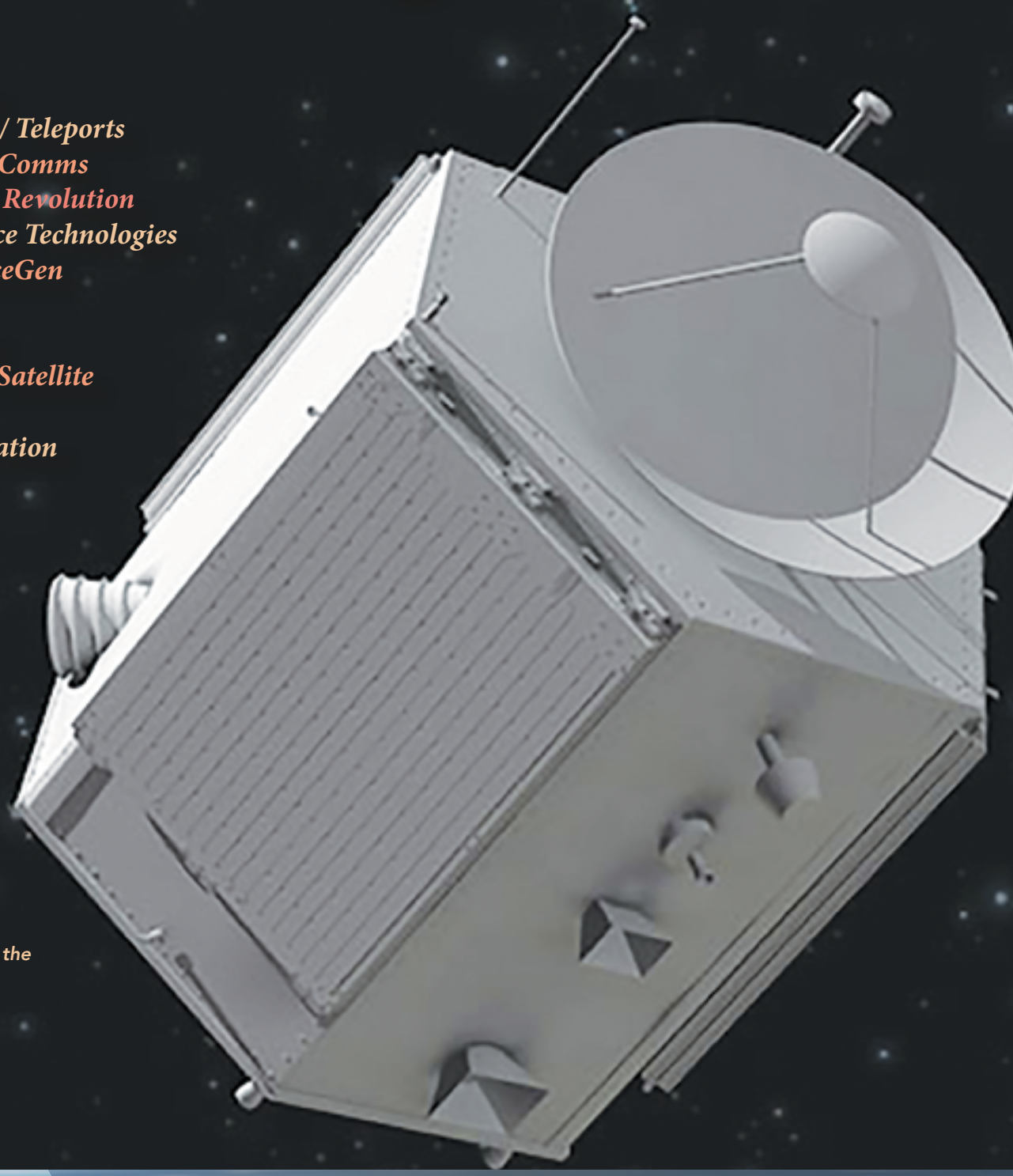
Worldwide Satellite Magazine – May 2019

SatMagazine



Artistic rendition of the UAE's Hope probe in Mars' orbit.

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InfoBeam

SpaceX lands their Falcons after their Arabsat-6A launch

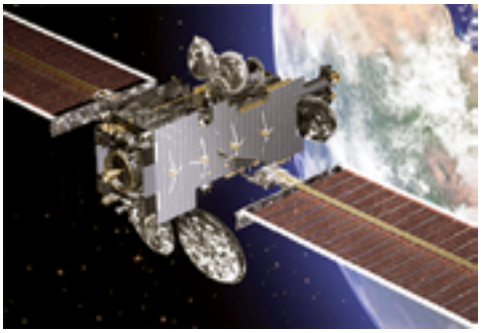
The SpaceX Falcon Heavy launch of the Arabsat-6A satellite.

Last year's test with a Tesla sports car aboard a SpaceX heavy lift Falcon was bested on April 11 after the successful launch of the Arabsat-6A communication satellite aboard the new and improved Falcon Heavy, SpaceX's most powerful rocket with 27 engines.

The engines, distributed to nine per booster, provided five million pounds of liftoff thrust and the launch occurred from NASA's Kennedy Space Center using the same pad that shot Apollo astronauts to the moon a half-century ago and, later, the space shuttle crews. The payload, the 13,200 pound Arabsat-6A satellite from the Saudi-led Arabsat consortium, headed into geostationary orbit to provide telecommunications services to the Middle East, Africa and Europe.

Just eight minutes after liftoff, SpaceX successfully landed two of the first stage boosters at Cape Canaveral Air Force Station in a side-by-side form at the company's Landing Zones 1 and 2 (LZ-1 and LZ-2) — the core booster returned two minutes later on the "*Of Course I Still Love You*" droneship located several hundreds of miles away in the Atlantic Ocean.

In an excited Tweet, ***Elon Musk*** sent out his message, "*The Falcons have landed,*" a relief for Musk who cautioned in advance that things might go wrong. Falcon Heavy is designed to launch large commercial payloads into high orbits, take on heavy-duty national security missions and potentially power interplanetary missions as well.



Artistic rendition of the Arabsat-6A satellite on-orbit.

Recently, the rocket has been given greater consideration by NASA for tasks such as sending a NASA probe to Europa, an ice-covered moon of Jupiter, or launching spacecraft with provisions that could eventually make their way to lunar orbit.

Khaled bin Ahmed Balkheyour, the President and CEO of Arabsat, said the company was thankful for the 6A satellite launch success, as this event was challenging for the firm and SpaceX due to this being the first largest and heaviest satellite lifted by SpaceX on the most powerful rocket in operation today, the Falcon Heavy — he added that this launch is considered a momentous leap in the field of commercial satellites manufacturing and launching.

Arabsat-6A is a high-capacity telecommunications satellite that will deliver television, radio, internet, and mobile communications to customers in the Middle East, Africa, and Europe. Built by Lockheed Martin, Arabsat 6A is the largest and most powerful commercial satellite ever produced. The modernized LM 2100 includes several innovations that make the satellite more powerful, more flexible and more versatile in orbit. Arabsat 6A provides advanced Ka- spot beam communications services and Ku- and Ka-band coverages in addition to other frequency bands. The satellite will be located at Arabsat's exclusive orbital position at 30.5.

Arabsat's success during the past two months — the launch of HS4 satellite at 39 degrees East for Hellas Sat, an Arabsat subsidiary, last February, and this launch success — would not have been possible without the help of the hard working Arab engineers from Arabsat headquarters and the company's two ground stations in Riyadh and Tunisia, where those satellites are operated and controlled, noted Arabsat's President, who added that the company's engineers were fully involved in the design of these satellites and are owed all of the thanks and praise.

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UAE's Hope Mars Mission nearing build completion

The plan by the UAE Space Agency and Mohammad Bin Rashid Space Center (MBRSC) is to launch their Emirates Mars Mission, known as Hope, next summer via a Japanese H-2A rocket, with a Mars orbit being reached by December of 2021.

The 1.5 ton Hope Probe build is now 85 percent complete, according to the organizations, with the majority of the parts in place and the unit going through the testing process.

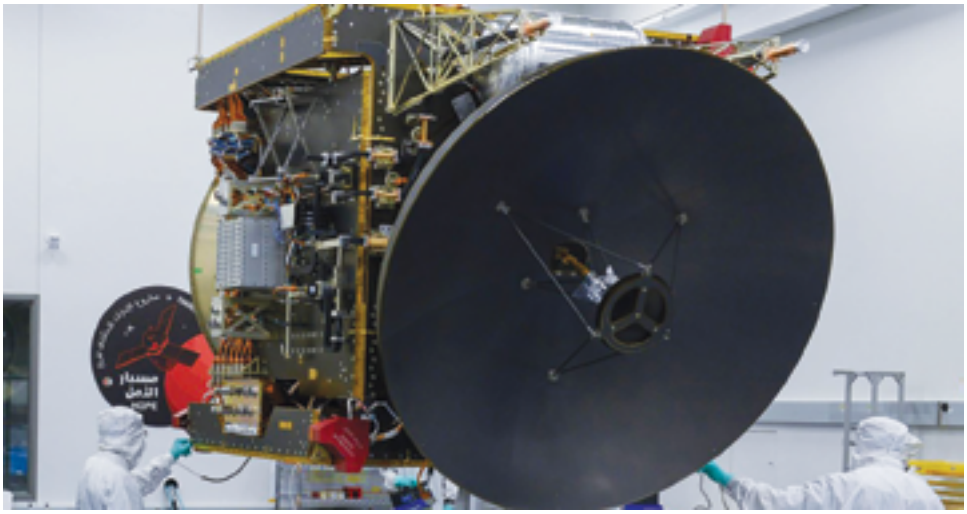
Major milestones that have been met during this process include the ability of the probe's to communicate with ground stations. Next up are the environmental tests, which are hoped to be concluded by December of this year. Aboard the Hope will be the fully completed...

- *Emirates eXploration Imager (EXI): capture and delivery of high-resolution color images*
- *Emirates Mars Ultraviolet Spectrometer (EMUS): examination of temperature patterns, ice water vapor and dust in the atmosphere of Mars*
- *Emirates Mars Infrared Spectrometer (EMIRS): upper atmosphere analysis*

According to Dr. *Ahmad Bel Houl Al Falasi*, the Minister of State for Higher Education and Advanced Skills as well as the Chairman of the UAE Space Agency, the UAE is on the verge of making history, after turning the nation's dream of becoming the first Arabic and Islamic country to send a spacecraft to Mars into reality.

He added that this monumental endeavor is the culmination of the efforts of a skilled and experienced team of young Emiratis, who with the support of the nation and visionary leadership, will secure the UAE's position at the forefront of space exploration and the international space sector.

emiratesmarsmission.ae/mars-probe



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Relativity's 3D printed rocket to launch mu Space satellite

Relativity has partnered with mu Space to launch a satellite to Low Earth Orbit (LEO) on Relativity's Terran 1 3D printed rocket.

Relativity's patented 3D printing technology platform, together with Terran 1's flexible architecture, provides mu Space a faster and more reliable launch at a lower total mission cost, according to the company, than any other launch services company in the world. With this launch partnership, the two companies will share their expertise, resources and capabilities to transform the satellite launch and services industry across the U.S. and Asia-Pacific (APAC) regions.

Relativity is developing the first and only aerospace platform to integrate machine learning, software and robotics with metal 3D printing technology to build and launch rockets in days, instead of years, and that's disrupting 60 years of global aerospace manufacturing. The company expects to build its Terran 1 rocket from raw material to launch-ready in less than 60 days.

As an innovator in the Asia-Pacific and international arenas, mu Space is developing LEO and GEO satellite and space technologies that will accelerate the adoption of Internet of Things (IoT) devices in smart cities as well as encourage new space investments in the APAC region. mu Space's LEO satellite will be a primary, dedicated payload on Relativity's Terran 1 rocket, launching in 2022.

This partnership also progresses a long-term opportunity and shared vision toward building the future of humanity in space. Relativity plans to 3D print the first rocket on Mars and build an interplanetary society to expand the human experience. mu Space has a goal of developing space technologies to ensure safer lunar missions and to enable human settlement on the moon within the next 10 years.

Recently, Relativity announced a multi-launch contract with Telesat to support Telesat's LEO constellation. This was the first time Telesat, or any major global satellite operator, had selected a fully venture-backed aerospace startup for launch services. This partnership with mu Space further establishes Relativity's emerging leadership in the global satellite launch services industry. The company is on track to conduct its first orbital test launch at the end of 2020, and continues to grow a customer manifest of leading global satellite operators, commercial companies, and government payloads.

Relativity recently became the first venture-backed company to secure a launch site Right of Entry at Cape Canaveral Launch Complex-16 from the U.S. Air Force, adding to its portfolio of major government partnerships including a 20-year exclusive-use Commercial Space Launch Act (CSLA) agreement at the NASA Stennis Space Center E4 test complex, and membership on the National Space Council advising the U.S. White House.

The company is expanding its infrastructure this year with a fourfold expansion to over 350,000 square feet of operations, production, testing, and launch facilities, including securing a polar orbit capable launch site. Relativity's team has grown 6x in the past year, from 14 to 83 employees.

www.relativityspace.com

www.muspacecorp.com

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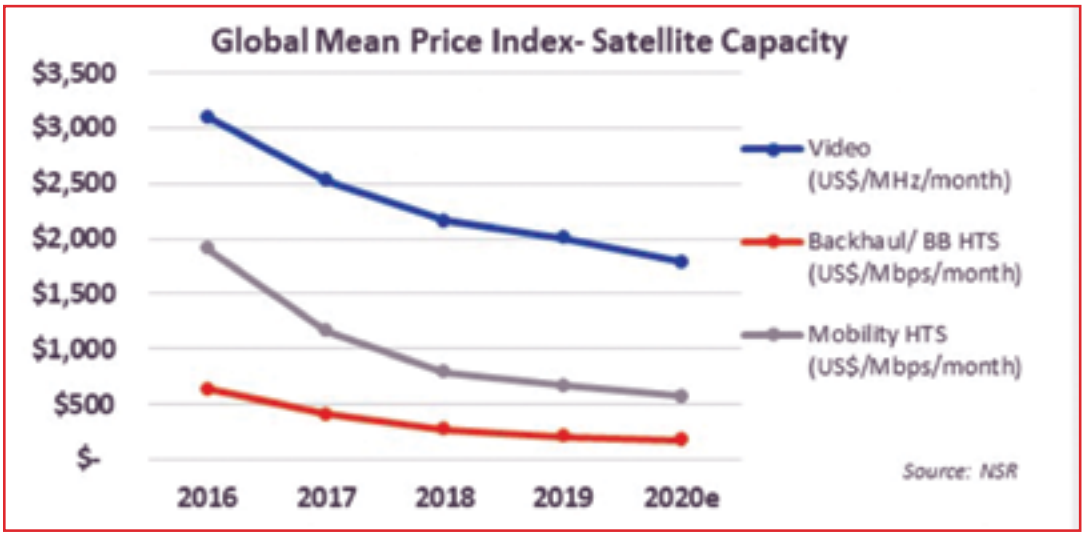
NSR Communique: The impact of capacity pricing on M&A and investment decisions



The SATCOM industry today relies on five major elements — Pricing (competition), Supply (indicating Asset worth), Demand (Growth), Break-even pricing (manufacturing innovation) and Ground System (efficiencies).

While the economics of demand growth and ground system efficiencies have been proven to be more linear in the last several years, the same cannot be said for Supply and Break-even pricing.

The latter two parameters have seen an exponential push in the past 10 years, widening the gap between supply-demand, whereas coupled with increased regional competition, pricing has undergone a steep decline in recent years.

The Global Mean Price Index, built from NSR's Proprietary Pricing tool in *Satellite Capacity Pricing Index, 5th Edition*, describes this rate of decline across key verticals in FSS and HTS.

Notwithstanding, as the 2018 to 2020e price graph dips, the Global HTS supply-demand gap in the next graph climbs from 50 percent in 2019 to 65 percent in 2021, and then closing out linearly until 2027.

Thus, the HTS Supply-Demand Gap, one of the key price pressure points for both FSS and HTS capacity peaks around 2021-22 time-frame, indicating a certain bottom pricing levels for GEO payloads.

Decreasing duration of contracts and further commoditization of capacity decrease the average price of lease capacity in the market as well impacting heavily on lease revenues, even if more demand can be generated through this elasticity.

With an average FSS Break-even price (lowest price for capacity without enduring a loss) of a satellite dropping from $1,500/MHz/month to $600/MHz/month, and with HTS

Break-even prices dipping from $28-60/Mbps/month in 2017 for large Consumer BB payloads to $12/Mbps/month by 2021, this timeframe will prove to be a litmus test for multiple operators.

The key question arises — How does one reduce the impact of pricing, and how does a company future proof growth? Is it through acquisitions?

Answering this necessitates to look at the change in current business models: Most operators are adopting service business lines in broadband, maritime or video, with a late surge coming in data segments as well.

Expectation of 25 to 30 percent managed services revenue by 2021 from the operator industry in not unlikely, thus acting as a shield to accelerating price decline.

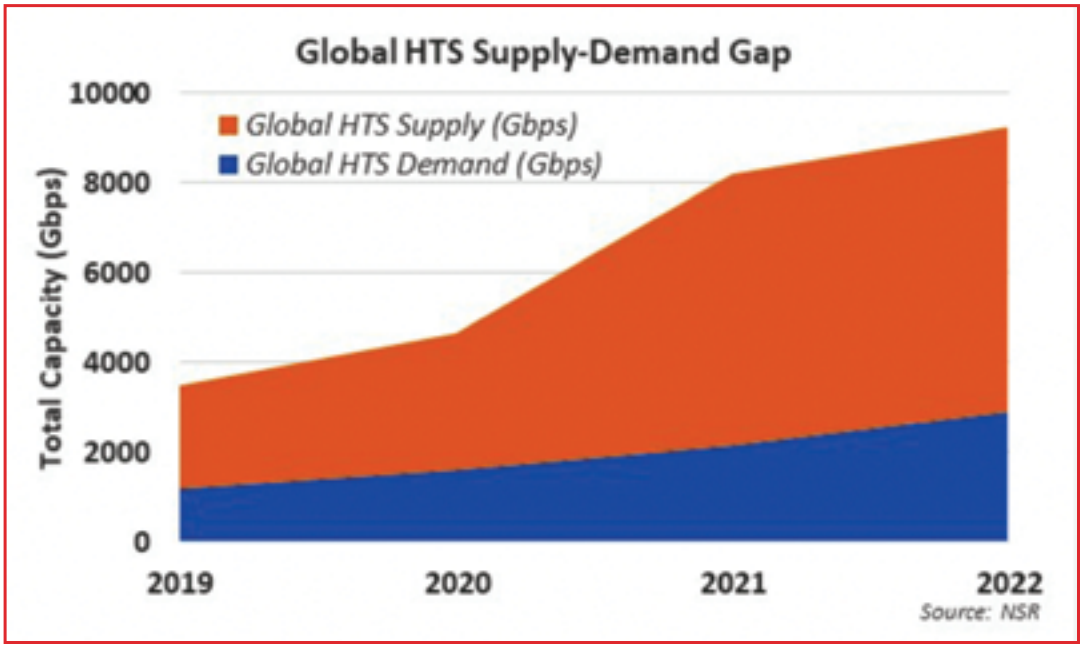
Preserving contract value via increased bandwidth consumption (with price reductions) has become a norm in 2018-19, showing partial elasticity in data, backhaul and maritime passenger segments.

Operators look to create captive growth markets undercutting competitors, and with interim CAPEX cycles ending, many operators are also creating favorable Net Debt/EBITDA positions to acquire other companies.

Growth through complementary mergers becomes straightforward, noteworthy with Inmarsat acquisition from PE investors, who unlike operators or service providers can shoulder a large cash burden to facilitate such scale.

Operators will look to invest to grow revenues via newer product lines capitalizing on HTS launches, entering into complementary service business lines, enter new markets via condosats or via incumbent-aided market entry partnerships.

Service Providers will look to invest to stabilize profitability and increase EBITDA via upstream fleet synergies (vertical integration possibilities), or horizontally consolidate to minimize competition in critical data centric growth markets.



Regional operators could most likely resort to down-pricing HTS capacity with expectations of elasticity from markets like South East Asia and Latin America, while strengthening their Mbps centric offerings through tech integration towards large customers.

Operators will look to build telco-like supply and distribution networks that enable recurring subscription retail models to ensure an efficient match between asset and revenue lifecycle, with duration of contracts tending to less than three months.

Non-GEO plans are expected to necessitate such models even further, due to shorter CAPEX cycles. Country-specific segment dominant (video/data/mobility) positions will be vital to stability for both operators and service providers, and coupled with service business line double digit growth, an increased competition may lead to a merger (vertical integration) towards 2021-22 between some companies.

Finally, cross-acquisition of satellites to support a segment specific dominant position for a service provider can't be ruled out, as the industry moves away from niche-lease plays to a more efficient pay-as-you-go business model.

With dynamics changing so fast, stakeholders will keep a close eye on the Pricing Index, complementary fleet synergies and distribution lines for a service provider, EBITDA margin recovery, and finally long-term sustainability of service business lines for semi-nationalized operators.

2021-22 may prove to be a litmus test for many companies, but it would also be an opportunity for a PE firm/Telco/Large Operator or SP to consolidate, streamline assets and build retail models.

Mobility and video services segments in developed regions, and data segments in under-developed regions may witness more such acquisitions or incumbent-aided market entries in the near to medium term.

www.nsr.com/research/satellite-capacity-pricing-index-5th-edition-2019/

Article by Gagan Agrawal, Senior Analyst, NSR

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Kacific signs agreement to supply broadband via satellite to Tonga

Kacific Broadband Satellites Group (Kacific) has signed a 15 year agreement with Tonga Satellite Limited, a Tongan government company, to provide high speed broadband via satellite to the Pacific Island nation.

The Kingdom of Tonga is a Pacific Island nation with 36 inhabited islands of its 169 total islands.

The bandwidth supplied by Kacific's high throughput satellite, Kacific1, will be used to connect communities in 89 remote outer islands with high-quality internet that is equivalent to that available in the main cities of Tonga.

In the case of a fiber cable outage, similar to the one experienced over 12 days in January 2019, the satellite bandwidth can be redistributed and shared with Tonga's main centers.

The bandwidth supplied by Kacific will be focused on government infrastructure such as hospitals, health clinics and dispensaries, primary and secondary schools, police stations and post offices.

The bandwidth will also be used to support local businesses and foster the creation of new platforms for economic development, such as cooperative marketplaces promoted by Tongan government.

The Kingdom of Tonga is a Pacific Island nation with 36 inhabited islands of its 169 total islands. These stretch across approximately 800 kilometres of water. The population of just over 108,000 people, of which 82,000 are classified as living in rural areas, usually consume around 2.4 Gbps of broadband bandwidth.

The Honorable Dr. *Tevita Tui'Uata*, Minister for Commerce, Consumer, Trade, Innovation and Labor, said Kacific will provide a formidable platform to develop powerful e-government applications and ensure continuous improvement of these applications. The Kacific system is uniquely designed for the rural and remote areas of Pacific nations and beyond. It precisely meets the needs of Tonga to provide real universal access, finally completing full broadband access to all residents of Tonga, wherever they are located.

He then stated that this system also uniquely provides backup to avoid deep digital disruption as has been observed in the recent fiber cut. The nation has seen, first-hand, the responsiveness and efficiency of the Kacific operations in such an event.

With this agreement, Tonga looks forward to moving these operations to the new powerful and Pacific-focused Kacific1 satellite

Christian Patouraux, CEO and Founder of Kacific said, the company's satellite technology is remarkably effective in providing low cost, accessible broadband to remote areas and fiber back-up for regional towns and cities.

Patouraux added that Kacific is pleased with this partnership with the Tongan Government which showcases how building infrastructure in rural areas can help provide urban areas with back-up connectivity options in case of fiber malfunction or natural disaster.

He noted that, until now, rural areas were depending on urban centers to distribute their bandwidth to them. With Kacific's solution for Tonga, urban centers need rural and remote areas in reciprocal cooperation to complete the urban infrastructure build up.

kacific.com

Photo: (L-R) Christian Patouraux, Kacific CEO and Honorable Dr. Tevita Tui'Uata.

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ORBCOMM and Kordia receive AIS contract from Australian Maritime Safety Authority

ORBCOMM Inc. (Nasdaq: ORBC) has announced that the Australian Maritime Safety Authority (AMSA) has extended their contract for another year through ORBCOMM's partner Kordia.

ORBCOMM and Kordia will provide satellite Automatic Identification System (AIS) data used for ship tracking and other maritime navigational and safety efforts to AMSA for designated regions and specific maritime projects.

The AMSA contract award, which extends into 2020, was the result of a competitive bid among providers of space-based AIS data services.

Headquartered in Canberra, Australia, AMSA is responsible for promoting maritime safety of navigation and protection of the marine environment as well as providing a national search and rescue service.

ORBCOMM's AIS service provides the most comprehensive and reliable global coverage, processing over 26 million messages from well over 200,000 unique vessels per day through a combination of satellite and terrestrial AIS data for marquee government and commercial customers worldwide.

Marc Eisenberg, ORBCOMM's CEO, said that through the company's collaboration with Kordia, both firms have been able to help AMSA improve navigation safety and environmental protection by providing ORBCOMM's satellite AIS data service for the past two years.

Marc added that the company's continued work with AMSA and other national regulatory authorities around the world confirms ORBCOMM's market leadership in delivering the most complete situational picture of global vessel activity available today.

Derek Neilsen, Executive GM of Maritime at Kordia, add that the extension of their contract with AMSA is an exciting opportunity to continue working with ORBCOMM to facilitate maritime surveillance and intelligence, while ensuring safety of life at sea within the Australian continent and surrounding regions. Leveraging the company's mission-critical maritime communications network, we look forward to continue supporting AMSA's efforts in one of the largest search and rescue regions of the world.

www.orbcomm.com/en/networks/satellite-ais

www.kordia.com.au

Finding a New Norm

A personal view regarding the hype of industry transformation

By Carolyn Belle, Director, KSATLite USA

The terms "*transformation*" and "*space industry*" are, time and again, thrown together by industry leaders and picked up in mainstream media.

Hardly a day goes by without an innovative technology, smallsat constellation or funding round lauded as a significant development for the industry at large.

Financial community estimates for industry growth range from <$400 billion today to a headline-grabbing $1 trillion — or even $3 trillion in annual revenue by the 2040s. Does all of this hype add up to real transformation, or are these terms just attractive sound bites?

The traditional behemoth of the space industry — the satellite communications that have fueled a majority of commercial growth since the 1980s — is the first yardstick by which to assess potential transformation.

GEO SATCOM operators have hastened their adoption of new ideas in recent years, no longer looking for incremental improvements in cost or capacity per satellite, but for wholly new satellite designs, fleet architectures, and ways of engaging with customers that enable greater system-level flexibility and responsiveness.

Implementation of this change is yet to come, but the commitment to a new approach by key operators will drive innovation forward. Additionally, new players are finding opportunities to deploy communications systems that are distinct from incumbent counterparts.

We have also seen the emergence of new markets and space-based business models at a more rapidly growing rate since 2011. Commercial Earth Observation (EO) and GNSS applications emerged in the 1990s, but these few companies, though successful, did not translate to a broadening or diversification of the space industry at large. This has changed today, as new companies are opening opportunities for partners and consumer demand and available technology supports new uses of space.

A full ecosystem has developed around smallsats and the rise of big data via satellite.

Markets that have remained merely talk and undelivered promises are on the cusp of implementation; Virgin Galactic's successful test flights in December 2018 and February 2019 set the stage for space tourism to (potentially) become available in 2019, and the first non-government mission launched to the lunar surface earlier this year.

These players are not alone, with multiple competitors nearing market availability along similar timelines.

Ultimately, the hype does reflect real transformation in the space industry: A change in the traditional market and the development of new markets.

However, this is not a single turning point for the industry, as is often implied. This is rather an approach to engaging with space that is evolving into a new normal.

The technology advancement — from both within the industry and beyond — demand evolution, and financing are fueling today's transformation, and will continue to exert this force as the industry progresses.

The development of in-space servicing capabilities, with the first commercial mission to launch in 2019, will grow into a long-term driver of ongoing transformation. If successful, in-space servicing, and ultimately robotic assembly and in-space manufacturing, will fundamentally alter the way we relate to space infrastructure and how we approach risk.

By mitigating launch constraints and removing commitments to fixed assets, this will impact the traditional space industry and will also shape the approach of emerging players and applications.

Low cost launch, whether through rocket reusability or other approaches, could likewise facilitate transformation, however, the industry has not yet achieved the level of price elasticity to make this happen.

Also fueling much of this change is greater financing availability. The progression from angel investing that championed certain causes to venture capital that spread greater volume of funding across start-ups has finally graduated to a level of more informed and calculated investing, involving institutional and strategic players as well.

These diverse funding streams, often associated with new partnerships, can help to realize novel ideas enabled by changing consumer demand and advanced technologies.

We are witnessing significant change in the space industry, yet there is much more transformation to come — capabilities such as commercial space stations and asteroid mining are in nascent stages, with myriad applications yet unimagined and disruption possible in any existing market.

The industry itself is simply becoming more dynamic and we must consider today's consistent innovation and the regular emergence of new markets and capabilities as business as usual.

The stage has been set for a more expansive and interactive space-based economy moving forward and I look forward to seeing what we achieve in the remainder of 2019.

www.kongsberg.com/ksat/

Carolyn engages in space industry growth and diversification, with expertise in the market dynamics of emerging satellite applications, in-space services, and the creation of diversified space architectures. She has advised Fortune 100 companies on key opportunities and strategic direction and has assisted government agencies to identify better ways to collaborate with industry. Carolyn currently supports communications for smallsat constellations and beyond in her role at KSAT, providing the infrastructure that enables space industry growth.

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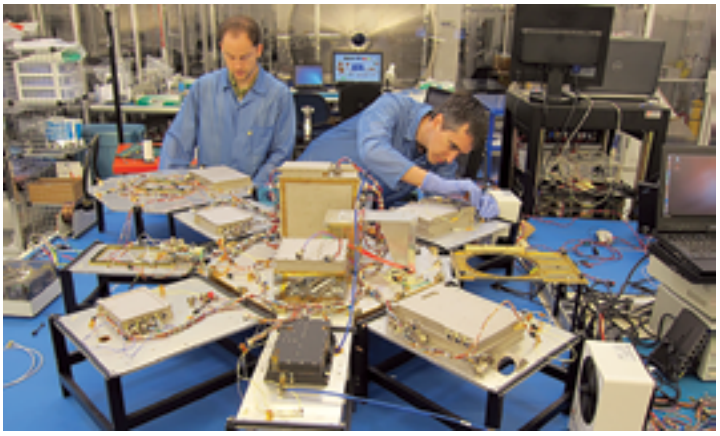
One hundred cumulative years of on-orbit smallsat ops achieved by Space Flight Laboratory



Smallsat missions developed and launched by Space Flight Laboratory (SFL) have achieved 100 cumulative years of on-orbit operations.

Over the past two decades, SFL has developed 25 smallsats that have been launched for space science, Earth Observation (EO), communication, radio frequency geolocation, environmental monitoring, technology demonstration, and ship detection.

SFL was established in 1998 as a self-sustaining specialty lab at the University of Toronto Institute for Aerospace Studies (UTIAS) to provide end-to-end microspace services on tight schedules and at low cost to deliver significant returns for clients around the world.

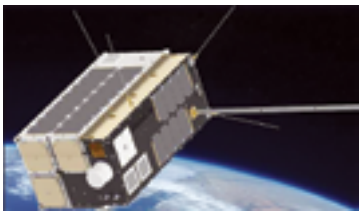
These technological breakthroughs include advanced control for formation flying and precise pointing and tracking, modular power systems for a range of spacecraft sizes, and propulsion systems tailored to sub-100 kg. platforms.

Advanced attitude control technologies have been a key differentiator for SFL since its first microspace mission launched in 2003.

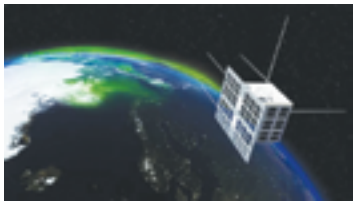
Several SFL staff members were key contributors to the Canadian MOST space telescope, which proved a smallsat could achieve the stability in space for serious astronomy applications.

Since then, SFL has continued to break down the barriers to what could be accomplished with nano- and microsatellites. Some notable recent missions include:

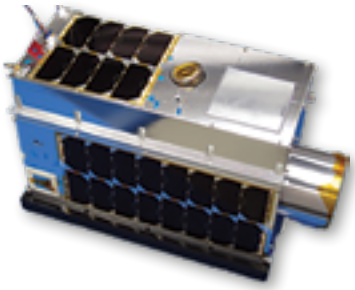
- *HawkEye 360 Pathfinder (artistic rendition above) constellation, three formation-flying smallsats built by SFL under contract to Deep Space Industries for HawkEye 360 Inc. Launched in December 2018 and commissioned in early 2019, the constellation is offering commercial space-based radio frequency (RF) detection and geolocation services.*



- *NorSat-1 and -2 smallsats (artistic rendition above) developed under contract with the Norwegian Space Agency (NoSA) and launched in 2017, have achieved significant improvements in maritime ship monitoring and important international scientific objectives, resulting in SFL being awarded the development contract for NorSat-3 in 2018.*



- *GHGSat-D smallsat (artistic rendition above) launched in 2016 by GHGSat Inc. to demonstrate that point sources of greenhouse gas emissions on Earth could be detected from orbit, leading to SFL being contracted to develop GHGSat-C1 and -C2 for commercial operations.*



Including NorSat-3 and the two GHGSat microsatellites, SFL currently has 12 satellites under development at its facility in Toronto.

Among these, SFL is developing an aerosol and greenhouse gas monitoring microsatellite, DMSat-1, for the Mohammed Bin Rashid Space Centre (MBRSC) in Dubai.

Additionally, SFL has completed Slovenia's first Earth observation satellite, NEMO-HD, for capture of high-definition video and imagery, which will be launched later this year.

SFL Director Dr. *Robert Zee* said the company was established with the goal of creating breakthrough technologies that enable smaller satellites to cost-effectively perform complex missions once believed only possible with expensive larger satellites.

Dr. Zee added that SFL is proud to be a world leader in developing microspace technologies that open the door for nanosatellites and microsatellites to perform cutting-edge commercial applications. Such applications would otherwise be forestalled or precluded by the expense of traditional satellite approaches.

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ESA opening up to new ideas for addressing space-related challenges

ESA aims to harness a new resource for future space activities: ideas from European researchers, businesses and the general public — through the organization's new Open Space Innovation Platform (OSIP), anyone is welcome to respond to space-related challenges.

The Agency's new Open Space Innovation Platform website is a streamlined entry point for novel ideas, both in response to specific problems and open calls.

The platform forms part of a wider effort to support the future competitiveness of European space industry with early technology development, implementing the new Space Technology Strategy.

ESA Director General, *Jan Wörner*, commented that through OSIP, ESA hopes to build and nurture a community of space technology enthusiasts, enabling people to inject their insight into the ESA and collaborate smoothly with ESA experts to contribute to the future of the Europe in space.

OSIP will challenge users to propose new ideas to address specific problems in form of thematic campaigns. The site currently hosts two such public challenges, both linked to the oceans, as well as a channel to submit ideas for co-sponsored research.

Two inaugural challenges have just been released on OSIP at ideas.esa.int:

- *Calling for novel ideas on ways of achieving the currently impossible task of detecting and tracking marine plastic litter from space*

- *Methods to enlarge the effective area of autonomous shipping — today heavily reliant on satellite navigation — into heavily-trafficked ports requiring precision navigation as well as the high Arctic, where satellite navigation is rendered less reliable.*

Another OSIP channel calls on ideas for research projects without a specific theme. These novel space-related research proposals would be co-funded by ESA.

While the two campaigns have deadlines, the channel is open ended with rolling evaluations and selections.

ESA's first contact with new ideas typically comes through the Discovery element, which also includes the Advanced Concepts Team (ACT), the Agency's future-oriented think tank staffed with a rotating roster of Ph.D. researchers. Initial studies are typically system studies, asking: if we incorporate this innovation into a space system, what would it enable, how could it work in practice?

The next stage is the Agency's Technology Development Element, similarly active across all sectors of space.

This is dedicated to creating the first laboratory prototypes of new ideas to demonstrate they are ready to be taken further by follow-on programs, such as ESA Science's Core Technology Program, the ARTES Advanced Research in Telecommunications Systems program or the General Support Technology Program, readying technologies for spaceflight and the open market.

The goal of ESA's seamless chain of innovation is to have a steady stream of new technologies ready for take-up by ESA missions and programs — making the correct discoveries available at the correct time as missions and applications require them.

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InfoBeam

Drop test success an important step for PLD Space

An important step has been completed by PLD Space in the firm's development of a European reusable launcher.

On April 11, the recovery drop test of the first stage of the MIURA 5 rocket was carried out from El Arenosillo Experimentation Center (CEDEA), of INTA (Instituto Nacional de Técnica Aeroespacial).

This operation, an essential part of the campaign to develop future launchers (FLPP) of the European Space Agency (ESA), serves the purpose of validating the recovery system of MIURA 5- PLD Space's first private reusable orbital launcher.

This successful drop places PLD Space in a good position for the further development of this reusable orbital launcher that will allow space access services for smallsats.

This test was carried out by the Transport Helicopter Battalion V (Bheltra V), of the Aeromobile Forces of the Army.

They released the demonstrator from a height of 5 km. using a Chinook CH-47 helicopter.
In the first attempt, an electric problem caused the cancellation of the mission and, after repairing it, the test was started once again.

The demonstrator, 15 meters long and 1.4 meters in diameter, fell within a controlled area of the Atlantic, located 6 km. from the coast of Huelva, part of a segregated space controlled by INTA.

In carefully timed sequence controlled by the electronic systems on-board, a series of three parachutes were ejected to decelerate the demonstrator, until its splashdown in the Atlantic Ocean at a speed of about 10 meters per second.

The parachute system was designed and developed by Airborne Systems North America, the company that developed the parachutes for the NASA Apollo capsule, among others.

This same parachute system, used aboard the drop test, will be used on MIURA 1 and MIURA 5 flights.

Once the demonstrator impacted the water, a team of divers recovered the demonstrator, dragging it back to a nearby tugboat.

The demonstrator has been returned to the port of Mazagón after its successful recovery and will be transported back to the headquarters of PLD Space, in Elche, for further analysis.

The FLPP-LPSR project has been funded by the European Space Agency (ESA) with the support of the Center for Industrial Technological Development (CDTI).

The company reported that this project was extremely complicated and required tremendous organization.

This project's success is due to the support that PLD Space has received from ESA, CDTI, INTA and the Army (Ejército de Tierra) .

Additionally, the coordination of companies and other organizations that have participated in the project include Tecnalia, Airborne Systems North America, Sensonor, Solycal, Nomasa, Itecam, Mecanizados especiales, Cadamadrid, Talleres Blasco, Sertrain, STS, Helibasket, the University of Alicante and Integral Risk Global.

pldspace.com

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InfoBeam

Provisional certification from the WTA for two U.S. Electrodynamics teleports

U.S. Electrodynamics, Inc. (USEI) has achieved provisional certification from the World Teleport Association of their Brewster (Washington, USA) and Vernon Valley (New Jersey, USA) Teleports under WTA's Teleport Certification Program.

Since 1985, USEI headquartered in Brewster, Washington, has been providing government, commercial and private satellite and terrestrial teleport network services from their four, global, serving teleports.

These services include Telemetry Tracking & Control (TT&C), broadcast video, mobility, GEO, MEO and LEO tracking and Internet services.

USEI's Brewster Teleport in Washington State and Vernon Valley Teleport in New Jersey are major satellite gateways, delivering connectivity to the Pacific Ocean Region (POR), Contiguous USA (CONUS), Central and South America and the Atlantic Ocean Region (AOR).

Combined, USEI offers a GEO satellite orbital arc view from 3° to 188° West longitude from the Brewster and Vernon Valley teleports. Additionally, USEI is in process of turning on eight, global, LEO/MEO stations, most with five, 7.6 meter NEC antennas. Three of these stations are already operating.

USEI mission statement is "Bringing the World Together" and defines the firm's quality of Spirit that accomplishes the highest levels of reliability, experience and world class customer service.

Since the program's introduction at IBC 2015, the Certification program has quickly grown in popularity. Starting with one certified facility in 2015, the program has added 40 in three years and currently has 12 teleports engaged in the quality evaluation process. Certifications have been issued to teleports operated by STN, Eutelsat, du, COMSAT, Signalhorn, Optus, Globecomm, Horizon, Media Broadcast, Elara Comunicaciones, GlobalSat, Talia, Telenor, Vivacom, Cyta, Batelco, SingTel, CETel, Etisalat, Hawaii Pacific Teleport, Intelsat, Speedcast, Telstra and Arqiva.

The industry has quickly adopted the transparent, independently verified standards as a means for teleports to differentiate themselves and for customers to choose the price-performance level suitable for their applications.

To achieve Provisional Certification, a teleport operator completes a +170-item questionnaire and submits it to WTA. The Association analyzes the data based on standards established by its Certification Committee and issues the Provisional Certification based on the self-reported information. The teleport then has six months to achieve Full Certification.

To achieve Full Certification under WTA's program, an auditor is dispatched to visit the teleport, provide independent validation of the data submitted in the questionnaire, and identify additional factors that may positively or negatively affect the score.

Full Certification is issued at a Tier number from 1 through 4, of which 4 represents the highest degree of excellence, and remains in effect for three years.

Jim Veeder, Founder of U.S. Electrodynamics, Inc. (USEI) since 1985, welcomes this opportunity to be evaluated by the WTA through its independent process and said that the company's core values: 1) Integrity of word, 2) vigilance to the firm's responsibilities to their customers. USEI's bottom line is built upon 100 percent reliability, quality and resilience delivered at a very personal level of service that we are known for delivering.

He noted that the company's facilities have been built with multiple redundancies and the training of staff is focused on building technicians and engineers well beyond operator skills, enabling USEI to meet all challenges. At USEI, human communications are considered to be a gift from the Creator and is a business facilitating His Love and Divine Will. Veeder added, "*Wherever there is sky, we aim to be there.*"

WTA's Executive Director ***Robert Bell*** stated that certification supplies the crucial, missing answer to the teleport customer's biggest question: what quality of service will really be received? Independent, standards-based evaluation and validation sets teleport operators apart and assures customers that they will receive the price-performance outcome they expect.

For more information about the Teleport Certification Program, visit ***www.worldteleport.org/?page=Certification***

www.usei-teleport.com/

InfoBeam

WTA sizes the teleport market

The teleport sector has seen consolidation as companies build scale to gain cost efficiencies and improve their competitive position.

This has produced an industry that is smaller in the number of facilities it operates but larger in total revenues.

The number of commercial teleports worldwide has decreased by 3 percent from 2016 to 2018, for an annual average of 1 percent.

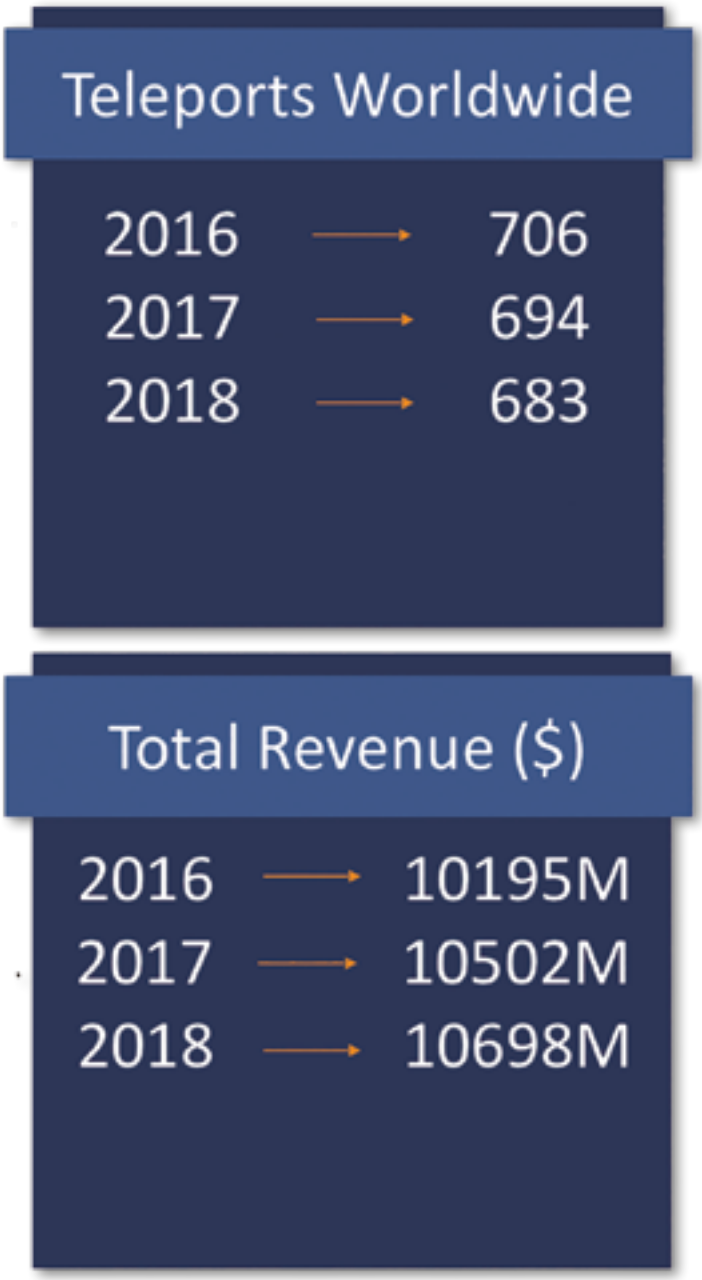
In 2010, WTA reported a worldwide commercial total of 996, representing an average 4 percent annual decline in facilities from 2010 to 2016. In that context, the 2016-2018 period saw a slower pace of consolidation in physical facilities.

Over the same period, however, estimated total revenues of the teleport sector grew 5 percent from $10.2 billion in 2016 to $10.7 billion in 2018. On that basis, average revenue per teleport rose 8 percent from $14.4 million in 2016 to $15.7 million in 2018. For the sector as a whole, consolidation did its job of creating fewer, more productive assets.

Consolidation has not been the whole story. In a mature technology market, mid-size companies become larger and the largest seek further increases in scale.

At the same time, however, new players enter the market to exploit new demand created by technology and market change.

The teleport itself undergoes radical change: packing far more services into fewer antennas, virtualizing operations into software that once required massive hardware investments, and substituting terrestrial networks for satellite distribution where they can.



Regional Overview

Europe and North America are home to the largest number of commercial teleports, with the geographically larger Asia-Pacific region coming in third. The number of teleports in the top three regional markets declined from 2016 to 2018, however, while Latin America and the Middle East/Africa logged corresponding increases.

Changes in regional revenues were also in single digits. North American teleport revenues grew 6.6 percent over the period, while Asia-Pacific revenues grew 4.5 percent and European revenues grew 3.9 percent. Latin America grew 3.0 percent while Middle East/Africa achieved a nominal 0.8 percent growth even as the number of facilities increased.

CAPEX and Capacity Spending

Capital expenditures varied among the regions in proportion to the number of facilities. Europe and North America are the two biggest markets for capital equipment purchases, with Asia-Pacific a distant third.

On a global basis in 2017, the teleport industry purchased 222,400 MHz of satellite capacity, with the spending in proportion to teleport counts in the regions. Capacity usage rose an average of 7 percent from 2016 to 2018, as detailed in the infographic.

The global teleport industry spent $4.9 billion on capacity in 2016, rising to an estimate $5.3 billion in 2018. Spending on capacity increased during the period across all regions as teleport operators continued to make satellite a vital part of their network operations. Average spending on capacity grew 6.90 percent from 2016 to 2018.

Download the Report

For the complete report including global and regional breakdowns of teleports, revenues, capex, headcounts and antenna counts, go to...

www.worldteleport.org/store/ViewProduct.aspx?id=13793334.

InfoBeam

Gilat gains leadership status for cellular backhaul shipments

Gilat Satellite Networks Ltd. (NASDAQ, TASE: GILT) has gained a global leadership position in shipping products for cellular backhaul over satellite, this according to Wireless Backhaul & 5G via Satellite – NSR report, 13 Edition, that was published in April 2019. Gilat achieved a 35 percent market share in modem shipments for cellular backhaul over satellite according to the NSR report.

Market analysts are unified on the fast growing 4G/LTE satellite backhaul market. NSR reports the service, equipment, and capacity for this market at $820 million in 2018 with an expected growth to $3,790 million by 2028.

NSR further reports that bandwidth pricing efficiencies will contribute to a growing demand for differentiated managed service solutions in rural areas, providing growing opportunities in the industry.

Gilat's cellular backhaul leadership is most noteworthy with tier-1 MNOs deploying LTE networks throughout the globe. Such deployments include T-Mobile and Sprint in the United States, EE/BT in the UK, SoftBank and KDDI in Japan, Telstra and Optus in Australia, and Globe in the Philippines. Gilat has deployed full turnkey solutions providing managed services in numerous deployments in America and Asia.

Lluc Palerm, Senior Analyst at NSR, reported that with their innovative technology, Gilat has been able to lead the way for 4G over Satellite with deployments for Tier-1 operators of unprecedented sizes in the satellite space. As MNOs continue upgrading its rural networks into 4G, and eventually 5G, Gilat is strongly positioned to continue experiencing growth in Backhaul.

Gilat technology is becoming a key tool for its network of partners to capture growth: MNOs experience extended reach adding new subs economically, satellite operators see growth in capacity leases as 4G services over satellite are enabled, and services integrators can tackle new customers with Gilat's powerful network management tools. This translates into Gilat achieving the first position in modem shipments in Cellular Backhaul with a 35 percent market share in 2018.

Asaf Jivilik, Head of Marketing and Business Development at Gilat, noted that providing end-to-end cellular backhaul solutions over satellite is a strategic focus area for Gilat, and the company is pleased with NSR's recognition of Gilat's global leadership in this important market segment. Gilat's future-ready cellular backhaul solution positions Gilat for further success and supports our vision of providing affordable, plentiful, high quality broadband connectivity.

gilat.com

nsr.com/research/wireless-backhaul-5g-via-satellite-13th-edition/

Datum Systems names David Koblinski to lead the company

Datum Systems has appointed David Koblinski as the company's President and General Manager — additionally, the company is on the move to Mesa, Arizona, (in the Phoenix metropolitan area). The founder and former President, Michael Boutte, will continue supporting Datum in the role of technical advisor.

Datum's HQ move follows a decade-long existing R&D presence in the Phoenix area, known for its history as a development hub for SATCOM technology.

David Koblinski served as Datum VP of Business Development for more than 10 years in Phoenix, from where Datum successfully launched the M7 Series modem platform, engineered for carrier efficiency and flexibility to support FSS and High-Throughput Satellite (HTS) networks. Major players worldwide, including global satellite service providers, fixed/wireless telecom operators, government and MILSATCOM users, connect using M7 proprietary and standard DVB-S2X modem modules to affordably meet needs of high-speed connectivity and network flexibility.

Prior to joining Datum in 2008, David served as General Manager for Radyne Corporation. As a satellite industry veteran with more than 35 years of experience in the business, with strong focus on SCPC technology and markets, David Koblinski will be responsible for leading Datum through the new SATCOM era of multi-orbit, multi-band high-throughput networks (HTS), GEO/MEO/LEO satellite constellations and spectrum management.

David Koblinski said he is excited to take on these new responsibilities in Phoenix, where the company will leverage the area's specialized resources to take Datum to the next level. The role of General Manager is not new ground for him, given the similar responsibilities he has previously held in the industry.

datumsystems.com/

InfoBeam

Comtech EF Data expands their Heights™ networking platform

H-Pico Heights Remote Gateway

Comtech EF Data Corp., a subsidiary within Comtech Telecommunications Corp.'s (NASDAQ: CMTL) Commercial Solutions segment, has expanded their Heights™ Networking Platform product line to add a new, low-cost, high-performance remote gateway, the H-Pico Heights™ Remote Gateway ("H-Pico").

The H-Pico will address CAPEX-sensitive end users while retaining Comtech EF Data's position as the high-performance, Very Small Aperture Terminals ("VSAT") solution.

H-Pico supports multiple remote to hub throughput tiers up to 10 Mbps, which is managed via a centralized licensing capability.

This scheme allows users to standardize on a single remote platform for low to medium capacity sites, simplifying stocking and sparing.

Additionally, H-Pico supports inbound hub to remote symbol rates up to 500 Msps with standards-based DVB-S2X MODCODs supporting up to 256QAM.

H-Pico incorporates a quad-core processor enabling high efficiency and throughput with multi-layer optimization. The increased EIRP and G/T performance of new High Throughput Satellites ("HTS") spacecraft allows for significantly higher user capacity.

This increased capacity cannot be met if the underlying packet processing is not able to keep up with the increased traffic flow.

H-Pico can support demanding user applications in a HTS environment enabling service providers to take full advantage of these new HTS designs and grow service levels as end users' demands grow.

Purpose-built to unleash the potential of these tight spot beams, Heights remote gateways provide the strongest processing performance, maximizing user IP bits per Hz while realizing significant gains in user IP bits per Amplifier Watt.

The Heights™ Networking Platform combines Comtech EF Data's most efficient waveforms, Heights™ Dynamic Network Access ("H-DNA"), header and payload compression engines, WAN optimization, multi-tier Quality of Service, proven dynamic bandwidth and power management along with bi-directional Adaptive Coding & Modulation ("ACM") capability to provide the highest user throughput, highest availability, and most optimal resource utilization available in the industry.

Heights meets the demands of those operating on traditional wide beams while providing distinct advantages for those using or considering migrating to HTS in their future.

Heights can economically scale from tens to thousands of sites.

The platform leverages a single comprehensive user interface teamed with a powerful traffic analytics engine that allows users to easily design, implement, monitor, control and optimize networks.

The result is an elevated Quality of Experience for end users.

Louis Dubin, SVP, Product Management and Marketing, Comtech EF Data said that this latest addition to the company's Heights™ Networking Platform product line will provide cost-effective, high throughput capabilities to support increasing end user traffic demands.

Dubin added that the flexibility provided by the multiple transmit throughput tiers combined with the high-performance waveforms and multi-layer optimization makes H-Pico the ideal choice for a range of applications — mobile backhaul, offshore communications, latency sensitive business applications, IP trunking and internet access, satellite news gathering and content distribution networks.

www.comtechefdata.com/files/ds-H-Pico.pdf

www.comtechefdata.com/products/heights-networking-platform

A Scourge in the Middle East...

Copyright Piracy...

By Chris Forrester, Senior Columnist

The Direct-to-Home (DTH) business in the Middle East is in an absolute mess.

On the '*glass half-full*' basis, a handful of broadcasters — plus the satellite broadcasting industry — is having a glorious time. Capacity demand, for **Eutelsat**, **Arabsat** and **Nilesat** is at an all-time high and there are more than 1,000 channels on air.

However, on the '*glass half-empty*' side of the equation, piracy is rife and is being described as '*a perfect storm*' for the MENA region.

Indeed, allegations of State-backed piracy are commonplace. 2018 was a true nightmare for the main DTH payTV broadcaster in the region and has resulted in **OSN** (the former ***Orbit Showtime Network***) witnessing their main shareholder, **KIPCO**, putting their majority stake in the company up for sale.

Moreover, the piracy shenanigans by the wholesale signal theft from **BeIN Sports** by **beoutQ** is decimating the manner in which sports rights are managed across the region — more in a moment.

A recent interview with ***Christophe Firth***, a principal at management consulting business ***A. T. Kearney***, and carried by ***Thomson Reuters'*** ***ZAWYA*** publication, and that publication's journalist ***Matt Smith,*** said that rampant piracy as well as "*plunging*" advertising revenues (down 30 to 50 percent over the past five years), as well as the rise of **Over-the-Top** (***OTT***) rivals have pushed OSN into further losses. Kuwait sovereign wealth investment firm KIPCO reportedly injected about $60 million into OSN last year, but has now put OSN up for sale — ZAWYA says OSN's losses last year were about $125 million.

In March, a payTV pirate was fined a miserable AED 50,000 (about $13,600) and sentenced to three months in prison for infringing OSN's copyrights and intellectual property rights. The dealer was pirating output from India's **Dish TV** in the United Arab Emirates.

The fine is quite modest, considering that the pirate was found with more than 2,000 illegal **Set-Top Boxes** (***STBs***), smart cards and — according to the authorities — a substantial amount of cash in his possession. The STBs and smart cards were destroyed and the dealer must pay compensation to OSN.

OSN has been trying to halt the illegal sale of DishTV India and **Bharti Airtel** receivers in the UAE and other **Gulf Cooperation Council** (***GCC***) countries. OSN has also filed lawsuits for infringement of their copyrights and damages at the Delhi High Court and has already obtained an injunction against DishTV India, which prevents Dish from exporting their receivers to countries outside India and from receiving any subscription revenues from outside India.

Simon Wilkes, the General Counsel of OSN, said, "*We are thankful to the Courts for their unambiguous verdict against TV piracy. The ruling sends a very clear message that selling Dish TV India subscriptions in the UAE is criminal, and any dealers doing so will be prosecuted. We hope that the stern and decisive actions being taken will continue to discourage the practice of selling or using pirate IPTV decoders and DishTV India in the UAE. The Public Prosecutor's Office, Department of Economic Development in Sharjah, Sharjah Police and the Dubai Forensics Laboratory have given their full support in the fight against piracy, and this ruling is another testament to the commitment and resolve of the UAE to uphold copyright law and protect the interests of lawful businesses.*"

This single instance is but the latest in a long line of transgressions where pirates are given a slap on the wrist while they are, at the same time, making fortunes through the sale of cloned cards or so-called '***Dreamboxes.***'

For example, **Kudelski**'s ***Nagra*** conditional access division, where ***Simon Trudelle*** (Senior Director Product Marketing at Nagra), said, "*As we all know we have challenges in the MENA region as far as piracy is concerned. No longer is it simply a question of commercial piracy, which is bad enough, but we now have political piracy which with beIN Media and the problems from Saudi Arabia is a real concern. It doesn't happen in other regions of the world, and is now a fight between Saudi Arabia and Qatar and is completely changing the piracy landscape.*"

The fight between beIN Media and signal theft by beoutQ — and the fact that premium sport is available at extremely low cost by 'subscribers' to beoutQ — has forced OSN to dump all their sports channels (except for some cricket coverage) — transmissions ended on March 31st.

OSN's recently appointed CEO ***Patrick Tillieux*** said the changes would allow for more movies to be screened and for additional programming that will be skewed toward female viewers. He also promised more frequent '*pop up*' channels plus a "*refresh*" of their overall entertainment experience.

Tillieux is the fourth recent CEO to attempt a rescue of OSN and is under considerable pressure with majority-owner KIPCO seeking to exit the operation. Tillieux joined OSN last November and took over from former Sky CFO ***Martin Stewart***, who himself took over from ***David Butorac*** in 2016.

Nagra's Trudelle added, "*As a technology vendor we have been working with beIN and helping them protect their property. We already had a relationship with them but we are now having to do a lot more. We have discovered that the pirates working with beoutQ are really very sophisticated and skilled operators. It is the same with our competitors working in the region, and we are all working hard to help BeIN to stop this piracy. We are using all the solutions we have to disrupt and issue counter-measures, but the pirates are working just as hard to fight back. At this scale of piracy it is a huge challenge.*"

Trudelle explained how piracy is widespread throughout the MENA region.

"Most pirates are dependent on so-called 'control word' sharing. Unfortunately, it is a key part of the DVB core protocol and is a weak point for all of us. The offenders extract this key word from a set-top box and then put the word onto internet servers and re-sharing for their customers to use. There is a huge black market, or perhaps more accurately a 'grey' market because consumers are paying real money for a decoder box, often bought through a retailer and often described as a Kodi [or XBMC] device.

"We have worked with broadcasters such a Canal Plus on their signals to North Africa and in a case that involved an estimated 200,000 units and which then people took out a low-cost subscription, perhaps a few dollars a month, to be constantly updated with the pirated control word. Some of these boxes would give access to every satellite in the region which had subscription TV available."

Talking specifically of the Saudi piracy of beIN Media, he said the pirates have managed to side-step the watermarking identifications embedded in a signal, "*which only shows how sophisticated their operation is. They have even managed to ingest various feeds into four quarters [of the screen] from four different boxes and then rebuild the images into HD-quality signals, and this means it is difficult to trace the original source. They also have boxes in multiple countries across the region, which also makes life difficult. There's little doubt that when pirates are this clever, they will find these weak links. At the same time, the older pirate boxes cannot handle HD and certainly not 4K.*

"The battle between beIN and beoutQ is complex. A satellite operator carrying pirated signals will know that they are infringing copyrights. But when political pressures are so high that there is literally little that they can do, it is difficult to say 'no.' The risks for the core rights holders are extremely difficult. They are selling their rights to broadcasters, often at very high prices, and it is their core business model which is under threat. At the end of the day, the authorized rights-holder might be paying a fortune and has little or no prospect of recovering their outlay because of piracy. When these rights come up for renewal, the soccer rights-owner, for example, might find a reluctance to find clients for payTV."

While OSN is suffering losses from this piracy, it is Qatar — where the soccer **FIFA World Cup** is due to be held next year — which is hugely embarrassed by the high-profile diplomatic row between the nation and Saudi Arabia. The beoutQ signals are carried by an equally embarrassed **Arabsat**, which has its headquarters in the Saudi capital of Riyadh.

Arabsat has the satellite's world most precarious balancing act. On the one hand, Arabsat's frequencies are being used by the unwanted Saudi pirates and the company would like nothing better than for the problem to go away. But being based in Riyadh, and with the Kingdom being Arabsat's largest shareholder, makes life doubly-difficult for Arabsat.

One report earlier this year described the Saudi pirates as the world's most sophisticated "*bootlegging*" operation, and condemned by the likes of FIFA, UEFA and other sports-rights holders. FIFA, UEFA, the English Premier League, La Liga, the German Bundesliga and the Asian Football Confederation have weighed in by blasting beoutQ's outrageous actions as "*a clear and flagrant breach of our intellectual property rights.*

"*Collectively, we, as rights-holders in various football competitions, condemn the pirate entity beoutQ, which continues to abuse the operations of rights holders and legitimate broadcasters through its persistent and illegal screening of events for which it has made no effort to secure the rights.*"

Various legal actions have been initiated, but legal actions of this magnitude always run slowly and, with the Kingdom of Saudi Arabia involved, then any action will occur at a snail-pace.

Indeed, beIN Media Group is gaining increasing support from the USA's major sport and entertainment broadcasters in their anti-piracy drive. BeoutQ fills 10 channels of mostly BeIN Media pirated content which it uplinks to the region using Saudi-based Arabsat. BeIN Media is also asking U.S. authorities to place Saudi Arabia on its high profile and important '*priority watch list*' due to the Kingdom's alleged support of beoutQ.

BeIN said on February 15 that they had delivered a 138 page dossier to the United States Trade Representative of evidence of Saudi Arabia's alleged and deliberate activity in this matter. BeIN argues that beoutQ "has *since expanded to cover the most popular movies and television programming in the world, much of which is produced in the United States.*"

Qatar's satellite operator is **Es'hailSat** which carries the legitimate beIN Sport signals (and those of Al Jazeera), and its CEO ***Ali Ahmed Al-Kuwari*** summed up the position by saying, "*There is an anti-piracy coalition and we are all members. These problems are addressed at our regular meetings and is a very hot topic for all of us. We try and support those affected by protecting them and giving them the very best quality of service. But if the proper regulations are ignored, and the pirates refuse to listen, this must result in government action. It is only governments which can now stop this piracy. Government must take action. For a satellite operator cannot be the decision maker on this level of piracy. Our support will continue, but beIN is suffering very badly from piracy, as are the content providers with the major sports rights holders being badly affected.*"

Mr. Al-Kuwari added that the language of government and international organizations is usually diplomatic. He argued that this must change and added, "*Most of the international organizations try to be diplomatic, and neutral. They do not want to be seen as taking sides, so in my view the likes of the ITU will not get very far. But there has to be enforcement, and punishment by way of fines.*"

The current financial pressure on the likes of OSN only confirms these anxieties. Nagra's Trudelle noted, "*In my view the legitimate broadcasters might have to come up with another strategy, and to recognize that there's a large share of the market that will never pay for their TV. They might have to consider switching to a streaming model themselves, where there will be a reliable on-line transmission and which can more easily be controlled and monitored. They can still consider premium services, but it has to be a truly superior experience, with perhaps loyalty schemes and thus transform the 'free' model into some sort or improved monetization model.*

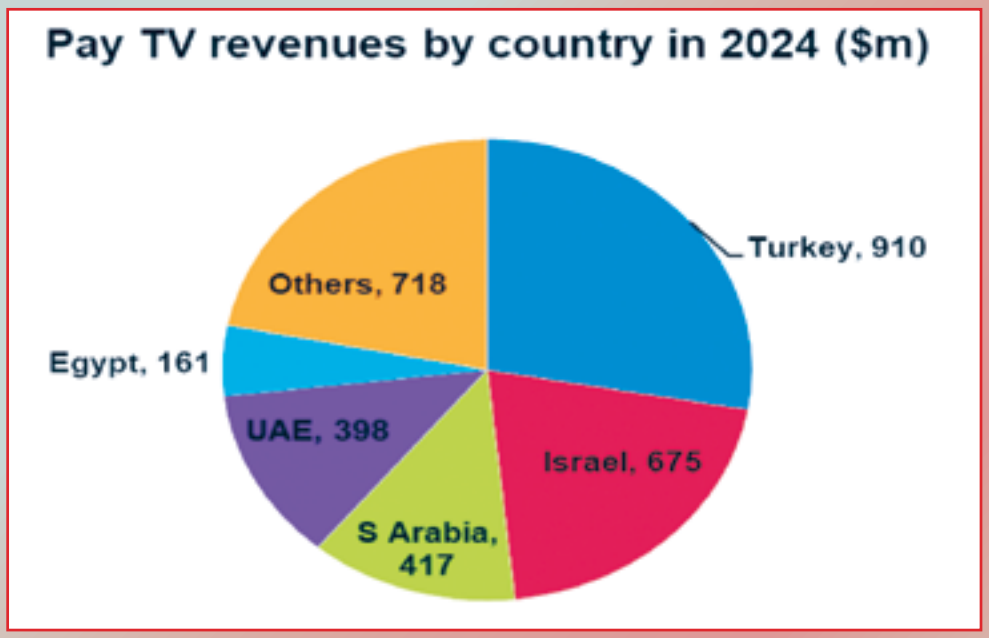
"*This could mean that the buying of rights might have to change in the MENA region. The broadcaster might switch from satellite, deliver an improved on-line experience. Today, it isn't possible because broadband supply is poor or not sufficiently deployed.*"

Senior Columnist Chris Forrester is a well-known broadcasting journalist and industry consultant. He reports on all aspects of broadcasting with special emphasis on content, the business of television and emerging applications. He founded Rapid TV News and has edited Interspace and its successor Inside Satellite TV since 1996. He also files for Advanced-Television.com . In November 1998 he was appointed an Associate (professor) of the prestigious Adham Center for Television Journalism, part of the American University in Cairo (AUC), in recognition of his extensive

How bad is the beIN Sport piracy?

According to 2019 data from Digital TV Research, payTV revenues for 20 MENA countries (including Turkey and Israel, which are outside the scope of our coverage) fell by 11 percent between 2016 and 2018 to just under $3 billion.

Given the hangover from the beIN ban and falling ARPUs in general, revenues in 2024 ($3.28 billion) will still be lower than in 2016 ($3.36 billion).



Data: Digital TV Research, 2019

Concentrating just on the 13 Arabic-speaking countries, pay TV revenues fell by a massive 16 percent from $1,254 million in 2016 to $1,059 million in 2018.

The total will recover, said Digital TV Research, to reach $1,432 million by 2024.

PayTV subscriptions fell by 9.5 percent between 2016 and 2018 to 3.40 million, but will progress to 5.23 million by 2024.

***Simon Murray,** Principal Analyst at Digital TV Research, said, "Pay TV in the MENA region has been hit by the Saudi-led ban on the sale of Qatar-backed beIN decoders and subscriptions since mid-2017*

The ban has been compounded by beoutQ, an illegal platform that retransmits some of beIN's content especially its exclusive sports rights. The region is no stranger to piracy, but the sophistication of the beoutQ operation is beyond anything seen before.

beIN is fiercely protesting beoutQ, with the support of major content owners, especially sports federations. We believe that the situation will be resolved in 2019; given the international pressure to drop the ban and to close beoutQ."

The MENA players, including those based in Qatar, can only say such will be the case.

InfoBeam

Helical Communications Technology launches their first antenna for Hiber satellite

Helical Communications Technology (HCT) recently achieved the status of "Flight Heritage Status" when their custom-built Quadrifilar Helical Antennas was launched as part of Hiber's smallsat mission.

The first two were launched into space at the end of 2018 from Vandenberg Air Force Base in California and the Satish Dhawan Space Centre in India — few private companies have reached this milestone.

Founded in 2013 by *Salvatore Bologna* and *Gregory O'Neill*, HCT began researching and designing a unique omni-directional antenna for smallsats that capture a much larger footprint of geography and topography on the Earth.

Within four years, HCT had developed a design that can be scaled depending on the customer's requirements to have a wide range of circularly polarized antenna patterns.

Hiber, based in Amsterdam, contracted with HCT to send their smallsats on this mission with the objective to offer IoT connectivity to the 90 percent of the world that currently lacks access to a network.

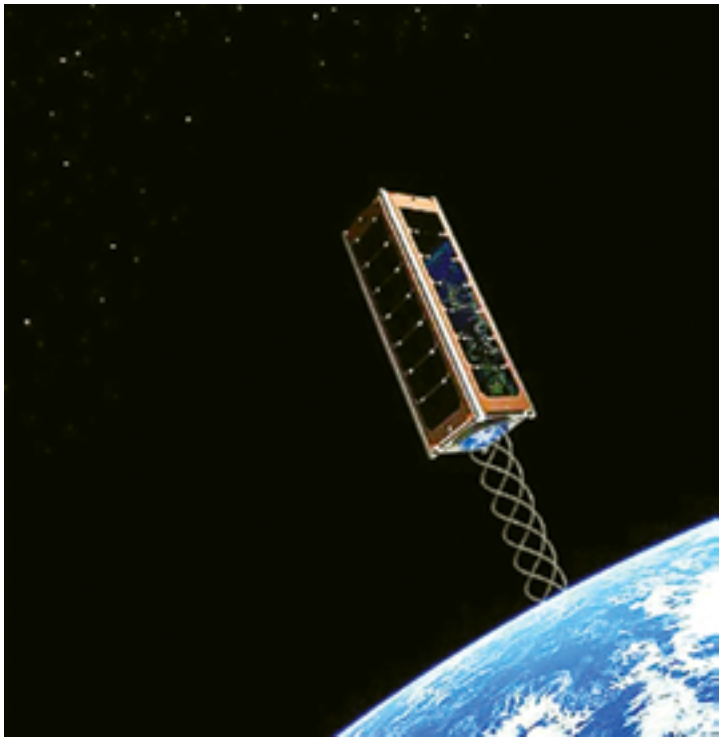
The company expects to launch multiple smallsats within the next year to keep up with customer demand.

The Helios Deployable Antenna is developed for small satellite applications and features a Quadrifilar Antenna with an electrically-powered method of deployment.

HCT designed the custom-built "quadrifilar" helical antennas at their Rockledge-based operations and shipped them to the Netherlands, where Hiber is based.

Hiber then shipped the smallsats to their launch destinations in California and India.

In remote regions and developing countries worldwide, subscribers purchase a low-cost modem that is then integrated with existing connected technology devices and allows them to connect to Hiber's IoT network.

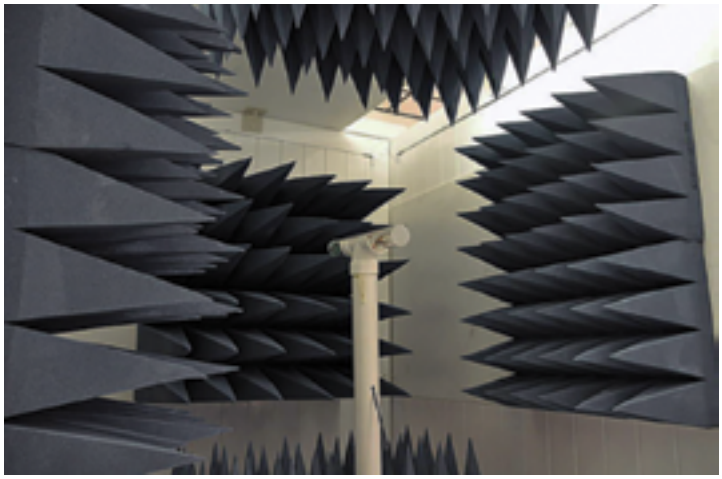


Artistic rendition of the deployed HCT antenna. Image is courtesy of Helical Communications Technology.

The goal is to have a constellation of dozens of satellites to enable customers to send SMS-sized messages in real time from IoT devices, such as sensors on fishing vessels or monitoring devices remote devices in locations such as Antarctica.

In 2017, HCT was selected for the NASA Technology Docking Program, a unique arrangement from the agreement between the Economic Development Commission of Florida's Space Coast (EDC) and NASA that awards select companies the opportunity to work with a NASA subject matter expert to review any technology hurdle they may be encountering. Typically only five companies are selected each year. The EDC is the only EDO in the country that offers this service to their local companies.

HCT's offices in Rockledge, Florida, also contain an anechoic chamber for testing radiation patterns without echo effects. Manufacturing is strictly completed locally in Brevard County Florida to maintain top quality and frequent inspections.



HCT's Anechoic Chamber.

The company has plans to ramp up production rapidly as customer orders increase.

HCT expects a significant upsurge in sales due to market expansion over the next two years as their patented technology is unique, will be manufactured at a lower cost and can be custom built to scale locally depending on the application in any quantity.

Salvatore Bologna said this flight heritage milestone opens the company's doors for more companies wishing to launch satellites into LEO in the future. The opportunity to offer daily internet access via modems located in remote regions of the world transmitted to Earth-bound, existing satellite stations is remarkable. HCT is proud to have been part of this much needed solution."

Gregory O'Neill added that it is an honor and privilege to work with a company such as Hiber, who possess strong business ethics. The company anticipates a long and successful relationship with them as they move forward to provide internet connectivity to millions of people who lack that ability in areas where cable connectivity is simply not a realistic option.

www.helicomtech.com/

InfoBeam

Double debuts from IEC Telecom and features Thuraya comms technologies

IEC Telecom is bringing flexible and cost-effective, high speed connectivity to the fast-growing Asian offshore market using Thuraya's VSAT+ service — the company launched this service in response to growing demand for reliable, higher bandwidth solutions to meet the needs of the offshore oil and gas sector.

Available for the first time in this region, Thuraya VSAT+ is a comprehensive maritime communications platform for vessel management and crew welfare needs, providing quasi-global coverage for a wide range of vessels and offshore operators. A wealth of value-added services from IEC Telecom enhance this package, while competitive tariffs, flexible contracts and IEC Telecom's back-up services provide the perfect solution for the offshore support sector or for short-term projects.

Thuraya VSAT+ combines the high throughput of Ku- bandwidth (up to 4 megabits per second) with the resilience of L-band to provide a fast and secure high bandwidth with a resilient back-up.

In addition, IEC Telecom has developed its own One Gate Solution to provide first-rate cyber security while allowing ease of control of VSAT+ assets. One Gate allows easy internet access for crew members and contractors and helps to maximize workflows while maintaining the highest levels of security.

For offshore companies, IEC Telecom's Thuraya VSAT+ service provides traffic optimization for a better user experience and flexible tariff plans with no yearly lock-in commitment. The company provides the same flexible contracts for its global coverage maritime sector services, as well.

Launching the IEC Telecom Thuraya VSAT+ service to the Asian market during the recent Sea Asia 2019 event, *Nabil Ben Soussia*, VP, Maritime, at IEC Telecom, noted that recognizing the need for a flexible, high speed solution for the growing offshore sector, the company has worked side-by-side with Thuraya to develop this product tailored for offshore companies. The product has been well-received in the Middle East and IEC Telecom is now delighted to bring this solution to Asia as it offers a real alternative and will transform satellite communications provision for offshore customers.

Kenny Koh, Managing Director at IEC Telecom Singapore, further explained that through this partnership, the company is confident that this service will further enable the digital oil and gas revolution. Telecommunications of this level, with unique tariffs and back-up solutions, enable operators to save money by reducing operational costs, through the ability to undertake tasks online such as logistics and maintenance, while also being able to provide crew welfare services such as remote training, telemedicine and internet/messaging abilities.

Nadeem Khan, Director, Maritime M2M & IoT, at Thuraya, added that by appointing a highly experienced, capable partner with wide geographical reach as this Master Distributor for VSAT+, Thuraya is simplifying the proposition for resellers to offer high-quality services with no investment in the infrastructure. This is a win-win partnership founded on creating new opportunities for the maritime industry.

Additionally, IEC Telecom has launched their Orion Edge+ satellite voice and data communication solution. Orion Edge+ provides high quality, reliable broadband with the ultimate cost effective operational benefits. It also provides flexible data plans with no long-term commitment. This flexibility makes Orion Edge+ ideal for busy offshore support vessels, tugs, and oil and gas contractors.

Powered by Thuraya's Orion IP broadband and Thuraya's Seastar circuit switched voice terminal, the Orion Edge+ solution offers high quality voice and data services bundled with consumption monitoring tools and controlled welfare applications – all regardless of vessel size.

Orion Edge+ is available through monthly plans with no long-term contractual commitments. Specialized hardware offered by IEC Telecom keeps upfront costs low and provides full visibility for management control, both onboard and onshore. Orion Edge+ is equipped with Wan Optimizer, enabling TCP acceleration and bandwidth optimization.

Crew welfare needs are enhanced by local WiFi management which enables vessel and offshore platform managers to provide crew with access to social media platforms and the internet, with safety maintained by high level security systems. Access is granted via an advanced captive portal and consumption can be managed via vouchers or scratch cards for crew members. Thanks to IEC Telecom's integrated solutions, this is possible even for small vessels that cannot accommodate a VSAT antenna.

Nabil Ben Soussia, VP, Maritime at IEC Telecom, said that this is a brand new, optimized voice and data solution, engineered by IEC Telecom and powered by Thuraya Telecommunications, that enables small boats to enjoy the high bandwidth that was previously available only to VSAT users. This game changer is designed to meet the requirements of short-term projects with flexible data plans, no long-term commitment, and zero upfront cost.

IEC Telecom also recently entered into a win-win partnership with Thuraya Telecommunications to commercially offer Thuraya VSAT+ across Europe, Asia-Pacific (APAC) and Middle East and Africa (MEA). This innovative solution ensures optimum flexibility of satellite service and is scalable to meet global and regional needs for essential communications such as voice calls, email and position reporting, and for high-bandwidth requirements.

iec-telecom.com
thuraya.com

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ASIA VIDEO INDUSTRY ASSOCIATION

Satellite Industry Forum 2019

17 June 2019, Four Seasons Hotel Singapore
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As 2019 progresses, it will be of interest for many to find out what trends the satellite industry will see play out this year, as well as what the key drivers of growth will be for operators and customers alike.

Gearing up with new discussion topics, AVIA Satellite Industry Forum 2019 is proud to announce the preliminary program and introduce an early lineup of distinguished speakers:

Keynote:
Steve Collar
President & CEO
SES

Huang Baozhong
EVP
APT Satellite

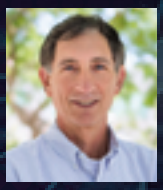
Roger Tong
CEO
AsiaSat

Jean-François Fenech
CEO
Eutelsat Asia, Chairman of AVIA Satellite Industry Committee

Mitsutoshi Akao
Executive Officer & Group President, Global Business Group Space & Satellite Business Unit
SKY Perfect JSAT

Barry Matsumori
CEO
BridgeSat

M.N. Vyas
Founder Member and Executive Director
Planetcast Media Services



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Suwit Pruckwattananon
Chief Business Development Officer
mu Space

Mark Rigolle
CEO
LeoSat Enterprises

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CCO
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Optical Wireless Comms for MENA

The future is hybrid RF

By Rick Sanford, Vice President, Strategy and Business Development, BridgeSat, Inc.

The Middle East and North Africa (MENA) region is home to 6 percent of the world's population and covers a surface of more than 15 million square kilometers that is rich in petroleum and natural gas resources.

The three smallest countries (Bahrain, Djibouti and Qatar) each have a population of about half a million. By contrast, the two largest countries (Egypt and the Islamic Republic of Iran) comprise about 60 million inhabitants each. Together with Algeria, Morocco and Sudan, these five most populated countries account for nearly 70 percent of the region's population, about half of which live in cities.

Within this general characterization, countries vary considerably in resources, economic and geographical size, as well as standards of living, yet share distinct common challenges and goals as they work to further develop their respective economies — among them is advancing their communications systems.

Economic Growth and the Connectivity Factor

To provide further context regarding economic growth in the MENA region, World Bank predicts a modest upward trajectory estimated between 1.5 to 3.5 percent during 2019-2021, expecting a continuing rebound from a sharp deceleration in 2017, which was driven by oil production cuts in oil exporters and fiscal tightening.

While oil imports continue to garner optimistic momentum, connectivity remains a significant economic growth factor. In 2018, **Internet World Stats** (***www.internetworldstats.com***) revealed that only 35.2 percent of Africans were internet users, compared with 58.4 percent for the rest of the world. According to the World Bank, for every 10 percent increase in broadband connectivity in developing nations, GDP rises by 1.38 percent.

Today, nearly all major African coastal cities rely on internet backbone fiber, with inland deployments quickly evolving. However, Africa continues to be the largest market for satellite trunking demand due to landlocked territories challenged not only by location but also capacity, availability and pricing — $439 per Mbps per end user.

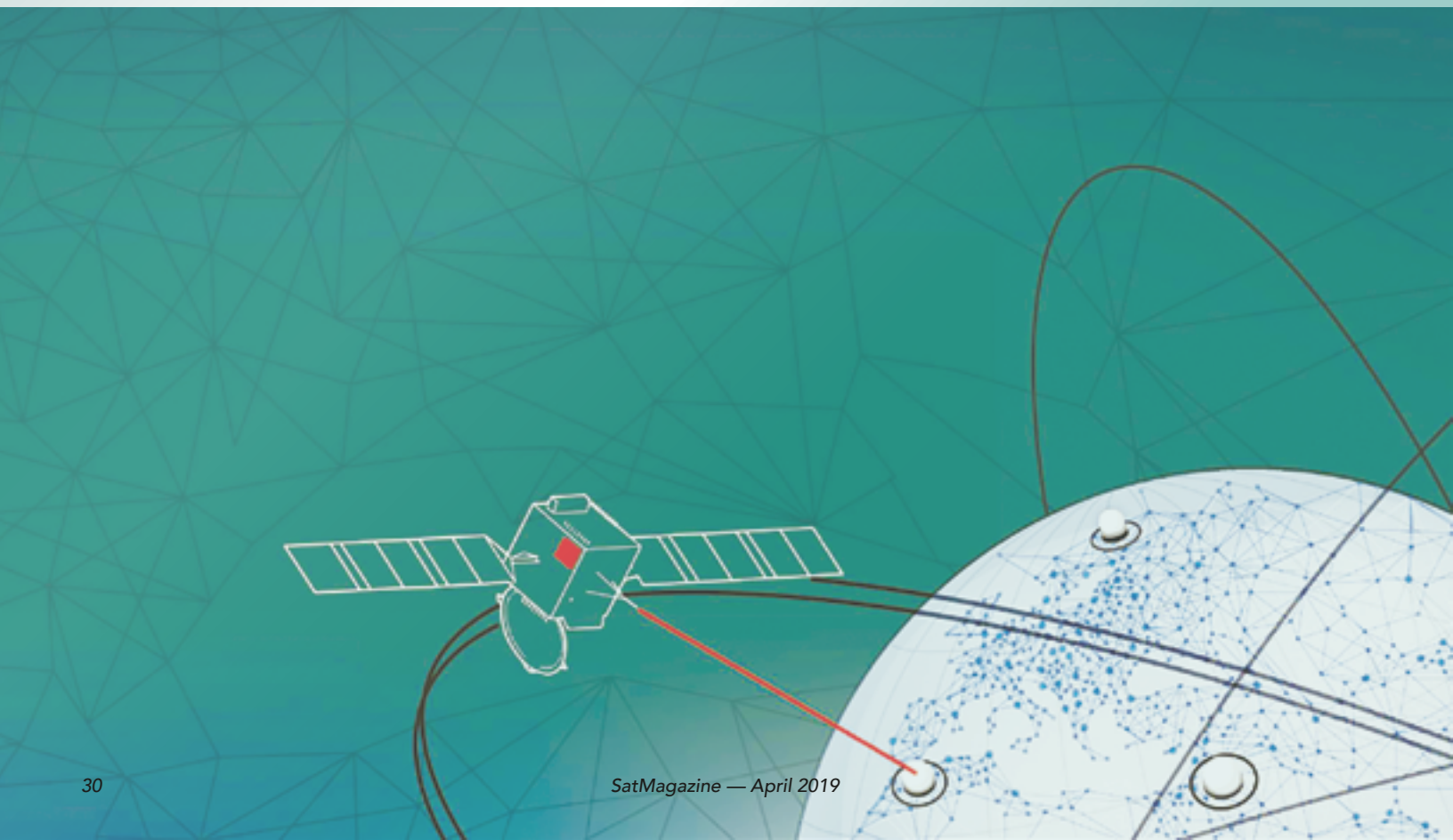
After the initial rapid development of fiber, expansion is slowing down and **Internet Service Providers** (***ISPs***) must balance the priorities of extending networks and improving services in high-value, easy-return urban areas.

A large proportion of fiber backbone in Africa is single-thread and prone to disruptions. **Akamai** reports that internet traffic levels to South Africa drop as much as 40 percent for two hours when construction results in damaged cables.

Demand for back-up services is growing, and in many instances, even if fiber lands locally, operators keep satellite links to ensure critical connectivity. Considering the relatively low broadband connectivity rates in much of Africa, this region is a prime target for satellite operators hoping to help bridge the digital divide with flexible, reliable and ubiquitous connectivity — three key selling propositions for satellite trunking links.

Demand Beyond the Terrestrial Grid

In the Middle East, the World Bank suggests the demand for widespread connectivity has never been greater in the Arab world, where aggressive initiatives in space exploration continue to unfold.



At the **2019 Global Space Congress** organized by the **United Arab Emirates** (UAE) **Space Agency**, 11 Arab states in the MENA region signed a new charter establishing the **Arab Group for Space Collaboration**.

Identifying its first project, Arab scientists will work together in the UAE to develop an advanced satellite to monitor environmental and climate changes.

According to UAE Space Agency's Chief Innovation Officer, ***Sheikha Al-Maskari***, member countries — Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Saudi Arabia, Sudan and the UAE — agree that space exploration will contribute significantly to sustainable development, particularly after years of political upheaval. Recognizing that some have been invested in the space sector since the 1980s, while other have yet to start their involvement, the group's first priority is to ensure equal capabilities among all member countries.

Though the pan-Arab agreement is an unparalleled milestone, the MENA region has already experienced considerable progress in the space sector. Over the past weeks, *SpaceWatch. Global* reported on a number of exciting space and cyber developments throughout the globe. Among them, the most notable included a space cooperation agreement between Bahrain and UAE's Mohammed Bin Rashid Space Centre and space cooperation agreements between France, Ethiopia and the African Union Commission.

Viewing the Middle East as one of the world's most consequential regions for space exploration, the expectation is that this will become the fastest-growing market in the coming years — understandable, considering the capabilities of Egypt, Morocco, Iran, Israel, Saudi Arabia and UAE among others to build and launch their own satellites into space as well as develop sophisticated, state-of-the-art centers for science and technology.

Satellite technology will undoubtedly continue to advance in ways that enable more efficient **radio frequency** (*RF*) reuse and greater ability to work around interference. However, it can only go so far... what is needed is a solution to augment existing technology.

Optical Wireless Communications (*OWC*), a technology **NASA** and other space agencies have been using for decades, provides that critical augmentation which can propel the MENA region into a new era of connectivity.

A Modern Approach to Secure Communications

Recognizing the growth of the communications market, Qatar-based communications satellite operator **Es'hailSat** (***www.eshailsat.qa/***) is making a bold move to support space initiatives, as well as help provide businesses and governments with more affordable access to laser-based satellite broadband services.

Through a strategic partnership with **BridgeSat (*www.bridgesatinc.com/*)**, Es'hailSat is developing MENA's first **optical ground station** (*OGS*) at the company's new, state-of-the-art, satellite operations center in Doha. Bringing secure, high-performance, low-cost OWC to the Middle East, the OGS will support customers in the region beyond traditional satellite services. When combined with RF in a hybrid system, OWC will provide an option that enhances the overall service experience with the benefit of much higher performance and security delivered at lower cost.

How is security enhanced by OWC? The fundamental nature of using a laser-based system means that the communications signal will reach only the intended receiver, and unintended receivers will not even see the signal. This is an additional layer of security that enhances the encryption already used.

Security comes through layers of protection mechanisms. That will result in true, trusted communications. The performance capabilities of OWC also address the needs coming for higher rate satellite communications, as well as the economic benefit of ground systems when compared to the high-rate demands for RF ground systems.

Technology for OWC is taking advantage of the maturation of the fiber optic communications market as well as the commercialization of many of the components that are used in common with OWC. Hence, commercially competitive solutions can be made for satellite communications as well. In addition, the state of the art has advanced rapidly in the past few years, led by developments in amplifiers, lasers and acquisition tracking technologies.

Finally, the commercial industry can now take advantage of these technologies thanks to investments that have been made into OWC by governments and agencies such as NASA, JAXA (Japan) and the European Space Agency (ESA), which have helped mature OWC capabilities.

For the application of space communications, the focus of these commercial developments has been on compact, high-data-rate OWC terminals ideally suited for **Low Earth Orbit** (*LEO*) satellites, which include applications for Earth observation and telecommunications. These LEO satellites have a common trait of traversing the Earth, and all will see the MENA region.

Es'hailSat's service will support the future of communications to all of these satellite systems, offering an OWC and RF gateway that exemplifies the modern approach to communications systems.

www.bridgesat.com

Rick is the Vice President of Strategy and Business development for BridgeSat. An executive leader with more than 34 years of experience in communications systems analysis, design, integration and maintenance, his areas of expertise include cryptographic, terrestrial carrier, satellite and timing systems.

Rick's core strength is in understanding program/project/mission requirements and aligning the people, processes, budget and technologies in order to achieve success and provide maximum return on investment.

A recognized leader in the space, cyber and networking communities, Rick possesses extensive international team leadership experience in the United States, United Kingdom, Australia, Germany, France, Singapore, Korea, Taiwan, Japan and select Middle Eastern countries.

Rick began his career in the United States Air Force, studied computer information systems at Strayer College and served over 12 years with Cisco Systems, Inc., where he was responsible for building the U.S. National Security business and founding the company's space business as part of the Global Government Solutions Group.

Rick founded SpaceGroundAmalgam, LLC in 2009 and served as a partner with mid-market strategic investment firm Hudson Fairfax Group for three years. Rick most recently served in business development for small satellite supplier Surrey Satellite Technology in their U.S. office.

He serves on the board of Space Micro, Inc. in San Diego, California, and is the President of the Board of Habitat for Humanity of Teller County Colorado. Rick was on the board of the International Space University in Strasbourg France for 10 years and was recently selected as a Forbes Business Development Council Member.

BridgeSat has designed an optical wireless communications (OWC) system that aims to improve connectivity and the wireless transfer of data from LEO satellites. The OWC system provides an alternative transmission mechanism that is designed to be faster, more secure and available at a lower cost than traditional radio-frequency transmissions while meeting the constrained size and power requirements inherent with small satellite operations.

As part of this total OWC solution, BridgeSat is building out an expansive global OWC ground network. With ground station site diversity essential to OWC, BridgeSat is establishing a network to support spacecraft operators.

Focus: Es'hailSat

The growth continues...

By Mr. Hamad Al Mannai, Commercial Executive Director, Es'hailSat

As one of the youngest Satellite Operators in the region, Es'hailSat was a late entrant in the Middle East satellite space. However, over the past few years, the company has been emerging rapidly into various verticals with a versatile portfolio of services to meet customer demands.

With two satellites on orbit, **Es'hailSat** is expanding their reach with fresh partnership programs for new satellites that will be launched during the coming years.

The biggest contribution the company has made is with their Direct-to-Home (*DTH*) services that delivers high demand, high quality video content to consumers across the region.

Having a wide and also strong beam coverage over the Middle Eastern and North African (*MENA*) region, viewers in a wide geographical range are able to watch Free-to-Air (*FTA*) and payTV content via a small and easy to install antenna dish.

Both the ***Es'hail-1*** and ***Es'hail-2*** satellites, owned and operated by Es'hailSat, are located at 25.5 degrees East / 26 degrees East orbital position, which is a hotspot in MENA for DTH television content.

With more than 700 TV channels available being distributed by these satellites from their orbital slots, with high quality premier sports and entertainment content readily available and with nearly 200 million viewers receiving channels from this location, this Es'hailSat orbital position is truly a hotspot for the region.

Consumers receive a numerous channels from this orbital spot and broadcasters can add new channels to reach broader audiences.

The key requirements for broadcasters and content owners is to ensure their product reliably reaches viewers without quality degradation and without service interruption.

To address this requirement, Es'hailSat incorporated an anti-jamming feature on-board their satellites that helps the spacecraft avoid unintentional or intentional signal jamming that may cause harmful outages to the broadcasters' television content.

For consumers, this means they are able to watch and enjoy their favorite television channels without interruption, especially the live sports content from the local region and from around the world.

In addition to sports content, news and general entertainment channels are the most watched programs in MENA and a number of these channels are available through Es'hailSat satellites delivery.

Broadcasters and content owners can leverage playout services and uplink services to deliver content to the consumer from Es'hailSat's newly inaugurated, state of the art teleport in Doha, Qatar.

Without major investments into systems and equipment, broadcasters have a reliable pathway to edit, transmit and distribute their content in their preferred formats over satellite.

In addition to distribution via satellite, broadcasters will be able to deliver their content through the Es'hailSat OTT platform that the company developed with their strategic partners

This offering will enable broadcasters to have their content on-air on multiple platforms and devices that will attract viewers from around the world.

Consumers, on the other hand, now have the luxury of watching their favorite content while on the move at anytime from any location and all while on the move. Consumer viewer habits are constantly changing and Es'hailsat works to ensure

Artistic rendition of the Es'hail-1 satellite. Image is courtesy of Es'hailSat.

Artistic rendition of the Es'hail-2 satellite on-orbit.

such viewer demands are seamlessly supported. In addition to the DTH services that the company offers, Es'hailSat has been providing services within the telecommunication sector to provide communication link connectivity to various markets.

Es'hailSat has developed their own managed VSAT Hub for telecommunication demands within the region. With this platform, and working together with strategic terrestrial network companies, the company is able to cater to various demands, such as mobile backhauling, IP trunking, backup connectivity, and cost-effective consumer internet connectivity to address the digital divide in areas that lack fiber network.

Providing backup and disaster recovery services for the telecommunications sector is also key to ensuring consumers have continued voice and data connectivity.

Es'hailSat has been providing backhauling services, back-up capacity, ground services, and remote connectivity to the telecommunication companies in the region to ensure communication services are available for consumers during emergencies and disaster situations.

In addition, mobility markets are another key segment within which the company is active with new services. In example, Es'hailSat offers enterprise and maritime connectivity services for government, enterprises and consumers in Qatar.

Ground station, Doha, Qatar.

The nature of satellite services is that services can be activated anywhere within the footprint subject, of course, to respective regulatory clearance. This has helped the company's customers obtain access to satellite voice and data services while on trips and expeditions in remote parts of MENA where traditional terrestrial connectivity is not available.

Given that the coverage of Es'hailSat's current satellites are limited to the MENA area, the firm has managed to extend the reach of their offerings beyond current locales through partnerships with other operators, all to satisfy the customers' needs for global connectivity on their mobile terminals.

Maritime is a strong market within which Es'hailSat has become active during the past year. With fleet management and crew welfare being key requirements for vessel operators, Es'hailSat has started supporting maritime companies with on-board connectivity for voice and data via satellite.

Es'hailSat will continue to strive to expand their technologies and capabilities to better serve customers and society in the ever-broadening realms of satellite communication.

www.eshailsat.qa/

Hamad began his career as a GSM Networks Engineer and later served as the Head of Operations and Maintenance Networks in Qtel. He then became the Head of wired and wireless networks in the military field until he was appointed Director of Communications.

He was a member of the Integrated System Committee, which later turned into a National Security Shield project, and a member of the establishment of the National Command Center Committee. He holds a BS degree in General Electrical Engineering specialized in Communication and Master degree in Business administration.

Low-Cost Ground Systems

A technology roadmap

By Paul Scardino, Senior Vice President, Speedcast

The coming wave of LEO communications constellations has focused attention as never before on the cost of ground systems.

Financial analysts cite ground system costs as one of critical potential bottlenecks that could slow adoption of the enormous new capacity that LEO satellites can add.

The R&D engines of flat-panel innovators are running at full speed in search of technology that, when produced in high volume, can drive prices to a fraction of current levels.

As always, the value of this kind of innovation spreads far beyond the specific application it targets. The entire satellite communications business would gain tremendously from lower-cost ground systems. This creates the opportunity to rethink all of the costs associated with ground systems.

I start that process from the satellite antenna and RF electronics and move down the block diagram to the IFL, indoor modems and operational systems. Costs come in both CAPEX and OPEX, from the hardware to the operations, which includes personnel and expenses like power, maintenance and SaaS.

Technology has been best at helping us reduce these CAPEX and OPEX numbers making ground systems more affordable for all operators.

Improving the Hardware

Last year, I celebrated my 30th anniversary in the satellite industry. Those of you who have been in the industry for as long remember a period of time when the multitude of letters describing the Standard Earth Station, starting from A and working down the alphabet.

We paid a premium for a 160oK, 60dB Ku-band LNAs and dealt with tuning the cavities of Klystron amplifiers for any power requirement over 500 Watts and the standard modem configurations of **Intermediate Data Rate** (*IDR*) and **Intelsat Business Services** (*IBS*) applications covering a range of data rates from 64 kbits/s up to, the high for the time, 8.448 Mbit/s.

Certainly much has changed in the industry and technology in general. Moore's law continues to deliver more bits per hertz per dollar to the end customer.

Advanced manufacturing techniques and increased production volumes have helped make that possible. Advances include remote management automation systems, more efficient RF electronics, smaller antennas made possible by more powerful satellites and the latest bandwidth (BW) management techniques.

Ground system costs have benefited from smaller components and chip sets, much-improved **traveling wave tube** (*TWT*) and solid-state technology, and outstanding modulation and coding capabilities.

We have seen the legacy 70/140MHz IFL and their associated synthesized frequency up and down converters replaced by L-band IFL technology solid-state amplifiers for satellite communication systems, with embedded block up and downconverters.

The transformation of those same solid-state amplifiers from **Gallium Arsenide** (*GaAs*) transistors to **Gallium Nitride** (*GaN*) transistors has reduced their size and improved their efficiency.

Single modems now have L-band Input/Output along with integrated equalization and uplink power control replacing three separate units. This has allowed the ground station designer to house all the RF electronics outside, closer to the antenna feed, which improves performance while reducing RF loss and cost.

More Powerful Design

The technology improvements also allowed the ground stations to operate 'greener' than their age-old counterparts.

The list of technology improvements includes energy-efficient, low-maintenance power supplies and ***SSPAs*** (**Solid State Power Amplifiers**), and linearized, energy-efficient, **multiple-stage, depressed collector** (*MSDC*) TWTAs which produced 50 percent energy savings and include automatic bias control systems that maintain constant beam current with precise matching of linearizer performance to a specific tube over a wide range of operating conditions, which maximizes power efficiency.

The data center where this equipment resides is benefiting from better design, the use of intelligent HVAC control systems, the reuse of HPA exhaust heat for comfort heating and antenna de-icing.

While these changes were happening on the ground, the technology in the sky was also improving. Satellite manufacturers have produced satellites that are at least ten-fold more powerful and transport more than ten times the data rates of those from only a decade ago. This has allowed us to design smaller, more agile and less costly ground system components from the antenna to the RF electronics.

Software Improvements

The majority of the improvement in SATCOM ground system costs — and in all industries, for that matter — comes down to software.

Remote Management and Automation software has allowed us to replace multiple tasks which were once time-consuming and highly labor-intensive reducing the manpower associated with operating the ground station.

The software that defines the signaling for better waveforms and networking for better multiple access protocols has contributed to greatly reducing the satellite bandwidth required for operational networks. We've seen more than 70 percent bandwidth efficiencies from technologies developed just ten years ago.

Software obviously provides the brains behind the software-defined platforms and networks, allowing virtualization and cloud-computing operation. This has also permitted the use of smart redundancy techniques, removing the need for multiple platforms while also allowing for lower-cost geo-redundancy capabilities.

Software now defines the radio hardware and allows multi-service antenna systems to open the possibility of operating terminals on several satellites simultaneously. That will reduce CAPEX exponentially compared to utilizing multiple systems to communicate with multiple satellites. The effect could be multiplied even more as flat panel, electronically scanned antennas proliferate in the markets.

I believe the SATCOM business is on the same path as the terrestrial telecommunication industry was 10 to 15 years ago. At that time, new technologies within telecoms were increasingly introduced through standardization — and this is what is needed for the SATCOM industry.

Hardware and software improvements, following a predictable roadmap based on standards, are creating a market right in front of us where high-volume, low-cost ground stations will make the satellite network an integral part of global telecommunications and drive high growth in volumes and total revenues.

www.speedcast.com

Paul Scardino is the Senior Vice President, Speedcast. He holds an MBA in Management (with Distinction) from Hofstra University in New York and a BSEE from Polytechnic Institute of NYU. Mr. Scardino is also a PMI certified PMP, a Six Sigma Green Belt and holds an ITIL Foundation Certification. He serves on the board as Northeast Chapter President of SSPI, director of Long Island Software & Technology Network (LISTnet) and senior advisor of the TIA.

Igniting The Next Revolution...

...in satellite constellations

By Shey Sabripour, Founder and Chief Executive Officer, CesiumAstro

The global space industry is undergoing rapid change. No less than 300 new companies are investing in new spacecraft and launch systems for more cost-effective access to space with greater frequency.

Over the past half-dozen years, several traditional large, geostationary, telecommunication satellites have been replaced by high-throughput (LEO and GEO) versions that are drastically disrupting the market. Today, the demand for large GEO commercial satellites has declined from a steady 25 to 30 satellites a year to five to seven per year.

Embracing this shift, a new generation of operators and satellite system manufacturers are re-tooling their infrastructure to better align to this changing market. General ***John Hyten***, United States Air Force (USAF), head of STRATCOM, and now nominated to be Vice Chairman of the Joint Chiefs of Staff, highlighted these strategies in the new '*space enterprise vision*' recently adopted by the USAF and National Reconnaissance Office (*NRO*)...

"*In that vision you won't find any of those big, exquisite, long-term satellites,*" stated General Hyten. "*With regard to military satellites, STRATCOM will advocate for a change away from "exquisite" costly systems that take years to develop in favor of "more resilient, more distributed capabilities.*"

An important parallel shift is in the deployment of proposed commercial and military constellations, aircraft connectivity solutions, and advanced weapon and C3ISR systems. These systems now require rapid insertion of Commercial-Off-The-Shelf (*COTS*) part solutions that have been adapted from disruptive developments in adjacent markets, rather than relying on "traditional" mil-qualified parts.

Within a decade, one or more large Low Earth Orbit (*LEO*) constellations of smaller satellites will be fully deployed, each likely numbering in the thousands. These will enable unprecedented services, including highly distributed, interconnected and resilient systems to improve our personal and business security, decentralized remote imaging for enhanced environmental and agricultural monitoring, and a full connection of the plethora of mobile devices that are woven into the fabric of our lives and enterprises.

Accelerating Change Drivers

During the past decade, three markets have pushed small form-factor COTS technologies to new levels: ***mobile consumer electronics***, ***"intelligent" automotive systems*** and ***next-generation-space capabilities***.

High-end smartphone and tablet markets require electronics that run sophisticated operating systems and radio platforms drawing on minimal battery usage. Many of the companies who have invested in those technologies are now pushing into driverless and driver-assisted automotive platforms, adding safety and reliability requirements.

CesiumAstro is an Austin, Texas, startup that was developed on the back of a market strategy to leverage the intersection of all three of those markets. Many system integrators choose not to invest resources into fully custom, fixed beam payloads, creating a market for "out-of-the-box" solutions such as CesiumAstro's ***Nightingale*** series products.

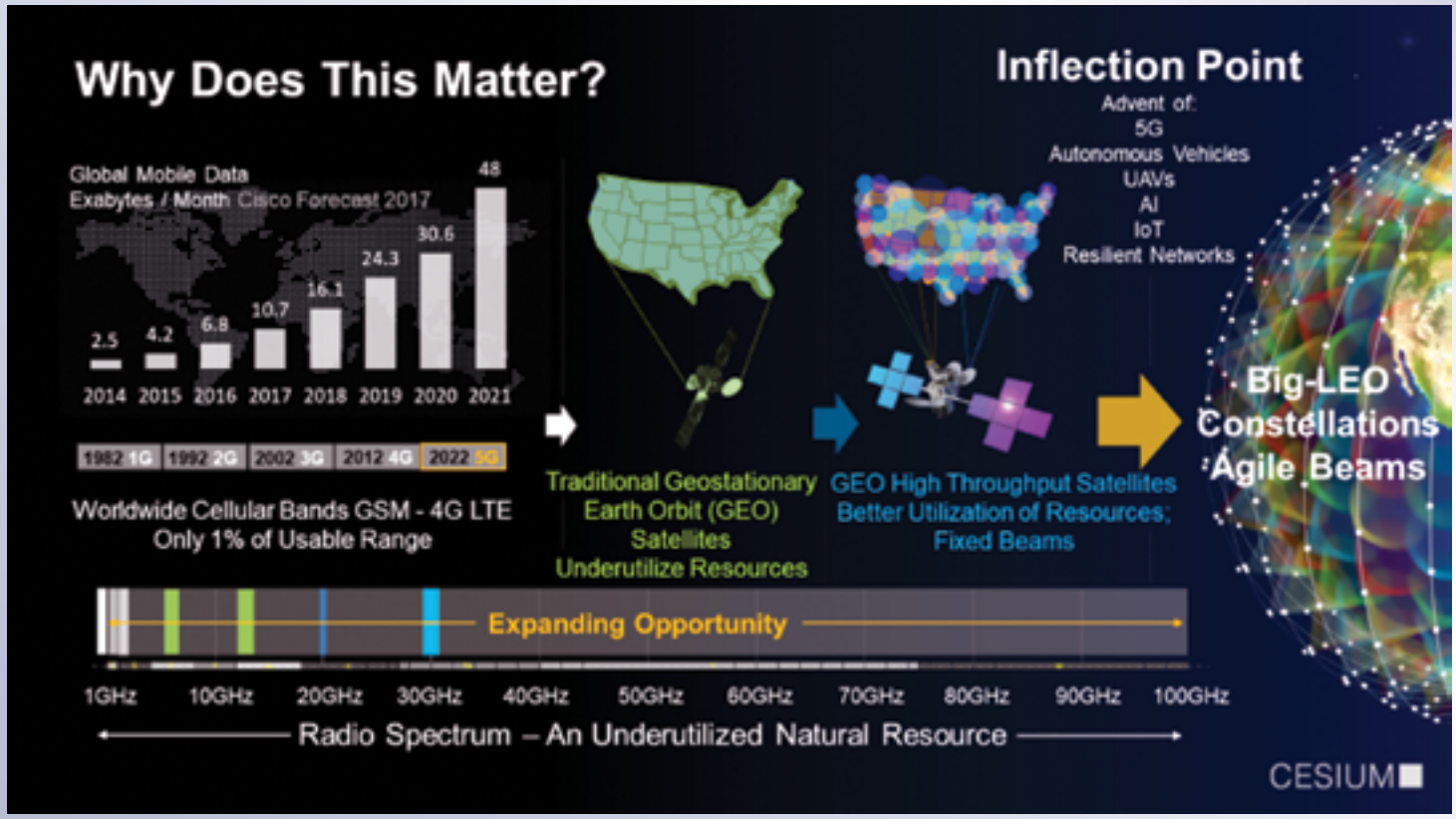


Figure 1. Markets are shifting from large platforms to smaller, distributed platforms and higher throughput systems. Image is courtesy of CesiumAstro.

Figure 2: Cesium introduces its first out-of-the-box agile payload system

At the same time, the new push for advanced automotive electronics provides a source of highly-capable and highly-reliable components that are well-suited to this next generation LEO space market. Now, reliability advancements have progressed to aerospace requirements, and LEO and low-MEO satellites are a particularly attractive application, as the strict reliability requirements are balanced by relatively low radiation levels. Therefore, CesiumAstro is in a unique position to leverage its existing COTS-based, miniaturized telecommunication and advanced avionic products for LEO constellations and other new aerospace applications.

The Cesium Model

CesiumAstro is keenly focused on commercializing out-of-the-box COTS-based phased arrays and modular, high-throughput, software-defined communication systems for LEO, launch vehicles, UAVs, and commercial and Department of Defense (DoD) aerospace applications.

CesiumAstro's paradigm shift is to build arrays on a system of scalable and modular "LEGO®-like" software defined architecture, turning digital bits into steerable, shapeable radio frequency beams — providing complete communications systems in an easily customizable plug and play kit.

To create a high-speed communications link, all that is required is a single power cable and a digital connection. (*See Figure 2, above*)

Nightingale for Commercial LEOs

Cesium's first product, Nightingale, is a complete plug-and-play, active-phased-array communication system in a thin tile — a key enabler for satellite integrators, data providers, and the military. The module combines a cutting-edge **software-defined radio** (SDR) with an ultra-wideband, multi-beam phased array antenna, offering a wide choice of communication parameters and dynamic reconfiguration of the system.

Traditional spacecraft antennas, such as shaped reflectors, direct radiating horns and patches, provide fixed spot beam patterns — an approach that commonly leads to a comparably high overall power efficiency and lower payload cost.

A fundamental challenge with this fixed pattern approach however is that, for highly dynamic, maneuvering spacecraft systems, the requirements tend to favor isoflux, omni or mechanically steered reflector antennas leading to inefficient distributions of bandwidth and power using uniform, fixed, wide beams.

These fixed beam/fixed waveguide systems are often custom designed solutions for each type of spacecraft and each mission.

Nightingale is an active phased array communication system that produces multiple steerable beams per aperture and allows for reconfigurable, on-board signal processing.

This payload architecture maximizes the bandwidth and power that is delivered to users.

Additional advantages of CesiumAstro's fully steerable phased arrays include:

- *Capability to shape Earth coverage areas through phase and amplitude control for each beam at each radiating element. This allows for dynamic optimization of gain pattern for each beam.*

- *Ability to re-allocate available RF output power among beams. This allows for increase of power in high-demand footprints or in applications that have higher priority.*

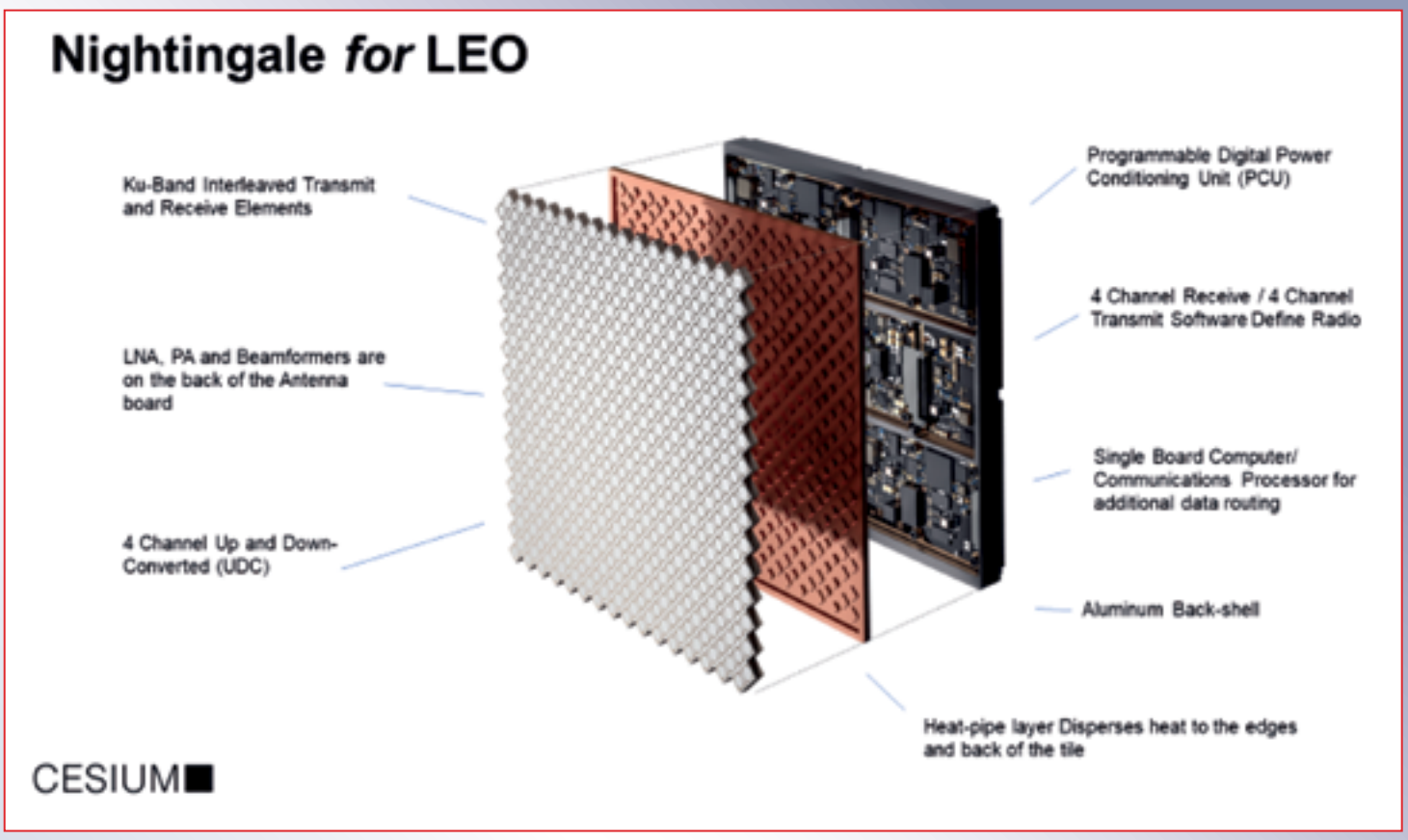


Figure 3. Nightingale system illustration, exploded view.

- *Distribution of solid-state power amplifiers (SSPA) and now low noise amplifiers (LNAs) over hundreds of elements. This leads to higher reliability, as the failure of individual amplifiers has minimal effect on overall array performance.*

The distinguishing features of Cesium's Nightingale active phased array system include:

- *Multiple transmit and receive beams from the same aperture. This reduces the overall aperture size for a given number of beams. Carrier frequency of each beam can be set independently.*

- *Interleaved transmit and receive antenna elements. This allows reduction in either number of components (when using TDD) or aperture size (when using FDD).*

- *A "reliable-COTS" part-selection approach, combining automotive-grade parts with design-for-reliability. This results in a flight-reliable system with state-of-the-art components at below-space-grade cost.*

- *Fully modular architecture. The antenna elements and RF electronics are designed in 'tiles,' while the processors and power control units are line-replaceable modules. This approach leads to a scalable system and lower generation-to-generation development cost.*

Nightingale also offers an order-of-magnitude lower market cost. Because CesiumAstro has designed Nightingale as a modular system, they can provide customers an end-to-end solution in months, not years. As they are platform-agnostic, Cesium products are also easily adapted to multiple aerospace applications.

Another element of Cesium's paradigm shift is their provision of a complete plug-and-play system directly to system designers, replacing a major R&D effort with a single product that works directly out of the box — eliminating the need for customers to employ dedicated staff to develop their own communications systems.

How Does Nightingale Work?

Customers tell CesiumAstro what kind of mission they have in mind, what frequency of operation they prefer and what features they need in their telecommunication systems — and Cesium addresses their needs from those starting points.

The company designs the end-to-end systems,starting from the link budget, to hardware and software directly down to the last digital and power connection needed for a customer's system.

Over the past 18 months, Cesium has been working with **NASA Ames**, the **Defense Advanced Research Projects Agency** (*DARPA*), the **Missile Defense Agency** (*MDA*) and **U.S. Navy** on customized communications systems.

In March, the company closed a $12.4 million investment, led by **Airbus Ventures**, and with **Kleiner Perkins**, **Franklin Venture Partners**, **Lavrock Ventures**, **Honeywell Ventures**, and **Analog Devices Ventures**. These investments provide the means to scale the team and expand the development of a wide range of frequency offerings and system configurations to meet the growing demand for affordable, high-throughput aerospace plug-and-play communications systems.

Figure 4: Cesium's LEGO-like architecture serves a broad and expanding market both in commercial and DoD.

Governments and global space agencies have issued a call to commercial companies to partner on major systems. They recognize that commercial companies and especially entrepreneurs such as CesiumAstro's team are delivering innovative technologies and new business models — and that the COTS approach lowers cost and risk, yet increases the speed to complete a mission.

www.cesiumastro.com

Shey Sabripour founded CesiumAstro in January 2017 and serves as CEO. He has nearly three decades of leadership success in design, development and execution of LEO and GEO telecommunication satellites, launch vehicles, and other interplanetary space vehicles.

During his 24 years of continuous career service with Lockheed Martin Space Systems, Shey led work as a design engineer, technology innovator, program manager and ultimately, the Director of Spacecraft Design responsible for an organization of 370 engineers, scientists, and business professionals in missions ranging from $100 million to $1 billion.

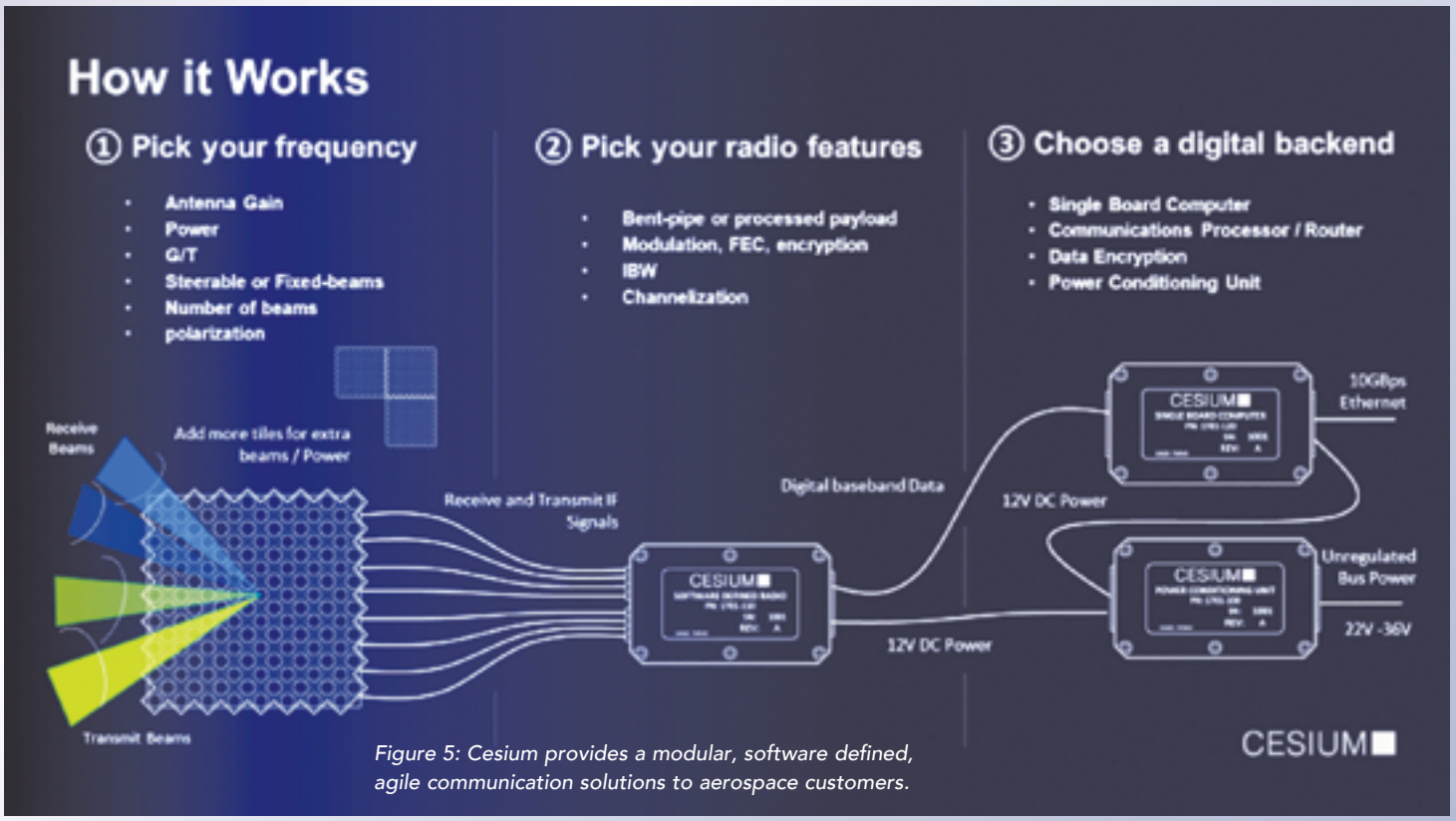


Figure 5: Cesium provides a modular, software defined, agile communication solutions to aerospace customers.

A Breakthrough Development...

LTE connects to satellite

By Guillaume Vivier and David Choukroun, Sequans

While the number of connected objects and mobile phones on Earth is now greater than the number of human beings, there are still some areas where there are no mobile networks available.

These are remote regions of the world where the density of human population is so low that mobile operators cannot economically install infrastructure, or areas where the environment is so inhospitable that it is nearly impossible to deploy infrastructure — areas such as open oceans, mountains or remote desert regions. To provide coverage and connectivity to these regions, satellite communication is the only technically and economically viable solution.

As a result, there has been a continuing desire to connect mobile terrestrial networks with satellite networks, even though developing these solutions has presented difficult business models and unique challenges.

Much progress has been made since 2G adaptations were made, but the solutions developed so far have relied on proprietary systems, networks and devices, and have not been able to benefit from mass market economies of scale. Moreover, end user subscription rates for these proprietary solutions have been expensive and user experiences unusual.

In response to this, a trend has developed based on adapting existing terrestrial networks and systems to support satellite-based communications. These efforts have focused on integrating satellite communication protocols directly into terrestrial systems in order to define a complete, end-to-end solution comprising chipsets, networks and user equipment.

Standardization for this satellite and LTE integration initiative is continuing on its own path and, despite a strong push from the satellite community, these standards have not yet been finalized, mostly because mobile operator interests have been prioritized first.

In the meantime, satellite companies and LTE chipmakers have been developing their own solutions through collaboration and partnership. In one such partnership, aerospace leader **Lockheed Martin** and LTE chipmaker **Sequans** Communications have developed an LTE to satellite solution, leveraging Lockheed Martin's expertise in satellite systems and Sequans' expertise in LTE chip technology.

The two companies have developed a solution that enables LTE end user devices to connect directly to geostationary satellites in a world-first achievement that has many applications.

This exciting development has the potential to create new opportunities for device connectivity in several markets where ubiquitous coverage is of paramount importance.

One of these is in the M2M and IoT market, where **Northern Sky Research** predicts there will be 5.8 million M2M and IoT devices connected via satellite over the next couple of years.

In order to enable LTE devices to communicate with satellite networks, several technical adaptations were made to existing LTE technology that leverage the optimized design of LTE while enabling easy roaming between terrestrial and satellite communications networks.

The following technology adaptations are all compatible with existing chipsets as designed for terrestrial 4G LTE and existing core and radio network equipment, though requiring significant engineering work.

Adaptation to Long Delay

Satellites are far higher in elevation than terrestrial base stations — the time it takes to send a signal from Earth to a satellite and return (*RTT*, or **round-trip time**) is much longer, requiring all closed loop procedures as defined in LTE to be modified.

These procedures include the initial **random-access procedure** (*RACH*) as well as the **hybrid automatic repeat request** (*HARQ*) process, combined with link adaptation.

RTT also impacts the end-to-end protocols in which timers are set to ensure proper operation. Software adaptations are therefore required for lower layer protocols as well as for higher layer protocols at the device side, while still allowing operation to continue as usual in the terrestrial core network, which is left mostly unaffected.

Adaptation to Link Budget

Satellites are much farther apart than terrestrial base stations — an adaptation of the power control procedure as well as the definition of a new power class for devices is required.

This involves the need for higher than the usual 3GPP transmit power of 23 dBm as well as the need to replace link adaptation procedures by setting different values for ***MCS*** (**modulation and coding scheme**) and possibly shift the operating point of the terrestrial system's 10 percent packet error rate to a more conservative value that is better adapted to satellite system requirements.

The operating point of a terrestrial deployment is quite different from that of a satellite deployment and much re-design is required to secure the best throughput for each of the planned services.

Adaptation to Cell Topology

GEO satellite systems cover the Earth with multiple beams creating cells that are usually much larger than a terrestrial cell. As a result, procedures to detect cells, to handover from one cell to another, and set timing advances were adapted to address the satellite network's completely different cell topology.

Adaptation to Satellite Wireless Channel

Devices on Earth are communicating directly to satellites in both GEO and LEO satellite systems.

The satellite channel model is quite different from a terrestrial network channel model that can benefit from a multi-path environment. It may appear to be straightforward when the satellite is in line-of-sight, but when the satellite is moving fast above the device, a Doppler tracking mechanism is required and location-based services can possibly assist the devices in various operations.

Adaptation to Narrow Channels and Specific Frequency Bands.

4G LTE is a wide-band system, using carrier channels up to 20 MHz wide for high throughput, and aggregating several carriers to increase the throughput even more.

In the spectrum channels historically allocated to satellite communication systems, available bandwidth is usually narrower and operating frequencies are often unique to the satellite system. As a result, specific adaptations to the RF subsystem (RF transceiver and front-end) must be made to accommodate these narrower channels.

In some cases, dedicated development is necessary to adapt the 4G LTE system to narrower bandwidths, even though LTE was defined to support bandwidths as narrow as 1.4 MHz. Antenna design may also need optimizing to overcome the ground-to-satellite link challenges.

The beauty of these LTE for satellite advancements is that they open the door to universal communication systems, encompassing both terrestrial and satellite networks, while using components that are already in use and deployed worldwide in commercial terrestrial LTE networks.

This technology can positively impact virtually any application or use case where ubiquitous network coverage is required.

Applications include the tracking of assets in worldwide shipping, connected cars, transportation, navigation, energy, and the list goes on.

www.sequans.com

Twenty Years of #SpaceGen

Promoting the peaceful uses of outer space

Twenty years ago, as an outcome of the UNISPACE III event, the *Third United Nations Conference on the Exploration and Peaceful uses of Outer Space* in Vienna, Austria, was in session from July 19 to 30, 1999.

The attending States drafted the declaration T*he Space Millennium: Vienna Declaration on Space and Human Development*, where it was stated the need...

> "*[t]o create, within the framework of the Committee on the Peaceful Uses of Outer Space, a consultative mechanism to facilitate the continued participation of young people from all over the world, especially young people from developing countries and young women, in cooperative space-related activities*"

as a way to

> "*enhanc[e] education and training opportunities and ensur[e] public awareness of the importance of space activities.*"

With these statements, the Vienna Declaration was laying the foundations of the **Space Generation Advisory Council** (***SGAC***).

SGAC is now an international organization with a network of volunteers and alumni that has grown to more than 15,000 members representing over 150 countries.

Throughout 2018 alone, the Space Generation Advisory Council in Support of the United Nations Program on Space Applications has assigned more than 140 Scholarships and Awards, held 37 events in 27 countries, formalized 24 new partnerships, and has accounted for more than 30 papers, publications and presentations.

Acknowledged by the **U.S. National Space Council User Advisory Group**, SGAC is celebrating its 20th anniversary in 2019, having become a well-established, global, non-governmental, non-profit (US 501(c)3) organization and network.

Headquartered in Vienna, Austria, SGAC works to represent university students and young space professionals, aged 18 to 35, to the United Nations, space agencies, industry, and academia.

With the vision to employ the creativity and vigor of youth in advancing humanity through the peaceful uses of outer space, SGAC bases its activities on five pillars:

> The organization of global, regional and local events, with global events as the **Space Generation Congress** (currently planning its 18th edition, held in conjunction with the **International Astronautical Congress**), **Space Generation Fusion Forum** (2019 marks the event's 8th edition and accompanies the recently

Participants at the Space Generation Congress 2018 in Bremen, Germany. Photo is courtesy of SGAC.

SGAC booth at the UNISPACE+50 at the United Nations HQ in Vienna, Austria.

held **Space Symposium**) and **SGx** (organized alongside the SATELLITE 2019 event and celebrating its 4th edition this year).

The execution of projects and activities by various SGAC Project Groups (PG) has recently increased to ten, namely:

- *Commercial Space*
- *Near-Earth Objects*
- *Space Exploration*
- *Space Law & Policy*
- *Space Safety and Sustainability*
- *Small Satellite*
- *Space Medicine and Life Sciences*
- *Space and Cyber-Security*
- *Space Ethics and Human Rights*
- *Space Technologies for Earth Development.*

The conception, implementation and conferment of scholarships and awards, often via partnerships and sponsorships, aim to empower its members to attend SGAC and non-SGAC events worldwide, and to grow as the next leaders of the space community.

Furthermore, the organization provides various opportunities for members to develop leadership and skills. SGAC members are able to actively share, grow, and apply their expertise to the organization's activities and for its goals. This is a volunteer-run organization, with executive team members addressing everything from Treasury to Strategic Partnerships, Human Resources and Data Management.

Lastly, the engagement and representation of the SpaceGen within the United Nations is an integral component to the organization's activities. In particular, this is conducted within the **UN Committee on the Peaceful Uses of Outer Space** (*UN COPUOS*), in which SGAC holds the status of *Permanent Observer*, the **UN Office for Outer Space Affairs** (*UN OOSA*) (with which SGAC has recently signed a MoU), and with the **UN Economic and Social Council**, in which SGAC holds a consultative status.

During the last 20 years, SGAC's work has been made possible thanks to the contributions of its many volunteers and more than 100 sponsors and partners worldwide. These have ranged from National Space Agencies to multi-national corporation and international advocacy groups. Furthermore, SGAC events, in addition to providing a source of income for the organization, also actively push local and regional teams to develop event formats to sustain regional SGAC chapters.

One initiative of which SGAC is proud of is the **Space for Youth** competition, organized together with the UN OOSA, as part of the MoU signed in February 2019. Asking young people around the world to identify how Space can contribute to one or more Sustainable Development Goals, Space for Youth is currently undergoing its final phase and will allow the best ideas to be circulated and presented during the 62nd session of the UN COPUOS, this June. By giving a voice to the youth, with a relevant presence of participants from developing countries, and enabling their opinions to reach international decision-makers of the space sector, this competition is a significant example of what SGAC can accomplish.

SGAC is always on the lookout for talented members to join the **#SpaceGen** community!

Find out more about current vacancies, scholarships and opportunities—visit ***spacegeneration.org***.

Additionally, learn about sponsorship and partnership opportunities at ***spacegeneration.org/about/sponsor-us***.

info@spacegeneration.org

SGAC is a global non-governmental, non-profit global non-governmental, non-profit (US 501(c)3) organisation and network which aims to represent university students and young space professionals to the United Nations, space agencies, industry, and academia.

Commercial Space Technologies & Applications

A Book-Look

Commercial Space Technologies and Applications was written by Dr. *Mohammad Razani*, the Professor and Chair of the Electrical and Telecommunications Engineering Technology Department at the New York City College of Technology, City University of New York.

The book has recently been updated and now adds questions and problems at the close of each chapter to make this a suitable textbook for classroom environments. The book also covers satellite debuts as well as new and emerging technologies.

Scientists and engineers are working tirelessly to provide a better quality of satellite services, to deliver higher resolution satellite imagery as well as to lower the cost of satellite services so that even the remotest areas on Earth can gain access to, and benefit from, satellite services.

Space technology is the technology that aims to conquer the new frontiers of space. The focus of this updated book are the satellites that are entering a new era of becoming smaller, smarter, less expensive, easier to launch, all the while providing a better quality of service, one that is less susceptible to interference, by employing sophisticated new technologies.

With the rapid pace of advances in electronics, semiconductors, modulation, access, and multiplexing techniques; better performing amplifiers; antenna; rocket fuel; launchers; and so many other technologies affecting the satellite industry, five years is a lengthy period of time to update new technologies. During this term, advanced research activities have occurred in space technologies and related fields.

Space technologies have progressed at a rapid and astonishing pace and have affected everyone's lives with the day-to-day functions, whether at home, at work or when traveling.

Seemingly, everyone has experienced some form of radio signal degradation in their cars or when mobile and transmitter range to a user's device increase. With digital satellite radio broadcasting, such worries have decreased; one can listen to his or her favorite channel while traveling across continents and obtaining CD quality signal.

Every year, millions are switching to satellite TV with hundreds of channel capabilities available for viewing. Remote and isolated areas in developing as well as developed countries can now watch the same TV channels that people who reside in metropolitan areas watch and enjoy. They can access e-learning, telemedicine, GPS, and numerous other services that seemed impossible only a few, short years ago. Through space technologies, one can penetrate deep into the Earth, the oceans or dense jungles to extract information from the data captured by satellites that are thousands of miles away on-orbit in space.

Floods can be predicted and even prevented by forecasting the amount of water resulting from snow melts, months before that even happens — the quality and harvesting of crops can be improved through the ability to estimate soil moisture contents from space, even when the crops are roofed by vegetation.

Oil spills can be estimated and controlled by real-time image collection and onboard processing by using Earth observation satellites. Having worked under National Aeronautics and Space Administration (*NASA*) contracts for many years in these areas, and having taught and carried out research projects in space related technologies, the author has a good understanding of how space and its technologies can benefit societies through a systematic and well planned set of policy-making decisions.

In this book, space and its applications are discussed and the role of satellites in communications, Earth resource utilization, weather forecasting, and other areas are explained (*see Figure* 1).

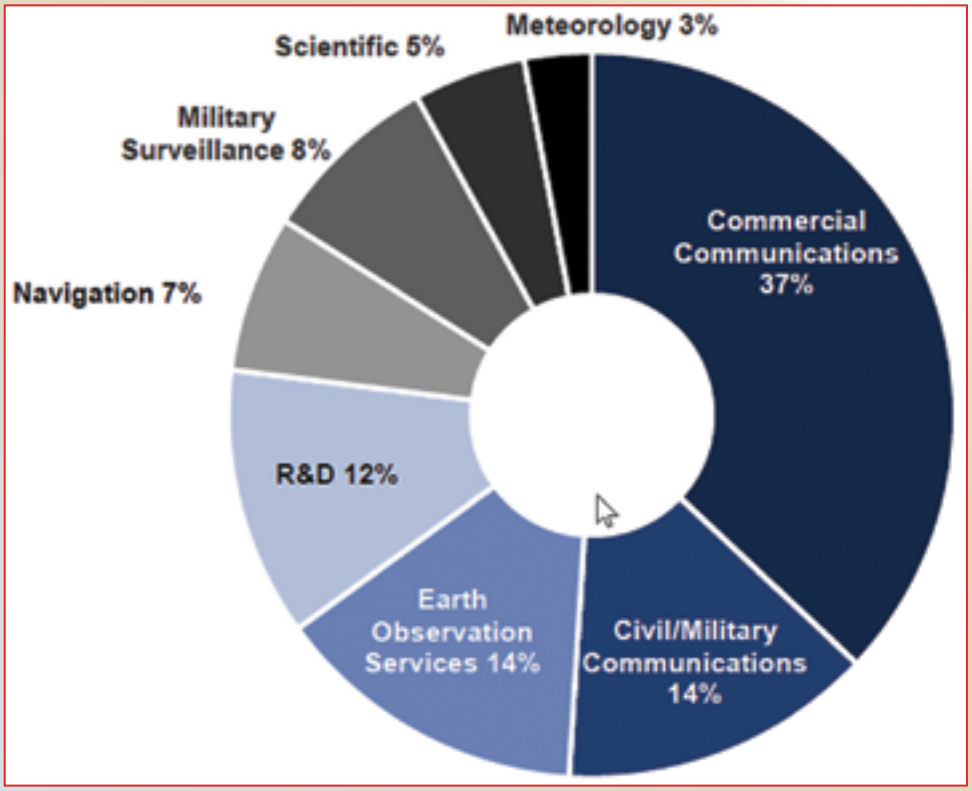


Figure 1. Operational satellites by function, 2015. Source: Satellite Industry Association, 2016

Commercial space technologies and applications have always fascinated the author, so much so that most of his time during the last four decades has involved working on the different aspects of space technology. How space was explored by humans, how it has expanded the understanding of the universe, and how lives have been — and will be — impacted in so many different ways are all tackled in this book.

The author provides a better understanding of the history of space, space exploration and space-related activities while explaining its various applications within three major categories: *application satellites*, *scientific satellites*, and *communication satellites*.

This revised book introduces what is on the horizon that the next generation could benefit from... the technologies that are dreams today that could come to fruition, thanks to satellite technologies.

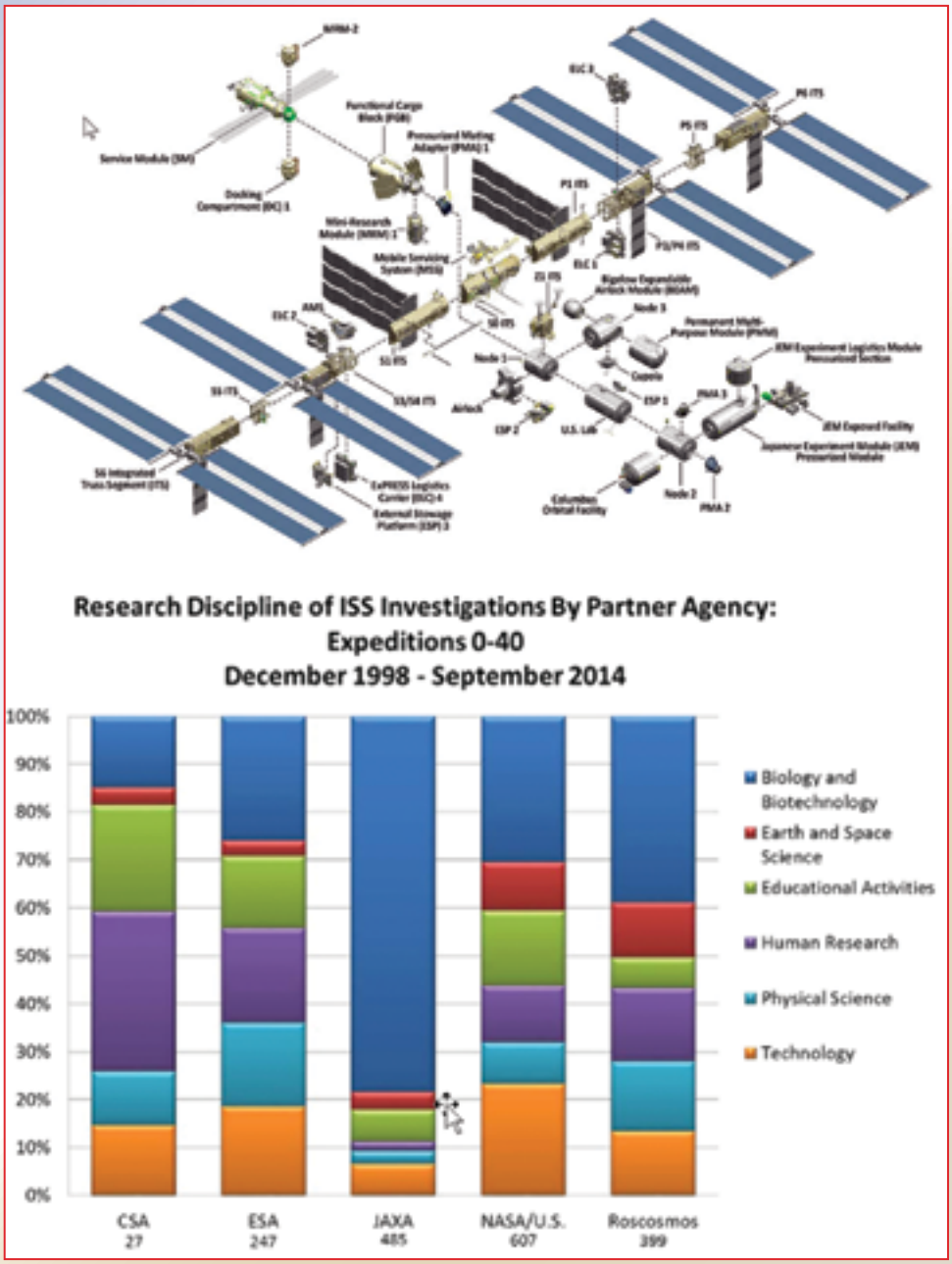
Distributing energy across the globe through the use of satellites that collect solar energy and then transmit that energy via microwave beams to different locations on Earth that are energy-poor, or launching spacecraft into space without

rockets, are among some of the innovative ideas that are introduced in this book to readers.

This book is intended for college students, undergraduates and graduate students, professionals in space-related industries, engineers and technologists in telecommunication organizations, educators at various levels of lower and higher educational institutions, and anyone who is eager and interested in space science and technologies and its applications.

Also introduced are the space technologies that are benefiting humans' everyday lives. As explained in detail, space provides a unique environment to carry out scientific research that otherwise would be impossible to complete on Earth. The results of such scientific research are monumental and the effects can impact everyone's life. Within the research laboratory facilities at the International Space Station, for example, scientists and engineers have been carrying out research in microgravity environments during the last 16 years to improve the quality and longevity of life on Earth. The fields of medicine, pharmaceuticals, metallurgy, physics, engineering, biology, and many others are benefiting from such unique research activities (*see Figure 2 and Figure 3*). Throughout this book, the unique characteristics resident with the International Space Station (*ISS*) have been addressed.

- *230 individuals from 18 countries have visited the ISS*
- *An international crew of six people live and work while traveling at a speed of five miles per second, orbiting Earth about every 90 minutes.*
- *The space station is 357 feet end-to-end, one yard shy of the full length of an American football field, including the end zones.*
- *A spacecraft can arrive at the space station as soon as six hours after launch from Earth.*
- *Four different cargo spacecraft deliver science, cargo and supplies: Orbital ATK's Cygnus, SpaceX's Dragon, JAXA's HTV, and the Russian Progress.*
- *Through Expedition 52, the microgravity laboratory has hosted more than 2,400 research investigations from researchers in more than 103 countries.*



Top image: Figure 2, ISS. Bottom image: Figure 3.

Humans are curious and are always seek new frontiers to expand their horizon that can someday be explored. This book addresses the motives for outer space activities that are purely scientific and will provide a better understanding of the universe, enabling the reader to appreciate the blessings here on Earth.

Readers will be made aware of the fact that it is humankind's responsibility to preserve the uniqueness of Earth for future generations by searching for new, clean energy sources and technologies and to ensure better use of the already available resources within the planet. Satellites are being used to provide information regarding global warming, a major area of concern to the global community (*see Figure 4 on the following page*).

Additional areas of interest that are addressed by the author include how the global community can create an outer space environment that is safe and secure for this generation and for the generations to come. This is already partially underway and, for the past 50 years, is being addressed by the United Nation's Committee on the Peaceful Uses of Outer Space (*COPUOS*).

Space is a natural resource that should be shared and used to benefit mankind and be free of any other use that would result in harm. Most of the fundamentals of international space law have been created by the Legal Sub-Committee of COPUOS. The fundamentals include:

- *No nation can make territorial claims to outer space and celestial bodies within it*
- *Nations have free access to space*
- *All nations are free to conduct scientific investigation in space*
- *National rights to space objects launched by nations are preserved*
- *Nations will cooperate in rendering assistance to crews of spaceships in emergencies.*

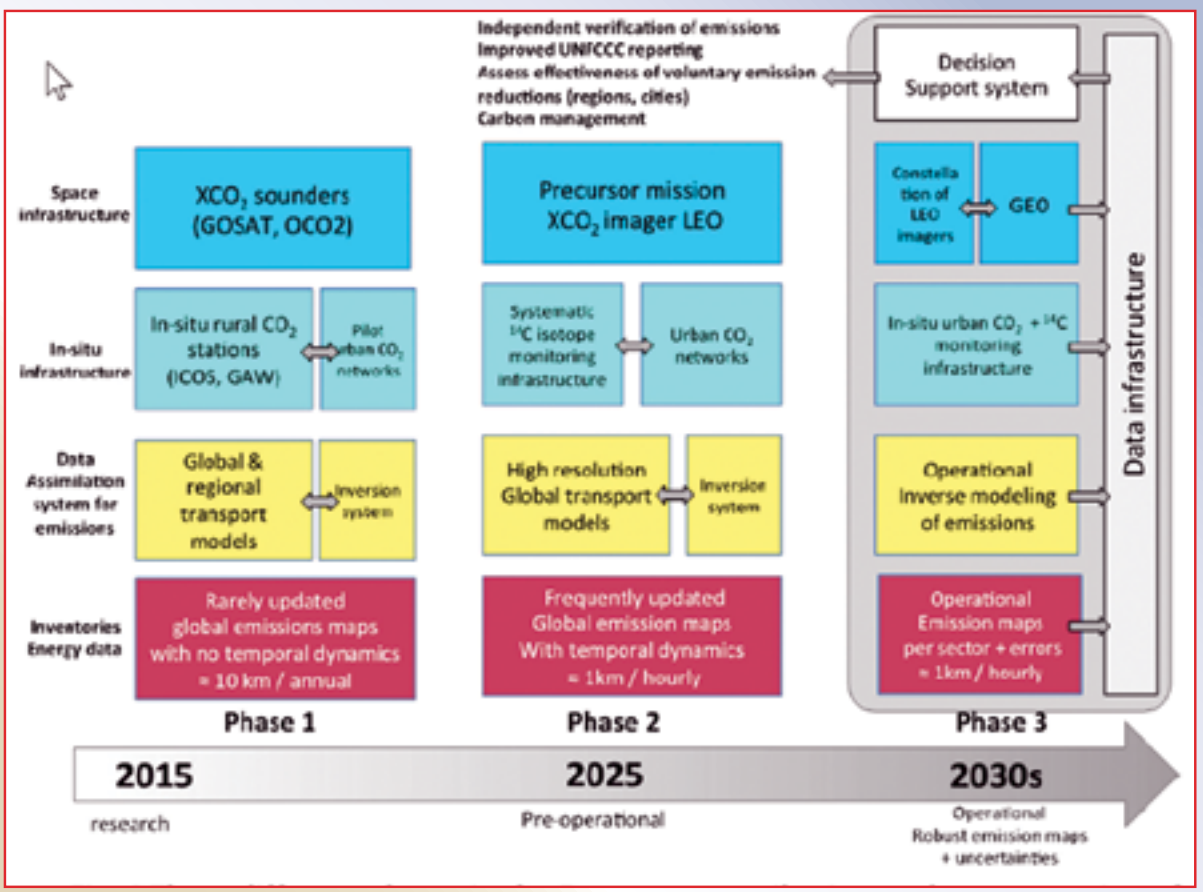


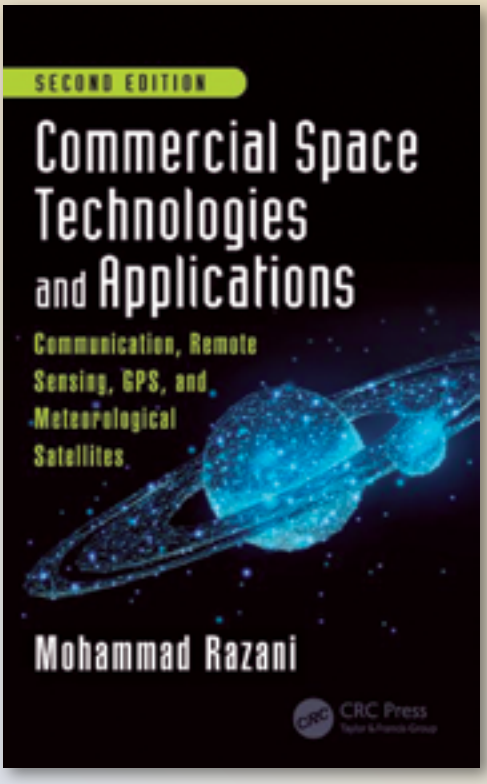
Figure 4. Three different phases in the European contribution to the construction of an operational observation system for monitoring fossil CO2 emissions.

More than 50 States and two international organizations have registered over 91 percent of all satellites, probes, landers, crewed spacecraft and space station flight elements launched since 1957. Currently, of the approximately 4,600 satellites in Earth orbit, nearly 2,000 are operational.

Challenges ahead for the use of outer space could be summarized as follows...

- *International agreement on a Code of Conduct for activities in space*
- *Space sustainability*
- *Space traffic management*
- *Space security*

As the book indicates, threats to space could be: intentional (the weaponization of space, as demonstrated by the proliferation of Anti-Satellite (ASAT) weapons; the use of conventional, kinetic energy and laser weapons; jamming and cyber threats; and unintentional, such as space debris, the risk of collisions and frequency interference.



Mohammad Razani has extensive experience in various fields of technologies that span Satellite Communications to Microwave Remote Sensing and Information Technology. Having received BS-EE and MS-EE from Kansas State University and a Ph.D. in electrical engineering from the University of Kansas, Dr. Razani has participated in NASA-funded research at the Space Research Center of the University of Kansas for many years and has applied his education and research experiences to numerous programs within various, related technologies during the last four decades.

This includes years of teaching and research positions in New York City College of Technology of the City University of New York, where he is now a full professor and chairman of the Electrical and Telecommunications Engineering Technology Department, a position he has held since 2007.

Dr. Razani has worked closely with the International Telecommunication Union, a specialized agency to the United Nations, and has participated for more than a decade as chairman and vice chairman of several CCIR and CCITT Study Groups.

Dr. Razani has published numerous papers in top peer-reviewed journals, presented at several domestic, regional, and international conferences, and has written several books, including Fundamentals of Satellite Communications in 1991, Information, Communication and Space Technology in 2012 by CRC Press (www.crcpress.com/product/isbn/9781439841631) and, most recently, Commercial Space Technologies and Applications in August 2018 by CRC Press (www.crcpress.com/Commercial-Space-Technologies-and-Applications-Communication-Remote-Sensing/Razani/p/book/9781138097858)

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The SIG Workshop @ Airbus

A personal view...

By Martin Coleman, Executive Director, Satcom Innovation Group (SIG)

At the close of March this year, the *Satcom Innovation Group* (SIG) headed to *Airbus Defence and Space* in Portsmouth, UK, for two days of presentations and discussions at our SIG Workshop.

This was a great location for our first workshop, especially as the name change from *Satellite Interference Reduction Group* to ***Satcoms Innovation Group*** has been made and this workshop promised to feature varied discussions.

Interference remained prominent, something that I made extremely clear at the outset. No other group is tackling interference and it remains a critical part of SIG's mission, along with other crucial issues being faced by our members. We started by discussing how the satellite environment is changing and the impact that SIG will have on the industry.

Changing Satellite Environment

The workshop kicked off with an excellent reminder from *Andrew Bond* of **ETL Systems** that teleport operators need to ensure RF performance and reliability that is second to none. He made the point that in certain countries you cannot get a broadcasting license without 98+ percent reliability. Achieving that means ensuring the correct products are in place throughout the RF chain and it also means ensuring redundancy.

ETL uses live hot swap to enable customers to grow the number of antennas that can be handled in a teleport as well as ensure they are able to change feed between systems. Andrew also reminded us that the biggest innovation currently making headway will be focusing on HTS, LEO, and MEO, though he did highlight that he is still not certain how and when LEO will work, as it is yet to be proven viable.

What is clear that site diversity, redundancy and resiliency are ,and will continue to be, key for all of those applications. He concluded by saying that teleport operators need a calm MCR so they can sleep at night knowing all is under control.

Bob Potter from **Kratos** spoke next, taking us into a number of items we need to think about right now in the satellite industry:

1. *Congested / contested space*
2. *New satellite architectures*
3. *Cloud computing*
4. *Software defined (radio access) networking*

With OneWeb due to launch 720+ satellites, Telesat launching 117 and SpaceX a whopping 4,425 satellites, it is clear LEO space is about to get extremely congested, raising a number of challenges.

He highlighted that, with these new constellations, we will need new access techniques and this will directly affect what happens in the ground segment. Kratos has been doing a lot of work around virtualizing the ground stations.

If you turn RF signals into a digital format, you can send data to the cloud and apply software modems and ultimately handle more data — and that means you can do more. However, it is still less expensive to buy physical hardware and satellite operators will continue to do just that;

The SIG Workshop at Airbus participants.

SIG Executive Director Martin Colman engaging in a presentation discussion during the workshop.

however, as the cloud becomes more economical, there will likely be a big move toward virtualized ground stations.

Roger Boddy of **Global Teleports**, addressing the use of space, presented a summary of the evolution of satellite communications. He highlighted the protection historically afforded by Radio Regulations to satellites in Geostationary Orbit (*GSO*) from interference by those in Non-Geostationary Orbit (*NGSO*).

He questioned whether the number of satellites scheduled for launch into NGSO during the next five years indicated a need for change in radio regulations to afford equal protection to NGSO as well as GSO spacecraft. He pointed out the increased risk of eclipse of GSO satellites by those in NGSO and that this has the potential to create another source of interference caused by diffraction.

SES' *Lance Hayward* talked about the changing satellite environment and focused on the customer landscape. Broadcast has always been a big revenue driver for satellite operators, but as Lance highlighted, the move toward Over-The-Top (*OTT*) video is disrupting the satellite ecosystem. However, consumers don't particularly care how they obtain content — just that they get it. Satellite has the potential to handle this new type of video consumption as well as emerging services such as Internet of Things (*IoT*) and satellite operators need to transform from being capacity providers to service providers.

Francis Kinsella of **Airbus** shed some light on just how Airbus and OneWeb will scale production so that the company can design, manufacture and test 900 satellites. This requires the complete reinvention of the way in which satellites are created, similar to when Ford first mass produced cars with the Model-T. Unlike cars, however, it simply is not, nor will be, a simple or feasible task to recall satellites if a problem occurred with the spacecraft — careful planning and management must be applied to mitigate such risks as much as is possible.

Kinsella encouraged the industry to become more aware and proactive with Space Situational Awareness (*SSA*). This should take the form of Spatio spectral models, big data sets and Artificial Intelligence (AI). SIG member **Safran** is already working on this issue, as was highlighted by *Thierry Balanche*.

Intelligent Use of Data

The discussion then turned to data and how we can gather and use data. *Valentin Eder* of **Space Analyses** talked about how they are applying business intelligence to technical data from VSAT systems to optimize the use of assets in SATCOM. This process can be used to inform a satellite operator how well stations have been installed, any signal problems in the complete system chain or the presence of weather-related incidents.

Alessandro Cacioni of **Inmarsat** talked about the **Space Data Association** and how that organization is providing operational data with good success. However, with a congested space, the data needs to become even more useful. He likened it to driving along the M25 highway wearing a blindfold. He pointed out that on the M25, if there is an accident, the traffic stops and the road is closed. In space, that doesn't occur — we just keep driving blindfolded. If there is a collision at GEO, the whole belt will be affected within a matter of 24 hours.

A discussion of data cannot ignore AI and there was some in-depth discussion around this technology, how it should be defined and what it could bring to the satellite industry, as well as the value versus cost challenge.

The ETL Systems presentation during the workshop.

Andreas Voigt, **SIG** Director, talked about the need to understand maths in order to leverage AI effectively. He also said that we need large amounts of high-quality data to make decisions but it will always be a digital helper, with the NOC operative having the final word on any decisions that arise from that data. This view was echoed by *Prashant Pillai* of the **University of Wolverhampton** who commented that AI will not replace people in the near future.

Andreas commented that subject-matter experts who understand AI and can process the data are lacking in number. *Miguel Angel Vazquez* of the CTTC research center responded to that comment and presented a project which was testing the use of AI on several different SATCOM use cases, including interference detection, and was producing highly encouraging results.

How should the industry move forward? Would satellite operators be comfortable providing data to a third party, such as CTTC, in order to deliver a way to predict patterns before issues arise?

Cybersecurity

Prashant Pillai discussed how AI can help with cybersecurity. As there is really no systems that is secure, he urged us to consider how to build and monitor cyber resilient systems if they are under an attack and how to gracefully recover from such an interruption. He also posed a thought about how to recover from a cyber attack on a satellite as the spacecraft can't simply be retrieved.

Kinsella pointed to the fact that most modern VSAT terminals have, for the most part, auto point technology so that soldiers without extensive satellite training can use antennas. That does mean the VSAT knows where it is positioned, so if a hacker can get into the system, they will have that location information. This poses a new challenge of keeping VSATs secure.

Type Approvals

A known fact is that many errors occur due to equipment design errors and failure and the antenna is at the top of that list. Therefore, we need type approvals and a commitment from satellite operators to require only type approved antennas and associated equipment to be used on their satellites. **SOMAP,** which was established by a group of satellite operators, is doing to do just that.

One technology that has the potential to revolutionize the process of type approvals comes from a Danish start-up, **QuadSAT**. *Joakim Espeland*, the company's Co-Founder, explained that currently a ship needs to be taken out of port on a specific trip to test the satellite antenna.

That is time-consuming and costly for the ship operator. That scenario also applies to the aircraft industry to. QuadSAT decided that, instead of moving the ship around the satellite, how about moving the satellite around the ship. Using an autonomous unmanned aircraft with RF payload, the company is able to perform tests on the antenna while the ship continues on its normal route. This technology is also cloud-based and can be controlled from any location.

Joakim did point out several considerations and attendant concerns for using drones, including the regulations that vary from country to country. In some areas, there is a maximum altitude of 120 meters, which creates a challenge for testing high frequency, large antennas.

Regardless, it is obvious and, especially from the discussion in the room, that this technology has some real potential. *Joakim* ended by saying that QuadSAT has ambitions to become industry compliant and the firm is keen to work with the test entities and satellite operators to verify this new and innovative solution.

Sharing Spectrum

Spectrum sharing is another important topic currently and one that we will address during a session at NAB. This is, naturally, a really challenging topic and one with some differing viewpoints.

BBC World Service's *Cath Westcott* explained the impact the loss of C-band satellite spectrum would have on the BBC's international distribution. She commented that if there are technologies that can enable effective spectrum sharing, that would be really important to facilitate.

Education

We ended the workshop discussing education and how we engage with the satellite engineers of the future. *Roger Boddy* talked about a group he runs, **EMSTA**, which runs an annual seminar for young people that is focused on a variety of technical topics.

How do we engage the younger generation and get them inspired about a career in satellite? This may be about going into schools, but maybe also about inviting schools to come to events and hear what is involved from the people who are working in this industry. To get involved in an initiative along these lines, I'd urge you to get in touch with us.

The event ended with a tour of the Airbus facilities where the processes involved in building satellites and related satellite products was seen and captivated the entire audience.

satig.space

Martin Coleman is Executive Director, the Satcoms Innovation Group (SIG), which is dedicated to promoting innovation in the satellite industry. Since taking on the position in 2011, Martin has been active in spearheading several significant initiatives, leading the advance in new tools to resolve all types of VSAT interference using SatGuard and the campaign to introduce Carrier ID across all SCPC/MCPC transmissions and subsequent ongoing activities.

Martin regularly addresses the industry on the challenges faced by the satellite industry and the innovative approaches needed to resolve them.

Martin's own company, Colem, which is now a part of Crystal, is a services, design and project management consultancy developing Network Management Systems (NMS) and automation control (NMS+) for the satellite and video distribution industry.

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Satellite Delivers Benefits for IoT

Essential connectivity...

By Graham Avis, Vice President, Hughes Network Systems

Research firm Gartner predicts that the Internet of Things (IoT) could connect as many as 26 billion devices by 2020.

Yet, by other measures, that staggering figure is conservative. No matter how you quantify it, the IoT era is upon us.

It's worth remembering, as IoT expert Edewede Oriwoh states, "*The Internet of Things is not a concept; it is a network, the true technology-enabled network of all networks.*"

Like any network — be it for enterprise, military or consumer use — these connected "things" must have the reach, resiliency and capacity to be ubiquitous, dependable and adaptable.

This is where satellite technology will play an important role in supporting the IoT and realizing the full potential of this increasingly connected experiences.

Ubiquitous Networking

Satellite already provides essential IoT-type connectivity in places where other transport technologies don't reach.

For example, more than two hundred sites in the Yukon use Hughes terminals and satellite connectivity to track and transmit seismic and weather data in near real-time. To achieve global scale, satellite provides IoT with the reach and coverage it needs to operate as the network of all networks.

Dependable Transport

As the world becomes more reliant on constantly connected devices, the necessity of "always-on" connectivity will rise. Natural disasters that knock out terrestrial telecom can also bring down exposed wireline IoT connections.

However, resilience is a hallmark of satellite. In the wake of natural disasters, many utilities require that satellite be part of the connectivity mix for utility network reliability. In the case of the IoT, satellite can power critical, always-on connectivity — even when other networks fail.

Adaptable Capacity

Today, many IoT applications use **MSS** (***Mobile Satellite Services***) or "*narrowband*" connectivity for reliable, wide-range, low-power transport in addition to cellular networks. For example, Hughes enables smart meter monitoring of energy consumption throughout California via MSS.

What's more, Hughes created the **GMR-1** (***GEO Mobile Radio interface***) standard for IoT which makes it possible for MSS services to use GEO connectivity.

This flexibility in transport type diversifies the network for IoT applications that require more bandwidth — whether due to application activity, like continuous monitoring, or coverage that extends beyond narrowband, wireline and mobile network capacity.

Ecosystem Cooperation

While conversation percolates around IoT, **Artificial Intelligence** (***AI***), **Machine-to-Machine** (***M2M***), 5G and more, it's important to remember that one stalwart of the communications landscape has the combination of reach, resiliency and capacity to augment the IoT — satellite.

The **EMEA Satellite Operators Association** said it best, "*No single communications technology can reach all the possible markets and users, and be able to handle the flood of connections required and mounds of data that will be transmitted and received for future IoT applications.*"

Hughes satellite networks and technologies enable high availability, multi-transport connectivity, and supports millions of connected devices and the networks that deliver their data.

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A Conversation With...

Laura Salcedo, Junior Legal Counsel, Hiber

Laura Salcedo is a junior legal counsel at Hiber, an Internet of Things (IoT) satellite communications provider. She graduated in law in Colombia where she also worked for the telecommunications sector dealing mainly with regulatory matters and supporting administrative claims. In 2017, she moved to the Netherlands to pursue her Master studies in Air & Space Law at Leiden University. Since joining Hiber in May of 2018, she has been responsible for regulatory issues regarding foreign market access and licensing.

Laura, please introduce yourself.

Laura Salcedo (LS)

I am a junior legal counsel at Hiber. In short, I am responsible for legal compliance and for the company's international regulatory and policy matters at the International Telecommunications Union (ITU), including spectrum allocation, market access and licensing globally.

What is the mission and focus of Hiber?

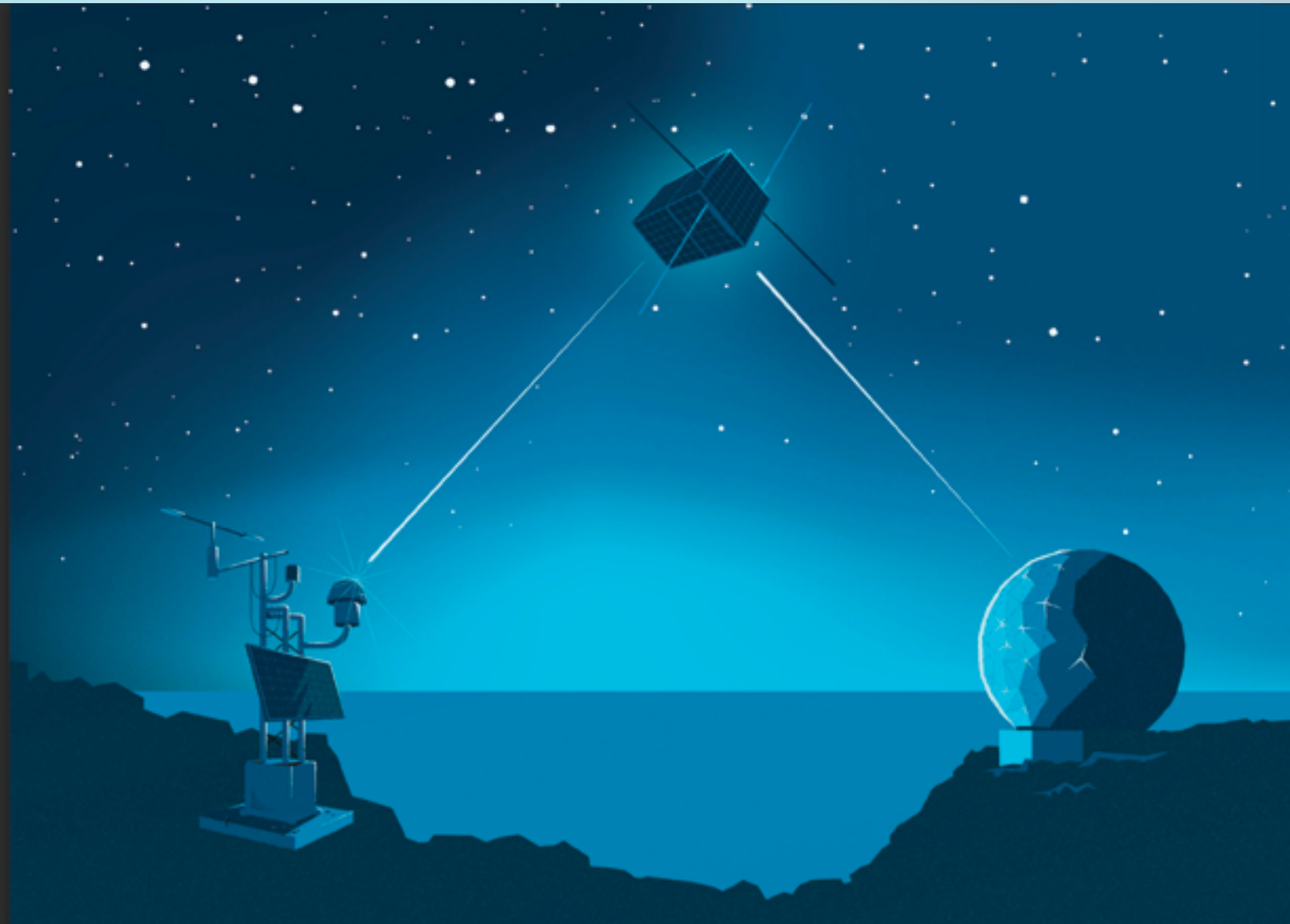
LS

Hiber started with a mission to fill in the lack of available low cost, low power, global IoT connectivity in remote and rural areas. As we are about to have that problem solved, we are slowly moving toward becoming an enabler of IoT use cases in general. This has been possible thanks to the work done with our selected ecosystem of customers, Systems Integrators, Original Equipment Manufacturers and Network Operators.

What geographic and vertical markets does Hiber prioritize and do you see new markets emerging?

LS

We are mostly focused on rural and remote areas where there is the need to collect and send not-time-critical data, but which necessarily relies on space-based connectivity. Our key verticals are agriculture, logistics, energy and infrastructure, and environment. The applications in this business are endless and this facilitates that we



are now moving towards satisfying every type of customers' needs.

What distinguishes Hiber from other IoT connectivity companies?

LS

We have done everything correctly, so far, I believe and there is no doubt that Hiber is among the leaders in this industry. And, of course, we intend to keep growing in this market segment. Have you seen how much progress the company has made during the last three years? Having all processes in place means we are the safe choice, as well as the best positioned to deliver these services.

In order to provide high quality services you have to secure high priority filings through the International Telecommunications Union (ITU) as well as ensure the spectrum that you are aiming for fits the goals of your company. That is to say that those companies using bands that serve other purposes, or which are not available for certain applications, (*i.e.*, unlicensed ISM bands) may be in derogation of the Radio Regulations.

Such misuse would surely lead to harmful interference to those services operating in accordance with the Radio Regulations, and as there is no way that the interference caused will not affect you as well, the ability to provision commercial services would certainly be jeopardized.

Over the last few years, the satellite telecommunications industry has witnessed the implications of ignoring the relevant regulatory framework. We know it is a highly competitive market, that securing suitable filings is far from being an easy task, that dealing with different legal regimes can be burdensome, but you have to keep your National Regulatory Agency (NRA) by your side. This is the only way in which you can show your customers you are being diligent enough, and that is what we have as priority at Hiber since the day the company was started, all to the benefit of our customer community.

What are satellite frequency bands and which one uses Hiber? And why? How can you get/claim a frequency?

LS

I have to start by saying that there is no sovereignty in outer space, which means that no property rights are granted there and its use is authorized only for a defined period of time.

As orbits and frequency bands for radio services are finite natural resources, the ITU must guarantee rational, equitable, efficient and economical use.

The orbit-spectrum resource (OSR) refers to the fact that satellites are assigned a GSO or NGSO slot as well as the frequency spectrum necessary for communications. The low cost aspect of the service we provide is based on the fact that we are focused on spectrum that will allow the operation of systems supporting small antennas using as little energy as possible.

When certain frequency bands are called upon during the planning procedure, the NRA of the concerned State notifies the ITU Bureau of the OSR needed to satisfy their actual requirements. This information is published in order for other States to determine whether their systems could be affected and, if so, the notification would be returned for corrections. If the findings are favorable, the coordination request starts with consultation with the affected State(s) to coordinate assignments. Once an agreement is reached, administrations communicate it to the ITU Bureau which records it into the Master International Frequency Register (MIFR), which gives international recognition and protection of a State's satellite system.

To be granted the use of the OSR, back in 2016, Hiber made the relevant submissions to the ITU. This procedure is governed by a first come, first served principle, with the date of receipt being vital as that secures the key spectrum ahead of potential competitors. This grants us a high quality of service — the priority date obliges you to only coordinate with those who have filed ahead of you (in our case, only a few parties). On the other hand, those with later filing dates have to show how they will not interfere with us. In other words, having a filing with an early date of receipt constitutes a competitive advantage. Depending on the frequency and service, further coordination is required with other administrations.

For our operation, we are using the UHF band to communicate with the payload of our satellites, the S-band to send the collected data back to Earth and VHF for telemetry, tracking & control (TT&C) purposes. Currently, we are concluding the coordination with those administrations that issued comments to our filing, to further request the recording of the frequency assignments into the MIFR.

Which are the different regulatory entities you are in touch with? Why do you need them?

LS

As mentioned, international, regional and national authorities play a major role in managing the access to the OSR.

The ITU is the United Nations (UN) specialized agency that is in charge of regulating the use of the radio spectrum and the avoidance of interference between countries and applications, accrediting international equipment and setting other standards for telecommunications.

Every three or four years, the World Radiocommunication Conference is organized by the ITU so that governments can discuss and agree pm new standards and policies that are then further transposed into a legally binding international treaty called Radio Regulations.

Regional cooperation is crucial in managing the access to the OSR, as it aims to develop common policies to harmonize the efficient use of the radio spectrum. However, their non-binding decisions represent a challenge. As long as administrations do not transpose the agreed instruments into their national laws, the provision of services within the different national markets will be subject to different and specific rules and practices. This constrains the potential of the IoT industry to develop and expand across borders.

Finally, the role of the NRAs are key for securing the use of the OSR as well as for entering the market. As the use of the OSR is allocated only to ITU Member States, and not to private entities, we first must obtain our own national telecommunications license through our own NRA, Agentschap Telecom, that is based in the Netherlands.

`Depending on the market Hiber has targeted for service provisioning, the operation of our network may be subject to a licensing scheme. This means that even when the registration procedure is concluded within the ITU, operators are not automatically allowed to operate worldwide. Depending on the country, Hiber needs to be assigned the use of the radio frequency band on a territory by the respective NRA, which is either done via general authorizations or individual licenses. One or the other will give us more certainty that the service will not be exposed to harmful interference from others.

How would you describe the business you oversee today?

LS

From the work I am engaged in, I can tell you that perhaps one of the biggest challenges is educating administrations about this technology.

We are paving the way for upcoming competitors, and even though that is not entirely fair, it is what has to be done and Hiber is happy to be in the forefront.

What we have seen at Hiber is that IoT applications show tremendous growth rates, which can only mean one thing: we are moving in the correct direction. With two satellites already on-orbit and a network that continues to grow, we will be soon providing higher service levels.

Today, the fact is that several devices will be connected in the near term via private networks, such as ours. This means our global connectivity service, together with the traction given by working with our Systems Integrators, Original Equipment Manufacturers and Network Operators, is certainly game changing.

Hiber is leading the race on transforming many industries — this was projected a long time ago and is finally happening — I am confident this is the correct place to be positioned today as well as tomorrow.

hiber.global/

Antenna Feeds & Reflectors for Space Comms

Current and future developments...

By Carlos A. Leal-Sevillano, Ph.D., Senior Electrical Engineer, SENER

Satellite communications technology has rapidly evolved during recent years, driven by the constant requirement for systems with higher data rates and the uncertain future of classical GEO satellites versus new architectures — HTS (High Throughput Satellites) and VHTS (Very High Throughput Satellites) —- as well as by the mega-constellations in LEO orbits.

Additionally, space exploration continues unabated, with each scientific mission requiring specific communications systems operating in extreme environments. Moreover, now more than ever before, new business formats are being proposed for space in which information and communications systems will be of pivotal importance — now known as **New Space**.

Given these scenarios, there is a growing demand for high-performance communications systems with lower production and delivery times. Most of these systems require the use of high-gain, reflector-based antennas. Essential to this are the optics of reflectors and feeds capable of handling high powers, working in multiple frequency bands and in dual polarization. The feeds are also responsible for the latest features of the system, which require a high degree of development and technological maturity.

Feeds and Current Capabilities

The current requirements for feeding the reflectors used in GEO satellites demand high illumination efficiency, the most severe requirement being the polarization purity, which often reaches discrimination values between orthogonal polarizations as high as 40dB and 50dB for circular and linear polarizations, respectively.

Given these demanding requirements, as well as the need to handle high powers, the most commonly used radiating elements are horn antennas. Specifically, corrugated horns are used with corrugations perpendicular to the radiation axis, and smooth profiled horns, depending on the bandwidth requirements.

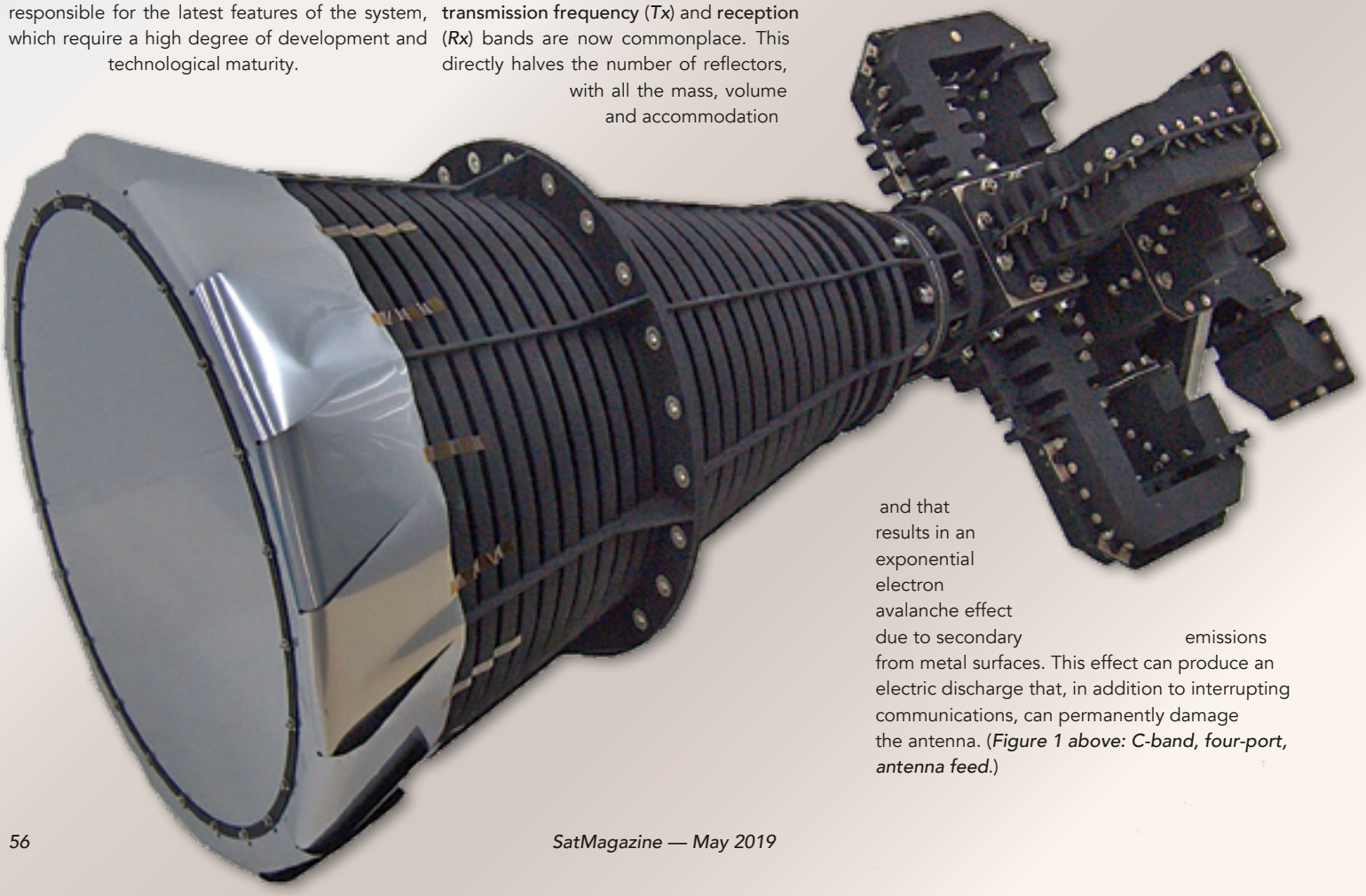
The ability to handle dual polarization is essential, as it allows frequency bands to be reused, thus doubling the communication capacity. Dual polarization operations require including devices capable of distinguishing the polarization before the horn. These are **Orthomode Tranducers** (*OMT*) in the case of linear polarization, or more complex polarizing networks for circular polarization.

In addition, problem-free operations in the **transmission frequency** (*Tx*) and **reception** (*Rx*) bands are now commonplace. This directly halves the number of reflectors, with all the mass, volume and accommodation advantages this entails. This requires including elements to separate and filter the bands in the feed.

Low-pass, high-pass and, recently, bandpass and band-stop filters, are used depending on the band separation and bandwidths. An important aspect is that these filters cannot include tuning elements or moving parts due to the high powers involved.

All of the above leads to sophisticated four-port antenna feeds, one per polarity and per Tx and Rx band. However, the complexity of these devices does not end there, as they must be as compact as possible (the average cost of putting 1 kg. in GEO orbit is estimated to be about $30,000) while also handling power levels that can be as high as thousands of watts. Handling these powers requires considering different limiting factors: multipactor, thermal dissipation and **Passive InterModulation** (*PIM*).

Multipactor is a high-power phenomenon that appears in vacuum conditions and that results in an exponential electron avalanche effect due to secondary emissions from metal surfaces. This effect can produce an electric discharge that, in addition to interrupting communications, can permanently damage the antenna. (***Figure 1 above: C-band, four-port, antenna feed.***)



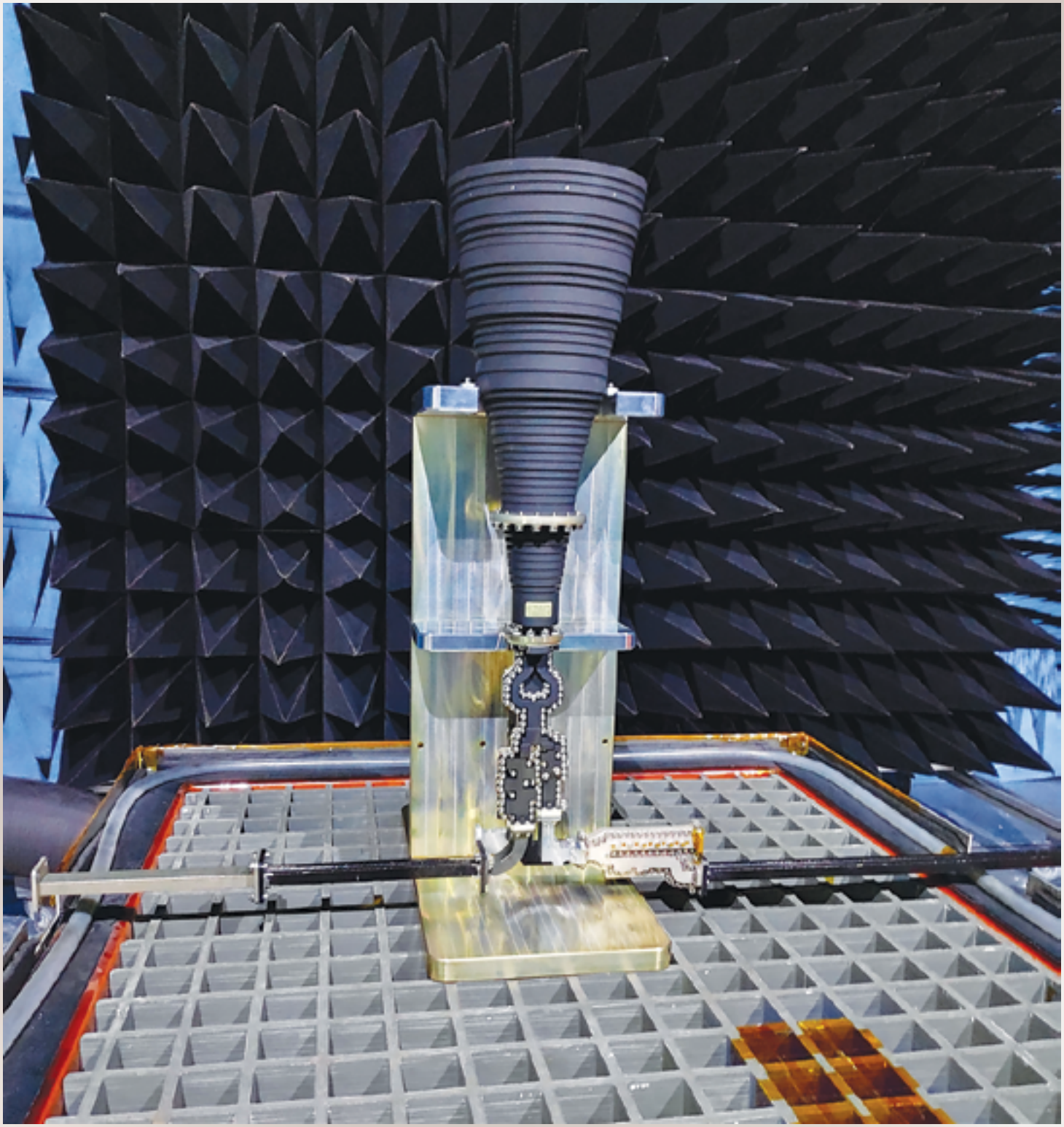


Figure 2. Ku-band feed horn before radiating PIM testing.

To prevent this harmful effect, a detailed analysis of the electromagnetic field is of critical importance to minimize the maximum intensity that is produced in the equipment.

As for the thermal limits, the antenna feeds are exposed to the outside of the satellite, with the extreme conditions this entails. They must also dissipate high powers due to ohmic losses that in some cases reach some 40W. It is thus crucial to minimize these losses. This is done by using waveguide technology and by paying special attention during the electrical design of the elements that dissipate the most power, mainly the Tx filters. If necessary, critical parts of the equipment are also silver plated to further reduce losses.

A proper thermal design requires protecting the antennas from the severe thermal environment of space, as well as minimizing the power that is delivered to the satellite platform. This is done by using passive elements such as paints (white or black), as well as thermal blankets, Multi/Single Layer Insulators (*MLI and SLI*).

Finally, one of the most formidable challenges to managing high power is generating low intermodulation products. PIM is a non-linear, high-power phenomenon that occurs in metal-metal junctions and generates a spurious signal that interferes with low-power signals received from the ground.

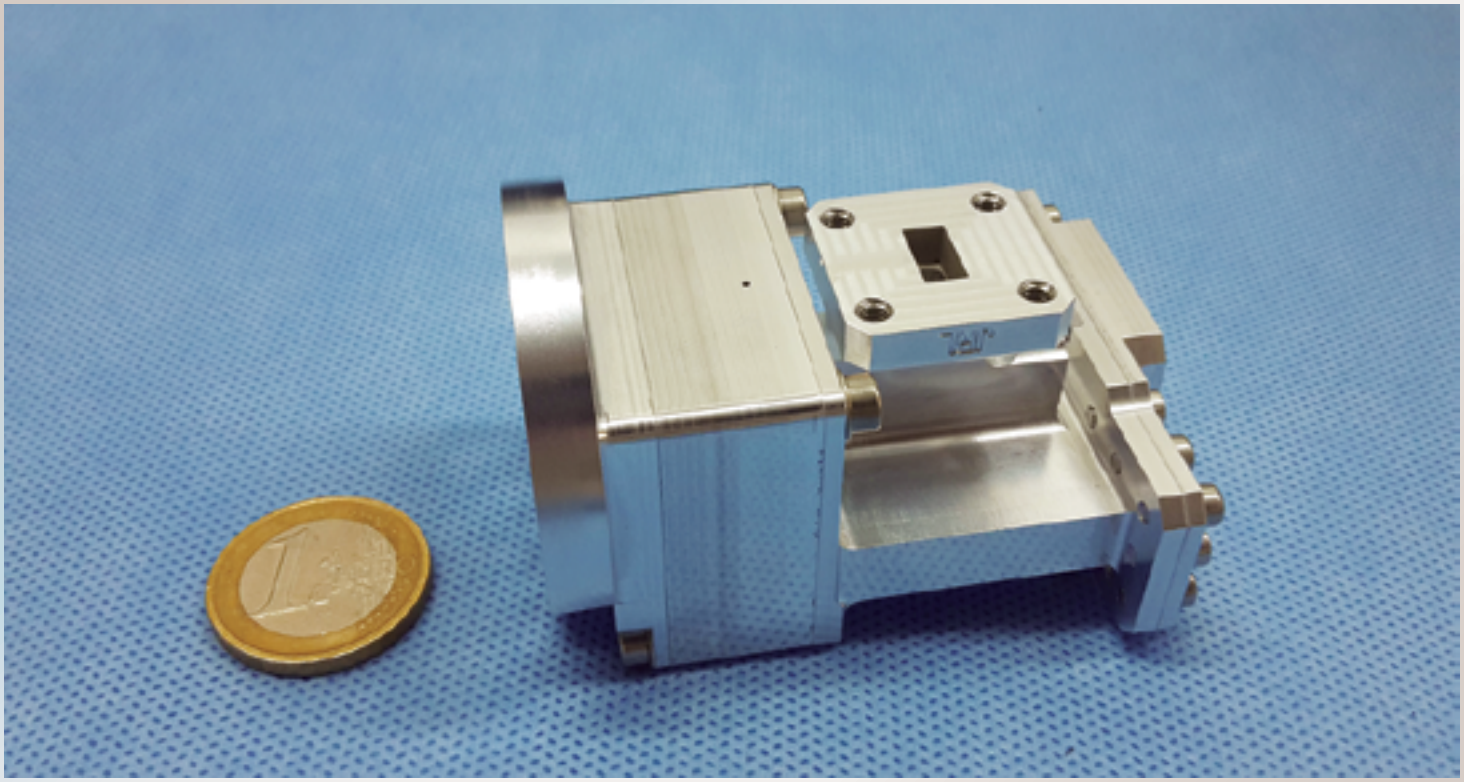


Figure 3. Compact K-/Ka-band user feed for multi-beam reflectors.

This parameter is especially critical in the bands where low-order (three or five) products are generated, as is the case of the X- and Ku-bands and, in the near future, Q-/V-bands. Currently, this parameter is mitigated with design rules based on the experimental characterization of previous equipment.

It is also vital that the personnel involved in the manufacturing, inspection, surface treatments and assembly processes of the equipment be highly skilled. PIM should be experimentally characterized at temperatures typically ranging between -50ºC and 110ºC. This requires complex measurement set-ups capable of feeding two Tx carriers and measuring the signal levels in the Rx ports during thermal cycling while the antenna is radiating inside an anechoic chamber.

SENER has developed its own solutions, which take into account all the technological challenges described above and covering the main frequency bands used in satellite communications:

- *C-band with Tx: 3.70-4.20 GHz and Rx: 5.925-6.425 GHz.*
- *X-band for government/military applications with Tx: 7.25-7.75 GHz and Rx: 7.9-8.4 GHz.*
- *Ku-band typically with Tx: 10.7.12.75 GHz and Rx: 13.75-14.5GHz.*
- *K/Ka-band Tx: 17.8-20.2 GHz and Rx: 27.5-30 GHz. For government/military use, the assigned bands are Tx: 20.2-21.2 GHz and Rx: 30-31 GHz.*

The solutions developed cover all or part of the assigned bands, based on the requirements specific to each satellite. In each case, the performance is optimized as far as possible, depending on the priorities stipulated by the clients.

Requests for dozens of units with short design, manufacturing and measurement turnaround times are increasingly common. In this context, the integrated capabilities and close collaboration between engineering and production is key to implementing high-performance antenna feeds.

Ongoing Developments and Perspectives

The space environment requires the ongoing development of equipment and systems so as to improve current performance and respond quickly to future requests for equipment and systems for eventual applications.

There are numerous, challenging objectives to the development of new high-bandwidth, high-power, compact and low-mass antennas. New frequency bands and new design concepts must also be explored. Moreover, equipment integration and cost reductions must constantly be improved. Given this context, three current developments that cover different areas are described.

C-band ultra-light corrugated horns

Even with all the current controversy in the C-band market to allocate part of the spectrum to mobile telephony, there are still many devices in the ground segment of satellite communications that operate in this band. Some of the C-band satellites are reaching the end of their useful life and need to be replaced. Therefore, there is still a demand for feeds in this band, where mass is a highly critical aspect.

A feed with an optimized mass can weigh around 10.5 kg., 8 kg. of which is the horn. Based on previous positive experiences with smooth horns, work is being done to develop corrugated C-band horns by using **Carbon Fiber Reinforced Polymer** (*CFRP*). This is expected to reduce the mass of the horns by up to 30 percent while maintaining similar electrical performance.

Feeds for multi-beam antennas

The new multi-beam antenna architectures used in HTS and future VHTS rely on horn arrays illuminating a reflector. Each element in the array is a complete feed with all the elements described above, although in this case a distinction is made between the two-port feeds for the user link, with bandwidths of around 1GHz, and the four-port Gateway link, which cover the entire assigned bandwidth.

All these systems work in the K-/Ka-band and the transition to the Q-/V-band is being considered for the Gateway elements, with the

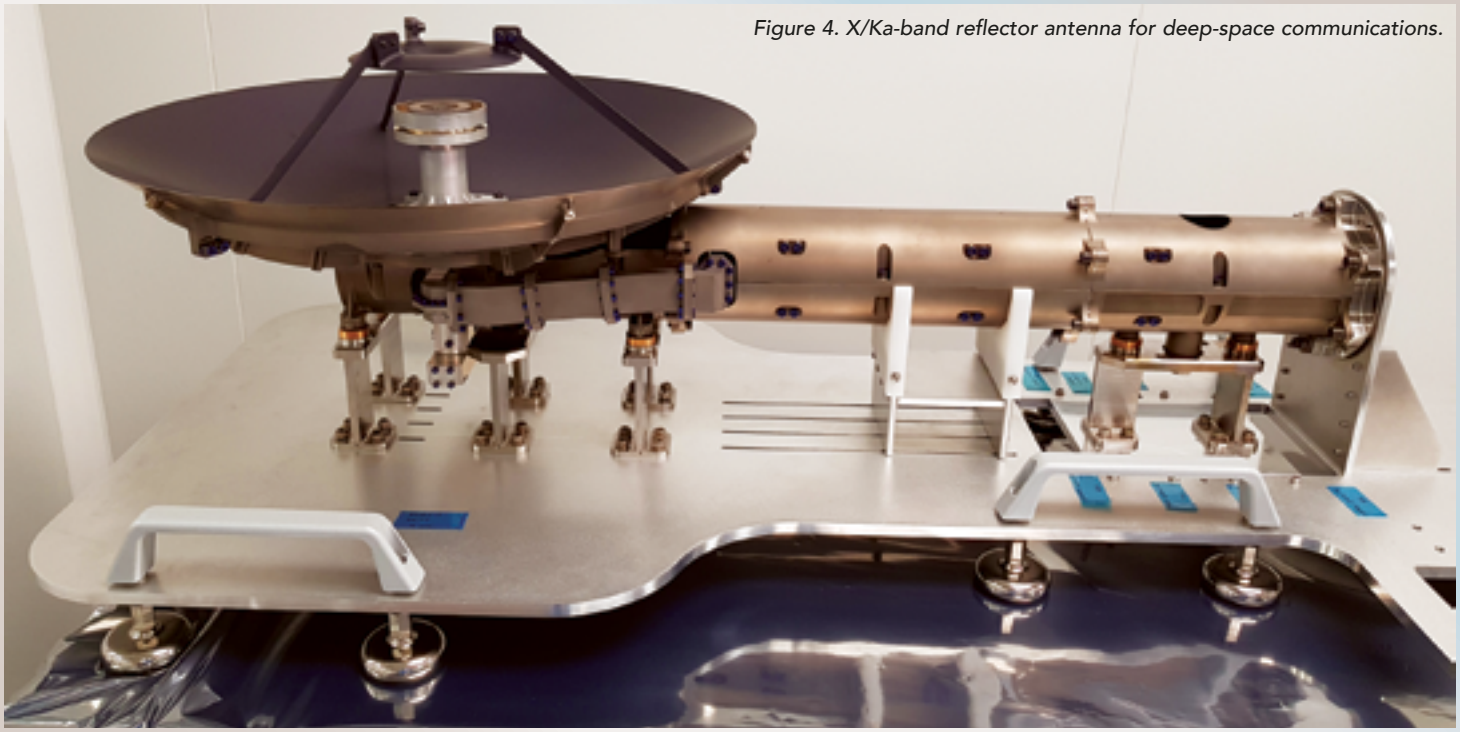


Figure 4. X/Ka-band reflector antenna for deep-space communications.

assigned bands being Tx: 37.5-42.5 GHz and Rx: 47.2-51.9 GHz. In the case of the K/Ka band, the equipment has to be as compact as possible due to space constraints in the array environment. The Q/V band offers numerous technological challenges, most notably the sensitivity to manufacturing tolerances, integrating extremely small equipment (the WR-19 waveguide is 4.775 x 2.388 mm) and achieving an acceptable level of ohmic losses.

Compact X-/Ka- reflectors

Deep-space communications with all the probes from the various scientific missions rely on medium- or high-gain reflecting antennas, typically with more than 35 to 40 dBi, on the carrier frequencies assigned within the X- and/or Ka-bands. These antennas have sophisticated steering and pointing mechanisms that are essential to their operation. As a result, the mechanical part of these systems takes on even greater importance.

The reflector requires the use of very compact geometries, such as Cassegrain, **Axis-Displaced Ellipse** (***ADE***) or shaped surfaces with low F/D ratios. This compactness results in more electromagnetic interaction between the different elements of the antenna, which translates into greater design complexity. To this we must add operations in a dual frequency band.

Although the usual application of this type of antenna has been deep-space communications, in the near future these systems could also be used for satellite-to-satellite radio links in constellations. This poses a new technological challenge to the mass-scale production of high-performance units.

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Dr. Leal-Sevillano received the Best Student Paper Award of EuCAP 2014, was a finalist at the 25th Anniversary Hispasat Award in 2015, and received the Best PhD Award from the Universidad Politécnica de Madrid in 2016. He has authored or co-authored more than 15 papers in technical journals and more than 30 conference papers. Additionally, he occasionally serves on the technical review board of IEEE journals.

The SENER engineering and technology group has been involved in both the institutional and commercial space sector for more than 50 years. It is currently a top-tier supplier of electromechanical components and systems, communications systems, and navigational (GNC/AOCS), astronomy and space optical systems

SENER's Aerospace area has around 700 workers and its turnover goes up to 120 million euros. In 2018, SENER acquired TRYO Aerospace & Electronics to reinforce its firm commitment to industry. As a result, the sum of both companies' capabilities enhances the presence and role of the SENER group in the value chain of the entire onboard communications system, where SENER has traditionally supplied several pointing systems for high- and medium-gain antennas for the ESA's main science missions (such as BepiColombo, Solar Orbiter, Euclid and Juice), designing, verifying and integrating key communications elements, most notably the antennas or the rotary joints integrated within the mechanisms. Developing these components requires capabilities that extend beyond the field of communications engineering (primarily radio frequency), to include mechanical and thermal engineering.

Today, SENER has the capabilities required to procure complete industrial packages in large programs. SENER is a global leader both in the institutional and commercial space markets, with units and systems successfully launched in over 1,500 satellites and spacecraft for the Telecom market and for NASA, ESA (SENER has become a leading supplier for science programs thanks to its engineering contributions), JAXA and Roscosmos. SENER's main space missions include the Hubble telescope, the Rosetta probe and the Gaia, MTG, SEOSat / Ingenio, SMOS, Pleiades, Herschel, Planck, IXV, Proba-3, Solar Orbiter, Euclid, Juice, and FLEX satellites, Mars 2020 and the Mars Curiosity rover.