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# SATELLITE EVOLUTION GLOBAL

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## Plus:

Can the satellite industry really bridge the Digital Divide?

## James Webb Space Telescope exceeds expectations



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## Upward mobility

This month our special focus is on satellite mobility and that got me thinking about upward mobility in the space industry and how far we've come in terms of diversity. On October 5<sup>th</sup>, Nicole Aunapu Mann launched to the International Space Station (ISS) as commander of NASA's SpaceX Crew-5 mission. What caught my attention is that she is a Wailaki member of the Round Valley Indian Tribes, making her the first indigenous woman from NASA to go to space.

It happens that I've been a resident of Round Valley, California for more than two decades. The history of this area is embodied in a book called, "Genocide and Vendetta" which in and of itself reminds us how the Wailaki people, and the majority of Indians in America, were treated back in the day. To know that Nicole Mann is not only circling 420 kilometers above us but is also on the list of astronauts training to go to the moon on a future Artemis mission is huge.

Women in space have numbered few and far between, compared to men. Of the more than 600 people who have gone to space, less than 80 are female. The very first woman to orbit the Earth, Soviet cosmonaut, Valentina Tereshkova, did so in 1963—three years before the founding of the National Organization for Women (NOW) in America. It took another 19 years before Svetlana Savitskaya flew aboard the Soyuz T-7 mission in 1982, returning in 1984 to earn the title of the first woman to perform a spacewalk.

The first British woman in space, Helen Patricia Sharman, was picked live on British television in 1989, after beating out 13,000 hopefuls who replied to a radio advertisement asking for astronaut applicants. Sharman, who was a chemist and a linguist, trained at Moscow's Star City to prepare for Project Juno—a collaboration between the UK and the Soviet Union. Launched on a Soyuz rocket in 1991, she spent 8 days in orbit aboard the Mir space station.

The US has sent the most women into space. The first class of NASA astronauts to include females was selected in 1978 with Sally Ride earning the title of the first American woman to enter space in 1983 while piloting the space shuttle Challenger. She is also the first known LGBT astronaut. The first African American woman in space, Mae Carol Jemison, was an engineer and biologist who spent 8 days in orbit as a science mission specialist on the STS-47 SpaceLab J.

To all the women who have pioneered the heavens, we salute you not only for your bravery and spirit of adventure but also for inspiring all the women who will follow in your footsteps.

In this issue of Satellite Evolution Global, we take an inside look at the gargantuan and complex undertaking by Northrop Grumman to build and successfully launch the James Webb Space Telescope. Scott Willoughby, Vice President of the Webb program, and Charlie Atkinson, who served as chief engineer on the telescope, reveal the ups and downs of getting the job done right. We also go behind the scenes with Dr. Leslie Klein, Founder, and CEO of C-COM, which pioneered mobile satellite-based internet connectivity.

Fabian Jordan, CEO of Astrocast addresses Internet of Things (IoT) interoperability and discusses why it is important to develop intelligent devices capable of seamlessly switching between several technologies, each being highly optimized for specific conditions. ●



Crispin Littlehales, Executive Editor ●●●



Photo courtesy Shutterstock

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## Crew welfare enhanced at Anglo-Eastern

**GLOBAL** - Anglo-Eastern Ship Management, a leading global provider of ship management services with more than 40 years of experience supporting shipowners worldwide, has chosen Inmarsat to connect its crew. Centered on the pillars of digitalization, decarbonization, and crew welfare, Anglo-Eastern's operations rely on robust connectivity and a forward-thinking approach. To meet the fast-evolving requirements of modern shipping, the company uses Fleet Xpress services from Inmarsat.

In 2019, Anglo-Eastern became one of the first companies to sign up for Inmarsat's award-winning crew internet solution, Fleet Hotspot, providing its seafarers with reliable, high-speed connectivity and the freedom to use their devices on board. The company doubled the free internet allowance for its crew in response to the Covid-19 pandemic and its impact on crew welfare. In addition, every year on the Day of the Seafarer and festive occasions, Anglo-Eastern increases crew internet allowance.

Captain Pradeep Chawla, Managing Director QHSE and Training, Anglo-Eastern Ship Management, commented "One of our main objectives as a ship management company is to improve the quality of life at sea – and since onboard connectivity is an essential part of that, we aim to provide the crew with a quality of internet similar to what they would have on land. That is why, through Inmarsat's Fleet Hotspot, we offer our seafarers free high-speed internet connectivity per month."

Gert-Jan Panken, Vice President Direct Sales, Inmarsat Maritime said: "Offering crew a high-quality internet connection is a prudent business decision for shipping companies. Through the user-friendly Inmarsat Fleet Hotspot portal, seafarers can monitor their usage and top up their balance using their own devices. Furthermore, recent enhancements to the portal have made the solution easier to use than ever, crew can access their accounts from home and purchase data even before boarding the vessel."

While the majority of land-based professionals might take workplace Wi-Fi for granted, high-quality internet has traditionally been hard to come by at sea. Such is the impact of Fleet Hotspot on the maritime industry that it recently won the Mission to Seafarers Innovation Award for its "outstanding contribution to seafarer welfare". As an advocate for the well-being of maritime personnel, the Mission to Seafarers is also a strong proponent of onboard connectivity, and its 2021 Seafarers Happiness Index identifies the amenity as critical to crew welfare.

Encouragingly, the shipping industry has made significant progress in this area in recent times. In Inmarsat's 2022 Seafarers in the Digital Age report, 78 percent of the shipowners surveyed said they had installed crew internet in the last five years. Meanwhile, another Inmarsat study published this year highlighted a 149 percent growth in data consumption for crew welfare and connectivity purposes from June 2021 to June 2022. As regards Fleet Hotspot specifically, uptake and usage of the solution are experiencing rapid growth – and with newly introduced amendments to the Maritime Labour Convention 2006 making crew connectivity a regulatory requirement, these trends look set to continue.

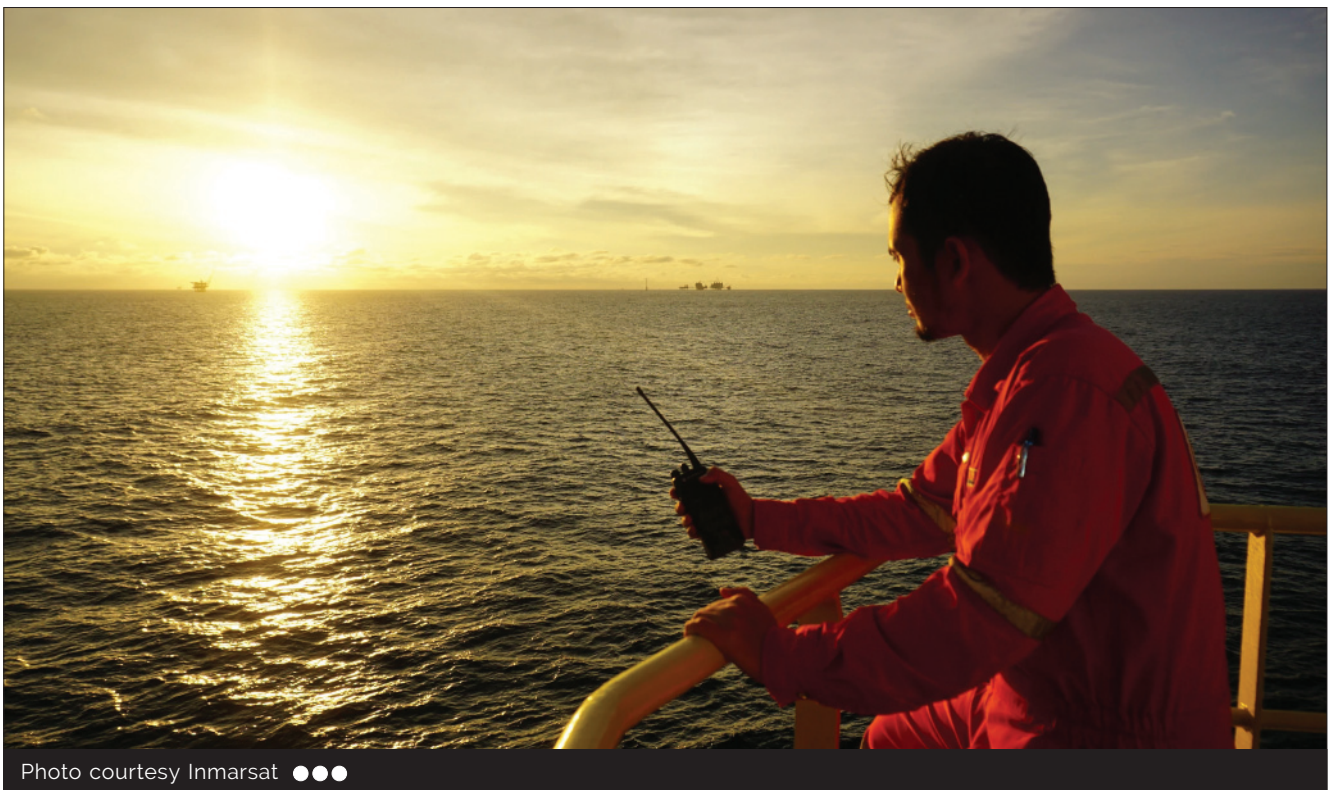


Photo courtesy Inmarsat ●●●



"The maritime industry has been facing a serious talent crunch for some time, and the situation has only intensified by the pandemic and the resulting crew-change crisis and geopolitical uncertainty," said Captain Chawla. "Owners and managers are now working with a smaller pool of talent, so the competition for the best candidates is fierce. To stand out from the crowd, companies need to place as much emphasis on crew internet access as they do on business-critical connectivity – and Fleet Hotspot makes this easy."

## OneWeb and Q-Kon Africa sign five-year agreement to distribute LEO satellite services in Africa

**AFRICA:** OneWeb has signed a distribution partner agreement with Q-KON Africa, a specialist technology company that supplies solutions based on satellite, wireless and VoIP technologies, to offer broadband connectivity services in African countries.

Q-KON Africa connects "off-grid" locations through their satellite broadband service, Twoobii, to core networks throughout Africa reliably and effectively. The OneWeb LEO satellite network will give Q-KON Africa's Twoobii customers access to high-speed, low-latency broadband to connect even the most rural or remote communities across several African countries. These include South Africa, Lesotho, Swaziland (eSwatini), Namibia, Botswana, Zimbabwe, Zambia, Malawi, and Mozambique. This strategic five-year distribution agreement was finalized at the digital infrastructure event in South Africa this month, AfricaCom. It will enable Q-KON Africa to unleash the power of OneWeb's network in order to provide vital internet service and Wi-Fi backhaul to connect schools, hospitals, civil government and other fixed enterprise and fintech services throughout the continent including banking, mining, and backhaul solutions.

This announcement is the latest effort for OneWeb to help bridge the digital divide across Africa through strong industry collaboration with local infrastructure and service providers. OneWeb remains on track to activate its coverage solutions in Africa, and elsewhere around the world, in 2023.

Ben Griffin, VP Mobility and AMEA at OneWeb, said: "At OneWeb, we believe that connection everywhere changes everything and that's why we are thrilled to be partnering with the engineering experts at Q-KON Africa to further our mission to connect those hardest to reach to the internet. Q-KON Africa's strong industry understanding,

flexibility, agility and local support will help us see OneWeb's LEO satellite network create opportunities to benefit unconnected and underconnected areas across Africa for today's digital environment. This agreement is another example of OneWeb's continued momentum, as we remain on track to activate coverage solutions in Africa and globally in 2023."

Dawie de Wet, Group CEO of Q-KON Africa and Chief Engineer for Twoobii, said, "For us, OneWeb's global lead and focus to deliver assured business grade, high-performance satellite services is the perfect option to expand our successful Twoobii Smart Satellite Services for Southern Africa. OneWeb's technology innovations will deliver data speeds of 100Mbps and low latency of 70msec, which will enable us to further service the business, enterprise, and financial markets. Leveraging emerging technologies to open new markets is in our DNA and we look forward to leading this new era in partnership with OneWeb."





## Sidus Space engages GTM advanced structures to integrate space-proven solar panels into LizzieSat

**NORTH AMERICA:** Sidus Space has announced a partnership with GTM Advanced Structures to integrate their space-proven solar panels into LizzieSat™.

Sidus Space is in advanced stages of developing LizzieSat, a proprietary partially 3-D printed satellite, expected to launch in 2023. The satellite design utilizes a combination of eight (8) deployed and additional body mounted solar panels to generate up to 400 watts of usable power for satellite operations and up to 50 watts continuous for payloads.

Since 2013, GTM has manufactured solar panels for the SmallSat market from 1U up to 12U solar panels. In the past two years, GTM has integrated more than 1400 triple junction cells onto solar panels. This, combined with GTM's development of a Plug and Play substrate using industry proven methods and products, creates a rapidly producible, highly reliable, cost-effective product. GTM's experience, combined with the selection of Azur Space, ensure both the efficiency and longevity of power collection which is vital to accommodating both vehicle basic operations and supporting payloads throughout the orbital lifetimes.

Azur Space assemblies provide space solutions with a higher integration level. Based on their high-efficiency solar cells of the 28 percent or 30 percent-Advanced class, the

assemblies are additionally equipped with cover glasses and interconnectors.

"We're excited to partner with GTM, an AS9100 certified company, to integrate its space-proven solar panels into LizzieSat™, providing our satellite with solar power and furthering our sustainability efforts. GTM is utilizing its space-proven solar panel manufacturing heritage, employing industry leading Azur Space solar cell assemblies (SCA) to provide Sidus Space with high reliability performance over the orbital lifetime of LizzieSat™. The solar panels are both fixed body mounted and deployable arrays providing a maximum level of exposure for power generation," said Carol Craig, Sidus Space Founder and CEO. ●

## NASA awards SpaceX second contract option for Artemis Moon landing

**NORTH AMERICA:** NASA has awarded a contract modification to SpaceX to further develop its Starship human landing system to meet agency requirements for long-term human exploration of the Moon under Artemis.

With this addition, SpaceX will provide a second crewed landing demonstration mission in 2027 as part of NASA's Artemis IV mission.

"Returning astronauts to the Moon to learn, live, and work is a bold endeavor. With multiple planned landers, from SpaceX and future partners, NASA will be better



Artist's rendering of SpaceX Starship human lander design. Photo courtesy SpaceX ●●●



positioned to accomplish the missions of tomorrow: conducting more science on the surface of the Moon than ever before and preparing for crewed missions to Mars," said NASA Administrator Bill Nelson.

Known as Option B, the modification follows an original award to SpaceX in April 2021 under the Next Space Technologies for Exploration Partnerships-2 (NextSTEP-2) Appendix H Option A contract. NASA previously announced plans to pursue this Option B with SpaceX.

"Continuing our collaborative efforts with SpaceX through Option B furthers our resilient plans for regular crewed transportation to the lunar surface and establishing a long-term human presence under Artemis," said Lisa Watson-Morgan, manager for the Human Landing System program at NASA's Marshall Space Flight Center in Huntsville, Alabama. "This critical work will help us focus on the development of sustainable, service-based lunar landers anchored to NASA's requirements for regularly recurring missions to the lunar surface."

The aim of this new work under Option B is to develop and demonstrate a Starship lunar lander that meets NASA's sustaining requirements for missions beyond Artemis III, including docking with Gateway, accommodating four crew members, and delivering more mass to the surface.

NASA initially selected SpaceX to develop a human landing system variant of Starship to land the next American astronauts on the Moon under Artemis III, which will mark humanity's first return to the lunar surface in more than 50 years. As part of that contract, SpaceX will also

conduct an uncrewed demonstration mission to the Moon prior to Artemis III.

The agency is pursuing two parallel paths for human lunar landers developed according to NASA's sustained requirements to increase the competitive pool of capable industry providers – the existing contract with SpaceX and another solicitation released earlier this year. The other solicitation, NextSTEP-2 Appendix P, is open to all other US companies to develop additional human landing system capabilities and includes uncrewed and crewed demonstration missions from lunar orbit to the surface of the Moon. Astronaut Moon landers are a vital part of NASA's deep space exploration plans, along with the Space Launch System rocket, Orion spacecraft, ground systems, spacesuits and rovers, and Gateway.

Under Artemis, NASA will send a suite of new lunar science instruments and technology demonstrations to study the Moon, land the first woman and first person of color on the lunar surface, establish a long-term lunar presence, and more. The agency will leverage its Artemis experiences and technologies to prepare for the next giant leap – sending astronauts to Mars. ●

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● ● Dr. Leslie Klein, Founder and CEO,  
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Q&A

## From on-the-pause to on-the-move ● ●

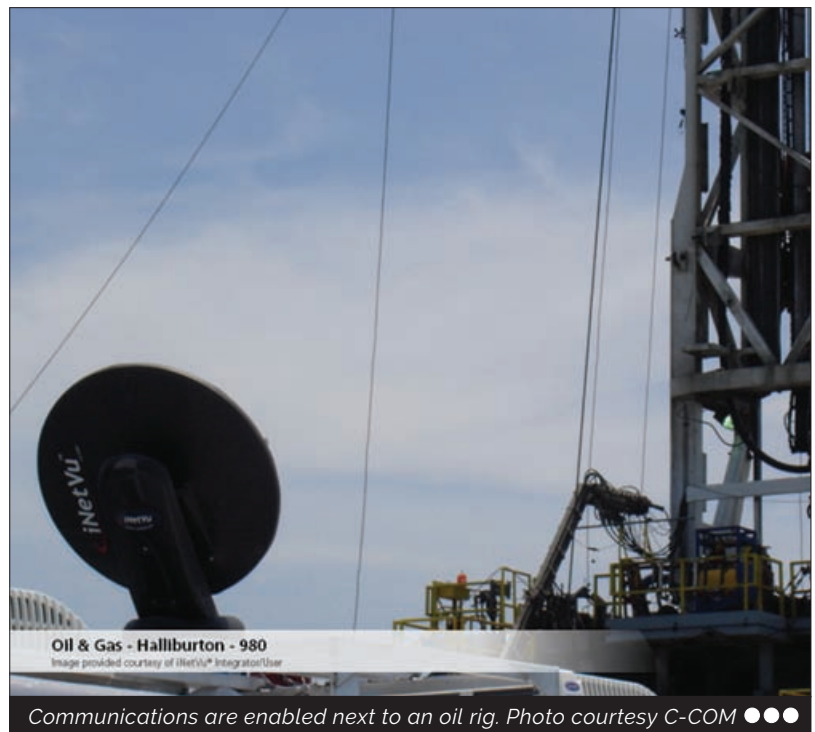
Ahead of its time as a developer of mobile satellite-based internet connectivity, C-COM has paid out about US\$19 million in dividends over the course of its 25-year history. Founder and CEO, Dr. Leslie Klein delves into the company's origins, evolution, and future plans. He also reveals the "secret sauce" that differentiates C-COM from competitors.

*Crispin Littlehales, Executive Editor, Satellite Evolution Group*

**Question:** What prompted you to found C-COM and how have you managed to stay at the forefront of the transportable and mobile satellite-based antenna business for all these years?

**Dr. Leslie Klein:** 25 years ago, Bilal Awada, our Chief Technology Officer, and I decided that perhaps, one day, connectivity to the internet will be required by vehicles—similar to the way that radio made its way into automobiles as a standard product. As it turned out, we were way ahead of our time as the satellite industry was not yet ready, either in terms of price or availability, to deliver that type of connectivity.

It took us some time to develop the technology and make a system that was capable of delivering high-speed internet to vehicles while on-the-pause. Using our technology required that you stop your vehicle, but you could then deploy an antenna automatically and find the satellite that delivered access to the internet at a relatively affordable price. Back then, we thought our market was recreational vehicles, but we soon







Mobile emergency operations center. Photo courtesy C-COM ●●●

learned those customers were not prepared to spend the money either for our hardware or for airtime, which was awfully expensive.

So, we had to quickly switch over to the commercial market which turned out to be a very fortuitous move. Our initial adaptors were oil and gas companies, disaster management customers, the military, and other vertical market users. Today, C-COM has a presence in 106 countries. We only sell through resellers, and we now have about six hundred system integrators and resellers who buy the product from us, install it for the end user, provide connectivity and offer support maintenance and warranties. In all, there are more than 10,000 C-COM antennas deployed around the world.

**Question: What have been the key drivers for product development?**

**Dr. Leslie Klein:** From the get-go, we decided to make a product that was extremely easy to use. As you can imagine, pointing the satellite antenna 25 years ago was not a simple task. Even today, you need a knowledgeable person, quite often a technician, who will spend a half hour to an hour to accurately point the antenna to the appropriate satellite. Our technical challenge was to make our products idiot-proof so that the user could just push a button and the system would do the rest. We designed all the hardware, the software, and the robotics to make a system that anybody—a bus driver, a rig worker, an emergency services provider—could use. That allowed the system to travel very rapidly from point to point and within minutes be able to connect.

Today our systems work with many different modalities and satellite services. They come in varied sizes from a small 74-centimeter antenna all the way up to 2.4 meters. We have more than 30 different products that do various things for different users using different frequencies. So, the systems have evolved over the years, but they use the same technology, the same controller, the same software, and require the same know-how.

#Softbank #CellularBackhaul #Antennas

The systems are also durable and reliable enough to provide communication in the middle of the desert or on top of a mountain, or wherever the customer was going and needed to be able to connect to a satellite. Some of the systems are still operating after 14 or 15 years. That, and the fact that they are priced right was the "secret sauce" that made our products so popular.

Our systems are life-saving devices. We sold 400 of our systems to Softbank in Japan during the tsunami when all of their cell towers were lost. These antennas became instant cell tower replacements making it possible to communicate within hours after the cell towers were lost.

**Question: What would you say are the most popular applications?**

**Dr. Leslie Klein:** The largest segment of the market initially was oil and gas exploration and also disaster management and cellular backhaul. We also have a large number of mobile banks and ATM machines that allow people to

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Mobile bank offers ATM services to customers in the Hawaiian Islands. Photo courtesy C-COM ●●●

withdraw and deposit money in remote areas. We also have a number of E-commerce type of applications for governments such as passport printing and ID verification. There was even a mobile jail in South Africa at one point where the unit would check weapons and those who carried them and didn't have a permit would be immediately incarcerated. Obviously, the offenders were not given internet access, but they were in the same unit where the checking was being done.

Another interesting application in South Africa was used to address the poaching of rhinos. The antenna was used to provide video of a very large segment of a park to monitor the poachers 24/7. The drone-based system would transmit information to our antenna which would then broadcast the imagery to officials who could dispatch either the military or local volunteers to stop the poachers from killing the animals.

**Question: Is there a big difference between the demands of the commercial market versus the government/military?**

**Dr. Leslie Klein:** The military market, especially NATO, US, and Canadian forces very often require MIL-SPEC products, which we do not manufacture. Nonetheless, a growing number of military organizations around the world, including NATO forces in both Canada and Europe, have recognized the reliability of our antennas and have been purchasing them for communications. They can buy two or three of our antennas for the price of one MIL-SPEC antenna plus they have the latest and greatest internal pointing technology. They also purchase our Manpack antennas which a single soldier can carry and deploy within minutes by pressing a button.

Both military and commercial customers appreciate the fact that C-COM has an extensive inventory of about US\$7 million worth of products which we can ship almost immediately. We do not ask our resellers to stock products because we can deliver large quantities of antennas within weeks, rather than months.

**Question: How have supply chain issues affected your ability to manufacture products?**

**Dr. Leslie Klein:** Our plan has always been to build exceptionally large quantities of products and in 2019 we ramped up in anticipation of orders to come. When COVID happened, many companies were unable to function at full capacity, but we had a great inventory that stretched into 2021. Then, knowing the supply chain was going to be an issue, we started buying and building products more than a year before we needed them for fulfillment.

The unfortunate part of the whole thing was that we used to pay US\$15 and US\$20 for an integrated circuit. Now those circuits are US\$300 unless you want to wait for 52 weeks to get them.

More than a year ago, we started to scour the market for all these long lead items and did our best to buy them at the lowest possible price—still not what we used to pay, but not at the outrageous prices that are going on today.



Emergency vehicle enables on-site communications. Photo courtesy C-COM ●●●





Officials can check for weapons permits and incarcerate offenders. Photo courtesy C-COM ●●●

That has enabled us to stay one step ahead and keep our cost to customers within reason.

**Question: Tell us about the C-COM Electronically Steered Phased Array antenna that you exhibited at Satellite 2022. What kind of feedback are you getting from the industry on this product and where are you now in terms of testing and validation?**

**Dr. Leslie Klein:** The antenna that we displayed in March was a 1000-element, fully functional antenna system that we tested over Telesat just to verify that the design works

as expected, which it did. Our ultimate production is a 4000-element antenna which is, at this moment, being completed and should be tested before the end of this year. Hopefully, we will be in production in 2023 with a number of beta units being distributed.

We anticipate that this technology will make it possible to develop new and interesting shapes and sizes of antennas. Because the antenna is conformal, it will be possible to use it in many different applications and over LEO and MEO as well as GEO satellites in the Ka-band frequency range. That means these antennas will be fully mobile and therefore ideal for use in vehicles, unmanned aerial vehicles (UAV's), aircraft, boats, trains, and military applications, among others.

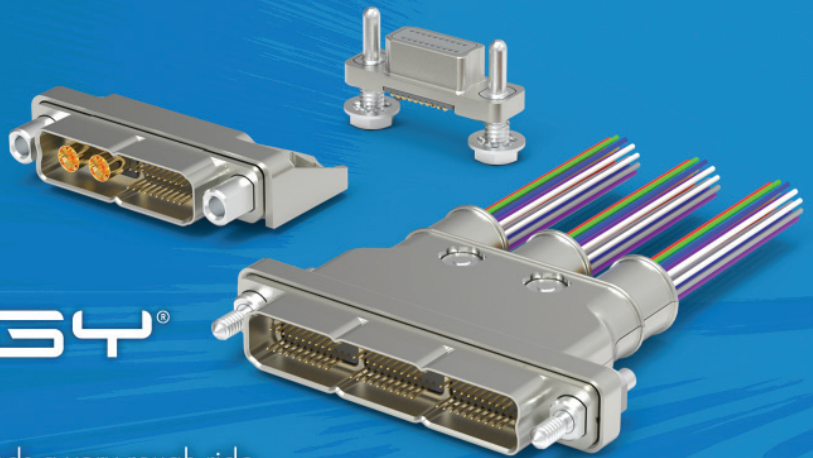
**Question: What can we expect to see from C-COM over the next several years?**

**Dr. Leslie Klein:** The phased array antenna market is predicted to be a US\$17 billion market over the next three to five years and even a small segment of that market would make a huge impact on our business. The introduction of the phased array antenna will change the direction of the company from an on-the-pause parabolic antenna system manufacturer to an on-the-move phased array antenna manufacturer. We would still be using the distributors that we have, and hopefully adding many new ones, but they will be selling an antenna that will have a tremendous impact on the satellite-based cellular communications market around the world. ●

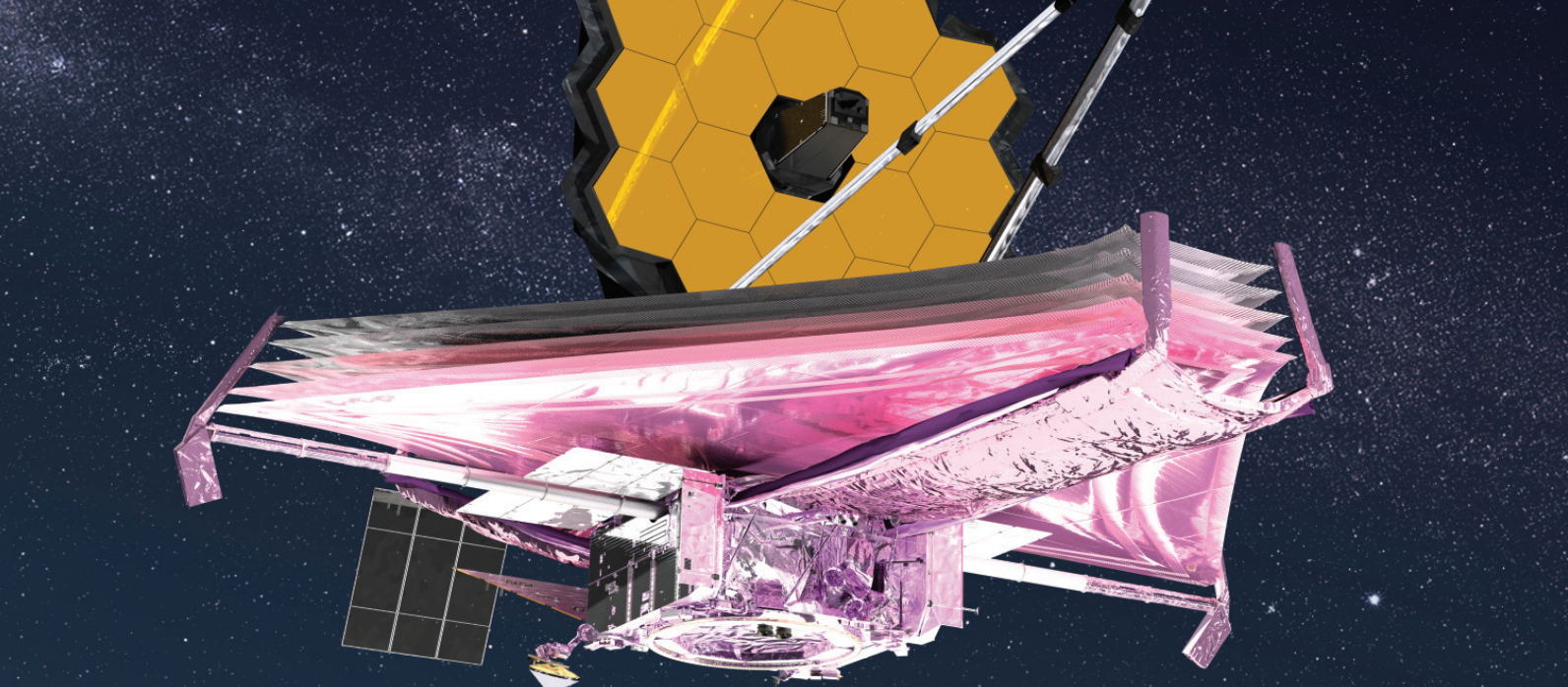
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Artist rendering of the James Webb Space Telescope. Photo courtesy NASA GSFC/CIL/Adriana Manrique Gutierrez ●●●

# James Webb Space Telescope exceeds expectations ●●

The stunning views of the universe emanating from the James Webb Space Telescope have already exceeded the expectations of every astronomer on Earth and this is just the beginning. Indeed, the buzz surrounding the imagery is so jubilant that it's easy to overlook the extraordinary effort required to bring the world's premier space science observatory to life. Scott Willoughby, Vice President of the Webb program at Northrop Grumman, and Charlie Atkinson who served as Chief Engineer on the telescope spent more than a decade making sure the job was done right.

*Crispin Littlehales Executive Editor, Satellite Evolution Group*

Who of us has not looked up at the stars and wondered, "Where do we come from, and are we alone?" Discovering the answers to those cosmic questions is what compelled NASA to embark upon the creation of the James Webb Space Telescope.

The notion of making an infrared-optimized telescope that could observe what the Hubble Space Telescope (HST) was not designed to detect surfaced in the late 1980s. But it wasn't until Dr. Alan Dressler and a committee of top-notch astronomers released the HST and Beyond report in 1995 that NASA committed to delivering the next-generation space telescope.

In an interview last February, Dressler, who is staff scientist Emeritus at Carnegie Observatories, told David

Zierler, oral historian for the American Institute of Physics, "NASA grabbed it and ran and I believe that part of the reason HST & Beyond caught on was that it was something new for these reports to see a big idea—origins, holding things together. Not just hardware, and not just the science of doing this and that, but something bigger. Here were astronomers showing the passion they had for their work, something very human that appealed to the general public."

## ENTER: THE DREAM TEAM

It is one thing to conceive of a telescope capable of seeing more than 13 billion years into the past and quite another thing to build one. NASA knew from the start that the next-generation space telescope would require complex and sophisticated state-of-the-art engineering and technology that had yet to be invented. That meant finding industry partners who were both capable of working miracles and committed to the long haul.

Only two teams were competing; one was led by Lockheed Martin and the other was assembled by Northrop Grumman and included Ball Aerospace; L3Harris, which, at the time was part of Kodak, and Orbital ATK, which was later acquired by Northrop Grumman (see sidebar, "Who did what").

Charlie Atkinson recalls, "In the late 1990s when we were first trying to conceive of what Webb was going to look like and how it was going to achieve the science objectives, we had a number of different architectures that we looked at. From the perspective of complexity, cost, and how able it was to achieve the mission science, it was very clear that the right choice was the architecture we see today. We also felt that the configuration of the optics and how to manufacture them was much, much more affordable if they were smaller segments. We made numerous decisions and evaluations before the selection, but the interesting thing is that the architecture didn't change much after that.



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*The James Webb Space Telescope shows how the galaxy cluster SMACS 0723, located about 4.2 billion light-years away, contains hundreds of individual galaxies. Photo courtesy Northrop Grumman ●●●*

"We'd put a lot of engineering and analysis behind it to have confidence that it was going to be successful," Atkinson explains. "We also made sure that the government saw how we were doing our analyses and we reviewed our results with them, so they had confidence that what we were telling them was, indeed, true."

#### A COMPLEX STRUCTURE WITH NO ROOM FOR ERROR

Webb is not only huge and complex, but it also needed to be folded up inside the cone of a rocket, survive the launch, unfold perfectly during deployment, and function flawlessly in orbit 1.5 million kilometers from Earth. "There are 344 single-point failures in the James Webb Space Telescope which is three or four times the amount on the Mars Perseverance rover," notes Scott Willoughby. "178 of those were just bolts that were used to hold it together for launch. Then there were lots of hinges and if one of those didn't work, the sunshield or mirror couldn't unfold."

"Our job was to make that number as small as humanly possible. I remember in 2011 when sunshield manager Jim Flynn was so excited that we finally went from 109 to 107 fasteners on the sunshield," says Willoughby. "It was two fewer things that could go wrong, but that's how hard this job was."

According to the literature, there were ten technologies that needed to be invented for Webb to work (See sidebar: Ten inventions), but if you drill down, you'll discover there's more than meets the eye. Atkinson explains, "For example, with the backplane or structure, we took what was the state-of-the-art at the time for implementing a spaceborne optical telescope and we needed to make it work at 40 degrees above absolute zero and we needed to make it three orders of magnitude more stable than has ever been demonstrated before. Then we had to prove that our approach was going to succeed. Well, we didn't have a way to do that since no one had ever tested a structure by itself to that precision, so NASA invented a technology called electron speckle pattern interferometry to go measure it."

The same is true for the telescope's mirrors. "Number one, they are ten times lighter than the mirror on the Hubble Space Telescope, and number two, it's a brand-

new type of beryllium processing that was invented to ensure it was stable enough," Atkinson continues. "The actuators behind it must operate at cryogenic temperatures and they need to make adjustments smaller than 10 nanometers, which was also a new technology. Then, too, we had to create a novel way to measure it."

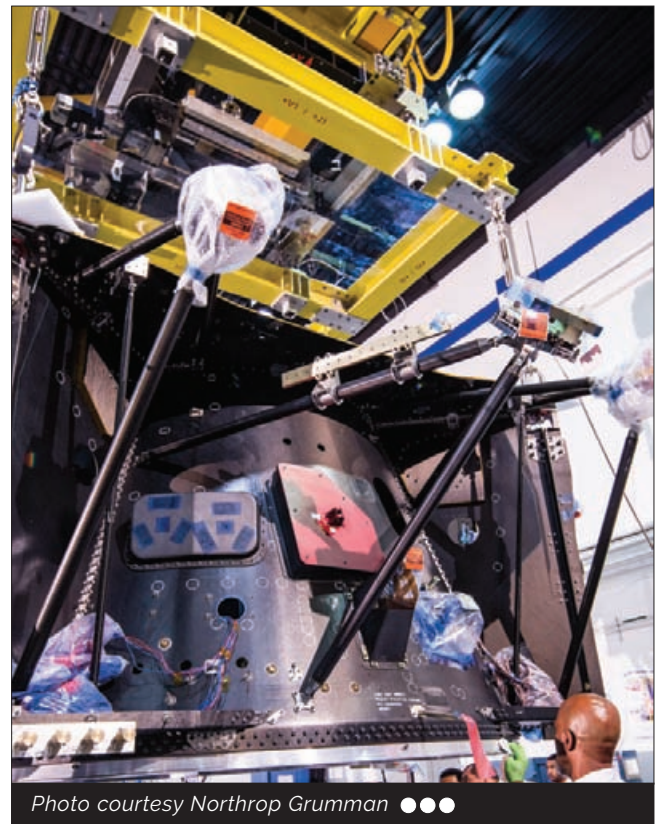
Willoughby echoes the sentiment, "What doesn't get the credit is the development of systems that never existed before. Nobody gives attention to creating a measurement technology or a way to prove that an invention works. Those efforts aren't seen as being exciting, but for us, it was critically important for something that was going to perform a million miles away from Earth and be unserviceable."

#### TESTING ON EARTH WHAT WILL HAPPEN IN SPACE

"We had to develop how we modeled the system because the deployed telescope operating in space never occurred here on Earth," notes Willoughby. "We could not deploy the sunshield and the optics together and we certainly couldn't put them in a thermal vacuum chamber and simulate the hot and cold environment. That was physically impossible."

Operating at cryogenic temperatures definitely added complexity and an engineering challenge across the entire observatory. "It meant that every single material that was used on the telescope and the instruments, as well as a good portion of the sunshield, had to be characterized at those temperatures," explains Atkinson. "When you get down into the 40 Kelvin and below range, you need liquid helium."

"The facility down at Marshall Space Flight Center was



*Photo courtesy Northrop Grumman ●●●*



### TEN INVENTIONS NEEDED TO CREATE THE JWST

- **Mid-infrared detectors** – arrays are lower noise, larger format, and longer lasting than their predecessors
- **Sunshield materials** – tennis court-sized sunshield is made of five thin layers of Kapton E with aluminum and doped-silicon coatings to reflect the sun's heat back into space
- **Microshutters** – tiny windows with shutters that measure 100 by 200 microns
- **Wavefront sensing and control** – senses and corrects any errors in the telescope's optics
- **Scaled telescope testbed** – for the development and testing of wavefront sensing and control
- **Lightweight cryogenic mirrors** – the primary mirror is 6.5 meters (larger than any other mirror launched in space)
- **Cryogenic detector readout application-specific integrated circuit** – functions at super-cold operating temperatures
- **Cryogenic heat switches** – used to cut off a thermal link for operational efficiency
- **Cryocooler for the mid-infrared instrument** – keeps instruments detectors at a temperature less than 7 kelvin
- **Large precision cryogenic structure** – backplane engineered to carry more than 2400 kg of hardware while remaining steady down to 32 nanometers

Source: NASA and ESA

augmented with a large helium shroud and we used it extensively for doing backplane characterization and the testing of the mirrors. Ball Aerospace put together a chamber in their facility and here at Northrop we had some test facilities that we modified for use at Webb's extremely cold temperatures."

The end-to-end cryo vacuum optical test for Webb's Optical Telescope Element (OTE) and Integrated Science Instrument Module (ISIM) was performed at the NASA Johnson Space Center which had been used to conduct thermal-vacuum testing for all manned spacecraft for the Apollo missions. Chamber A was retrofitted with thermal shrouds, helium refrigeration, liquid nitrogen system, high vacuum clean airflow system, and utilities.

"The chamber could be cooled to somewhere around 10 degrees Kelvin. We then had to attach the telescope and dynamically isolate the optic to measure micron or sub-micron wavelengths. Plus, the chamber was shaking because there were pumps pumping the air out to keep the vacuum and pumping in helium to keep it cold," recalls Willoughby. "These dynamic isolators were hanging from six points on the top of this seven-story chamber with the telescope dangling below and we're doing nanometer precision optical measurements. It was magnificent."

"We would build, then test," says Atkinson. "You build a mechanism, you test that mechanism and make sure it works in cryogenic temperatures and through all of its performance—the torque versus angle and the amount of

current that it draws, then you build that up into a structure so that now you have a deployable structure, and you test it at that level. Then you build it into the observatory and test it at that level so you're creating a test record on all these components and all these systems and how they behave over time."

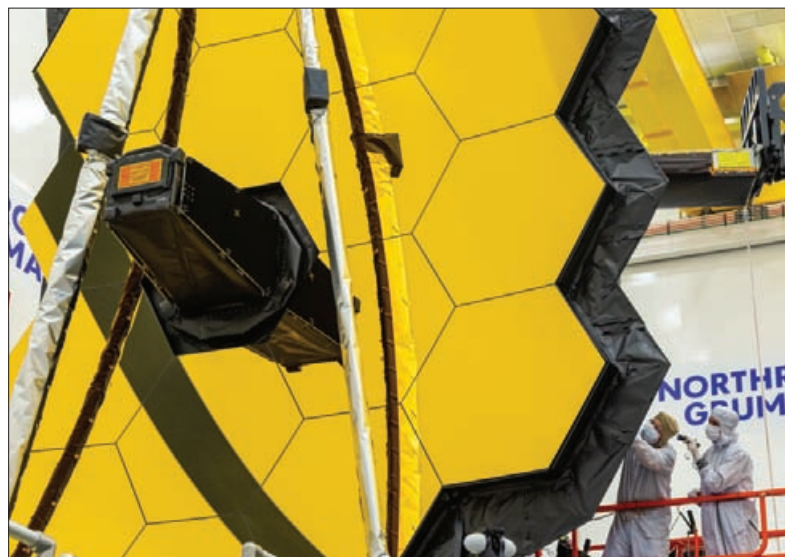
One of the other things that Northrop Grumman introduced as part of its proposal was a Pathfinder. "We built up a telescope structure before the flight one was created," Atkinson explains. "Then we practiced putting the mirrors on it. Then we practiced the Johnson Space Center test on it. By doing that, we could test out all the integration processes and get all those test bugs out of the way before we had to do it on the flight."

### ESTABLISHING TRUST AND WORKING AS A TEAM

"Our suppliers were our teammates and we treated them as such," Willoughby states. Indeed, Atkinson split his time between Ball Aerospace in Boulder, Colorado; L3 Harris in Rochester, New York; and Orbital ATK in Magna, Utah. "It was really important to be there in person because looking someone in the eye and having an honest conversation is crucial to building a trusting relationship," says Atkinson.

"There was such synergy going into the proposal: what Ball was capable of in terms of their history with cryogenic optics and their work on other parts of the telescope; what L3 Harris had done building large optical systems like the Chandra where they integrated this enormous 10-meter-long telescope that included very unusual cylindrical optics; and Orbital ATK who developed the backplane composite structure. Bringing all those strengths together and making sure we worked as a team was very important."

Needless to say, the team worked closely with NASA as well. Northrop Grumman set up an office right down the street from the NASA Goddard Space Flight Center and Atkinson moved from Redondo Beach, California to Maryland. "I went to meetings on the Goddard campus practically every day to make sure that we were



For the last time on Earth, the James Webb Space Telescope opened its primary mirror in May 2021. Photo courtesy Northrop Grumman ●●●

**NORTHROP GRUMMAN SUBCONTRACTORS: WHO DID WHAT****Ball Aerospace**

- Led the development, design, and manufacture of JWST's entire optics system, including the primary, secondary, tertiary, and fine-steering mirrors.
- Using Wavefront Sensing and Control, Ball's advanced software calculates the optimum position of each of 18 beryllium mirror segments working as one
- Built cryogenic actuators to accurately align the telescope and enable the telescope's high-quality, sharp images
- Supported integration and test on these systems

**L3Harris**

- Integrated components made by various partners to form the Optical Telescope Element
- Combined the components of the Integrated Science Instrument Module
- Administered about 100 days of testing in a cryogenic vacuum chamber at Johnson Space Center

**Orbital ATK** (now part of Northrop Grumman)

- Delivered the primary mirror backplane support structure which holds the telescope's primary mirrors motionless while the JWST is in orbit
- Designed and manufactured fuel and oxidizer tanks for JWST
- Performed qualification testing and shipped the propellant tanks to Northrop Grumman for final integration

Source: Ball Aerospace, L3Harris, Orbital ATK

communicating effectively and frequently. We invited NASA to join us when we met with the other team members to ensure there was transparency up and down the line," he explains.

Representatives from all those entities were needed to integrate the optics into the telescope structure at Goddard. "We were all there during those operations and also when we did the testing at Johnson," notes Atkinson. "It was the same when we were up at Space Park in California when we all supported the integration of the telescope to the sunshield and the spacecraft. We started as separate entities in physically different locations, but then all of us followed the observatory around as it was being put together."

**BOOSTING MORALE IN THE FACE OF SETBACKS**

Exciting though it was, creating Webb was stressful, and it took years to get to the finish line. One might well wonder how Northrop Grumman managed to keep the team inspired and on track. "It's sprints inside a marathon," says Willoughby. "We had to admit that the mission would be hard, and that the expectation was singular: we will be successful in orbit. We acknowledged there were going to be stumbles on the ground."

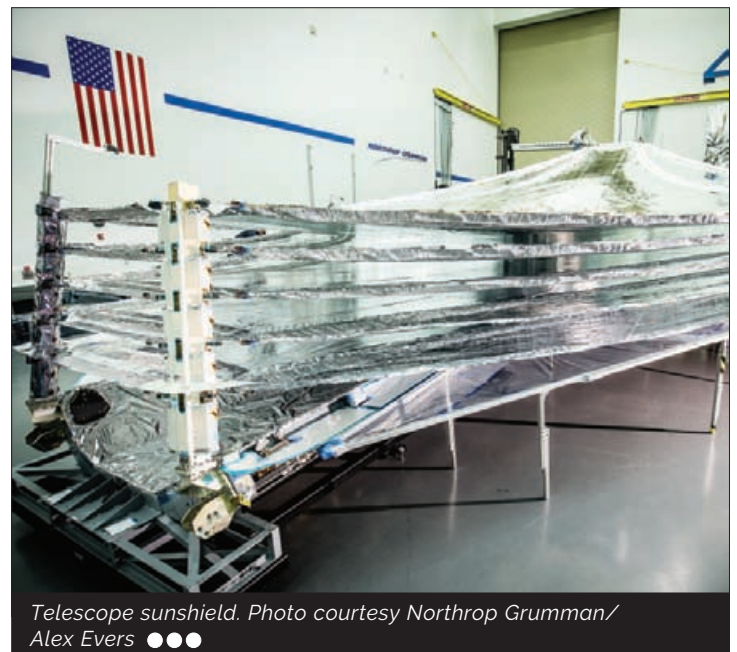
"When something went wrong, we would ask ourselves, what did we learn from this? What do we do next? Let's not make the same mistake twice. So, we gave ourselves a different vantage point. In staff meetings, I encouraged everybody to tell us if they were worried and reminded them that they had a right to say, 'let's read the procedure again'," he adds.

"Every time we had a success, we celebrated it. We did fun things like going to a bowling alley or a local place in the park. We had a monthly recognition where we would read people's names out loud and present them with a challenge coin and applaud."

That went on every four weeks for more than a decade.

**THE FINAL FRONTIER**

What was it like when Webb finally left the Earth and headed to its ultimate destination? Atkinson recalls, "It was one long, slow breath out from launch all the way through commissioning. We got past the launch, and that was great. Then we saw the solar array deploying and that was fantastic. All the way, 14 days of deployment, that was huge. Then we saw from the telemetry that everything was performing as expected. The temperatures on the telescope started to drop and we knew the sunshield was doing its job. Once we got the telescope aligned, there was that first image, and we knew we had a science mission. Finally, we commissioned all the instruments. Oh my, it was just incredible."



Telescope sunshield. Photo courtesy Northrop Grumman/Alex Evers ●●●



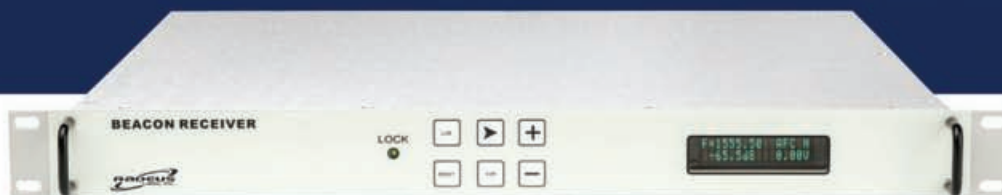


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● ● Jan Hetland, Director, Data Services Division, Telenor Satellite

Satellite Evolution Global

Q&A

## Agility and reliability are key to mobility sector success ● ●

Connectivity has always been a key priority for the maritime sector but today, as geopolitical events place new demands on the industry, the need for satellite communications companies to be both agile and reliable is more imperative than ever. Satellite companies need to demonstrate their innovation and resourcefulness to ensure their client's evolving requirements can be met promptly and effectively. We spoke to Telenor Satellite's Jan Hetland, Director of their Data Services Division, about the current state of the sector and what he sees for the future of the satellite communications industry.

*Laurence Russell, Associate Editor, Satellite Evolution Group*

**Question: Could you summarize the challenges and milestones that Telenor Satellite has faced in the last year?**

**Jan Hetland:** COVID has obviously been challenging for everyone but planning for a post-COVID world has been difficult because we haven't known what to expect. We have had to anticipate what demand would be like from each sector and then design our networks to fulfil that anticipated demand.

For example, the ferry business is coming back stronger and more quickly than we had anticipated, not because of an increase in passenger numbers relative to pre-COVID times, but because each of those passengers seems to have a higher requirement for connectivity. It seems people have become much more used to having connectivity at their fingertips and also making use of it, and they take that with them when they travel. So, the average revenue per passenger has been higher post-pandemic than it was before.

We are also seeing a surge in demand for oil and gas connectivity, not just from our maritime clients but also for our land-based services. This is not necessarily from new clients, but we are finding that our existing clients have been cancelling downgrades, requesting upgrades, developing new projects, and increasing exploration. The upshot is that we have needed to rebalance our business, and this has been helped by the new and more efficient technology we have introduced which has increased our capacity and made possible higher bandwidths in the Nordics.

**Question: You've enjoyed a healthy collaboration with Xiplink™ on your Anker Managed Service and through their WAN optimization service. Could you recap how that partnership has progressed?**

**Jan Hetland:** Earlier this year we started to offer XipLink, an end-to-end WAN optimizer solution, as part of our Anker Managed Services portfolio. This provides increased throughput, maximum wireless performance, and an improved end-user experience. XipLink has proved very beneficial to our passenger ship clients as it offloads the computational burden of a large number of end-users and TCP sessions from the satellite modems, which often prove to be the bottleneck.

We are finding our clients across the board in this sector are opting



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for XipLink and, in fact, having tried it on a first vessel they have chosen to roll it out throughout their entire fleet. The amount of uptake we have seen on the XipLink service is very encouraging and we expect it to continue to grow.

**Question: With developing geopolitical events placing new demands on the industry week by week, how have you seen connectivity demand shift?**

**Jan Hetland:** I think the biggest change we have seen has been with the oil and gas sector as explained earlier. Prior to COVID, there had been a reduction in exploration and, of course, that reduction was expected to continue following COP 26. With the onset of the conflict in Ukraine, everything has been turned on its head and we are seeing greater demand for connectivity in support of a rise in activity.

Certainly, in a country like Norway which has enjoyed revenues from the oil and gas sector for many years, the discussion that had centered around tailing off, or even ending, oil exploration activities has now been put aside as the EU attempts to reduce its reliance on Russian energy. However, I think the shift goes beyond simply oil and gas and encompasses the entire energy sector as we have also seen a lot of activity related to offshore wind projects including floating wind farms which will also increase demand for connectivity. It's all about ensuring energy security and developing alternative and renewable energy sources.



*People have become much more used to having connectivity at their fingertips and expect it even when travelling in remote areas. Photo courtesy Telenor Satellite ●●●*

**Question: How can satellite companies work with their clients to anticipate changing requirements and deliver reliable service?**

**Jan Hetland:** There is really only one possible answer to this question – satellite companies need to listen to the demands of their customers and then make sure that they have the right products and services to deliver the connectivity they need. For satellite operators such as ourselves, the key challenge is that you need a three to four-year lead time when designing and building a satellite, so both we and our clients need to have a very good idea of our future needs well in advance. And you try to build a bit of flexibility into your satellite design to cater for changing demands.

Still, not all of our customers take a long-term view so we also need to look at market reports and overall trends although you wouldn't launch a broadcast satellite without having firm requirements from the broadcaster and you would design it around their needs.

It is fair to say that today's satellites offer much more flexibility in terms of redistributing capacity so that, combined with talking to clients about their projected requirements, means that we have more certainty that we will meet demand moving into the future. Data connectivity is certainly going to increase and part of our role is to make customers aware of what is possible so that they can make the most of their opportunities.

**Question: Going forward, how do you see mobile satcom technology changing?**

**Jan Hetland:** In the future, you will see bit rates continue to increase and connectivity requirements will only rise. People expect more, for roughly the same amount of spend, so we have to try and deliver on those expectations and provide more for the same amount of money. While demand grows for increased services and performance, the baseband platforms and modems which form the infrastructure of the business are having to keep pace. This is the main reason for our recent adoption of the Newtec Dialog® platform which ensures we can provide services up to 100/25 Mbps in order to support high-end user cases.

Maritime antenna technology is another important area. Today's modern satellites are more powerful than older satellites, and in turn, this allows smaller, lighter, and lower-cost antennas to be used. This is a particularly important area for the maritime sector since the typical maritime stabilized antenna platforms account for a large portion of the total cost of a maritime satcom terminal. For some time, flat-panel antennas have been seen as the holy grail for maritime satcom, as they have no moving parts and motors which are subject to wear and tear in a challenging maritime environment. Although progress has been made in this area, the equipment manufacturers have yet to solve all the issues required for flat-panel antennas to become a mainstream technology. Today, they are either too low in performance, they cost too much, or they consume too much power.

The new LEO and MEO systems may help bring about this change since they heavily rely on such antennas being available in order to offer low-cost terminal equipment. But the past eight to ten years show that improvement



comes in gradual small steps and not in giant leaps. In the current geopolitical landscape, we are seeing supply chain issues, embargos and looming trade wars which all contribute to rising prices and schedule delays.

Hence, several of the planned LEO/MEO systems have already announced delays or have to scale back on their initial ambitions. Starlink's recent launch of a service for the yachting market is perhaps a sign of progress being made, however, and it will be interesting to see if they are able to satisfy the requirements of this maritime segment going forward.

**Question: What is the most important thing that the maritime sector needs to understand about connectivity?**

**Jan Hetland:** I think the entire maritime sector will need to focus more closely on cybersecurity. There have already been some high-profile breaches involving large shipping companies which have caused problems within the supply chain and more recently a two-way service in Ukraine was hacked and effectively shut down. This just shows that the industry must take a holistic view of cybersecurity.

Having secure satellite networks will not help much if a ship's own IT infrastructure is left vulnerable and exposed to the Internet.

There are still far too many examples of clients and ship owners operating network equipment using default factory login credentials. So, everyone's mindset has to change really.

Being part of a large multi-national telco - Telenor Group - cybersecurity is something we have to take seriously, and within the Telenor group of companies, we have access to some of the best expertise in the country



*Telenor Satellite has seen increased activity related to offshore renewable energy projects. Photo courtesy Telenor Satellite ●●●*

to help us design our networks and improve our security posture.

**Question: What can we expect from Telenor Satellite in the years ahead?**

**Jan Hetland:** For sure we will continue to evolve as a satellite operator, we need to continue to put new additional capacity into the sky when there is a need, and the time is right. We will continue to invest, evolve, and develop new technology to meet our customer's demands.

So, in a nutshell, we are planning to be productive, planning to be around for a good many years and planning to invest in and adopt new technology whenever the possibility arises. No revolution on our part but steady evolution going forward. ●

An advertisement for Azure Shine International Inc. featuring a city skyline at night, a satellite in space, and three VSAT antennas. The text includes the company name in Chinese and English, and mentions 'Eutelsat / Intelsat Type Approved VSAT ANTENNA SYSTEM' and 'DTH ANTENNA SYSTEM'. Logos for Eutelsat and Intelsat are at the bottom, along with the website URL and QR codes.

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## IoT Interoperability – Optimizing every aspect of the Sat-IoT component

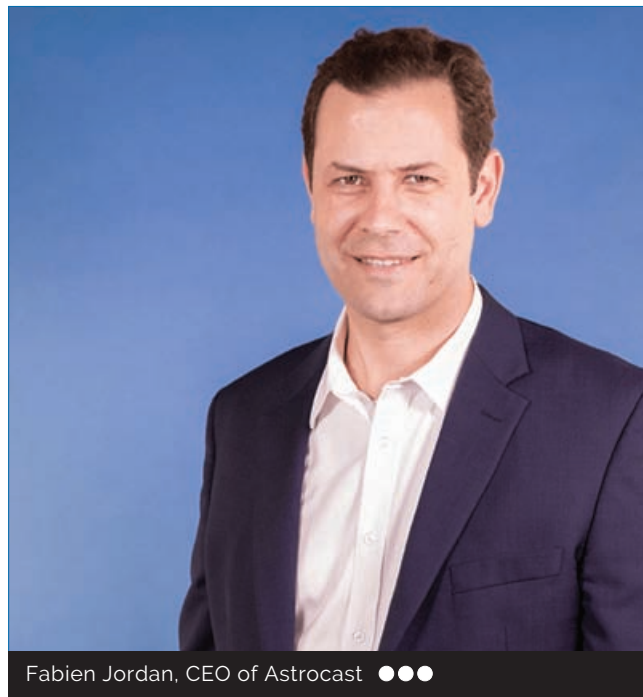
With 85 percent of the planet not covered by cellular networks, the introduction of cost-effective satellite IoT (Sat-IoT) has left systems integrators rushing to meet the overwhelming demand for complete, global asset tracking solutions. It is now possible to develop fully connected IoT solutions, which track mobile assets as they move and seamlessly connect to an array of networks, from cellular to LoRaWAN, Sigfox, and satellite.

*Fabien Jordan, CEO of Astrocast*

Some integrators are relying on future 3GPP standards to promise the one-size-fits-all approach but is this really a safe bet? While using existing terrestrial protocols for satellite communication is technically feasible, it is not favourable for performance. In addition, IoT is extremely sensitive to cost and power consumption meaning seemingly minor differences in performance, like battery life and or device lifetime, bring the potential to derail the business case. The soundest approach, therefore, is to develop intelligent devices capable of seamlessly switching between several technologies, each being highly optimized for specific conditions.

### IOT GOES GLOBAL

2022 is proving to be the year IoT goes truly global. Now for the first time, cost-effective Sat-IoT solutions are



Fabien Jordan, CEO of Astrocast ●●●

enabling businesses to track assets in even the most remote locations on the planet. By connecting the 85 percent of the world not covered by cellular networks at a price point far lower than previously possible, the opportunity to collect data from assets as they move between networks – from cellular to satellite – is incredibly exciting.

The use cases are vast. Supply chains are being revolutionized through the seamless tracking of shipping containers. Agriculture is being transformed by remote monitoring of both animals and environmental factors such as moisture; new levels of insight which is being utilized to reduce reliance on antibiotics and optimize the use of scarce resources. Our understanding of environmental issues and strategies to address them has accelerated using data from monitoring oceans.

Amid significant pent-up demand for seamless global IoT solutions, retaining focus on the core components of IoT success is essential. Large-scale deployments can involve hundreds of thousands of devices, often in inaccessible locations. Optimizing device lifetime and design is therefore central to the business case and companies need to pay careful attention to factors such as battery life and size, updates, frequency of transmission, and antenna design.

### COMPARING STANDARDS

In this emerging market, systems integrators face challenges in achieving integration without compromising performance or undermining the business case. The question is whether the industry should rely solely on cellular IoT standards in the hope that they might one day be satellite-compatible, hence minimizing device complexity is central to the current debate. Or should they opt for the operational performance benefits of combining the available and highly efficient proprietary Sat-IoT data protocols with cellular and LPWAN technologies which would make mass-scale deployment financially viable for the first time?

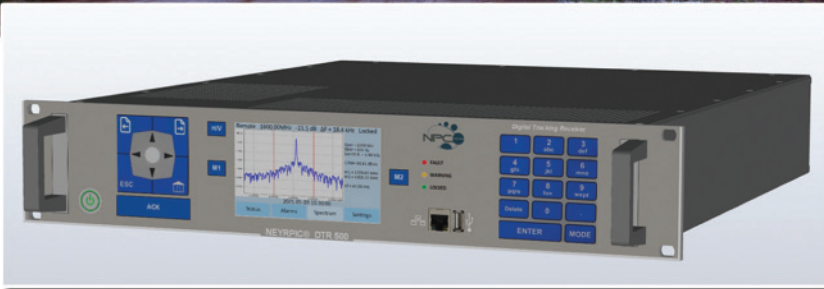
Adhering to industry standards in any technology deployment is understandable in principle, bringing the benefits of application longevity and improved agility.



*Photo courtesy Astrocast ●●●*



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Photo courtesy Astrocast ●●●

However, the value in taking this approach is reduced if performance is fundamentally compromised, especially when the business case is as financially sensitive as IoT.

At present, a standard for Sat-IoT deployment has not been established. It will take years for the proposed 5G Narrow Band Internet of Things (NB-IoT) standards to become fully ratified, not forgetting that NB-IoT is real-time only. This option wouldn't support store-and-forward operations, a vital component of operating through a network of LEO (Low-Earth Orbit) satellites. The requirement to manage various frequencies used on the ground by NB-IoT devices also brings significant complexities. Although often overlooked, this is likely the biggest challenge to overcome. The cost and complexity of satellites make the business case more difficult, and in some cases, impossible to close.

At the same time, some systems integrators are trialing the use of the established LoRaWAN standards over satellite, which is achieved over a licensed or unlicensed spectrum. But both cases present some significant challenges to overcome to make important features such as bi-directional communications or store-and-forward capabilities possible.

In addition, the fact that 5G NB-IoT and Long-Range Radio (LoRa) over satellite involve more data overhead than an optimized proprietary protocol like Astrocast means significantly more energy is consumed per byte sent. Although these standards might simplify the deployment model in theory, systems integrators need to appreciate the devastating impact the use of non-optimized data protocols for the Sat-IoT component has on IoT device performance. This impact can be so severe that the IoT business case is destroyed.

#### THE BENEFITS OF OPTIMIZED DEPLOYMENT

Various factors have made proprietary data protocols a vital component of the Sat-IoT development model. Optimized deployments are more cost-effective, more reliable, and higher performing. This is especially true in key areas such as power consumption, which has the potential to make or break an IoT deployment. Battery or device replacement is extremely challenging in remote locations and at times, impossible for goods in transit, for

example, so excessive power consumption should be avoided. Devices with optimized data protocol and chipsets bring significant advantages – without them, a device using a generic network standard for Sat-IoT will use up to ten times as much power.

Furthermore, simply adding a Sat-IoT connection to an existing device, even if using the same network standard such as LoRaWAN is not a viable option. Unlike plug-and-play, devices must be fitted with a new antenna or a new radio frequency (RF) front-end to connect to the satellite. It therefore makes far more sense to opt for enhanced data protocols and devices with a chipset optimized for Sat-IoT. Design is another important aspect – devices need to be small enough to be used on livestock, for instance, without getting caught in vegetation and strong enough to withstand years outside without needing repair or replacement. The same wear and tear requirements and robustness requirements apply in several other use cases too.

The ability to provide remote device upgrades through two-way communication is also key, further extending the life of a device in the field. In innovative IoT applications, such as the creation of virtual fences for livestock, bidirectional communication removes the need for costly processes to install and maintain fencing across remote areas.

#### THE PROPRIETARY CASE

Using proprietary data protocols should be recognized as an enabler for deployment. It allows systems integrators to develop solutions that use multiple networks to track assets as they move across the world (or even if they remain static). In addition, users can switch the primary network at any time – changing from cellular to Sat-IoT in certain high-cost regions, for example, to achieve a greater level of control over the operational cost base.

While full integration remains a long-term dream, standards will emerge over the next decade and progress will accelerate. To capitalize on the power, potential and financial benefits of Sat-IoT today, dedicated proprietary protocols, such as those offered by Astrocast, present the best way to develop a robust, achievable business case for IoT. ●

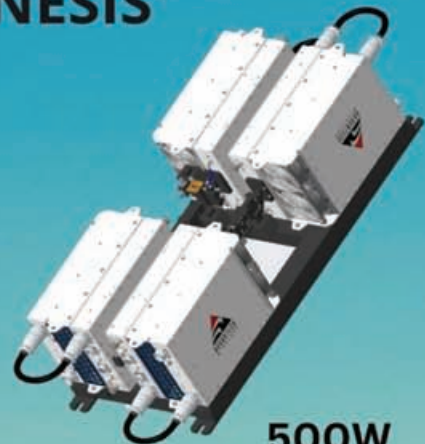




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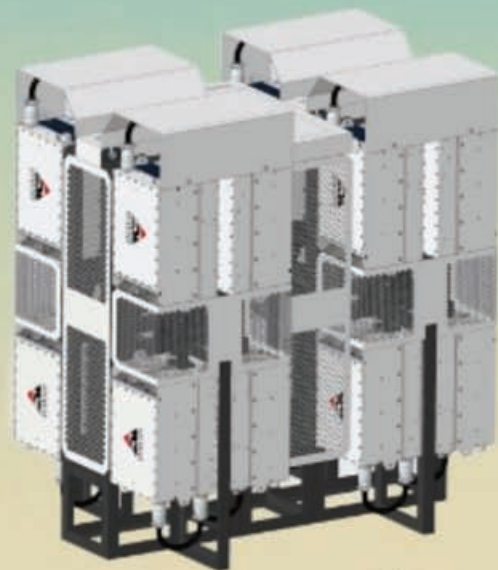
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## Can the satellite industry really bridge the Digital Divide? ●●

The Digital Divide has created a real inequality and division when it comes to accessing information and resources. With satellites becoming popularly understood as a key turning point in the struggle, we spoke to landmark connectivity providers at Forsway, as well as a foremost expert on the subject in Waheed Adam, Board Member at the Mobile Ecosystem Forum.

*Laurence Russell, Associate Editor, Satellite Evolution Group*

Since the satellite industry aspired to connect people across the vast distances of orbital coverage, there has been an elephant in the room in terms of the subject of the unconnected and underserved population suffering at the wrong end of a global digital divide.

These unconnected peoples, disproportionately situated in the southern hemisphere, have not been waiting for vastly more advanced technologies to digitize their communities and economies, with fiber ready-and-waiting, but economically unviable. Yet the most prominent of LEO broadband brands remain happily patting themselves on the back for providing a vastly more expensive solution than the one the so-called developing world was already unable to finance.

In conversation with Forsway, a company that's part of a leading affordable solution in collaboration with Arabsat called XtndNet, we asked what the industry's been missing.

### THE SCOPE OF THE CHALLENGE

"Forsway's research has determined that we have about

2.5 billion people today with no internet access," says Forsway's Bengt Jonsson, Vice Chairman, "down from a relatively recent figure of three billion, which has shrunk thanks to significant rollouts of broadband access to the developing world. These people are primarily spread across Africa, Asia, and Latin America."

"We're entering markets where people are disproportionately underprivileged at an income of perhaps a few dollars a week," adds Anders Brandter, the company's Director of Global Sales & Marketing. "Those individuals are unable to afford their own personalized services, so until development forges a strong quality of life, the only way to connect these demographics in a reproducible way is through aggregated packages. In some XtndNet centers, we can serve up to 500 users, which means one satellite terminal can enable community WiFi for a whole village, giving them all some access to the connected world until more advanced solutions become economically practical."

"Internet access has become a human right," Bengt agrees. "We can't develop and price the devices that enable essential connectivity as luxuries when they're





Bengt Jonsson, Vice Chairman, Forsway ●●●

baseline necessities. Being able to connect large public service buildings does a world of good, enabling technologies where they can do the most. We have a customer in the Philippines that is delivering to small offices and schools, working to this exact model."

XtndNet began as an affordable service tailored for Africa, which specialized in developing key infrastructures across the continent, supporting critical access to community services, education, health information, business opportunity, entertainment etc.

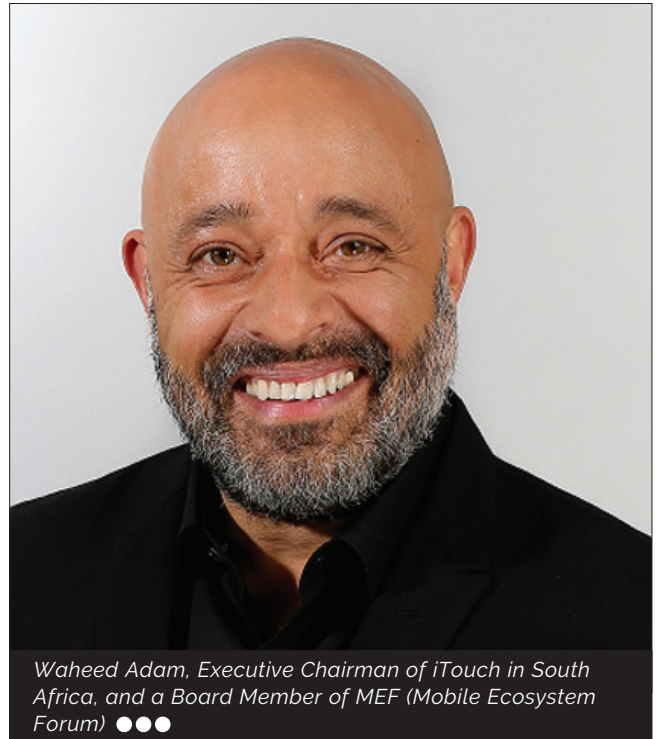
At the time of the initial agreement with Arabsat, Tobias Forsell, Forsway's CEO, stated, "We are excited to be working with Arabsat, a leading satellite operator, to create a new way of delivering highly cost-effective broadband services in Africa. Tapping Forsway's hybrid technology, we are helping Arabsat Broadband Services enable rapid deployment of robust, satellite-based internet services and eliminate the need to deploy costly additional

infrastructure. The Forsway Odin technology is furnishing Arabsat Broadband Services with a competitive, low-cost alternative to VSAT for the new Arabsat Broadband service model and offering."

#### THE AFRICAN PERSPECTIVE

Speaking to Waheed Adam, Executive Chairman of iTouch in South Africa, and a Board Member of MEF (Mobile Ecosystem Forum), we wanted to make sure we weren't talking about African solutions without African voices.

"With a population of 1.4 billion, and an average age of around 20, Africa's potential outstrips most in the world," Waheed explains. "And with a continent of unique



Waheed Adam, Executive Chairman of iTouch in South Africa, and a Board Member of MEF (Mobile Ecosystem Forum) ●●●

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problems, it opens up a world of opportunities to find solutions, making for a very attractive investment outlook. This is evidenced by the growth of foreign investment into the continent.

"Connectivity is key to driving this potential, with a young population where mobile adoption is part of their DNA. Africa is the next 'gold rush' and we are seeing the early pioneers or adopters take their place in the ecosystem of African opportunities."

The challenge of bringing this enormous treasure trove of unexplored talent to the global community isn't just one of affordability, but one of regulation. "Africa has 54 countries, making up a continent with a landmass that could encompass all of Europe several times over, each with its own policies and regulations creating a complex environment in which one size does not fit all. This can lead to a lack of investment or in some cases disinvestment, as potential partners lose interest in favor of simpler market opportunities."

Anders Brandter spoke about this very obstacle. "There's a lot of people we're still struggling to reach. It's difficult to approach certain African schools or their governments to negotiate the implementation of our solutions, so we're working with a large satellite operator who has the authority to engage with UN agencies and governments to create the necessary inroads to bring this connectivity forward."

#### WHO HAS THE COMMON-SENSE SOLUTION?

With a variety of solutions likely being necessary to serve the breadth of the African continent, best practice is still being hammered out.

"Considering the costs of deploying necessary infrastructure," Waheed goes on, "innovative technologies such as RAN, backhaul and renewable/reliable energy will assist in deploying the 4G standard. In addition, Mobile Network Operators (MNO)'s must find new commercial models, and African governments must provide supportive policy frameworks that will serve as the backbone of

improving the commercial feasibility of rolling out mobile internet broadband networks."

While the colossal hurdle of navigating the disparate regulatory frameworks of Africa continues to stand in the way of providers like Forsway, there can, at least, be some consensus around what service models don't present practical solutions.

"We've seen high-profile LEO solutions from some of the world's foremost space companies claiming to be able to do this job," Bengt describes, "but we believe their offering is too expensive and too reliant on complicated technologies unlikely to be found in economically destabilized areas. Our service is robust and built to work with existing technology as painlessly as possible. You won't get ease of use with a VSAT system, and you won't get affordability with OneWeb or Starlink. As much as they pride themselves on it, we think these options just don't do the job." ●



Anders Brandter, Director of Global Sales & Marketing, Forsway ●●●





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● ● Dario Betti, CEO of the Mobile Ecosystem Forum

Satellite Evolution Global

Q&A

## What are we missing about the metaverse? ●●

Since Meta's startling reveal of their new market direction toward virtualization, the tech world has been abuzz with both hope and derision for the explosive new "metaverse" reality that has been harkened. The exact nature of these technologies and their reliance upon location-aware satellite support remains in debate, fueling publicity that Meta executives have been no doubt banking on. Dario Betti, CEO of the Mobile Ecosystem Forum discusses the commonalities he has seen, and what those clues could mean for our new digital reality.

*Laurence Russell, Associate Editor, Satellite Evolution Group*

**Question: The Mobile Ecosystem Forum (MEF) is a trade association seeking to advance the mobility industry as it approaches the technologies of the future. How do you benefit your members?**

**Dario Betti:** In its twenty years of service, MEF has provided a place to think for our members across a great breadth of industries, even up and down the value chain from executives to end-users, allowing for an interdisciplinary forum in which multiple perspectives can offer insight across the ecosystem, bringing experienced observers together to recognize and diagnose problems. This is facilitated across a series of high-profile events as well as our research budget which covers surveys, reports, reviews, and so on.

**Question: Many observers can't help but regard the metaverse with confused apprehension. Could you define it in your own words?**

**Dario Betti:** I grieve for the apprehension that can be seen in this space,



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though we shouldn't discount the hype that's mounting about it too. Now it really depends on who, and when you ask. To better define this confusion, I think it began with putting a name to it. The "metaverse" was a culmination of many ongoing concepts, some still very ephemeral. We prefer to think of it as a user interface first and foremost.

A lot of the foundational concepts of the metaverse already exist, and some with which people are even quite familiar. The digital world is already very well established. Now in 2022, people have already been born into it, even grown up in it. It's already a staple of our lives.

What is dramatically changing is the dynamic shifting of this same world across to user inputs dictated through Virtual Reality/Augmented Reality (VR/AR) technologies. This is where the apprehension comes from, both from those still adrift on the sea of technological changes they're already having trouble adjusting to and from those who have followed virtual reality technologies since they began accelerating in the 2010s. Then there are those who aren't all that impressed with the lukewarm commodification of a decade-old technology. Beyond that, it's important to recognize that while changes are coming, much will remain just the same, and that's been something we've been working to help people recognize.

**Question: With augmented and virtual reality technologies mounting, how do you foresee digital realities overlaying our own in the next decade?**

**Dario Betti:** It's not hard to recognize the amount of time we spend in digital spaces in the modern world. How much

we communicate, how much we work, how much we spend, and how much of our lives are defined by these spaces. When our real, analogue lives are overlapped with that same digital realm, those spaces, and the applications they afford us will become a lot more accessible and dynamic.

Of course, AR/VR is still quite bleeding-edge, with all sorts of issues that hold them back from feeling authentically "next-gen". That is to say, the authentic metaverse that its developers and fans want to bring to the world is still under development, and it may take five years or so to glimpse how it's supposed to look.

**Question: Location-aware applications operating with a moving user have proven heavy users of satellite connectivity. How do you foresee VR/AR technology affecting the demand for LEO broadband?**

**Dario Betti:** This is an interesting notion since location is at once everything and nothing to do with the metaverse. While this digital realm is consummately apart from our own, it will only ever be glimpsed within the analogue spaces that we exist in.

The satellite technologies that location-aware connections often rely upon have historically been unreliable, which means the places where we can expect the metaverse to be overlaid would likely either be covered by pervasive 5G Wi-Fi or hybrid networks that call upon satellites to shore up their service in spots where terrestrial connections don't perform.

Of course, IoT technologies are already reliant on



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satellites in a similar context and will be sure to come to represent an essential companion technology to realizing the metaverse.

**Question: Do you foresee VR/AR becoming the banner technology of 5G mobility, alongside sophisticated IoT, as video calling, and accurate geolocation were with 4G? What do you see as the defining pillars of mobile 5G?**

**Dario Betti:** We can be sure that 5G's speed and power will help realize certain mobile use cases that we haven't been able to rely upon in the 4G era, however, we shouldn't forget the unrealized promises of the past. Back in the day, 3G was supposed to herald the world of reliable video calling but ended up being far too weak to provision it. It took 4G to approach strong connections that made it feel like the other person was in the room with you.

With the growing demands of the internet, 5G will go a long way to shoring up the most basic modern demands of broadband, which in some parts of the developed world are still not strong or widespread enough to trust. So, while we can certainly expect the metaverse to be built out across 5G, we may ultimately need 6G to get those infrastructures running seamlessly, to a standard that delivers the wow factor.

**Question: The metaverse is often recognized as the convergence of the mythical vision of "Web3", often repeated across hubs of crypto culture. How accurate is that association? Can we expect Meta's VR/AR products to be big adopters of cryptocurrencies and Non-Fungible Tokens (NFTs), and are these associations being cemented into all VR/AR technologies?**

**Dario Betti:** Web3 has long been established as a philosophical conversation about the internet. Web3, as it has commonly been described conjures a vision ancillary to the metaverse as it's being marketed right now. The core of the web3 and blockchain ideologies was more about questioning the foundational nature of the internet, taking back control from multinational conglomerates, and reclaiming privacy, supposedly returning us to the original founding principles of the internet, which was built with powerful democratic principles which we've seen steadily eroded since by tech giants.

The everyday robbery of our private data has never sat well with the average consumer, not at the degree of transparency that they're offered. We've seen the internet become something of a marketplace for data, which will make it that much harder to separate the two and go back to models of greater privacy. If nothing else, the public will be being comprehended by tech giants, who are at least becoming more sensitive about the issue.

Blockchain was sold as a means for the consumer to possess control over their own data. By having records of value exchanges stored on their own machines and corroborated across the chain through all other decentralized nodes and that's a great model. Although we haven't seen it working as intended yet, it's a step toward web3.

Of course, this is just philosophy, and the crypto entrepreneurs eager to associate these noble concepts with their digital currencies have been met with healthy



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scepticism but we've already seen that the digital currencies they were working with are now coming to the metaverse at the behest of the tech giants they supposedly challenged.

Web3 remains a high-minded belief that people continue to hold dear, but remains in infancy, still distant from the boardrooms where the parameters of digital infrastructures are hammered out.

**Question: As these virtual realities are formed, the principles that ground them will be set in stone. Considering what we've learned from the establishment of the internet, the mobile phone industry, and other technological phenomena, what philosophies should developers and investors keep in mind as we build these new worlds?**

**Dario Betti:** We might well have forgotten these lessons that brought us to this stage of technology. Open-source assets, fair industry standards, and a democratic spirit built the basis for something very special, which went on to define the world we know today.

In the conversations we're seeing around the metaverse, there have been very few commonalities; a common platform has yet to be agreed upon, nor has a common standard technology. This has led some to expect many proprietary ones, as has so often been the bane of technological design ideology.

What many of us have been hoping to see is universalized platforms, and open, democratized architectures for everyone. This is precisely why the metaverse as it's been popularly imagined may never exist. We may simply see A Meta world, a Sony Playstation world, a Disney Inc. world, etc. The metaverse itself as a holistic concept may well be mere snake oil. That's what we'd like to avoid. ●



● ● David Henri, Co-Founder & Chief Product Officer at Exotrail

Satellite Evolution Global

Q&A

## How propulsion and mobility can eliminate market risk ● ●

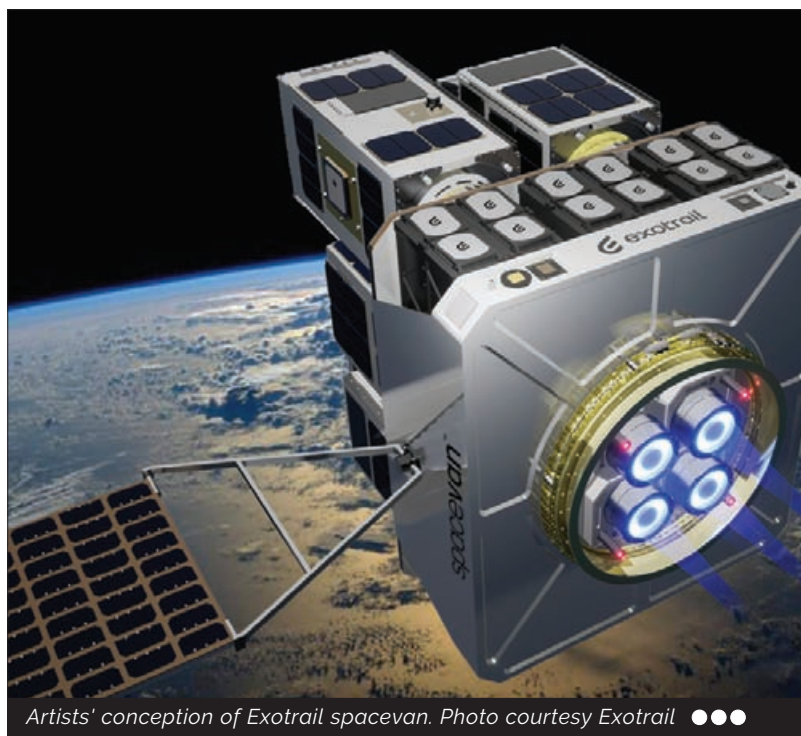
In a congested NewSpace market, thick with market volatility, it has been the goal of many institutions to pave the bumpy road to space commerce for new entrants and shore up business confidence and government investment. Still, the nitty gritty of making what's risky safe tends to be easier to talk about than to bring about. David Henri, Co-Founder & Chief Product Officer at Exotrail tells us how his company did the job and discusses what the market needs next.

*Laurence Russell, Associate Editor, Satellite Evolution Group*

**Question: How has Exotrail approached 2022? Could you share some milestones and challenges for the company?**

**David Henri:** 2021 had put the bar quite high: successful testing of our propulsion in space, confirmation of commercial traction on our software and propulsion product lines, several commercial milestones passed, our 10<sup>th</sup>+ customers signed, +1M+ revenues, millions of additional sales in our order book, first US customers, etc. Beating this was hard! We had ambitious objectives and we have met them and sometimes even exceeded them.

We had challenges as well: hiring has been a challenge; inflation, rising of material cost and stress on the global supply chain forced us to slightly increase pricing. We also had some delays on some of our customers missions, which means that some propulsion systems that will fly in space



Artists' conception of Exotrail spacevan. Photo courtesy Exotrail ● ● ●



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soon will do so four years after having been designed. So, we obviously made a lot of progress since then and have released many versions to improve reliability and performance. But still, we should fly at least ten propulsion systems next year, on top of our spacevan.

**Question: Commentators enjoy discussing barriers to market for NewSpace enterprises. Could you simplify what these barriers are, and how ancillary solutions providers like Exotrail can accelerate the growth of these new players?**

**David Henri:** Barriers to entry come from several factors. I will simplify them into the following:

- The space industry likes big programs.
- Space institutions remain averse to change and risk.
- Incumbent lobbying is powerful and wide-reaching.
- Governments tend to be more interested in "number of jobs" than in "number of jobs created".

All of that has a consequence: most of the public spending in space is concentrated in large, closed programs for large incumbent companies. We however have done a lot to change this, together with other European NewSpace companies. We have officially started the Young European Enterprise Syndicate for Space (YEESS) Association. We are one of the companies chosen by the French Ministry of Finance & Economy to represent the start-ups at the COSPACE (governing body for the space industry in France with member of institutions, government, and private actors) and this has already sparked some changes.

ESA has created the NewSpace Advisory Board, where I am glad to represent Exotrail, and where the ESA Director General sits. I would say that this is still very much ongoing, and it still needs to deliver actual results. I guess we will see what happens at the ministerial committee of ESA in

November. At the French level, there are already tangible results: in France, as part of the "France2030" program, 1Bn – two thirds of the funding available in the France 30 program – will be directly given to start-ups. In fact, CNES asked us to deliver a payload to a specific orbit in LEO as part of a contract worth millions of Euros.

**Question: Some experts predict that the NewSpace market is steadily being monopolized. How can start-ups be supported to critically disrupt those processes and create high-competition environments that fight harder for the end-user?**

**David Henri:** We need to break big programs into smaller ones. I do not believe that all the institutions will change instantaneously. You can't just "decide" that things will change, you need to build that change, but you must start small. You must demonstrate that fair and open competition and taking risks works for 1-10M programs. This will precisely help in building confidence that this approach can work; and can potentially work for other, much bigger programs. Other countries in the world know that.

It's also important to engage with lobbying via start-up coalitions. We have less money and resources than primes, so we need to gather forces. This is what YEESS is about. This is a way to set up our own lobbying efforts, joining financial forces to sustain a permanent presence at the institutional level to push messages that are good both for the taxpayer and for European space industry. If you are a European start-up reading this, join YEESS – you will be able to be part of that lobbying effort! The same happens at the US level within the Small Satellite Alliance.

Finally, we need to gather forces and explain to institutions that the only way to save sovereignty and jobs in the space sector in the medium and long term is doing this our way. If we succeed, we can break monopolies and create an open competition environment that will allow new entrants to come and play in this game.

**Question: In the wake of the debris debate, there has been some scrutiny of satellite models themselves, specifically their longevity, flexibility, mobility, and even reparability. In your eyes, what would the most sustainable satellite we could build today look like?**

**David Henri:** I can tell you for sure that the ideal satellite will have propulsion. No propulsion, no collision avoidance, no deorbitation. I think we need to build modular satellites. Right now, repairing a satellite is a bit like repairing an iPhone. It was not designed for repair – it was designed to minimize volume and mass and maximize power density.

If you want to be able to repair satellites, to increase their longevity, and increase the sustainability of the space industry you need two things. First, you need to enable an evolution in the launch sector (Starship, can you hear me?) so that we can afford launching "useless" mass and volume. Then too, you need to reach an agreement on standards for servicing and satellite design.

That is why Exotrail is looking closely at what is happening on Starship side and joining the CONFERS alliance. CONFERS gathers all the main on-orbit servicing actors to precisely discuss standards.



Exotrail cleanroom production. Photo courtesy Exotrail ●●●



**Question: Do you foresee your satellite propulsion systems laying foundations for the hypothetical orbital servicing market that some experts predict? If so, how do you shape those foundations in the hopes of influencing a more responsible market?**

**David Henri:** For us, the on-orbit servicing industry is a growing market segment as far as propulsion is concerned. We already have a few on-orbit servicing companies among our customers – one of them being in the US and we are our own customers – the **spacevan** is designed to become an on-orbit servicing vehicle.

With some partners (Thales being one of them), we are going to demonstrate some advanced on-orbit servicing capabilities as part of the EROSS+ European Commission program. But to do on-orbit servicing, electric propulsion alone is not enough. Even though we are preparing to demonstrate together with an on-orbit servicing customer some advanced capabilities to use electric propulsion to perform some proximity operations, we believe that complementing this with impulsive propulsion will be necessary. This is why we are also developing also cold gas propulsion and looking at the chemical propulsion technologies.

As for the foundations to pursue responsibility, we need to push for standardization so that things are easy to repair and to refuel. This is key and requires a strong dose of international collaboration. Needless to say, we also need clean propellant – let's not forget that there is no cleaner propellant than Xenon or Krypton (we use both), which are inert gases that are part of the air we breathe every day!

**Question: You plan to perform a space demo of spacevan™ in late 2023. What can we expect from the solution?**

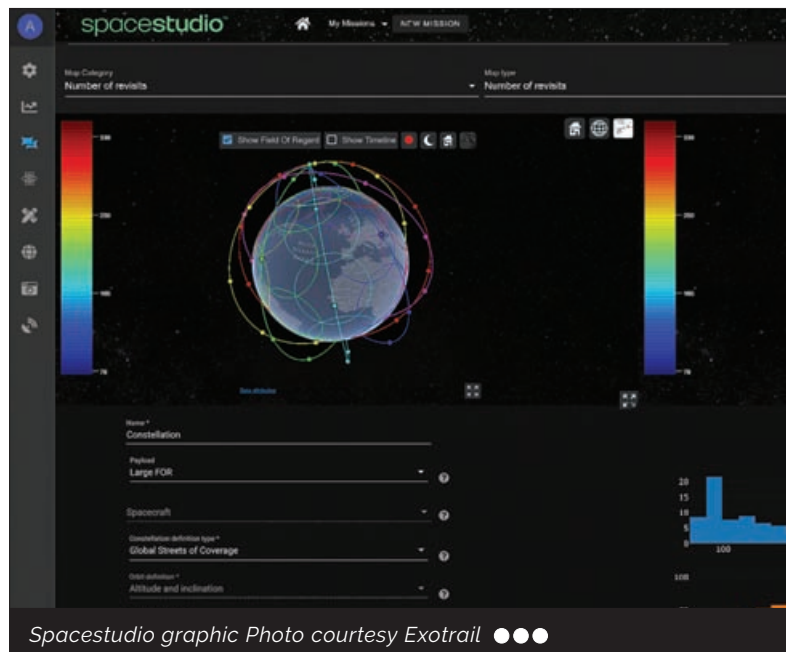
**David Henri:** The **spacedrop** service is the launch & deployment service that uses the **spacevan** as an Orbital Transfer Vehicle (OTV). **spacedrop** does two things for our customers: Access-to-space and orbital positioning. What you can expect from us is a flexible choice of orbits, large passenger capacity, end-to-end solutions, competitive pricing for access to space, remote access to your satellite during coasting with **spacetower**, reliable propulsion on the OTV, and of course, a reliable OTV.

You will have noticed that we are not the only company that thought of designing orbital transfer vehicles for post-launch deployment. We are arguably the first though – this idea dates from 2015 and the **spacevan** brand name was deposited in 2017 in France.

You will also have noticed that most of them use chemical propulsion. Why so? It is much easier to build a chemical OTV than an electric one; and people are often not experts in flight dynamics and so think that chemical propulsion is faster for every manoeuvre.

In truth, for one of these manoeuvres – arguably the most important one in LEO, due to plane change – this is not the case. Plane change is a so-called “indirect manoeuvre”, where you build up J2 drift to change the RAAN of your orbit. If you move further away from your destination orbit than what you could do with chemical propulsion, you will drift faster.

So, when you run the simulation, using electric



Spacestudio graphic Photo courtesy Exotrail ●●●

propulsion = more deltaV = further orbit = faster drift = faster plane change.

In addition, electric propulsion allows you to deliver much higher value missions for your customer as well as access to low-inclined orbits, high altitude SSO, distant planes, and access to MEO or to GEO. People are ready to pay for this. This allows us to offer competitive access to space pricing for people that just want to get there. Chemical OTVs can't do that – or at least, not in a sustainable way. Customers need to be careful about who is paying for their ticket: themselves, because this ticket is part of a sustainable business model, or their suppliers' investors?

The other big difference between us and every other OTV company is that we are not an OTV company. We are a mobility company. Sometimes the best solution will not be an OTV but propulsion systems. It is not uncommon for us to recommend another propulsion system to a client because ours was not the optimal answer to their specific mobility problem. The same can be said for our OTV service. Exotrail is here to offer the best mobility solution to our customers' mobility problems. We are a market-driven company, not a techno-push company that only has one solution to offer to their customers, and which will thus always push for this solution.

As providers of end-to-end service for a large quantity of passengers that need to access far and flexible orbits, we offer the ideal solution for constellations.

**Question: Beyond spacevan, what more can we expect from Exotrail?**

**David Henri:** The **spacevan** is only one element of the equation! We have released our mobilityhub concept recently and will do a full release of **spacetower** next year (right now it's in beta). But then in the future, we are obviously looking to extending our **spacevan** capabilities towards on-orbit servicing.

We are looking especially at refueling (in a complementary way to existing actors like OrbitFab) and space cleaning. We are doing this step-by-step. I can draw pretty slides illustrating that vision, but I prefer to first demonstrate our vehicle in space, get customers, heritage, and credibility from that step, and then move to the other steps. Exotrail is all about execution. ●

## Dr. James A. Kenyon named as Glenn Research Center Director

NASA Administrator Bill Nelson has named Dr. James A. Kenyon Director of the agency's Glenn Research Center in Cleveland, effective immediately. Kenyon has served as the Acting Director of Glenn since June.

"Dr. Kenyon is an exceptional leader who will help propel Glenn and NASA forward as we revolutionize air transportation and venture farther into the cosmos than ever before," said Administrator Bill Nelson. "With Jimmy continuing his service to NASA as center director, I know the NASA family at Glenn will continue to improve life on Earth by making our research and technology accessible for the benefit of all humanity."

"I'm honored to be chosen to lead the more than 3,200 employees and contractors at Glenn Research Center who work each day to design, develop, and test the innovative technologies that make NASA's space exploration, science, and aeronautics missions possible," Kenyon said. "Glenn's research and development efforts are crucial to the Ohio and national space economy, fueling new industries and technologies, supporting job growth, and increasing the demand for a highly skilled STEM workforce."

Before being named Glenn's Acting Director, Kenyon served as Director of the Advanced Air Vehicles Program in the Aeronautics Research Mission Directorate at NASA Headquarters in Washington. He supported the mission directorate and its leadership in a broad range of activities, including strategic and program planning, budget



Dr. James A. Kenyon, Center Director, NASA Glenn ●●●

development, program review and evaluation, and external coordination and outreach.

Prior to joining NASA in 2019, Kenyon worked with Pratt & Whitney, where he held leadership roles in business development, program management, and engineering. Kenyon also served as a civilian with the Department of Defense, including 11 years at Wright-Patterson Air Force Base in Dayton, Ohio and six years in the Office of the Secretary of Defense.

At Glenn, Kenyon will oversee a center responsible for leading the Gateway Power and Propulsion Element, supporting the Orion spacecraft and Space Launch System rocket, and conducting revolutionary aeronautics research to make sustainable commercial aviation a reality. ●

## Hope Damphousse, to serve as Vice President of Ball Aerospace's Strategic Operations business unit

Ball Aerospace appointed Hope Damphousse, to serve as Vice President of the company's Strategic Operations business unit, in October. In this role, Damphousse will lead Ball Aerospace's Washington, D.C. office; guide public policy, regulatory and government relations activities; and lead the company's strategic planning and partnerships.

"Hope is a respected leader with an impeccable record of solving complex challenges through strong, collaborative relationships, trusted communications and a passion and dedication for mission success," said David Kaufman, President, Ball Aerospace. "She brings extensive government and legislative affairs experience to her new role as the company's senior executive in the Washington, D.C. area. We are thrilled to have her in this role."

Damphousse joined Ball Aerospace in 2008, delivering results in various roles within Strategic Operations, most recently serving as senior director within the business unit where she managed government relationships and agendas to drive business priorities forward. Prior to Ball Aerospace, Damphousse served as a legislative advisor to US Senator Robert Bennett of Utah and US Senator Mitch McConnell of Kentucky. ●





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## Space Data Association appoints new Chairman – Joe Chan of Intelsat

Joe Chan, Director of Flight Dynamics at Intelsat has been appointed as the new Chairman of the Space Data Association (SDA), a non-profit international association of satellite operators. Joe Chan will take over from SES's Pascal Wauthier, as Chairman from 1st November.

Having worked with Intelsat for 22 years, Joe brings invaluable knowledge and experience to the role. As Director of Flight Dynamics at Intelsat, he oversees the FDS operation and engineering of more than 70 geostationary satellites that Intelsat currently operates. Prior to joining Intelsat he worked at Goddard Space Flight Centre on the TOPEX/POSEIDON and Mars Observer projects.

The Space Data Association is an international organization that brings together satellite operators to support the controlled, reliable, and efficient sharing of data critical to the safety and integrity of the space environment. Formed in 2009, the SDA aims to enhance safety of flight via sharing of operational data and promotion of best practices across the industry.

Joe Chan, Intelsat commented: "The SDA plays an incredibly important role in enhancing the safety of space flight through the sharing of knowledge and data. I have



Joe Chan, Director of Flight Dynamics at Intelsat ●●●

long been a supporter of, and contributor to, the work of the SDA and am pleased to be appointed as Chairman. I would also like to say thank you to Pascal Wauthier for his expert chairmanship over the course of the last few years, during which time the SDA has gone from strength to strength."

Pascal Wauthier, Chairman, the Space Data Association, commented: "I'm pleased to be handing over the baton to such a well-qualified and knowledgeable individual as Joe. I look forward to watching the SDA membership grow and strengthen in the years to come, as the SDA continues to work together to enhance and improve space flight safety." ●

## Firefly Aerospace names former GE Senior Executive Dan Fermon as Chief Operating Officer

Firefly Aerospace, a new space leader in launch, spacecraft, and in-space services, has appointed Dan Fermon, a veteran operating leader with decades of experience leading teams in highly technical industries and primarily aerospace, to Chief Operating Officer (COO). Mr. Fermon, who has served in this role in an interim capacity since May, will be based in the Company's corporate headquarters in Cedar Park, Texas.

"Firefly is at an extremely exciting moment in our history," said Bill Weber, Firefly CEO. "We are supporting the great leaders who got us to this point in time with seasoned professionals who can build dependable, reliable, and scalable production around our technologies, and care greatly about the culture of the organizations they lead. Dan is exactly that kind of senior leader. He has decades of operational experience, he has the trust of the company, and we immediately become a better team because he has joined us as our Chief Operating Officer. I could not be more excited to work with him."

Prior to joining Firefly, Mr. Fermon was a Vice President at AE Industrial Partners, ("AEI"), a US-based private equity firm specializing in aerospace, defense & government services, space, power & utility services, and specialty industrial markets. At AEI, he was a member of the firm's Portfolio Strategy and Optimization Group, focused on improving the operational performance of its portfolio companies through cross-portfolio projects, best practice sharing, and synergies execution.

Previously, Mr. Fermon served as the P&L and Operations Leader for GE Aerospace's fast-paced Global Component Repair team, doubling revenue in just three years to over \$3B with strong margins by utilizing technology, lean improvements, and powerful team engagement.

"I'm excited to become a permanent member of the Firefly leadership team," said Mr. Fermon, "Having spent the last five months with the team, I have been impressed with their passion, commitment to continual learning, and drive to excellence. I'm looking forward to helping scale these efforts to support the team's transition into full-rate production on all our vehicles, facilities, and capabilities in the years ahead." ●





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