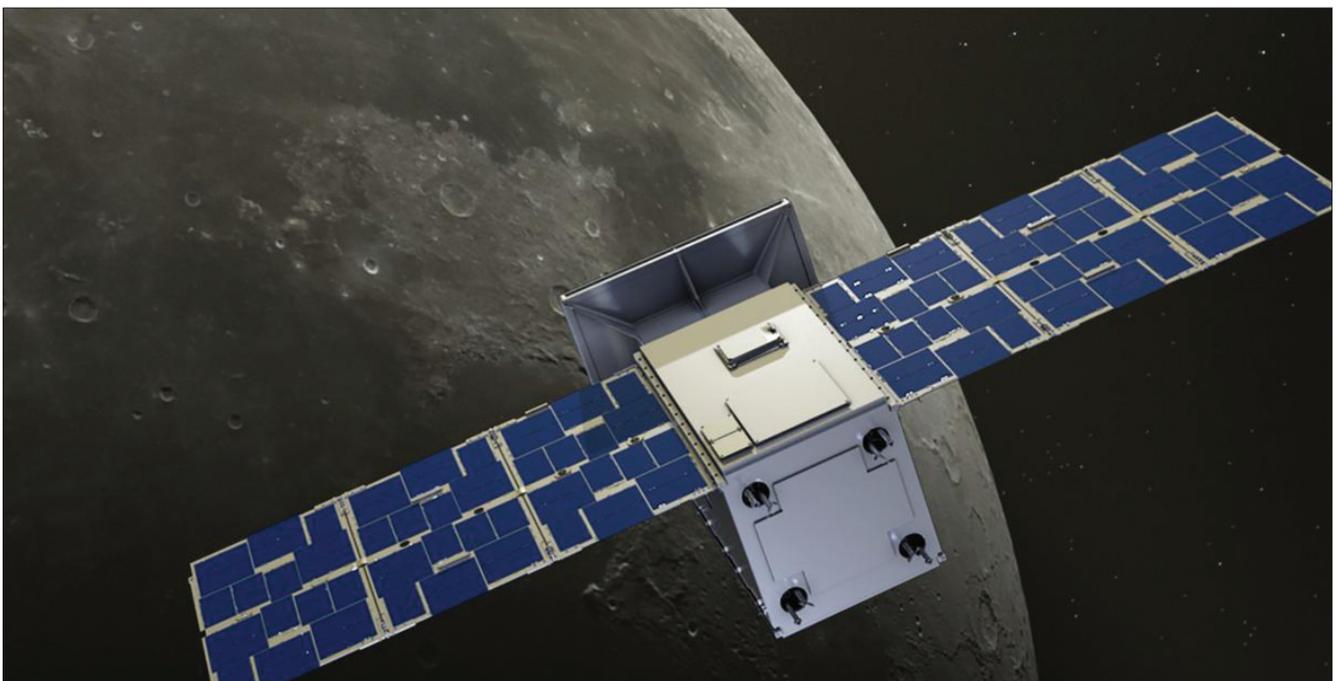
astronauts on the surface for a brief walkabout, the US wants to establish a permanent outpost—one that can be used as a stepping stone to Mars. NASA's Artemis program proposes to do just that, and the agency is using the CAPSTONE™ mission to verify the best way forward.

SMALL SATELLITE ON A BIG MISSION

The Space Technology Mission Directorate via the Small Spacecraft Technology and Small Business Innovation Research programs at NASA's Ames Research Center is supporting CAPSTONE's development and the Artemis Campaign Development Division within NASA's Exploration Systems Development Mission Directorate is supporting the launch and mission operations. The agency's Jet Propulsion Laboratory (JPL) is backing the communication, tracking, and telemetry downlink via NASA's Deep Space Network (DSN), Iris radio design, and groundbreaking 1-way navigation algorithms.

The lunar orbiter that NASA has assigned to conduct this critical mission was built by Tyvak Nano-Satellite Systems, a subsidiary of Terran Orbital Corporation. It is 144.5 CM x 50.1 CM x 33.0 CM and has a mass of 26kg. There are two MKII deployable solar arrays providing 120W of peak power and triple redundant MKII 12V battery modules.

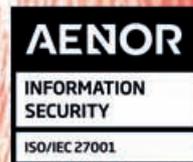
The satellite includes a radio tower on top and is equipped with a SWIFT-SLX S-band radio with ranging functionality provided by Tethers Unlimited, Inc. NASA/JPL IRIS band radio provides the uplink, downlink, and navigation ranging. Redundant MKII sensors and actuators, including two star trackers, four reaction wheels, two coarse sensor modules, and two IMUs have been integrated for guidance navigation and control. An innovative hydrazine propulsion system from Stellar Exploration provides upwards of 200 M/S for orbit adjust and vehicle momentum management and there is a



CAPSTONE will demonstrate spacecraft-to-spacecraft communications from NHRO orbit. Photo courtesy NASA ●●●

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Installation of solar panels. Photo courtesy NASA ●●●

dedicated MKII Linux flight computer to manage on-board processing of the payload Cislunar Autonomous Position System (CAPS™) software.

The prime contractor and the lead for the mission, Advanced Space, handled the pre-launch coordination and analysis of activities to support the sustainable exploration of space. The mission was awarded a favorable Payload Review and Determination from the Federal Aviation Administration and approval from NASA for both an Orbital Debris Assessment Report and a Planetary Protection Plan.

UP, UP, AND AWAY

Integrated into Rocket Lab's Photon spacecraft bus inside the fairing of Rocket Lab's Electron launch vehicle, the CAPSTONE satellite departed Earth on June 28. Minutes later the payload entered an initial low Earth orbit at an altitude of 165km. Over the next six days, Photon's HyperCurie engine fired seven times at key intervals thrusting CAPSTONE's orbit to around 810,000 miles from Earth before releasing the CubeSat on its ballistic lunar transfer trajectory to the moon. From that point forward the satellite uses its own propulsion, along with the Sun's gravity to make a four-month-long journey to the Moon and enter its Near Rectilinear Halo Orbit (NRHO) on November 13th.

To ensure that CAPSTONE stays on target, the satellite needs to make periodic trajectory correction maneuvers (TCM). The first was successfully completed when the spacecraft was approximately 465,000 km from Earth and the second took place five days later when CAPSTONE was approximately 789,000 km from Earth and moving at 1,313 mph. Apogee was raised from 1.47 million km to more than 1.48 million km during the burn.

Mission operations and in-orbit support are conducted and guided by a team of specialists: the Advanced Space

flight dynamics team, who designed the maneuvers and maintain knowledge of where the satellite is located; the Terran Orbital spacecraft operations team, who is responsible for spacecraft commanding activities; Stellar Exploration, who designed and built the propulsion system; and NASA's JPL, who supported the communication, tracking, and telemetry downlink through NASA's DSN.

ASSESSING A NOVEL CISLUNAR ORBIT

The NRHO that CAPSTONE will enter takes advantage of what researchers call "a gravitational sweet spot in space." According to NASA, the orbit is located at a precise balance point in the gravities of Earth and the Moon. This makes for a stable orbit that requires minimal energy to maintain. CAPSTONE will come within 1,000 miles of the one lunar pole on its near pass and 43,500 miles from the opposite pole every seven days. The satellite will remain in this orbit for at least six months

CAPSTONE will verify the characteristics of this orbit, including power and propulsion requirements, and demonstrate the entering and maintaining of the orbital path. This not only supplies NASA with the vital logistical information needed to support the Artemis missions and the establishment of the Gateway space station which, like the ISS, would have docking ports, living quarters, and an onboard laboratory to conduct scientific investigations. Having an in-depth understanding of the NRHO is key to making Gateway a reality. Such knowledge will also be crucial to laying the foundation for commercial support for future lunar projects.

IMPROVED LUNAR NAVIGATION CAPABILITIES

The CubeSat's CAPS, which was developed and implemented by Advanced Space, is also being evaluated. To test its spacecraft-to-spacecraft navigation

technologies and ranging capabilities, CAPSTONE's flight computer and radio will communicate with NASA's Lunar Reconnaissance Orbiter (LRO) and use it as a reference to pinpoint the CubeSat's position in space. According to NASA, this peer-to-peer information will enable future spacecraft to determine their location without having to rely exclusively on tracking from Earth, thus freeing up ground-based antennas to handle valuable science data. The CAPSTONE team coordinated with both regulators and other operators on the Moon to prevent interference in terms of radio frequency utilization when communicating with the ground and the LRO.

SO FAR, SO GOOD

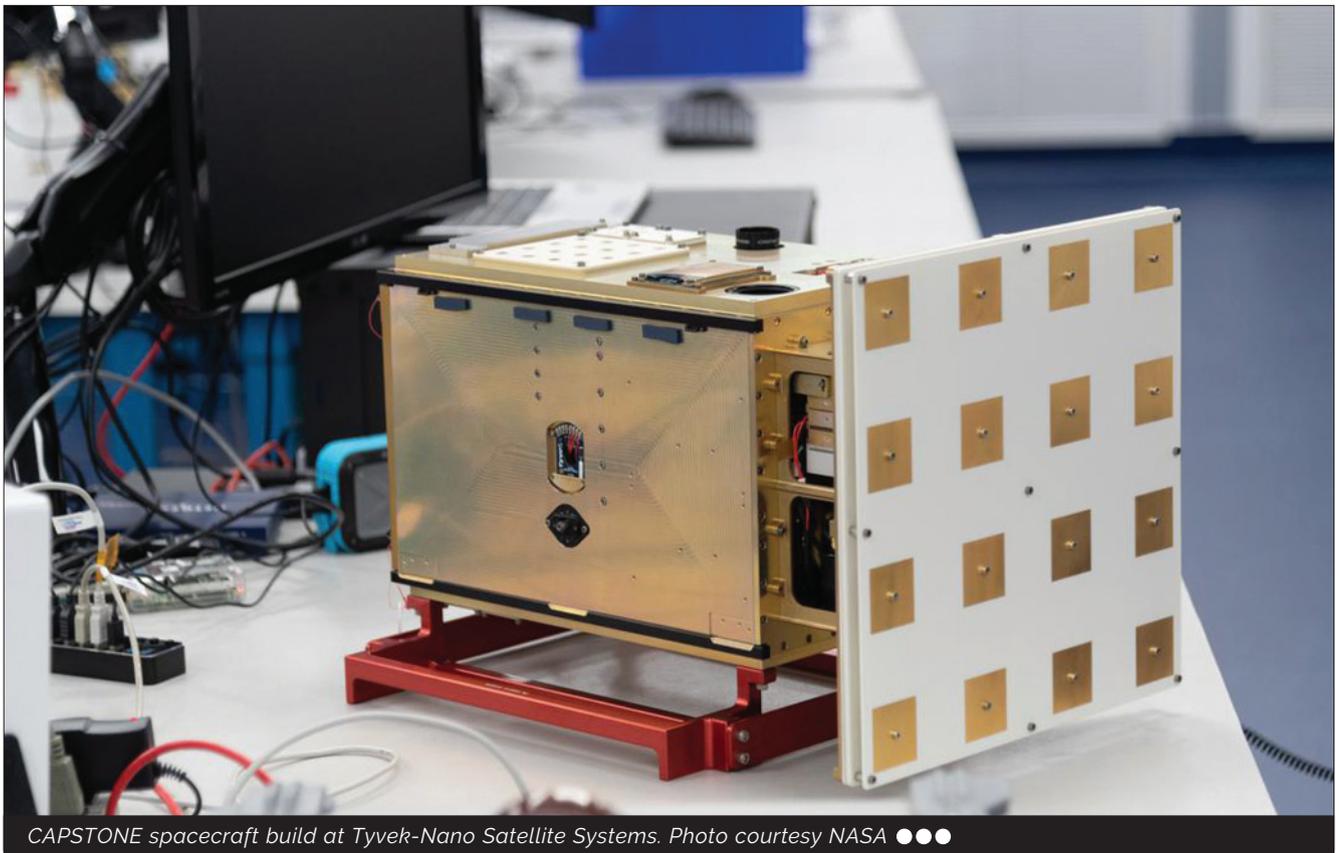
On July 4, after CAPSTONE had been successfully deployed, NASA issued a statement saying that the CubeSat was experiencing communications issues while in contact with the DSN. A day later, NASA announced, "CAPSTONE made initial contact with the DSN ground station in Madrid, Spain, followed by a partial contact with the Goldstone ground station in California. From these contacts, mission operators have been able to determine CAPSTONE'S approximate position and velocity in space." By July 8th, thanks to the efforts of the integrated mission team, the problem was resolved, and the satellite was back on track and operating normally.

NASA has set up a site for the public to follow CAPSTONE on its journey with a simulated view of the solar system using the agency's Eyes on the Solar System interactive real-time 3D visualization:

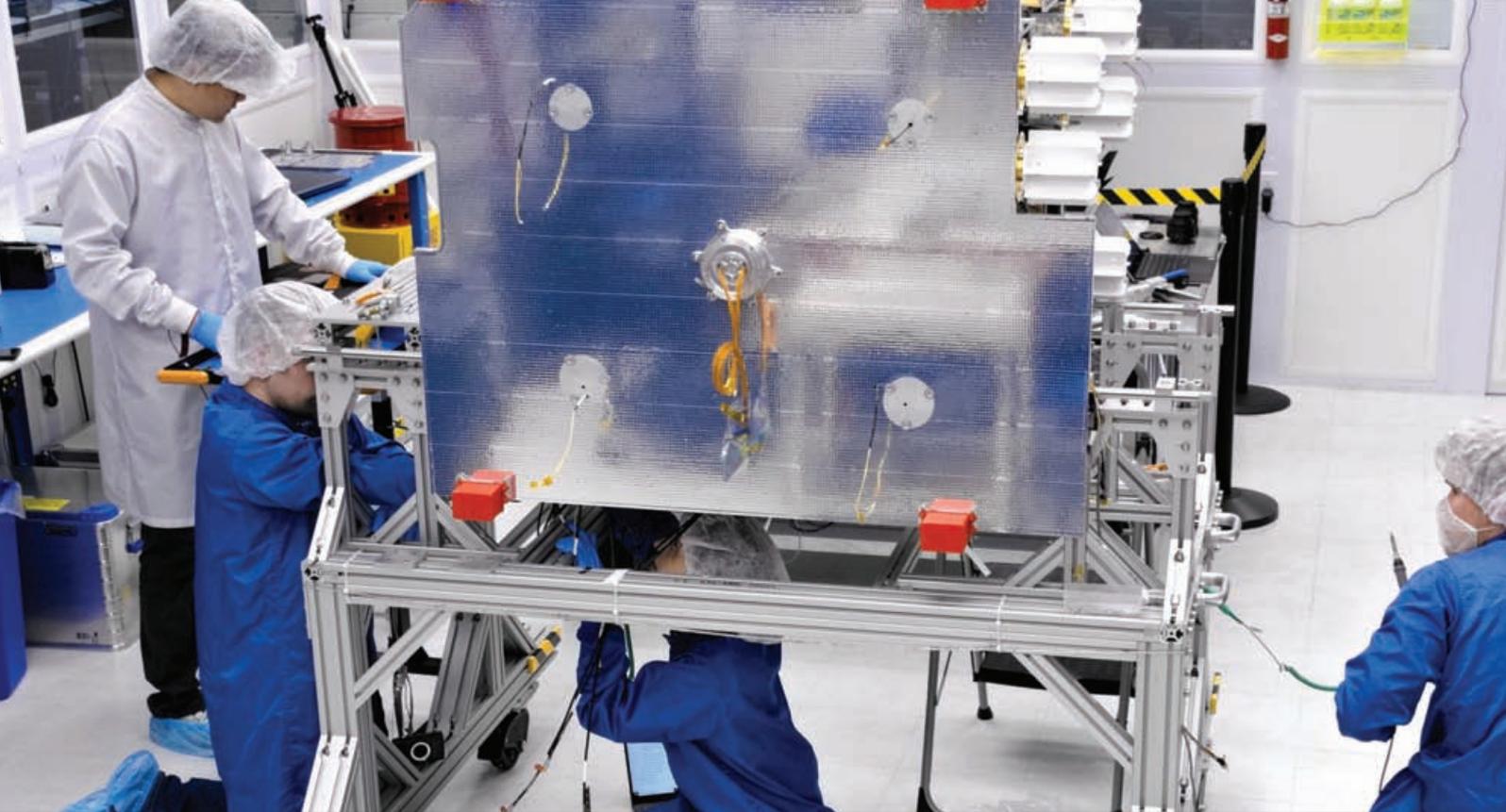
(<https://eyes.nasa.gov/apps/orrery/#/home>). ●



Solar panel string voltage test (red glow). Photo courtesy NASA ●●●



CAPSTONE spacecraft build at Tyvek-Nano Satellite Systems. Photo courtesy NASA ●●●



Arcturus microGEO from Astranis ●●●

Delivering broadband to rural and indigenous populations in Alaska ●●

According to the Federal Communication Commission's 14th Broadband Deployment Report issued on January 19, 2021, only 63.7 percent of Alaskans living in rural areas have access to wired broadband at speeds of at least 25 Mbps downstream and 3 Mbps upstream. Thanks to the efforts of Pacific Dataport, Inc., Kratos, and Astranis, Alaska's middle and last mile broadband capacity is expected to triple. The plan is to expand 25/3 broadband service to the isolated and remote communities who need it most at a price they can afford.

*Crispin Littlehales, Executive Editor,
Satellite Evolution Group*

Rugged, wild, and vast, Alaska has the nation's lowest population density—just 1.3 persons per square mile. Alaska natives, organized into 228 tribes, account for 15.7 percent of the population and approximately two-thirds of those people live in remote rural villages. A significant number of these communities are in areas accessible only by boat or aircraft. Not only is the terrain challenging and the population dispersed, but the harsh weather also makes the construction of any kind of infrastructure all but impossible during the winter months.

Given these difficulties, it is no wonder that satellite-based services were viewed as the perfect solution. Indeed, Alaska-based reseller, Microcom, has been providing satellite broadband and TV to rural Alaskans for decades and has tens of thousands of customers. However, several years ago Microcom realized that satellite operators were running out of capacity with many

Alaskans still awaiting connectivity. In 2017, Microcom spawned a new satellite communications company called Pacific Dataport Inc. (PDI) to address Alaska's digital divide.

AURORA TO THE RESCUE

From the start, PDI's aim was to provide ubiquitous broadband coverage to Alaska at a competitive price through the creation of its own multi-service network called Aurora. Shawn Williams, Vice President of Government Affairs and Strategy for PDI notes, "Our ultimate goal is to sell cellular and broadband backhaul capacity to tribes, tribal consortiums, schools, health clinics, and Alaska telecoms. Our wholesale pricing will be a fraction of what everyone's paying right now. In fact, it will bring Alaska very close to the wholesale pricing that you see in the lower 48 and that's absolutely market disruptive."

Phase 1 of the Aurora Network includes the installation of a 9.4m Ka-band dual-purpose antenna from Kratos, coupled with a first-of-its-kind software-defined MicroGEO™ satellite from Astranis, scheduled to launch



Ruggedized options for harsh environmental conditions .
Photo courtesy Kratos ●●●

later this year. PDI secured two orbital slots at 163 degrees and 154 degrees west and selected an LBiSat greenfield site in Eagle Mountain, Utah for the ground system. "They have almost 100 percent clear sky days and the atmospheric weather conditions are near perfect at that location. We also have access to low-cost redundant fiber-based internet services with multiple providers. Power reliability was also a big deal, along with clear look angles with no chance of blockage from future construction," explains Williams.

A FAIL-SAFE ANTENNA

Although Utah boasts many days of sunshine, the weather can sometimes prove challenging with temperatures

ranging from below zero to triple digits Fahrenheit. PDI needed an antenna system that was rugged enough to brave the elements with redundancy for all critical systems including tracking. Kratos, with its proven track record and highly ruggedized antenna options, proved to be the partner of choice.

Kratos installed a full de-ice system, reflector, feed, and subreflector tracking (SRT) heater to combat subzero temperatures. Kratos added a rain blower, also referred to as an air knife, to mitigate the effects of fast-moving rain showers and placed balancing fans to distribute heat, guarantee minimal temperature fluctuation, and avoid hot spots that can affect the RF signal.

PDI selected Kratos' Compass Monitor and Control (M&C) solution for their ground system operations. PDI also selected Kratos' proprietary subreflector tracking technology for redundancy, automatic refocus, and reduced wear and tear. According to Mark Lambert, President of Kratos Communications UK, "Most antennas have two axes which require a set of motors for azimuth and a set for elevation. The addition of a sophisticated antenna control subreflector facilitates tracking the satellite by making much smaller movements, rather than moving the entire antenna using the large motors at the pedestal."

At the end of November 2021, the Kratos team arrived on site to begin the installation process. The antenna system was built before the end of December with configuration, testing, and training underway the following month. "Our early design work and planning enabled us to complete the task in just over two months, despite the supply chain and access challenges presented by the pandemic," Lambert notes.

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A DEDICATED SATELLITE

One of the most exciting aspects of the Aurora Network is its use of Arcturus, the first MicroGEO satellite produced by Astranis. "This will be the first dedicated satellite just for Alaskans," says John Gedmark, CEO, and co-founder of the NewSpace startup. "It is about the size of a mini fridge, as opposed to a traditional GEO which is the size of a double-decker London bus. We took advantage of several advancements that have happened over the last 20 years, like lithium-ion batteries and electronic improvements including electric propulsion. Arcturus uses ion thrusters which have much better performance than liquid rocket engines."

Astranis also tackled two major technology challenges: how to get rid of the thermal energy generated by the tightly packed satellite and the building of a flexible software-defined radio for space. "The satellite world had been stuck in the analog radio age up until very recently," explains Gedmark. "When you move to the digital world, you have a huge range of benefits—higher performance, a cleaner signal, and most importantly for us, you get this flexibility where the satellites can be agile across these big wide ranges of frequencies. You can put up satellites without having to worry about exactly what location they're going to, or what area they're going to be serving. You just dial that into the software when you need to."

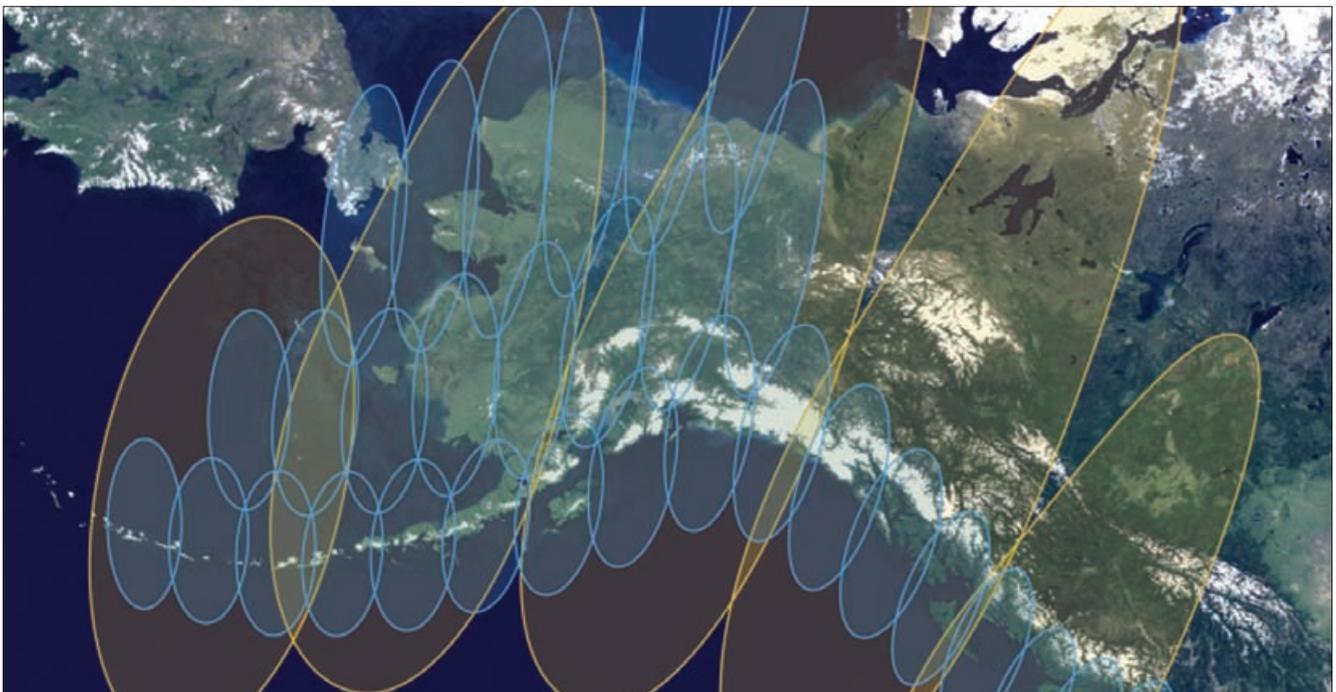
Because Arcturus uses brand new technology, Kratos provided support and flexibility for the integration and testing of the system prior to launch. In addition to supporting PDI's broadband payload, the Kratos antenna will also be used for telemetry, tracking, and control (TT&C) of the MicroGEO.

Once the Aurora network is up and running, the lives of many indigenous Alaskans will change dramatically. They will have access to health information, telemedicine,



Kratos antenna with subreflector tracking ●●●

education, and online courses. "Imagine if you're someone who has the talent and capability to become a software engineer and all you need is access to the knowledge to be able to learn those skills," says Gedmark. "I think we'll find that the next Einstein or Isaac Newton may be in one of those isolated places and that will be transformational not just for those communities but for the whole world; to allow us as humanity to have access to another thousand potential people of that caliber." ●



Estimated Aurora Network coverage at project completion ●●●

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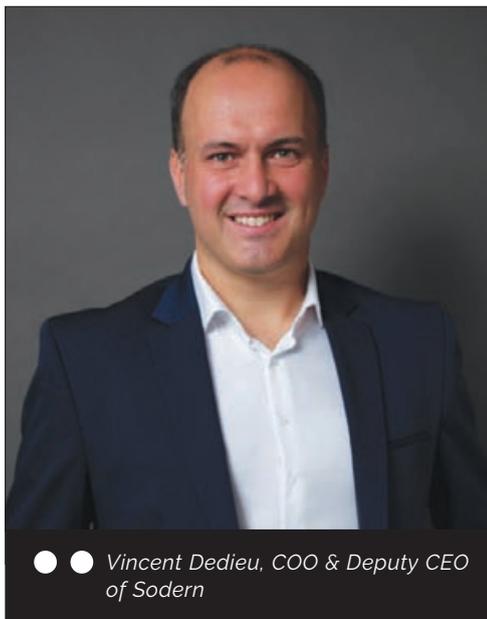
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● ● Vincent Dedieu, COO & Deputy CEO of Sodern

Satellite Evolution Global

Q&A

Tracking the stars to navigate our orbits and beyond ● ●

The small satellite boom has been fueled by countless space components specialists innovating in the market, fueling success that has allowed for ever more advanced technological milestones. Sodern, an ArianeGroup company, is producing space optronics enabling satellites and space vehicles to navigate, as well as high-profile scientific missions far beyond Earth. Vincent Dedieu, COO & Deputy CEO of Sodern told us how the company came to develop the trust required for such a monumental undertaking, and where they plan to take us in the future.

Laurence Russell, Associate Editor, Satellite Evolution Group

Question: You describe yourselves as the world leader of star tracker development with your Auriga, Horus, and Hydra devices. What puts them ahead of their competitors?

Vincent Dedieu: That's true. We estimate we have 40 percent of the open market share of star trackers in the world. That's thanks to our strong relationships with our partners and clients. We have about 50 customers, which constantly change in the volatile NewSpace economy, with whom we take great pride in serving.

We've built those relationships on the back of our high-quality portfolio, which serves the needs of any mission across all orbits and even deep space transit, which can be flexibly integrated. That portfolio includes the Hydra star tracker, a powerful mainstream contender,



Technician at work. Photo courtesy Sodern ● ● ●

especially for low orbit Earth observation. We also have the Horus single box which is better suited for geostationary satellites at a strong competitive price. Finally, we have Auriga for small satellites, which is a highly competitive product, outclassing its peers on the market at a bold US\$50,000 price point.

Because we produce in high volume, we have the capacity to serve constellations with hardware like this, equipping satellite fleets for high-performance service.

The other thing that keeps us ahead is our heritage. We're a 60-year-old company with dozens of years of experience in space with 1000s of hours of orbital service across our star trackers.

Our customers give us clear requirements and qualitative feedback, which gives us the power to serve them best. That's given way to a strong culture of trust, which has made us a reliable partner for global government groups, such as the French Ministry of Defence.

Question: Orbital space is set to become much more congested, with the satellite population expected to multiply dramatically in the next few years. Do you anticipate a growing need for accurate, reliable space positioning?

Vincent Dedieu: We see a growing need for accurate star trackers that can operate reliably in the hostile environment of space at a strong price point. This is definitely more the case than a need for greater accuracy, as we've seen, since the market has that part cornered. Our technology serves this demand, especially Hydra.

We also see new markets manifesting in this space all the time, for which new navigation equipment must be devised. Conversations about vision-based navigation, in-orbit monitoring, rendezvous monitoring, and so on are really taking shape. Those new missions require the kind of innovation that we're already anticipating.

It was our systems that guided the transits of the European Automated Transfer Vehicle (ATV) to the International Space Station (ISS) from 2008 onwards. Since then, we've been developing rendezvous algorithms for the recognition of objects in space based on vision called ARAMIS, and most recently we've been developing NAVCAM systems for the JUICE (JUperiter ICy moons Explorer) mission to be launched next year.

Question: You've produced navigational optronics for ESA's JUICE scientific mission. How do design requirements change when developing deep-space applications?

Vincent Dedieu: We've had two main projects concerning scientific space

exploration missions which have required very specific, mission-critical needs. In recent years, we've been developing for two main missions; the European JUICE mission and the American NASA Europa Clipper mission, both going to Jupiter and its system of moons, as well as the Jovian system.

What I can say about these top-priority missions is that the deep-space environment is more complex than those of Earth's orbits, especially the Jovian system which is highly radioactive.

These technologies are entirely apart from the commercial-off-the-shelf (CotS) world of products, where you can produce solutions ahead of the need of purchase and deliver quickly with a long history of successful testing and patching.

Custom markets like these require dedicated materials, development, and testing specific to them. They require the wheel to be reinvented every time, which is less competitive, but actively pushes forward the frontiers of

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what technology can and can't do for future generations of mankind.

We will employ this very same methodology on the Mars sample return mission which will require a camera to prospect regolith. Again, this is all possible because of our great heritage of innovating in this field for so long.

Question: What's your impression of the proposed orbital servicing market? What sort of navigational expertise will it take to run an ecosystem of autonomous orbital drones maintaining our satellites?

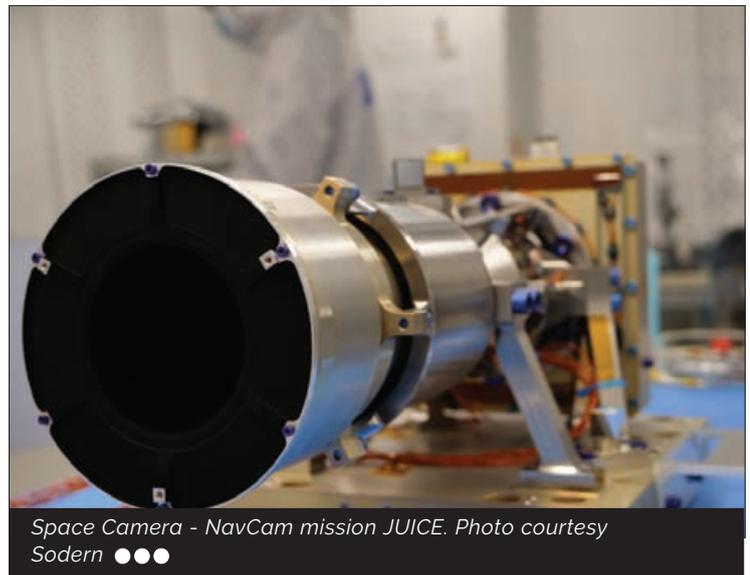
Vincent Dedieu: We strongly believe Star trackers will remain the standard for navigation technology in orbit, and the in-orbit servicing market is no exception. Right now, we're working mainly on two-dimension detection software and adapting our space cameras for that purpose. These will allow autonomous orbital vehicles to move around orbits and locate satellites for automatic docking for orbital transit or precision operations.

It's a market that's still very much taking form, but we're working on our piece of it, and it's an honour to bring this new economy into reality with the enterprising culture of our clients and the NewSpace industry they are part of.

Question: You also serve defense industries, mostly for the French military with positioning and intrusion detection. In these days of global contention, are we taking foreign satellite monitoring seriously enough?

Vincent Dedieu: Sodern indeed serves the Syracuse 4 French military telecommunication satellites with intrusion sensors, where we've developed a healthy concern for space situational awareness.

I believe France and Europe at large have been taking such things very seriously across various initiatives, mostly across ground sensors and command and control systems. It's important to understand that these topics are not localized concerns. It's not just the country developing space technology that needs to pay attention to it, but



Space Camera - NavCam mission JUICE. Photo courtesy Sodern ●●●

every nation-state, and every commercial company within them.

We're seeing more and more companies understanding the gravity of the situation, and the recognition that it will be a commercial service that addresses it. Sodern believes that a space-based surveillance system can be part of this work, serving both defense and civilian concerns.

Question: What's the future of small satellite optronics?

Vincent Dedieu: The future is bright here. As I previously mentioned, we're very proud of the Auriga star tracker that we launched in 2016 for our first customer, OneWeb, for which we've already delivered hundreds of cameras optimized for advanced star tracking algorithms.

In 2021, we sold 150 small satellite star trackers outside of our business with OneWeb which is a huge number for the market. In the traditional market, we're more likely to see between 50-100 per year. As of June 2022, we're already at 220 Auriga star trackers shipped, with six months more to go. Just as experts predicted, this market is exploding as small satellites grow in popularity.

This is possible because Sodern takes on the risk of producing these star trackers ahead of demand, taking on the market risk so startups don't have to, and we're there to serve when those companies are ready to manufacture their satellites, and at a competitive price too.

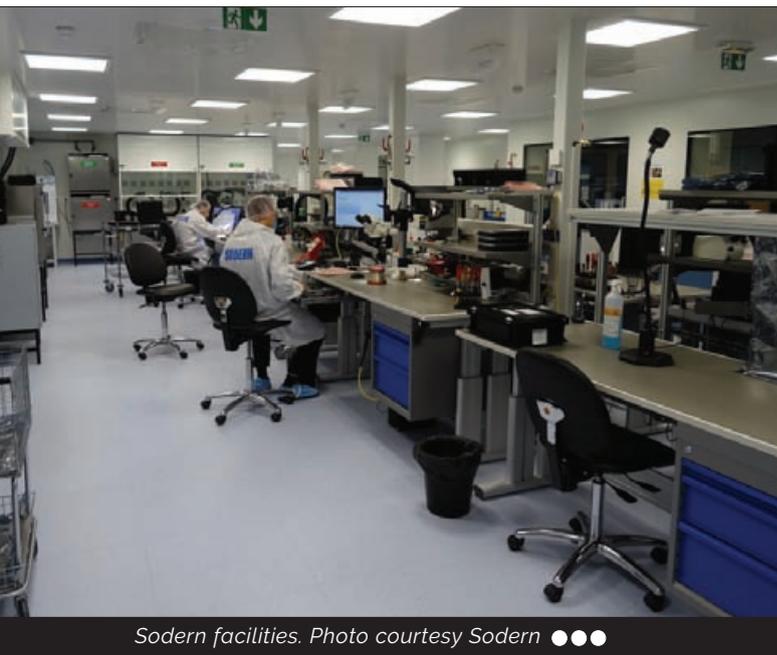
We're now working on new products like Auricam, a space camera based on the Auriga star tracker, as well as upscaling our production capacity. We're now at a place where we could produce roughly 1,000 star trackers in a year, if necessary.

Question: What can we expect from Sodern in the years ahead?

Vincent Dedieu: Players in the space economy will be hearing more about us as we continue to innovate. We're now making waves in the space logistics markets and the services between the Earth and the Moon are taking form, producing new software and smart cameras for more advanced needs.

One day we hope to be able to track stars on Earth during the daytime, through blue skies. That'll come to military users first, who have the greatest need, but as always, we are hoping to expand it beyond that.

We're honoured to have pushed forward the work of celestial navigation on Earth. ●



Sodern facilities. Photo courtesy Sodern ●●●



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Australians see space more as a danger than a benefit

Australia was at the forefront of the first space race and played a vital role in Apollo 11's iconic Moon landing in 1969. Half a century later, Australians are more likely to see space as a threat than a frontier full of positive possibilities, and just one in ten say they would like to work in the space industry.

According to a new global report from Inmarsat – *'What on Earth is the value of space?'*, based on a survey of 20,000 people in 11 countries – 49 percent of Australians are concerned about space junk and collisions and 44 percent are worried about polluting space, while just over one third (36 percent) say they feel hopeful about the possibilities of space, one fifth (21 percent) say they don't understand much about space and 10 percent say they don't care about space at all.

With the space sector attracting record levels of investment and expanding faster than ever before, it is essential that Australians learn more about an industry that will increasingly impact their lives, according to Inmarsat.

According to the report, Australians are twice as likely to associate space with aliens (21 percent) than with communications and connectivity (10 percent). Most concerning for the future is that younger generations appear to have a view of space built on movie depictions rather than reality. 31 percent of Australians aged 18-24 associate space with aliens, compared with just 11 percent of people aged 65+. In comparison, only 8 percent of this younger age group associate space with communications – the sector that is leading global growth in the industry – half that of the over-65s (16 percent).

Meanwhile, 70 percent of Australians said they had never heard of or had no idea about space-based Internet, and 36 percent said the same for weather and climate monitoring – despite the first weather satellite having been launched in 1960 – and 31 percent had never heard or knew nothing about GPS and Satnav.

"I have a positive view that we can help people fall in love with space again. I've worked in the industry for decades and see the truly amazing stories that are just waiting to be told," said Todd McDonell, President of Inmarsat Global Government, based in Sydney. "It's understandable that with space-based technology so embedded in our everyday lives, it has become largely invisible, especially to a generation brought up with smartphones and tablets.

"Space can enable a better way of living for us all, but public support will make or break this vital contribution to a better future.

"What was really interesting is that, like their counterparts in other countries and despite a generally low level of awareness, Australians identified genuine causes of concern related to the space industry. As the sector goes

through a period of major expansion – with forecasts that the number of satellites in orbit will rise from 7,000 to over 100,000 by the end of this decade – players in the industry have a vital duty to manage this growth responsibly.

"Having come so far, we cannot afford to destroy the gift of space through poor stewardship, fear, ignorance or inaction. Sustainability on Earth cannot exist without sustainability in space. Responsible space exploration and stricter regulation is a must."

"I see first-hand how space is playing a vital role in putting food on our tables, how it keeps us safe when we fly, how it enables us to buy goods from home and have these shipped to us from the other side of the world. Whenever a natural disaster strikes and damages Earth-based telecommunications, satellites are there immediately to support search & rescue and rebuilding efforts. Perhaps most importantly for the future, space technology lies at the heart of efforts to combat climate change.

"I'm sure that if the industry can tell these stories, especially to the younger generation, then interest in space will grow and we will see a new generation emerge – one, much like back in the 1960s, who regard space as an amazing opportunity both as a career and as a force for positive change."



Photo courtesy Inmarsat ●●●



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Omnispace strengthens its executive team

Omnispace today announced key moves to strengthen its executive leadership team as it pioneers the delivery of a global network to provide ubiquitous direct-to-device connectivity. Brian Pemberton will be assuming the role of Chief Commercial Officer, while Jay Yass will transition to the role of Chief Corporate Development and Strategy Officer. These appointments will support focused initiatives to accelerate strategic partnerships with satellite and mobile industry participants as the company drives toward development of the world's first global 5G non-terrestrial network (NTN).

The Omnispace 5G NTN network, combined with terrestrial mobile networks, will provide ubiquitous direct-to-device connectivity worldwide. Operating in licensed mid-band spectrum and providing unmatched capacity and coverage for mobile users, the Omnispace network will offer communications for billions of smart phones and IoT devices around the globe.

As Chief Commercial Officer, Brian Pemberton will be leading initiatives with customers and ecosystem partners on the development, validation and commercialization of applications across key industry verticals. In his newly created role, Pemberton will now lead strategy and direction for the company's commercial, enterprise, government and internet of things (IoT) businesses.



Jay Yass, Chief Corporate Development and Strategy Officer, Omnispace ●●●



Brian Pemberton, Chief Commercial Officer, Omnispace ●●●

Pemberton will draw on his more than 20 years of leadership experience working for public and private companies in the satellite and wireless communications industries running business development, product marketing and communications.

Jay Yass, as Chief Corporate Development and Strategy Officer, will focus on developing strategic relationships that will help accelerate the implementation of the Omnispace global 5G NTN network.

In this role, Yass will identify and execute the company's strategic initiatives with industry partners and lead growth and funding opportunities. He will use his expertise garnered from leading Corporate Development at Omnispace over the past five years, as well as his 40 years of experience in the telecommunications and satellite industries to formulate, facilitate and execute the company's key strategic initiatives.

"We're establishing the world's first global mobile communications network leveraging the power of 5G. This requires a strong leadership team to develop the technical, commercial, and market access partnerships to continue to move Omnispace towards this objective. In parallel, we require experienced leadership focused on executing the company's strategic and commercial objectives," said Ram Viswanathan, President and CEO, Omnispace. "I'm confident in Jay and Brian's ability, along with the rest of the senior leadership team, to create and execute on opportunities that will guide Omnispace as we continue to reinvent mobile communications that empower consumer, enterprise, government and IoT customers worldwide."

The Omnispace network will enable consumer, enterprise, government and IoT customers to communicate in real-time through a single, seamless global service.

The use of 3GPP standards will deliver the power of 5G directly to billions of devices and applications everywhere. ●

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Boeing names Brian Besanceney as new Communications Chief

The Boeing Company has named Brian Besanceney as the company's senior vice president and chief communications officer effective September 6, 2022. A corporate affairs leader with more than 25 years of strategic communications and government relations experience, including senior roles at Walmart and Disney, Besanceney will oversee all aspects of Boeing's communications, such as communications at its commercial airplanes, defense and services businesses, media relations, external affairs, employee engagement, and company branding.

Besanceney will report to Boeing President and CEO David Calhoun and serve on the company's Executive Council.

"Brian is an outstanding communications executive with a proven record of leading global teams and helping several of the world's well-known companies and organizations tell their stories, in addition to managing complex issues in the private sector and at the highest levels of government," said Calhoun. "I am confident Brian will help us build on our ongoing commitment to engaging our employees and stakeholders transparently as we continue to navigate a challenging global environment and work to position Boeing for the long term."

Most recently, Besanceney has served as senior vice president and chief communications officer at Walmart, where he has been highly regarded for his strategic communications counsel and his effective leadership of the company's comprehensive global communications, including media, social and digital, stakeholder engagement, and events for the world's largest company.

Prior to Walmart, Besanceney served as senior vice president of public affairs at Walt Disney World where he led external and internal communications and corporate citizenship, as well as worldwide government and industry relations for Disney's Parks & Resorts division.

Before Disney, Besanceney served the US Government in key roles, including as deputy chief of staff to Secretary of State Condoleezza Rice at the US State Department, and assistant secretary for Public Affairs at the US Homeland Security Department. In the early 2000's, Besanceney served in the White House under President George W. Bush, including two years as Special Assistant to the President and Deputy White House Communications Director for Planning. Previously, he served as communications director for then - US Rep. Rob Portman and as a public relations and government relations consultant.

Outside work, Besanceney serves on the board of Orlando Health, a not-for-profit healthcare system in the southeastern US with \$8 billion of assets under management, as well as the Institute for Public Relations. He previously served on the boards of the Trust for the



Brian Besanceney, Senior Vice President and Chief Communications Officer ●●●

National Mall and the Florida Chapter of The Nature Conservancy.

Besanceney succeeds Ed Dandridge who departed Boeing in June. He will be based at the company's global headquarters in Arlington, Va. ●

MDA names Holly Johnson, Vice President of Robotics and Space Operations

Holly Johnson has been appointed as the company's Vice President of Robotics and Space Operations (RSO), reporting to MDA Chief Executive Officer, Mike Greenley. Ms. Johnson stepped into the role in an acting capacity earlier this year.

With 14 years of experience at MDA, including a decade in engineering and business development and four years in corporate operations, Ms. Johnson is ideally positioned to lead the RSO business area as it accelerates through a period of tremendous growth, maximizes new commercial market opportunities, and focuses on delivering Canadarm3.

"Holly has quickly established herself as a customer-centric business leader and skilled operational executive, and I am incredibly proud that we are able to tap into MDA's deep talent pool to fill this critical senior executive position," said Mike Greenley, CEO of MDA. "With a strategic vision for MDA to capitalize on the growing commercial market for RSO products and services and the operational mindset to deliver Canadarm3 and multiple other programs, Holly is the right leader to take us forward."

A professional engineer (P.Eng.), Ms. Johnson earned a Bachelor of Applied Science (B.A.Sc.), Mechanical Engineering, from the University of Toronto. ●



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