Worldwide Satellite Magazine – April 2018

SatMagazine

SpaceX successfully launched the Iridium-5 mission. Archive photo of a Falcon-9 leaving the launch pad. Photo is courtesy of SpaceX.

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InfoBeam

Iridium's Next NEXT settles into orbit following SpaceX Falcon 9 launch

SpaceX successfully launched the fifth set of 10 Iridium NEXT satellites into orbit from Vandenberg Air Force Base in California on March 30 at 7:13 a.m.

The 10 new satellites successfully communicated with the Iridium Satellite Network Operations Center and are now engaged in the testing process.

Shortly before launch, the Iridium network met a major milestone as it surpassed one million active subscribers. This continues a trend of significant growth for the Iridium network.

Paving the way for Iridium's growth is the Internet of Things (IoT), where Iridium has established itself as the satellite network of choice to keep "things" connected beyond the limits of cellular coverage.

More than half of the subscribers on the Iridium network are IoT devices, delivering a wide variety of solutions by hundreds of licensed technology partners.

These devices are designed to do everything from tracking endangered species and monitoring power lines to controlling shipping container temperature levels or serving as tsunami warning systems.

Further positioning the company for success is the Iridium NEXT satellite constellation, which is now well more than half way completed.

Once fully deployed later in 2018, the constellation will blanket the entire Earth with new capabilities, such as the Iridium Certus^{SM} L-band broadband service and Aireon^{SM} global aircraft surveillance and tracking.

To date, Iridium has completed five launches of 10 Iridium NEXT satellites, all with SpaceX from Vandenberg Air Force Base in California.

A total of eight Iridium NEXT launches are currently planned with SpaceX delivering a total of 75 new satellites to orbit.

In total, 81 satellites are being built, with 66 in the operational constellation, nine serving as on orbit spares and six as ground spares.

The first stage booster for this launch was previously flown during Iridium-3 in October 2017, making this the second Iridium NEXT launch to use a flight-proven Falcon 9 rocket.

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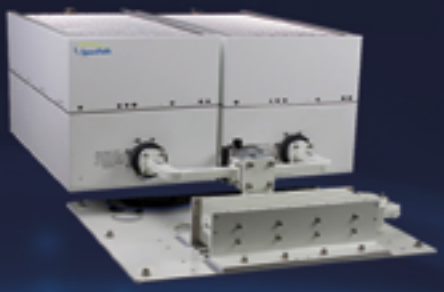

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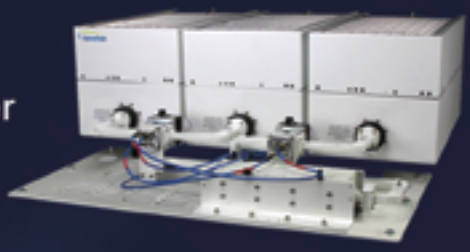

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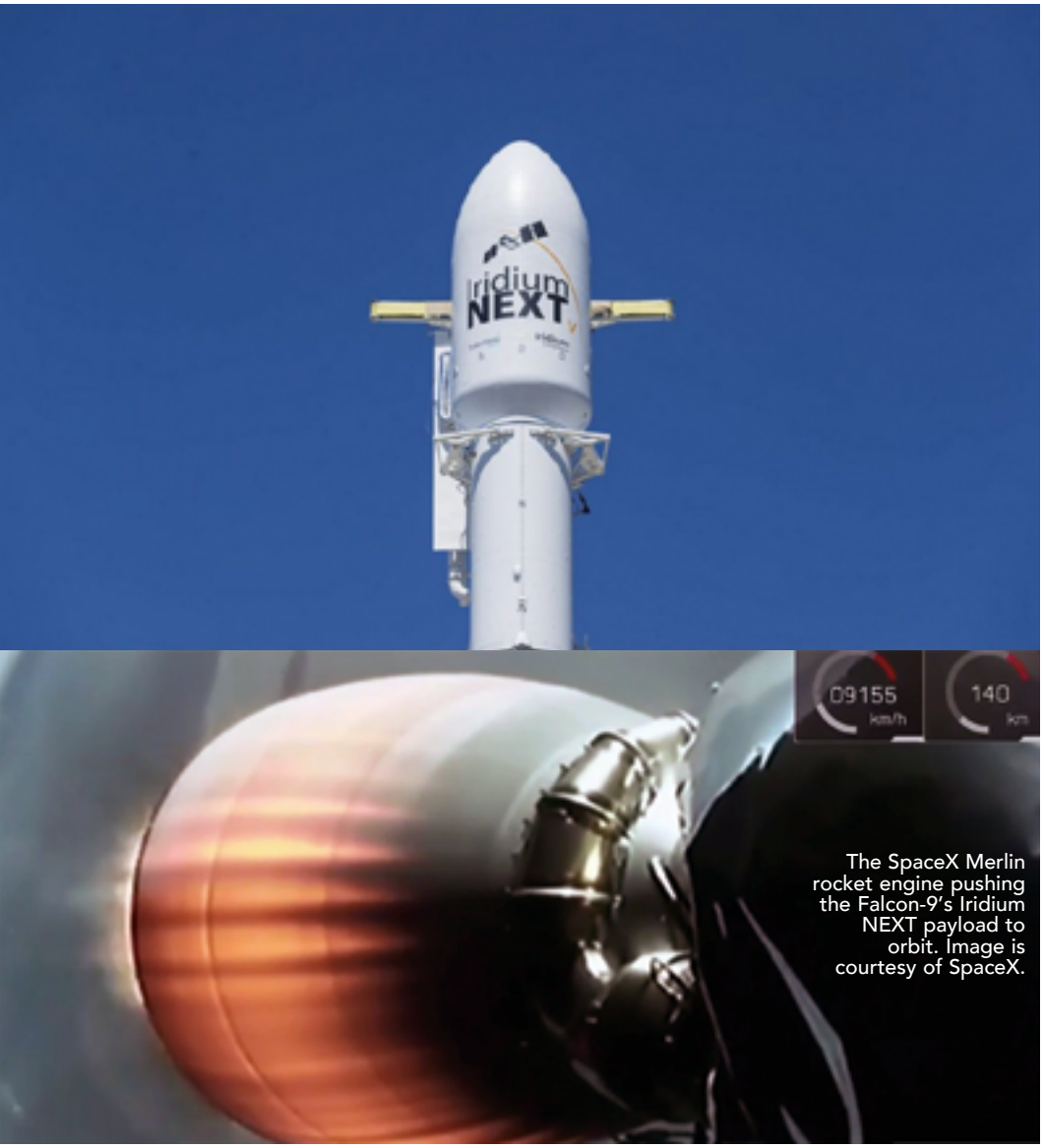


The SpaceX Merlin rocket engine pushing the Falcon-9's Iridium NEXT payload to orbit. Image is courtesy of SpaceX.

Iridium NEXT will replace the company's existing global constellation in one of the largest technology upgrades ever completed in space. It represents the evolution of critical communications infrastructure that governments and organizations worldwide rely on to drive business, enable connectivity, empower disaster relief efforts and more.

"*It's a unique coincidence that we passed the one million subscribers mark right at this launch, and it's particularly exciting because we've surpassed this milestone earlier than we had anticipated*," said Matt Desch, chief executive officer at Iridium. "*The new satellites and services we're launching and continued strong subscriber growth are cementing our position as an industry leader and critical global communications platform and underscores the significant transformation we've undergone as a company over the last 10 years. This truly is a testament to the trust our partners and customers have in our network, which is only going to continue growing as the deployment of the Iridium NEXT constellation nears completion*."

For information about Iridium Certus, please visit ***www.iridium.com/network/iridium-certus/***

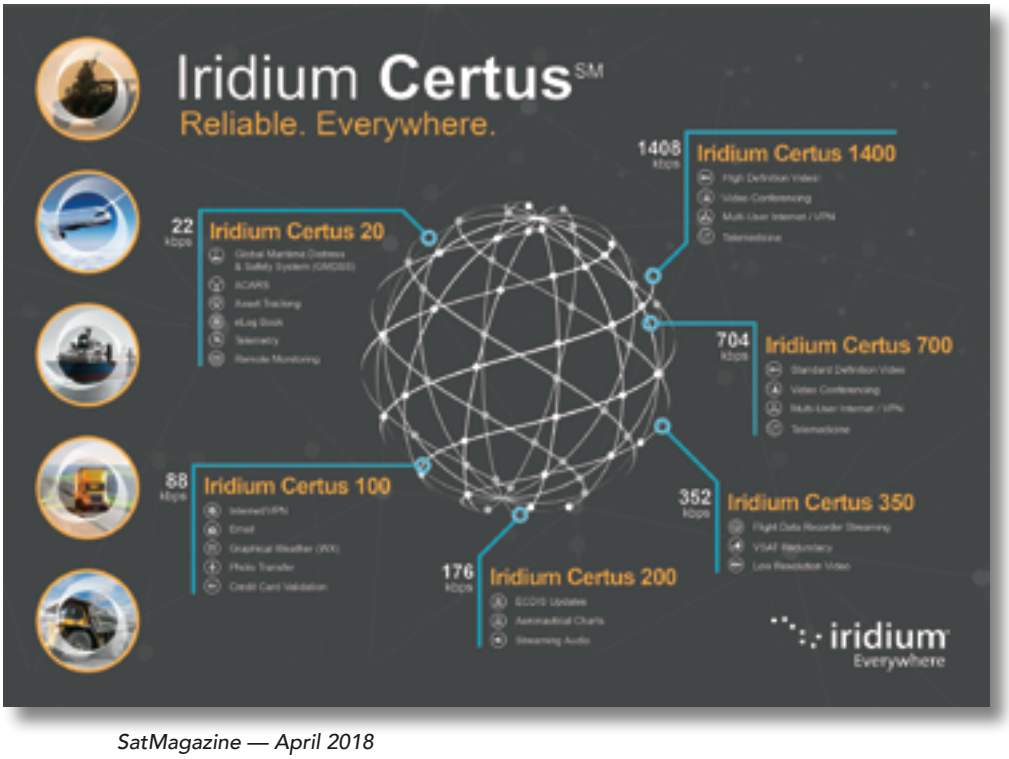
For more information regarding Iridium NEXT, please visit ***www.IridiumNEXT.com***

Each launch strategically delivers new satellites to specific orbital planes to ensure the earliest possible completion of the constellation.

The Iridium network is comprised of six polar orbiting planes, each containing 11 operational, crosslinked satellites, for a total of 66 in the active constellation.

The 10 Iridium NEXT satellites launched were successfully delivered to orbital plane one, where they will replace first generation satellites over the next 30 days.

Iridium NEXT is the company's $3 billion, next-generation, mobile, global satellite network scheduled for completion in 2018.



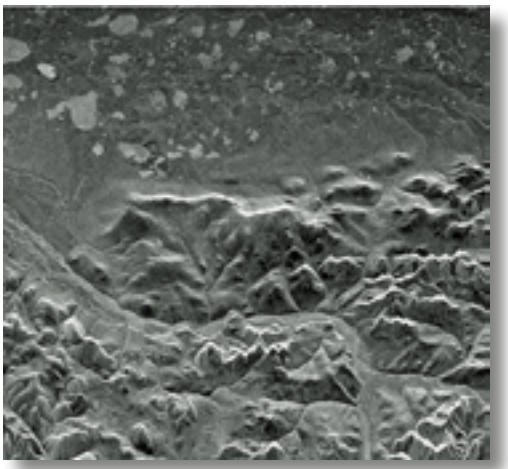
InfoBeam

ICEYE and ESA disclose a new partnership

ICEYE will be cooperating with the European Space Agency (ESA) to mutually explore opportunities provided by ICEYE's technology.

By using **ICEYE**'s SAR satellite technology and imagery, this new agreement demonstrates ESA's interest in taking advantage of recent innovative New Space developments to foster business. The cooperation encompasses activities that focus the design of the ICEYE microsatellite and its X-band SAR instrument, as well as identifying the most promising applications for the data collected by such a smallsat constellation.

By empowering **ESA** with ICEYE data, the constellation is helping to shape the future of observing the planet from space. Data collected by ICEYE benefits both researchers and a wide range of commercial industries. Challenging issues such as natural disaster response and climate change research, oil spill and illegal fishing detection all require repeated and timely imaging, regardless of the weather conditions or time of day.



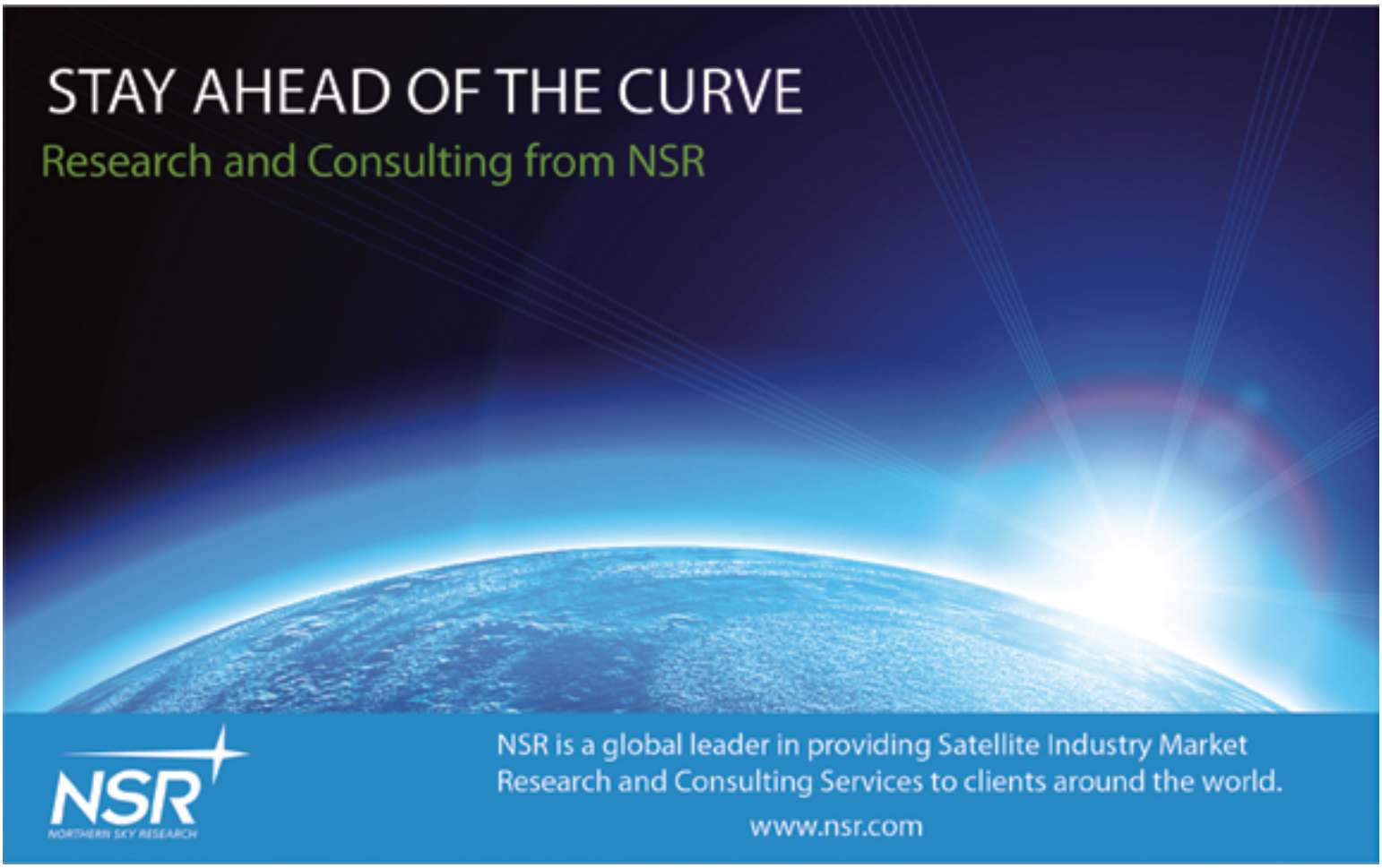
The first ICEYE-X1 radar image from space — this is the world's first SAR satellite under 100 kg. and validates the capabilities of miniaturized SAR technology. Image is courtesy of ICEYE.

This shared effort to gain vast SAR imaging capabilities from new technological developments impacts the whole Earth Observation (EO) industry and its end users.

ICEYE also recently announced collaborations with two other European entities, **Kongsberg Satellite Service** (KSAT) and **Aker Arctic**, to collect and provide SAR data for maritime and ice monitoring.

ICEYE remains on track to launch its next two SAR-enabled satellites, **ICEYE-X2** and **ICEYE-X3**, later this year.

www.iceye.com/



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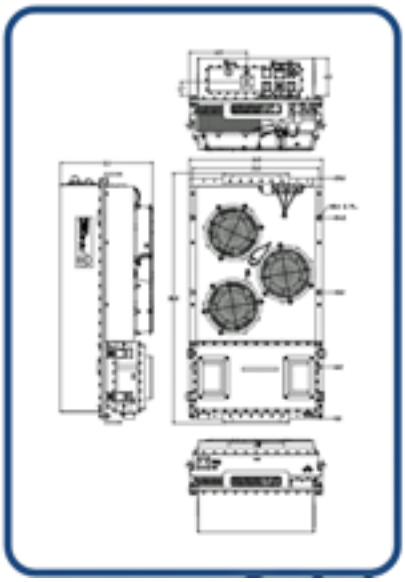
An award winning jewel from Advantech Wireless

Winning numerous awards for their products validates the success that this company enjoys for their powerful second generation GaN technology.

Advantech Wireless' Ku-Band 3200W Hub-mount SSPA/SSPB/BUC UltraLinear™ SapphireBlu™series GaN Technology was awarded Teleport Technology of the year 2014 by the World Teleport Association and Most Innovative Product of the Year 2013 for its ground breaking performance and pioneering technology.

Advantech Wireless' SapphireBlu™ Series of UltraLinear™ GaN based High Power Amplifiers and BUCs is the solution for wide bandwidth, ultra high power satellite teleport uplinks.

Advantech's development revealed that saturating all transponders of an entire satellite enables one to obtain the maximum power/bandwidth combination necessary.



This will translate into energy consumption savings in energy cost, satellite bandwidth and CAPEX.

This product is a solution for Direct to Home (DTH) TV that can:

- *Cover multiple transponders, full DVB-S2 enabled*
- *Rugged, Weatherproof Outdoor Package*
- *MIL-STD-188-164A Compliant*
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- *Save 8 to 10 dB power compared to Indoor Klystron*
- *Save millions of dollars in Energy Cost, Satellite Bandwidth, CAPEX*
- *Provide the highest linear power available*

www.advantechwireless.com/wp-content/uploads/2018/03/PB-SAPPH-2G-Ku-3200W-18046.pdf

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GSAT-6A heads to orbit, launched by an Indian GSLV rocket

The GSLV-F08 launch, carrying the GSAT-6A satellite. Photo is courtesy of ANI.

An Indian GSLV rocket has pushed a GSAT-6A communications satellite into orbit.

The rocket, carrying the country's communications satellite GSAT-6A, lifted off from the spaceport today.

The GSLV-F08 rocket and the passenger satellite blasted off at 4:56 p.m. from the second launch pad at India's Sriharikota launch site.

The 49.1 meter tall GSLV carried the 2,140 kg. GSAT-6A satellite to a geostationary orbit at a height of about 36,000 km.

According to ISRO, two improvements — induction of high thrust Vikas engine and an electromechanical actuation system — have been incorporated into the rocket's second stage for this launch.

The ISRO stated that the GSAT-6A was similar to the GSAT-6 and will provide a platform for developing technologies, such as demonstration of a 6 meter, S-band, unfurlable antenna, handheld ground terminals and network management techniques. These are useful for satellite-based mobile communication applications.

ISRO Chairman K. Sivan indicated that the GSAT-6A would be followed by the launch of a navigation satellite within the next fiscal year.

www.isro.gov.in

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South African nSight-1 smallsat success

What started out as an experiment with an African smallsat launched from the International Space Station has proven so successful that some of the satellite's subsystems have created their own market and have generated international sales for a niche market.

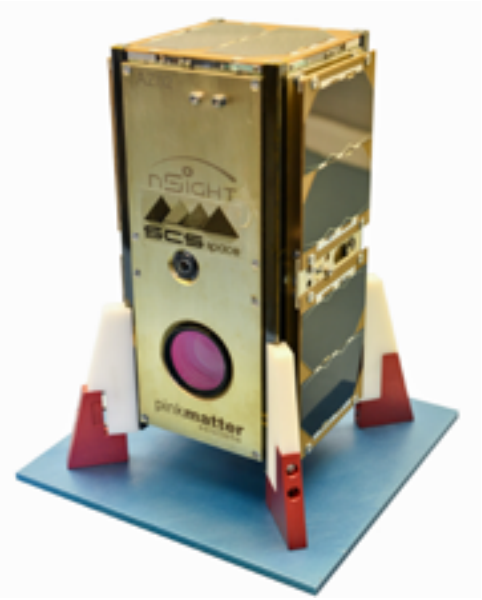
The satellite — called **nSight-1**— is a product of the **Somerset West-based SCS Aerospace Group** (SCSAG), Africa's largest privately-owned group of satellite design and manufacturing companies with more than 25 years of experience in this domain.

The satellite was launched from the International Space Station in May of last year with 28 other satellites as part of the **European Space Agency**'s **QB50** project, which collects research data from the Earth's lower thermosphere.

Francois Denner, Managing Director of the SCS Aerospace Group, said that they are delighted and extremely proud of the performance of their satellite nSight-1. The satellite is in a stable and healthy state and the various on-board payloads are working well and have resulted in a number of major sub-systems sales to international clients.

Denver continued by saying that the success of nSight-1 certainly strengthens the company's position to play a leading role in forging a new satellite business cluster in the South African economic sector. Their group now has the ability to manufacture as many as 80 percent of the needed small satellite components locally — and they are proudly South African.

The three companies in the SCS Aerospace Group which are directly involved in providing commercial satellite solutions are **Space Advisory Company** (SAC) their satellite program and systems consulting and engineering house; **SCS Space** which provides satellite mission solutions as well as satellite systems; and **NewSpace Systems,** which develops and manufactures high-quality space components and sub-systems. The group employs some 90 highly trained satellite specialists such as electronic, systems, software and mechanical engineers.



The fully completed nSight1 satellite which has been orbiting Earth for almost a year.

According to *Hendrik Burger*, CEO for SCS Space, the primary contractor for the nSight-1 nanosatellite, the **Attitude Determination and Control System** (ADCS) used on board is one of the most advanced to be used in a satellite this size. This is another South African product designed and manufactured by **CubeSpace** and has given the satellite a high degree of pointing accuracy in orbit some 400 km. above Earth. The company is now looking at extending the orbit lifetime of the satellite from 18 to 24 months due to its low drag, specific mass and orientation control.

The milestone achievements for their satellite so far are the following:

- *Their primary science payload (FIPEX) to feed regular data for thermosphere analysis to the* **Von Karman Institute for Fluid Dynamics** *is working well by providing double the contracted data volume*
- *The* **Gravity Wave Experiment** *is producing measurement data that is being processed by Mr. Philip Wagner (the South African creator of the experiment)*
- *Ongoing radiation impact detection results are being monitored by the Radiation Experiment and delivered to the Nelson Mandela Metropolitan University (NMMU) for interpretation*
- *Their SCS Gecko Multispectral Imager has been seamlessly producing high-quality pictures that are made freely available. The Space Advisory Company was awarded with the "Best Innovation Concept for a medium enterprise" award for the Gecko imager development during the 2017 Da Vinci Top Technology (TT100) Awards, South Africa's foremost technology innovation awards*
- *The Grabouw-based ground station that controls the satellite is autonomously operating and will in the future form part of an international network of satellite ground stations servicing the ever-growing need by LEO satellites.*

Denner concluded that the nSight-1 mission demonstrates the ability of the SCSAG to leverage the capabilities in the South African space industry cluster, and he thanked all the South African project partners including **SCS Space**, **Space Advisory Company**, **NewSpace Systems**, **Pinkmatter Solutions**, the **Department of Trade and Industry**, **Stellenbosch University**, **CubeSpace**, **Denel Spaceteq**, **DeltaV Aerospace**, **Simera Technology Group**, **Cape Peninsula University of Technology**, **Nelson Mandela Metropolitan University** and the **Amateur Radio Society**, who made this project possible.

www.scshgroup.com/
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Euroconsult's satellite report insights

Euroconsult's analysis and forecast of satellite manufacturing and launch services worldwide is available in their "Satellites to be Built and Launched by 2026" report and includes PDF and Excel files.

The report highlights include...

- *Nearly 3,000 satellites, weighing more than 50 kg, will be launched in 2017–2026 (threefold increase compared to the previous decade)*
- *Revenues for the world space industry over the next decade are estimated at $304 billion (manufacturing and launch services)*
- *In the first nine months of 2017, a total of 70 satellites weighing more than 50 kg were launched out of a planned total of 173*
- *In 2016, 100 satellites were launched for a market value of nearly $32 billion (average capex of $322 million per satellite)*
- *Growth in satellite launches in recent years was driven by the launch of LEO and MEO constellations*
- *As opposed to the previous decade and due to constellations, the largest market will be for commercial satellites, with approximately 2,000 satellites*

Key Trends, Drivers and Forecasts

- *Exclusive 10-year forecasts including breakdown by customer and by orbit, with number and mass of satellites to be manufactured and launched, plus market value (manufacturing and launch services)*
- *Review of strategic issues from both supply (industry) and demand (customers) perspectives*
- *Detailed demand database for commercial (order book) and government satellites (forecasts) including: application, launch date, launch mass, satellite platform, manufacturer, launch provider*

New in this edition

- *Retrospective analysis of Euroconsult's forecast matching with satellite reality over the past 17 years*
- *Market share of the satellites of the report relative to the cubesat and mega-comsat constellations*
- *New data series in Excel files*
- *New format and layout*

To learn more about this highly informative report and to download an extract, please access
euroconsult-ec.com/download-satellites-built-launched-extract

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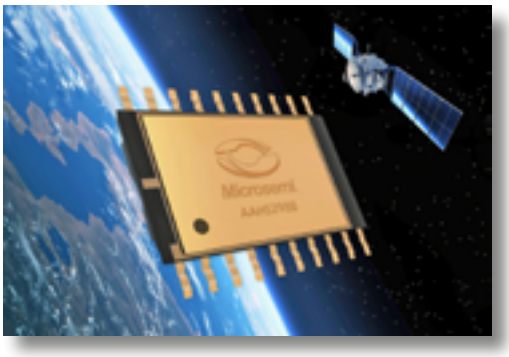
Microsemi's radiation tolerant channel source driver gets DLA qualified

Microsemi Corporation (Nasdaq: MSCC), a provider of semiconductor solutions announced its radiation-tolerant AAHS298B eight-channel source driver for space applications, which has been successfully qualified and certified by the U.S. Defense Logistics Agency (DLA) as Qualified Manufacturers List (QML) Class V and Q, with four Standard Microcircuits Drawings (SMDs) listed, is now in production.

Offered in two package types with various screening options, the device has met the key requirements to operate in space environments, as the qualifications are mandatory for design-ins for space programs and for manufacturers to be listed on the QML by the DLA.

Dorian Johnson, Microsemi's product marketing manager, said that successfully achieving these qualifications is vital to securing design-ins in satellite programs requiring the highest quality and reliability performance. Obtaining QML status not only demonstrates Microsemi's continued commitment to supplying integrated space solutions, but gives their customers the added assurance that their radiation-tolerant AAHS298B source driver can meet the demanding requirements of the DLA while offering the ability to use the device in conjunction with their LX7730 telemetry controller, LX7720 motor controller and LX7710 diode array devices.

Microsemi's high-performance AAHS298B source driver provides an interface between spacecraft bus electronics and other subsystems, with the highest output source current for space applications requiring radiation tolerance. Command signal outputs from the spacecraft's digital control electronics are typically TTL (5-volt) (V), CMOS (3V) and high-level (12V) logic and are not directly compatible with users' command input requirements. These user requirements occur in payload, power, thermal and housekeeping subsystems and range between 14V and 45V. The AAHS298B is an interface between these systems, providing a continuous 700 milliamps (mA) current to switched high side-drivers on the output.



The integration of eight non-inverting high side channels gives satellite designers reduced weight, resulting in smaller board space, and higher reliability as compared to discrete implementations. As many satellite manufacturers and projects require the DLA QML certifications and listings as assurance the product meets Military Performance Specification (MIL-PRF) requirements, the AAHS298B meets these standards as part of the company's growing portfolio of mixed signal integrated circuits (ICs) for demanding space applications.

Glenn Lommasson, Vice President of Design and Development Engineering Services (DDES) Corp. said that increasing requirements for higher output currents combined with demands for weight and board space reductions were compelling reasons to initially investigate Microsemi's AAHS298B source driver for their designs, and in addition, the presence of the internal clamp diode in the driver output allowed a much more efficient method for implementing transient protection during inductive kickback events, which reduced the number of clamp diodes needed in other solutions. The recent device qualification and SMD listing as a QML-V device was also a very important element for them to baseline this part as more programs are mandating Technical Operating Report (TOR) guidelines for parts quality, DLA certification and radiation assurance.

As satellite manufacturers typically require Class V and Q qualifications, the designations provide customers with an added level of assurance that the radiation-tolerant AAHS298B eight-channel source driver has met the stringent industry standards. The QML qualification achievement allows designers across the entire spectrum of space designs, from low cost commercial and scientific applications to human rated and top priority government systems, to use the parts without cumbersome part selection justifications or source control drawings.

Microsemi's AAHS298B source driver is ideally suited for applications including command and data handling power subsystems, spacecraft control electronics attitude control, relay/solenoid drivers, as well as stepper and/or servo motor drivers. Key features of the device include:

- *700mA output source current*
- *Zero quiescent off-current*
- *Full channel isolation to prevent fault propagation*
- *Internal ground clamp diodes*
- *75V output breakdown voltage*
- *TTL, 5V and 12V Logic-compatible*
- *Internal thermal shutdown to protect against over-current and soft-start occurrences*
- *Radiation-tolerant to 100kRad (Si) total dose, 50kRad (Si) enhanced low dose radiation sensitivity (ELDRS)*
- *Temperature range of -55 degrees C to 125 degrees C*
- *Available in 20-pin ceramic small outline integrated circuit (SOIC) with formed and flat leads*
- *QML listed with SMD 5962-15231*

www.microsemi.com/applications/space

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InfoBeam

The Aireon[SM] global air traffic surveillance system gets closer to deployment

Aireon's fifth successful launch and deployment of the company's space-based Automatic Dependent Surveillance-Broadcast (ADS-B) payloads, hosted by the Iridium® NEXT satellite constellation, succeeded at 7:13:51 AM PDT (14:13:51 UTC), as a flight-proven SpaceX Falcon 9 rocket lifted off from Vandenberg Air Force Base in California — this brings the total number of Aireon payloads on orbit to 50.

When the **Aireon** payloads from the fifth launch come online, the system will have nearly global coverage with 15-minute or better update intervals.

This signifies optimal timing for airlines to begin testing the capabilities of space-based ADS-B. This will assist airlines with meeting the International Civil Aviation Organization (ICAO) and European Aviation Safety Agency (EASA) regulations that require aircraft be equipped with an aircraft tracking system for those flights not tracked by air traffic control by the end of 2018.

With the Aireon service and access to the space-based ADS-B data, airlines can meet this directive set by regulators and safety organizations.

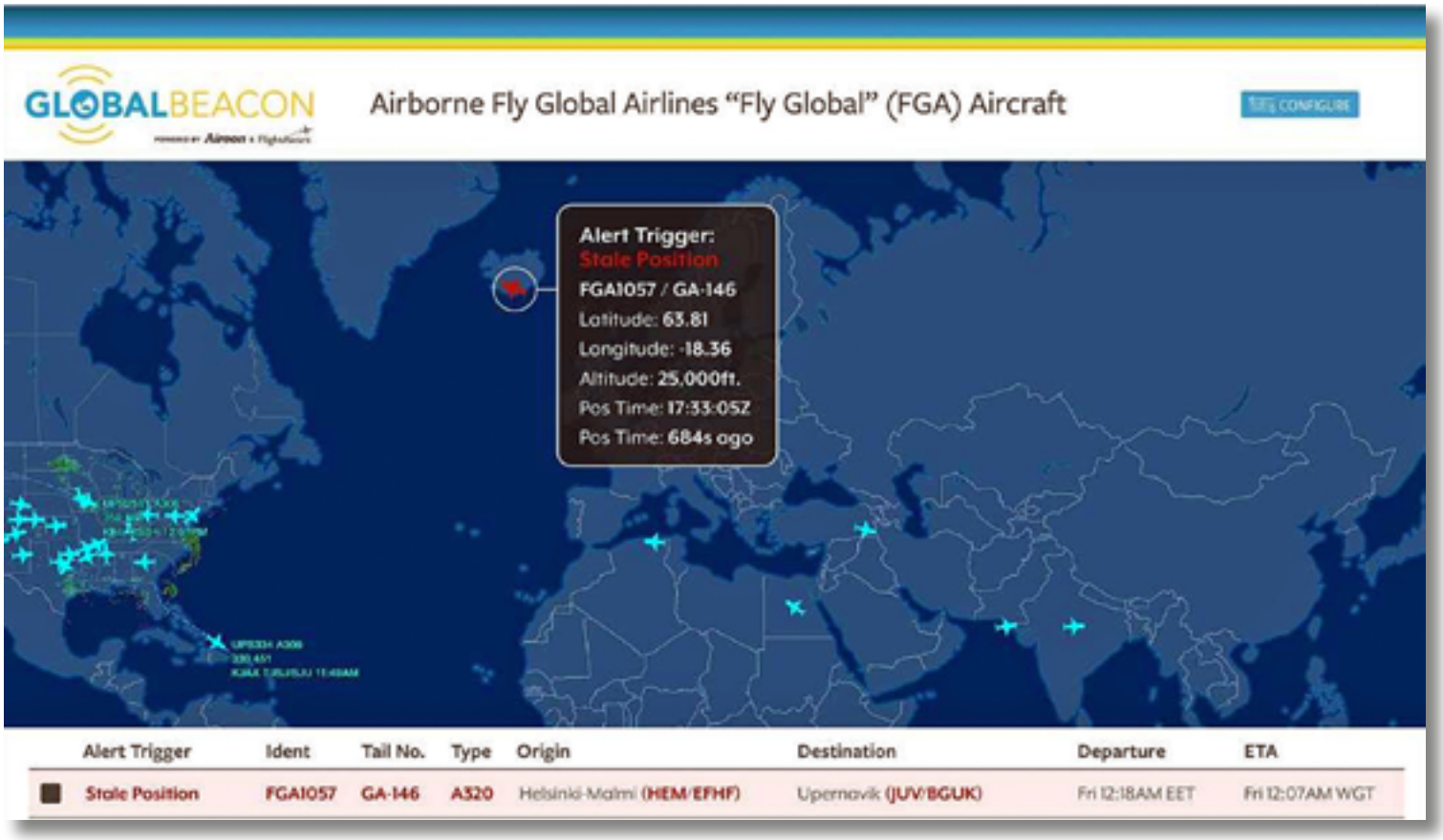
"*We're more than two-thirds of the way there*," said ***Don Thoma***, CEO, Aireon. "*And as we get closer to a fully operational system, thorough testing and validation is now underway with our customers and partners." Thoma continued, "Aireon is working closely with not only ANSPs, but partners like FlightAware to ensure airlines have early access to this global data, ahead of regulations and requirements. Aireon will be able to help airlines meet these mandates, and upon completion of the constellation, update rates of a few seconds will be the service standard around the world*."

FlightAware and Aireon have worked together to create GlobalBeacon, a first-of-its-kind product. GlobalBeacon combines FlightAware's data processing platform and web-interface with Aireon's space-based ADS-B data for a cost-effective, easy to deploy solution to help meet the ICAO Global Aeronautical Distress Safety System (GADSS) standards.

"*We are fusing Aireon data with FlightAware data to empower airlines and other aircraft operators with products that exceed GADSS recommendations for flight tracking*," said ***Daniel Baker***, founder and CEO, FlightAware. "*With the satellites from today's successful launch, customers will be able to beta test coverage that meets the November 2018 requirement for aircraft tracking*."

In addition to GlobalBeacon, FlightAware is delivering the data through services that are already commonly used by airlines and industry leading service providers such as SITAOnAir.

"*Our partnership with FlightAware means that any airline using AIRCOM® FlightTracker will have at its fingertips a dynamic tool providing an overview of the exact position, speed and altitude of its airborne fleet*," said Dominique El Bez, Vice President, Product and Strategy, SITAOnAir. "*Most critically, the coverage will now be 100 percent even over oceanic, remote and polar areas. By receiving once-per-minute positions from Aireon's network of space-based ADS-B receivers, airlines will exceed the ICAO GADSS upcoming 15-minute recommendation*."



The Aireon system is hosted on the Iridium NEXT satellite constellation. A total of 81 Iridium NEXT satellites are being built, all of which will have the Aireon payload onboard.

Currently, 75 satellites are planned to be deployed, with nine serving as on orbit spares and the remaining six as ground spares.

The constellation is planned for completion during 2018.

www.aireon.com

InfoBeam

World Teleport Association certifies three Speedcast teleports

The World Teleport Association (WTA) has announced that Speedcast has achieved provisional certification of three teleports in Australia:

- *Bayswater (Perth, Western Australia)*
- *Henderson (Western Australia)*
- *Mawson Lakes (Adelaide, South Australia)*

These teleports were awarded the certification under WTA's Teleport Certification Program — further certification of Speedcast teleports globally will be forthcoming.

Since the program's introduction at IBC 2015, the Certification program has quickly grown in popularity, with 16 teleports currently engaged in the quality evaluation process and certifications already issued to teleports owned by **Eutelsat**, **du**, **Signalhorn**, **Optus**, **Globecomm**, **Horizon**, **Media Broadcast**, **Elara Comunicaciones**, **GlobalSat**, **Talia**, **Telenor**, **Vivacom**, **Cyta**, **Batelco** and **Arqiva**.

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.

WTA's Teleport Certification Program serves both teleport operators and their customers by creating an objective, transparent, and internationally accepted method for teleport operators to document the quality of their operations for customers and strategic partners.

This certification also provides a means for customers to select teleport vendors delivering the price-performance level that is appropriate for their applications.

Keith Johnson, the COO of Speedcast, noted that the WTA certification program demonstrates Speedcast's focus on quality by meeting the requirements of the only certification program for teleports, facilities, and technical infrastructure in the industry.

WTA Executive Director Robert Bell added that the teleport industry faces increased competition for complex managed services, which are the specialty of operators suchn as Speedcast, from satellite operators and cloud service providers. Certification defines the quality difference that will ensure teleport operators remain competitive in the market.

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

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The fifth set of Thales Alenia Space-built Iridium NEXT satellites ascend

Artistic rendition of an Iridium NEXT satellite.

The fifth batch of Iridium NEXT satellites built by Thales Alenia Space have been successfully launched by SpaceX from Vandenberg Air Force Base in California.

Thales Alenia Space, the system prime contractor for the Iridium® NEXT program, is in charge of engineering, integration, and on orbit validation of all 81 Iridium NEXT satellites, in addition to the definition and validation of the overall system.

The satellites are manufactured in production line process by Thales Alenia Space's subcontractor **Orbital ATK**, at that firm's Satellite Manufacturing Facility in Gilbert, Arizona, under the supervision of a dedicated local Thales Alenia Space team.

Launch and Early Operations (LEOP) and In Orbit Tests are performed by Thales Alenia Space from Iridium's Satellite Network Operation Center (SNOC) in Leesburg, Virginia.

"*Two-thirds of our satellites are now on orbit and performance is exceeding expectations. The next two sets of Iridium NEXT satellites are already available in anticipation of the 6th and 7th launches. Everything is on track to meet our objective, namely to launch all 75 Iridium NEXT LEO satellites in 2018*," said Denis Allard, Constellations Vice President for Thales Alenia Space.

The Iridium NEXT constellation will offer global connectivity, thanks to 66 interconnected satellites at an altitude of 780 km., along with nine spares in parking orbits and six more spare satellites on the ground.

According to the company, this global network provides unrivaled capabilities for communications on the move (individuals, land vehicles, aircraft and ships), and ensures fully global coverage, including the poles and over the ocean.

Thanks to the global coverage and independent operation that does not require any ground infrastructure, Iridium NEXT provides vital assistance under very challenging conditions, such as in isolated areas, during natural disasters or during conflicts, to name a few.

The independence from local ground infrastructures delivers secure communications, including protection against intrusion and hacking.

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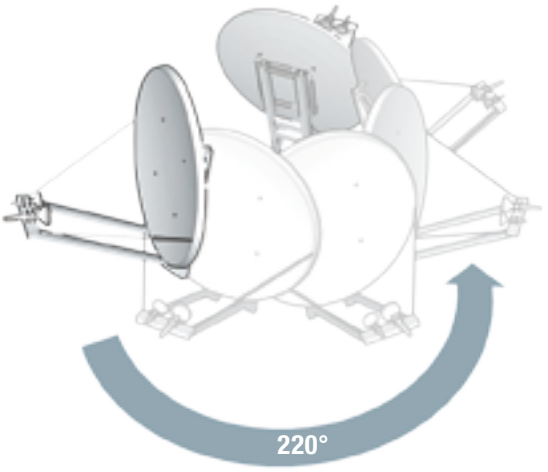

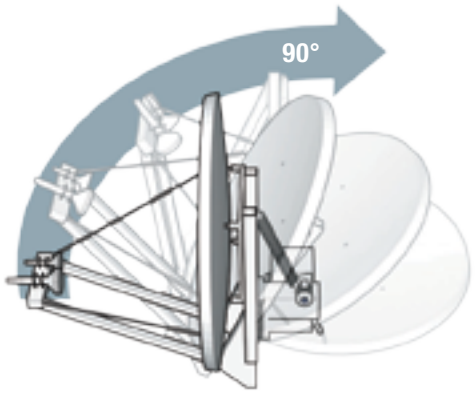

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The Forrester Report

Challenges Ahead for SES... Inevitable

By Chris Forrester, Senior Contributor

While many industry commentators expressed shock and surprise at the departure of SES CEO *Karim Michel Sabbagh* which becomes effective April 5, this has been seen as rather inevitable as the company is under such extreme market pressure and swimming against industry-wide concerns as to future prospects.

As SES stressed with their February 12 announcement, the retirement of Chief Financial Officer ***Padraig McCarthy*** was unconnected and is 'just' a normal retirement for the CFO, although probably brought forward in order to have the clean sweep that the SES Board of Directors clearly want, and to draw a line under the Sabbagh era. Sabbagh had been in his leading post at SES for four years.

One comment made by your columnist on November 13 of last year said, perceptively, "*That there are internal management rumblings at SES is a recognized fact — the inevitable comment that 'the market is always right' as regards overall sentiment toward the company (and the satellite business in general) is also not helping SES. CEO Karim Sabbagh's management style may not be to everyone's taste, but he has made no secret that SES is undergoing a period of necessary structural change, and his strategic changes have all been supported by the Board — at least to date.*"

Artistic rendition of the SES GEO-MEO constellation. Image is courtesy of SES.

SES CEO Steve Collar.

That support evaporated over the past quarter-year and in appointing ***Steve Collar*** (and ***Andrew Brown*** as CFO-elect) SES is choosing an extremely safe pair of hands.

Indeed, Collar's rapid rise from running **O3b** as a stand-alone investment to CEO of a newly-created division (**SES Networks**) more than proved his mettle as a precursor to his new position.

His energy and enthusiasm are infectious, but now his personality and expertise must be transferred across the whole group and this will take time. His personal contacts at SES will do much to lift morale, which from every quarter has recently suffered.

Laurie Davison, an equity analyst at investment bank Deutsche Bank headlined his report as a "*surprise replacement…but one to be welcomed.*"

Davison added, "*An unannounced change in both CEO and CEO will likely be received negatively at the outset. But uncertainty raised over Group strategy looks limited in this case. Incoming CEO and CFO are both coming from O3B, which has been central to the group's growth plans. Operational experience of the MEO operations, which represent the majority of new CAPEX over the next five years is welcome.*

"*Commercial and technical performance in this new area is the greatest uncertainty in forecasting SES earnings and CF going forward. Both are familiar to investors and the CFO has also served as Group CFO previously. The outgoing management have been tarnished by repeated earnings downgrades and withdrawal of guidance over the past 12months. SES stock has underperformed FSS peer Eutelsat by 23 percent in the past year.*"

Key challenges for Collar will be to explain how his appointment will change — and hopefully invigorate — the current suite of SES commitments and missions. Not the least will be the SES investment in a fleet of seven Boeing satellites for O3b's second generation of MEO craft (the **mPOWER** fleet) which will provide a step-change in bandwidth capacity for SES.

With the promise of 4,000 beams per craft, and more than 1 terabit/s output, this will be a spectacular addition to capacity. However, the investment tops $1 billion and will not fly until 2021 (although SES has canceled two 'conventional' GEO satellites that were in the original plan).

Senior Contributor Chris Forrester is a well-known broadcast 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 of 1998, Chris was appointed an Associate (professor) of the prestigious Adham Center for Television Journalism, part of the American University in Cairo (AUC).

Innovation: Solid State Amplifier with 21st Century Technology

A CPI Satcom Products Focus

By Douglas Slaton, Marketing Products Manager, and Mike Cascone, VP Technology, CPI SMP Division Satcom Products Group

The rapidly increasing use of gallium nitride (GaN) technology to power solid state amplifiers is well known in the market. This article discusses why the change is occurring and whether there is a place for the older gallium arsenide (GaAs)-based amplifiers.

From the early 1980s until just a few years ago, gallium arsenide (GaAs) field effect transistors (FETs) were the mainstay of the solid state high power amplifier (HPA) industry for radio frequency (RF) transmission.

Invented more than 30 years ago, the GaAs FET quickly gained acceptance over silicon-based devices due to its superior efficiency and ability to operate at much higher frequencies. In similar fashion, GaN FETs are now rapidly supplanting GaAs FETs for almost entirely the same reasons: better efficiency and the ability to operate at even higher frequencies. GaN FETs also outperform GaAs FETs in other key metrics, such as maximum temperature, gain, power handling, size and weight.

The adoption of GaN devices is occurring at a rapid pace, with foundries around the world racing to create new GaN devices. As a result of GaN technology's superior performance (when compared to GaAs) in almost every attribute critical to the satcom market, research and development funding for solid state amplifiers is almost exclusively directed toward GaN efforts. This migration to the new technology has been surprisingly quick, given the traditional product cycle lengths in the satcom industry.

A typical example of the reasons for the preference of GaN technology is demonstrated in **Table 1** on the following page.

CPI Model 7720H
100W C-band GaAs BUC

CPI Model 471H
100W C-band GaN BUC

At Ku-band, the results are also striking when comparing GaAs versus GaN. For the 40 W BUC comparison depicted in Table 2, GaN is again better by every key measure.

For Ka-band, the advent of GaN technology has enabled the design and manufacture of a 160 W amplifier, which provides four times the output power of the previous generation of GaAs ========== characteristics of this more powerful CPI amplifier are as follows:

Table 1.	Model 7720H 100 W GaAs	Model 4710H 100 W GaN
Power Input	AC Operation only	DC or AC option
Power Consumption at P_{lin}	450 W typical 700 W max.	300 W typical 420 W max.
P_{lin} (power level at which -25 dBc is achieved with regard to each of two carriers)	45 W	50 W
Prime to Output Power Efficiency at P_{lin}	10.0%	16.7%
Volume	0.88 m^3	0.505 m^3
Weight	7.6 kg	4.9 kg

- *Provides up to 100 watts of linear power over selected bandwidths (from 500 to 2500 MHz) within the 27.5 to 31.0 GHz frequency band*
- *Multiple bands available (Multiple LOs ; selectable with 1.0 GHz bandwidth)*
- *Multiple L-band input signal options for instantaneous 2.5 GHz output*
- *Designed for satellite uplink applications*
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The reasons why GaN is frequently superior to GaAs lie in the electrical properties of the materials, as illustrated in the following chart showing the three types of materials that have been used to manufacture FETs for HPAs used in satcom uplink applications, *i.e.*, silicon (Si), gallium arsenide (GaAs) and gallium nitride (GaN).

The first row of Table 3 compares the three types of FETs for relative permittivity (also known as the Dielectric Constant), or the impedance to RF currents. A higher number represents greater impedance, while a lower number represents lesser impedance. In terms of performance, the rate of signal loss is higher where impedance is greater. GaN is the clear winner here.

The second row, band gap, expressed in electron volts, is the energy range where no electrons can exist. It is also the energy required to promote a valence electron bound to an atom to become a conduction electron, which is free to move within the crystal lattice and serve as a charge carrier to conduct electric current. The lower the number, the less voltage it takes to start the movement of electrons.

As illustrated in Table 3, GaAs amplifiers make very strong semiconductors due to their small band gap and superior electron mobility, but these characteristics also make them weaker candidates for higher frequency and higher temperature operation compared to GaN-based products. Gallium nitride's band gap characteristic

Table 2 Ku-Band	40 W GaAs	40 W GaN
Power Consumption at P_{lin}	430 W typical 570 W max.	280 W typical 400 W max.
P_{lin} (power level at which -25 dBc is achieved with regard to each of two carriers)	15.8 W	20.0 W
Prime to Output Power Efficiency at P_{lin}	3.7%	7.1%
Volume	1.043 m^3	0.445 m^3
Weight	8.0 kg	4.5 kg

Table 3 Technology Comparison	Si	GaAs	GaN
Relative Permittivity (Er)	11.9	12.5	9.5
Band Gap (eV)	1.12	1.43	3.4
Electron Mobility (cm^2/V-sec)	1350	6000	1000
Critical Electric Field (MV/Cm)	0.6	0.5	3.5
Thermal Conductivity (W/^{P}K – cm)	1.5	0.54	1.5
Charge Density (x10^{13}/cm^2)	0.3	0.3	1.0

allows for operation at higher voltage. As the satellite industry is trending to progressively increased frequencies that require more power due to rain fade issues, GaN is by far the most promising material among the three.

When electron mobility, meaning the ease with which electrons can move through the semiconductor, is examined, as in row three, it is clear that GaAs technology is superior. High electron mobility results in a lower noise amplifier. For this reason, GaAs technology is still used in those applications where managing noise level is critical, such as in Low Noise Amplifiers (LNAs) or pre-driver stages. At the power booster stages, noise is less critical and provides the opportunity for GaN technology, with the already mentioned advantages in various parameters.

The critical electric field characteristic, expressed in megavolts per centimeter in the fourth row of the table, is also a measure of robustness. It measures tolerance against electric field stress. In this particular measure, the higher the number, the more robust the material is. GaN's higher rating indicates that GaN technology and materials are more tolerant to higher voltage operation than the GaAs equivalent.

The thermal conductivity comparison shows a superior ability by GaN and silicon to handle higher power than GaAs. And in the final comparison in **Table 3**, charge density measures the number of electrons that are available to charge per given volume: a higher number results in more output power per unit, resulting in a component and thus a smaller amplifier.

In the end, the measurements in the table demonstrate that GaN amplifiers handle heat, voltage and electric fields better; are more efficient; and can operate at higher frequencies while providing more output power.

GaN amplifiers are also superior to GaAs amplifiers when looking at overall system costs. Although individual GaN parts may have higher initial cost, overall cost reductions at the amplifier level are achieved due to better prime power efficiency and smaller size, enabling the amplifier supplier to incur less expense related to sheet metal, heatsinks and power supplies. Additionally, the cost of GaN MMIC parts has been trending lower over the last 10 years. These cost reductions are due in part to:

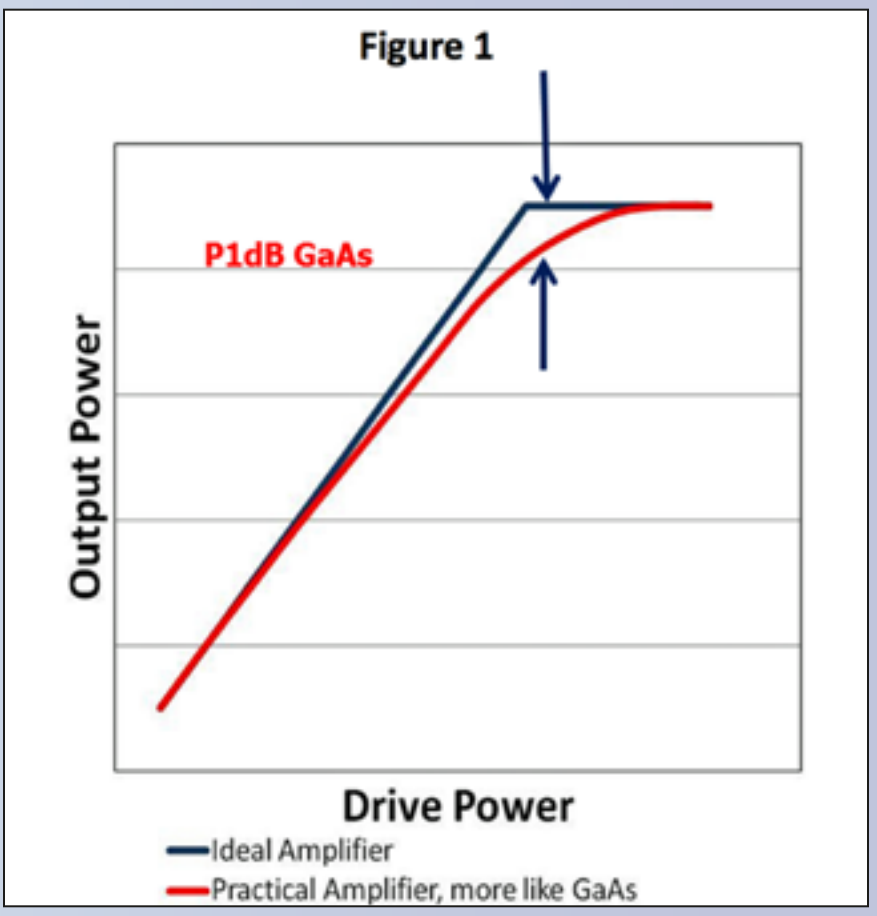
- *Process improvements enabling better yields*
- *Increase in user demand (volumes)*
- *Increase in competition among device manufacturers*

As an example, Communications & Power Industries (CPI) has seen a 50 percent reduction in the cost of 120 W C-band GaN devices between 2005 and 2014. These cost efficiencies are primarily driven by government funding of process improvements at the foundry level, with similar cost reductions occurring for GaN-based components and materials in the Ku- and Ka-band frequency ranges.

From a user or operator standpoint, RF performance is a principal measure for determining what amplifier technology should be selected. Users who compare GaAs to GaN often attempt to identify a common point of operation to make an equal comparison. The most common point chosen is the P1dB point, because almost every GaAs-based solid state amplifier or BUC produced in the last decade was specified with a performance at the P1dB point. However, due to the inherent differences between GaAs and GaN technologies, this P1dB point is not an accurate comparison metric, nor is it an accurate representation of the linear power capability of the GaAs-based amplifier.

The power at the P1dB point is occasionally misinterpreted as a measure of linear output power (or Plin). In practice, the P1dB mathematical metric is not relative to the ability of the device to transmit unimpaired signals. Rather, it is simply the point on a transfer curve where the gain has dropped 1 dB due to compression (see **Figure 1**).

Figure 1



To successfully transmit low bit-error-rate (BER) signals for most typical uplink applications, the user must operate below this P1dB point. For GaAs technology-based amplifiers, this operating point (to transmit low BER signals) has typically been at 3 dB below the theoretical P1dB point. Unfortunately, P1dB is used so frequently in the product marketing material that it is frequently confused with true linear power.

Linear power is more correctly defined as the point on the transfer curve where a meaningful parameter is reached. Such parameters are intermodulation (IM), spectral regrowth (SR), noise power ratio (NPR) or error vector magnitude (EVM), all of which have a real impact on the transmitted carrier or the adjacent channels which can be impaired. Adding to the confusion is the fact that some (but not all) GaN devices have a more gradual (softer) transfer curve than most GaAs devices.

This soft curve can falsely depict GaN devices as having a lower linearity, as the artificial P1dB metric is lower (See Figure 2). In fact, GaN devices have relatively superior efficiency and power, such that the linear power performance is actually better for GaN technology than GaAs technology.

The most common parameters where this can be seen are (see Figure 2):

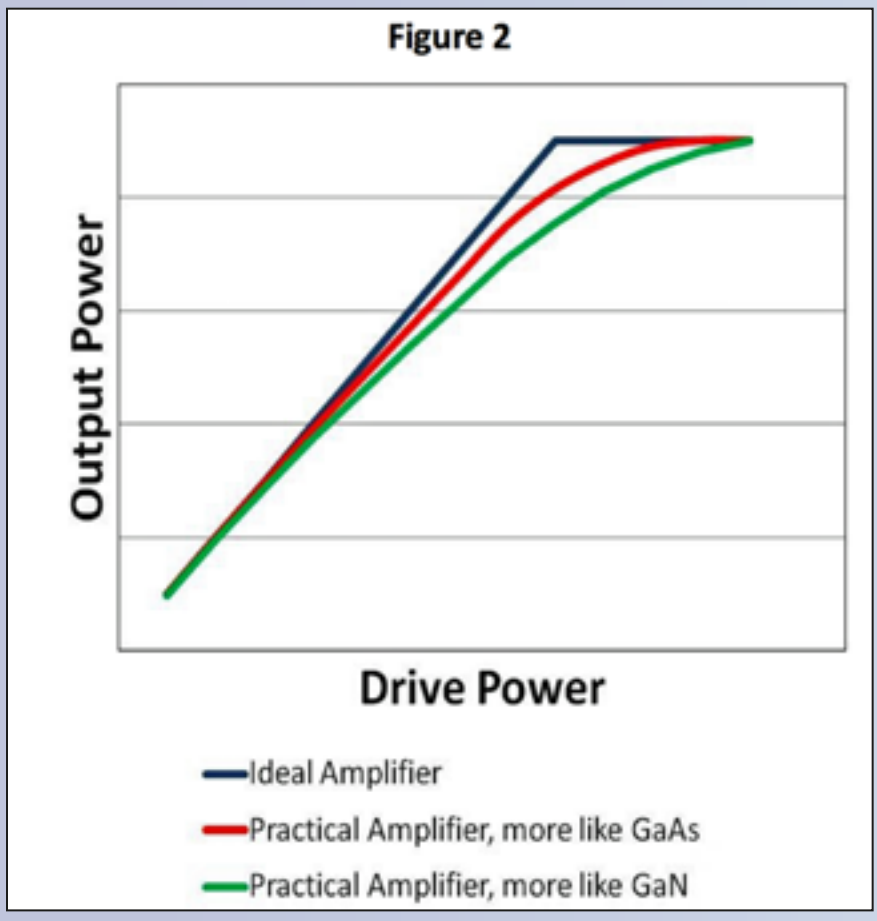
- *IM (2-tone Intermodulation)*
- *SR (Spectral Regrowth)*
- *NPR (Noise Power Ratio)*
- *EVM (Error Vector Magnitude)*

As a result of the inherent differences in the measures of GaAs technology versus GaN technology, as well as the resulting performance parameters that are key measures for performance, Satellite uplink operators and companies, such as CPI, are moving away from specifying P1dB on any Earth station amplifier product. Instead, they are simply stating the true linear power required based on IM, SR, NPR or EVM.

The following observations are clear when directly comparing the two technologies:

1. *GaN technology has enabled much higher output power and prime power efficiency than GaAs can achieve.*
2. *GaN amplifiers are smaller and lighter than GaAs.*
3. *The cost of GaN amplifiers is lower than GaAs amplifiers due to savings in the cost of housings, heatsinks and power supplies.*
4. *The P1dB metric is being replaced (especially for GaN products) by the more meaningful linear (Plin) measure based on Intermodulation, spectral regrowth, noise power ratio, or error vector magnitude depending on the application.*

Figure 2



To learn more about CPI's full line of GaN based SSPAs, as well as amplifiers using TWTA and Klystron technology, please visit our website at ***www.cpii.com/satcom*** *or download the CPI mobile app for Android or iOS.*

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CPI Model B5KO
160W Ka-band GaN SSPA/BUC.

Improving Space Systems Designs Using FPGAs with RISC-V Cores

A Microsemi Tech Focus

By Ted Marena, Director of Marketing, FPGA/SoC Marketing, and Ken O'Neill, Director of Marketing, Space and Aviation, Microsemi Corporation

Designers face many unique challenges when developing systems used in space that do not exist for terrestrial systems.

Among these are the need to ensure the trustworthiness of intellectual property (IP), overcome a lack of widespread industry support for radiation-tolerant devices, and amortize high design costs across low production volumes.

These challenges are particularly important when evaluating processors for space designs, and difficult to solve using a closed processor architecture. That is why designers are increasingly choosing the **RISC-V fixed instruction set architecture (ISA)**, in a major industry shift aimed at solving unique space system challenges while realizing other multiple and valuable benefits.

Understanding RISC-V

Processor options for space designs are limited to closed architectures such as ARM, RAD (Power PC), Leon, and SPARC varieties. Although it is unlikely these processors will lose popularity in the foreseeable future, the open RISC-V processor ecosystem is poised for rapid growth in the space community.

Because the RISC-V ISA is open, the design of the processor micro-architecture is flexible. Vendors are free to implement whichever architecture they deem best for their application. This allows broad innovation for designs that, for instance, have some operations accelerated in hardware, or perhaps require a processor designed for the lowest possible power consumption.

To enable broad use, the non-profit and member-controlled **RISC-V Foundation** opened the instruction set and also froze the base instruction set in 2014. This allowed the market to dictate what type of processor micro-architectures to develop. Thus, all the variations in a RISC-V micro-architecture are acceptable because the underlying ISA is open and fixed. Designers can now fully optimize a processor architecture for their specific requirements.

RISC-V for Space Applications

Space system developers can benefit from RISC-V whether their design uses a real-time OS (RTOS) or is a "bare metal" implementation for a virtualized environment.

RISC-V code written today will be compatible with RISC-V processors developed years in the future, enabling designers to seamlessly migrate from one RISC-V core to another. Most other processors typically add instructions with each new generation, which forces the designer to recompile and update software. However, because the RISC-V instruction set is frozen and eliminates this requirement, the space market can rapidly adopt RISC-V as a new standard open architecture for direct native hardware implementations. That is one of the main reasons RISC-V is attractive for the space market; however, there are additional factors that make RISC-V a better choice than other processor architectures.

First, *RISC-V-based designs add trust to IP* by giving designers the option to view the register transfer level (RTL) code — something that cannot be done with closed processor architectures. One example of this capability is **Microsemi**'s family of RISC-V IP cores for the company's RTG4 radiation-tolerant FPGAs (see Figure 1). These 32-bit RISC-V IP cores and the source RTL code are available for users.

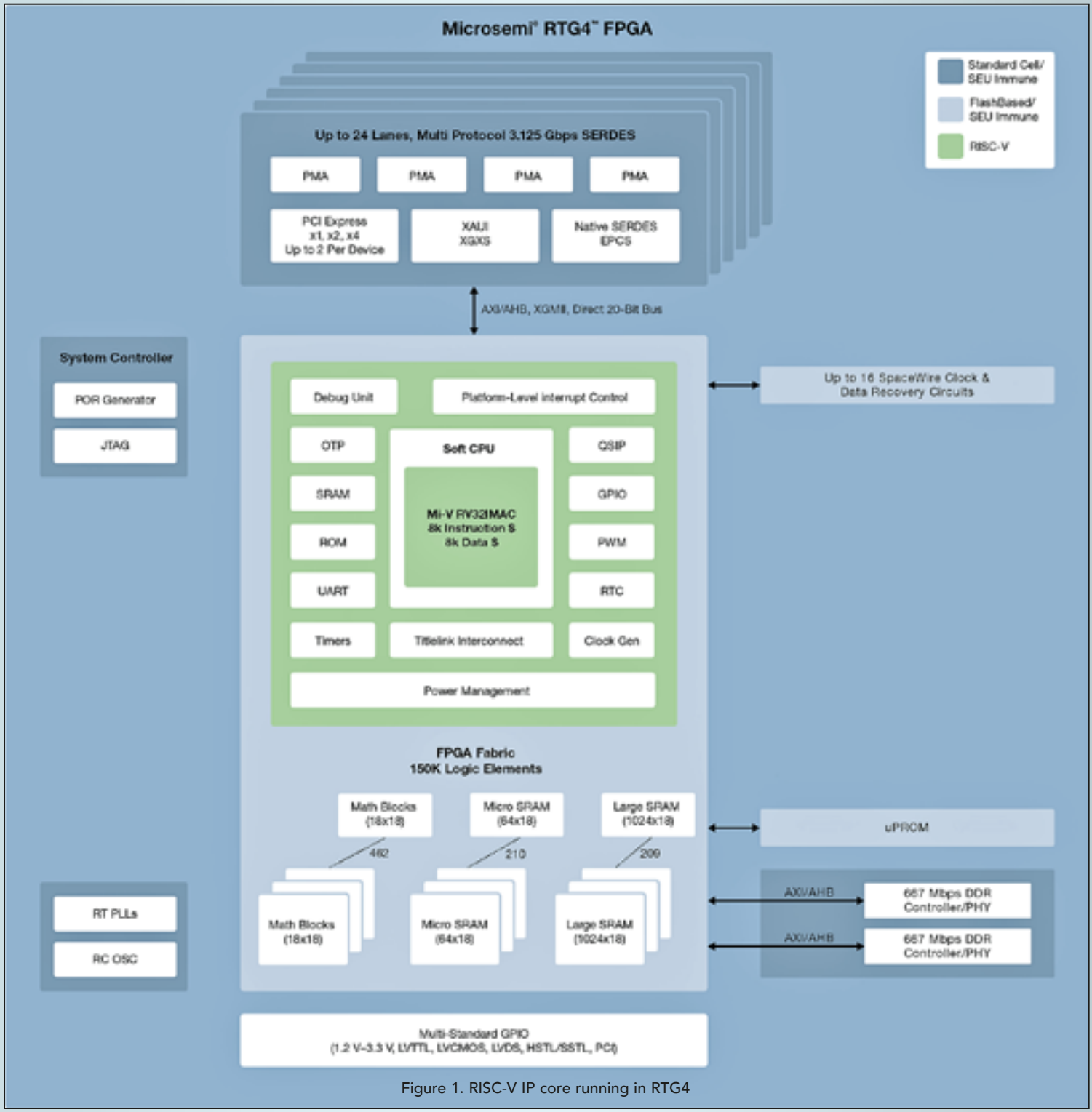


Figure 1. RISC-V IP core running in RTG4

With the ability to inspect the RTL, designers can ensure that the IP contains only intended functions and does not contain RTL code with malicious intent.

In this way, program supply chain risk assurance management objectives can be met. The initial RISC-V IP for RTG4 runs at 70 MHz and consumes only 8 percent of the logic resources provided in the RTG4 FPGA. RISC-V is not limited to 32-bit implementations; a 16-bit compressed instruction set as well as a 64-bit and 128-bit ISA are also available and ratified.

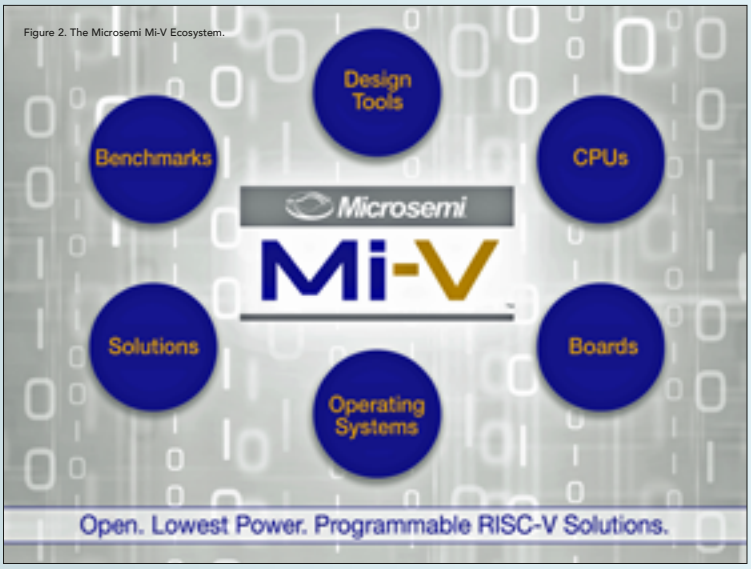
A second additional benefit of the open ISA is that ***RISC-V creates a "royalty-free" processor sub-system***. As the RTL code is available in RISC-V IP cores, designers have the flexibility to modify and implement designs in any hardware, for multiple applications or environments.

For example, designs that operate in deep space generally require the latest radiation-tolerant FPGA architectures to protect them against harmful single event and total dose effects. In contrast, designs used in the less demanding environments of sub-orbital space and certain Low Earth Orbit (LEO) craft can sometimes use a different FPGA with designer-instantiated triple-redundancy mitigation techniques where needed and don't have the same stringent quality conformance inspection and QML manufacturing flows.

Clearly, the development of different designs for each market is preferable, using different FPGAs. It is much easier to do this with royalty-free RISC-V cores, which only require a free **Berkeley Software Distribution** (BSD) software license that imposes minimal restrictions on IP use and redistribution.

Longevity is the third major benefit of RISC-V, which enables designers to rely on the fixed ISA and preserve software investments across multiple implementations. Because the RISC-V ISA is fixed, space designs that are often expected to be reused over periods of several years, or even decades, can depend on software continuity. Once the software code is written and validated, it can be run on any RISC-V core forever.

Figure 2. The Microsemi Mi-V Ecosystem.



The initial manufacturing can be completed with a soft RISC-V core in one FPGA and the code will be completely compatible with a future FPGA implementation, or even an ASIC. As the design of modern systems tends to rely increasingly on software, the ability to reuse previously validated and deployed software code from one generation of a system design to another can result in significant cost and schedule savings.

Leveraging a RISC-V Ecosystem

The value of RISC-V can be enhanced through an ecosystem of devices, cores and development tools. One example is Microsemi's recently announced **Mi-V RISC-V** ecosystem, which contains the first FPGA-based open architecture RISC-V IP core and a comprehensive software integrated development environment (IDE) solution called SoftConsole (**see Figure 2**).

A RISC-V ecosystem makes it easier for space designers to deploy a RISC-V IP core in multiple flash-based FPGAs. Designs requiring high security, for instance, might require an FPGA that enables storage of the boot code for soft core in secure NVM, preventing malware or a root kit from being installed in the system. Embedded engineers can leverage the benefits of the ecosystem's RISC-V IP in their custom FPGA designs by using design suites that incorporate numerous third-party tools. The Mi-V ecosystem's Soft Console IDE, for example, includes the **ThreadX RTOS** that **Express Logic** has ported to RISC-V, and an instruction set simulator for the Mi-V RISC-V IP core that **Imperas** has recently introduced.

Another important ecosystem feature is a set of reference designs for evaluating a RISC-V core and writing software executable code. For software code development, the IDE should ideally be hosted on a Linux or Windows platform and provide complete development support, including a C or C++ compiler and complete debugger capability.

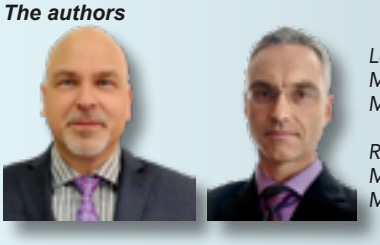
With the mainstream adoption of RISC-V, space designers now have an alternative processor architecture to consider. The advantages of trusted IP, open RTL, and lower costs can benefit virtually every space application. Customers can also count on the fixed ISA to ensure software compatibility and longevity of the architecture.

The RISC-V processor is also compelling for applications where inspection and stringent certification is important. These and other benefits of RISC-V cores are enabling a new generation of innovation for space designers.

For background information about RISC-V and its member organizations, visit ***www.riscv.org***.

If you are ready to initiate a design and start RISC-V core coding, head over to Microsemi's Github site, ***github.com/RISCV-on-Microsemi-FPGA***.

The authors



Left: Ted Marena is the Director of Marketing, FPGA/SoC Marketing, at Microsemi Corporation.

Right: Ken O'Neill is the Director of Marketing, Space and Aviation, at Microsemi Corporation

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Flawless Broadcast Delivery to FPAs on Moving Vehicles

KenCast Innovative Input

By William Steele, President, KenCast

Emerging LEO and MEO constellations are poised to bring high-throughput and low-latency connectivity to moving vehicles around the world.

Unlike geosynchronous (GEO) satellites, which orbit about 22,000 miles above sea level, MEO and LEO satellites orbit as close as 1,200 miles. This relative proximity to Earth dramatically reduces their cost and signal power requirements.

Delivering large files and live video streams to cars, planes, trucks, ships, trains and other vehicles on-the-move is a massive market opportunity.

To realize this potential, these constellations must master the reliable delivery to low-cost, smart, phased array antennas (a.k.a. Flat Plate Antennas, FPAs), which can be stationary or mounted on moving vehicles.

FPAs are small, ultra-thin and flat, without any moving parts. Instead of aiming a physical dish, FPAs use electronic beam steering to pick up a signal.

However, early tests reveal that these beam steering, phased array antennas need to improve if they are to be fully market-ready. To be fair, the problem is extremely challenging:

- *Both the transmitter and receiver are moving. For example, LEOs orbit at 17,500 mph.*
- *Inclines can create elevation angle issues, and tunnels will interrupt the signal altogether.*
- *Bad weather — especially rain clouds — can corrupt the signal.*
- *The satellites are small and use less power, so the signal is accordingly weaker*

What's more, a broadcast can be captured using readily available tools. Sensitive content, then, must be secured with strong encryption (for example, 256-bit AES). But this places an even higher premium on reliability, as small errors can render encrypted content undecipherable.

The economic advantage of satellite networking is partly a result of its one-way nature, which keeps costs down by not requiring a return link. While terrestrial networks check for errors end-to-end and can request corrupted or missing data to be retransmitted, one-way networks can't interact with the sender — it is then essential that data is transferred such that all recipients can autonomously recover from transmission errors. This is called **Forward Error Correction**.

Fortunately, **KenCast** has been solving problems like these for more than 20 years. The company's patented, innovative Forward Error Correction (FEC) software uses sophisticated algorithms to securely encode content such that it can be perfectly reconstructed by the recipient — even when the signal has suffered corruption, interruption or excessive fading.

Fazzt FEC is a KenCast-proprietary set of methods for forward error correction and is protected by multiple patents and is the most efficient and economical way of assuring that transmissions are received in perfect condition the first time they are sent.

The company's **Fazzt® Digital Delivery System** securely delivers content over satellite and terrestrial networks directly to authorized computers at up to thousands of sites. Fazzt (pronounced "fast") reliably delivers streams and large files of multimedia content at speeds in the Gbps-per-channel range, using advanced error correction, compression and validation.

KenCast's innovative approach is showcased by **Fazzt Forward Error Correction** (**Fazzt FEC®**), a patented method that ensures payload integrity, despite rainy weather, the lack of return links or randomly visible recipients. Fazzt reliably delivers end-to-end, network-to-network, from content provider through to the end-user, including mobile recipients.

Fazzt FEC provides flawless digital delivery for file transfers and live streams, with minimal overhead or delay. Operators can select from multiple FEC modes — FECv2, Braided or Compound for files; FECv3 for live streams; and can extend protection across multiple channels or subchannels.

Fazzt FEC uses complex mathematics to analyze a given block of data packets and generate a set of supplemental packets, 3 to 8 percent of the size of the original block. As long as the number of missing or corrupted packets doesn't exceed the number of supplemental packets, the receive side can perfectly recreate the original data block (*e.g.*, file or stream segment) from any combination of valid packets.

Most satellite operators use a different form of FEC, called error detection and correction (EDAC). EDAC schemes generally operate at the bit level by adding enough redundant bits to the data to correct bit — level errors (*e.g.*, Reed - Solomon, Viturbi).

However, these are not robust enough to correct the vast majority of packet-level errors addressed by Fazzt FEC.

Most of the Fazzt software modules can be downloaded and installed on supported Windows and Linux based systems, or purchased as a turn-key **EdgeSpan®** appliance. The company can also pre-install and configure the software on bare-metal servers.

An industry-leading low overhead of 3 to 5 percent is added to the original file size and voids the cost of two-way satellite networks (*e.g.*, VSAT) and multiple transmissions.

The KenCast technology could be a real boon for FPAs while they experience their growing pains. KenCast's FEC could compensate for their early challenges and, potentially, bring them to the mass market many months ahead of current schedules.

If you are interested in adding security and reliability to your digital delivery solutions, please contact ***wsteele@kencast.com***.

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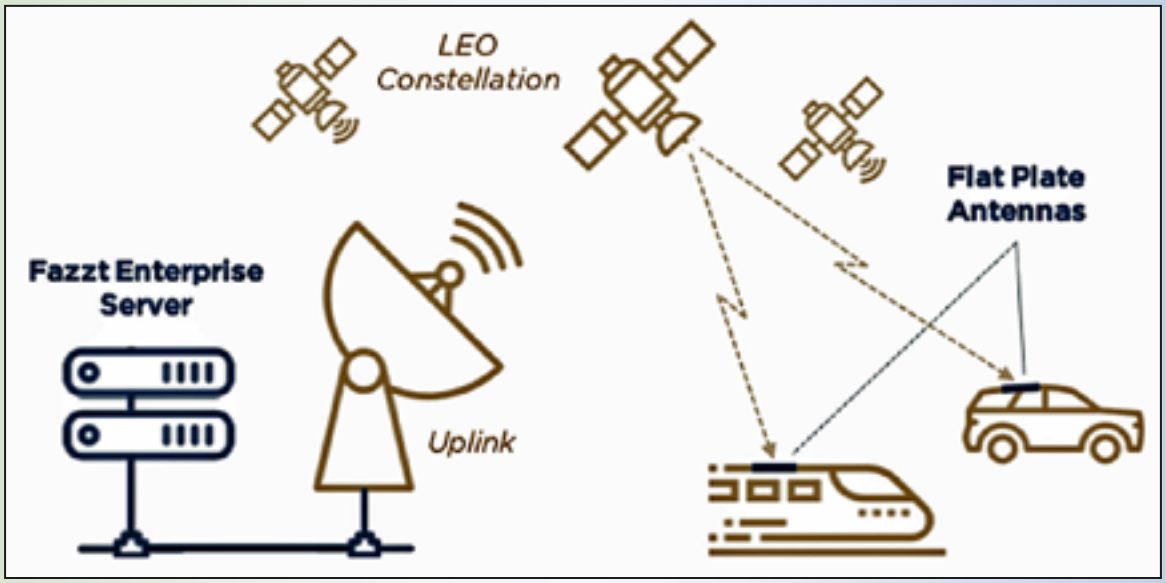


Grasping the In Orbit Servicing Opportunity

An NSR Report

By Carolyn Belle, NSR Analyst, USA

As the space industry looks toward a future built on diverse and resilient architectures, rapidly evolving demand, fast technology development, and multifaceted economic activity in-orbit and beyond, servicing spacecraft is a key capability to bring along for the ride.

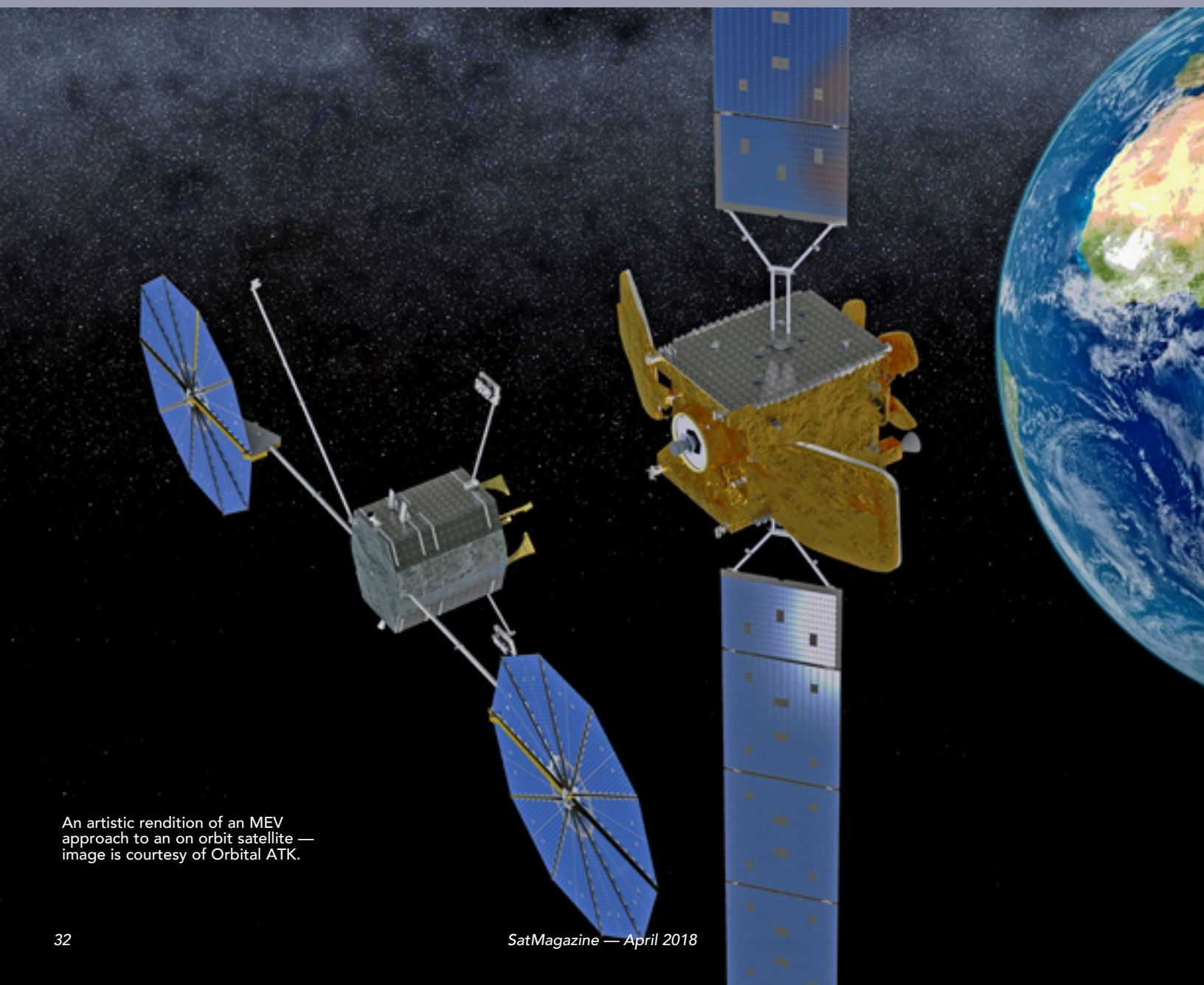
Applications envisioned have the potential to both ease historic pain points for satellite operators and open new possibilities to the space industry, delivering value at multiple places in the chain and making in-orbit servicing (IoS) an opportunity to be grasped.

Recent high-profile announcements highlight the race to deliver multiple capabilities to a market primed for fresh solutions.

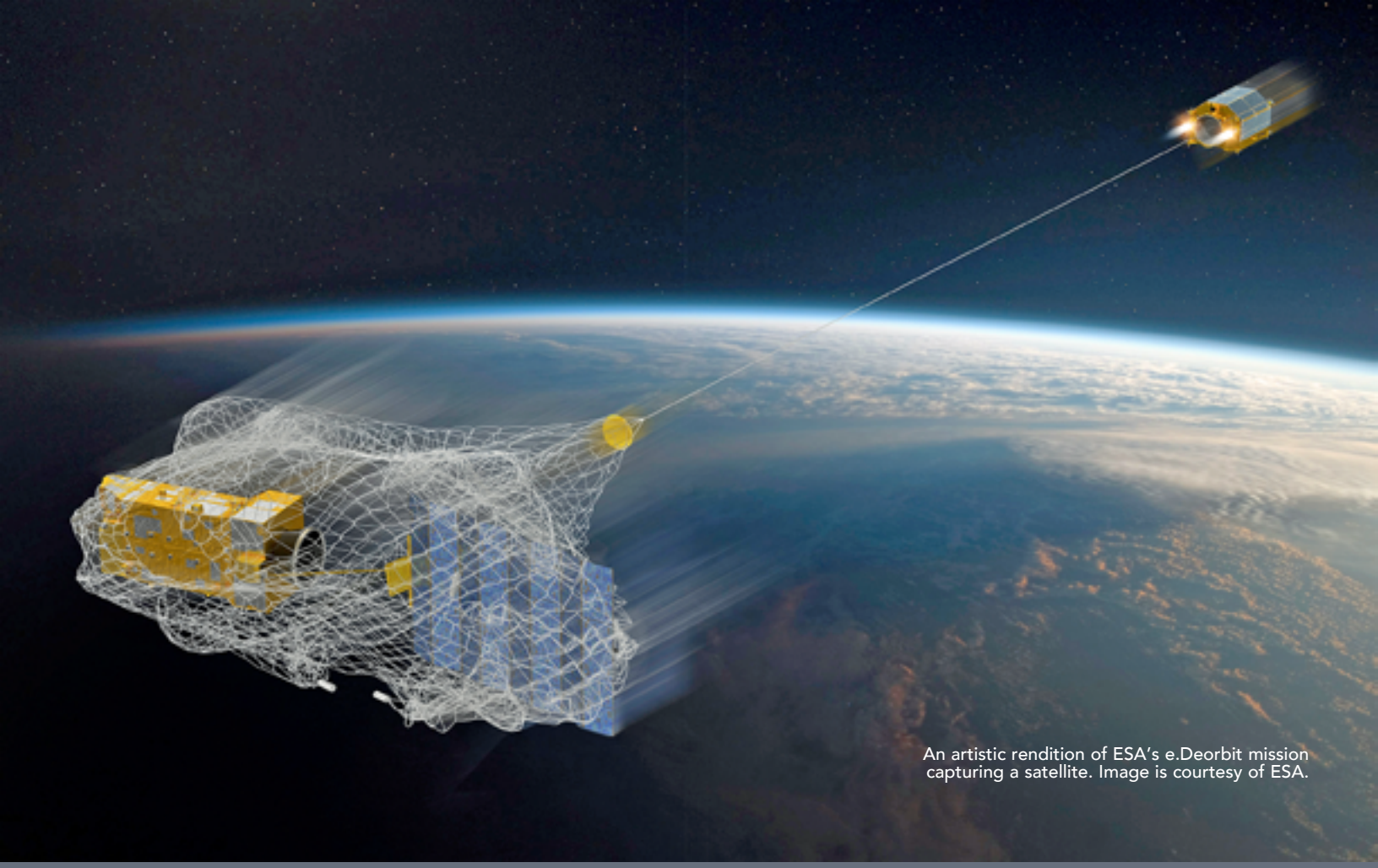
Orbital ATK has announced the expansion of their **Mission Extension Service** (MEV) to include two additional components, paving the way for more complex robotic services down the line.

ESA, likewise, shifted gears on their planned **e.Deorbit** mission, prioritizing development of robotic arm capabilities for satellite servicing over the initial focus on R&D of net technology for debris removal.

SIS and **Effective Space Solutions**, as well as a handful of LEO operators, maintain robotic capabilities as a key component of their initial services or product roadmap.



An artistic rendition of an MEV approach to an on orbit satellite — image is courtesy of Orbital ATK.



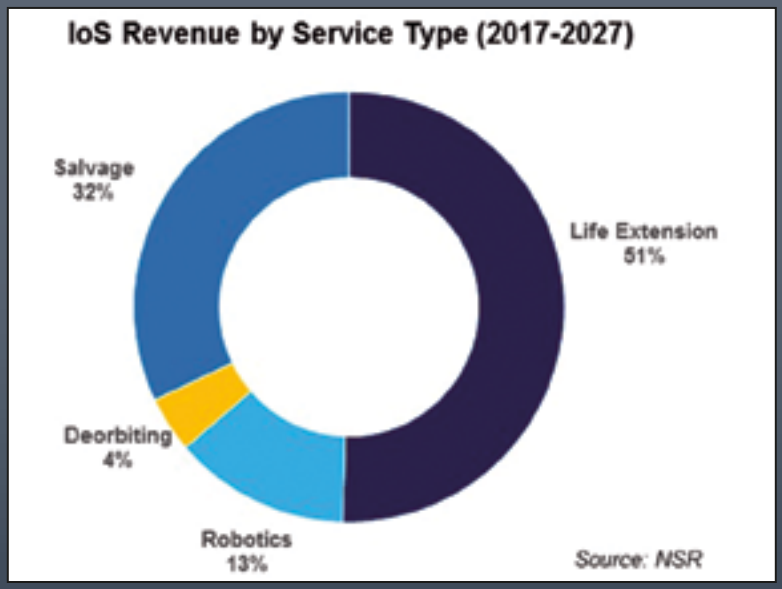
An artistic rendition of ESA's e.Deorbit mission capturing a satellite. Image is courtesy of ESA.

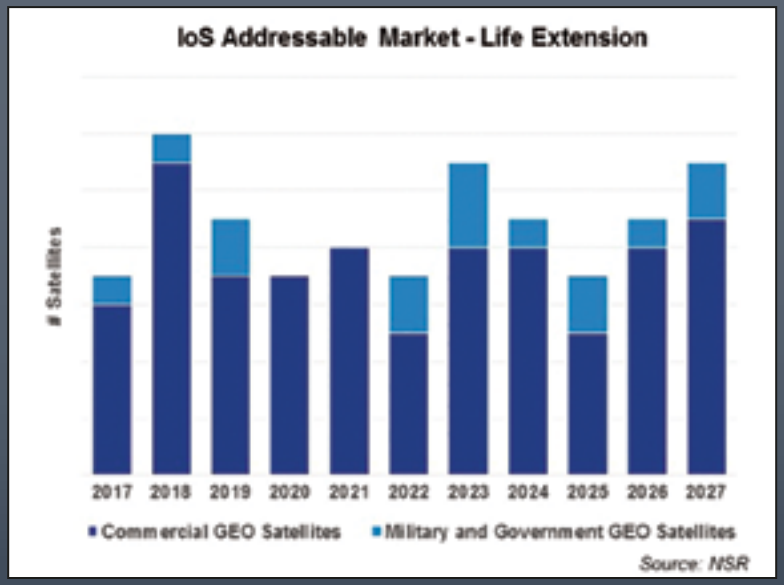
The market is nascent but offers diversity and looks quite promising: NSR's *In-Orbit Servicing Markets* report forecasts revenue from servicing contracts to generate a cumulative $3 billion by 2027, growing at a 62 percent CAGR from start of operations in 2019.

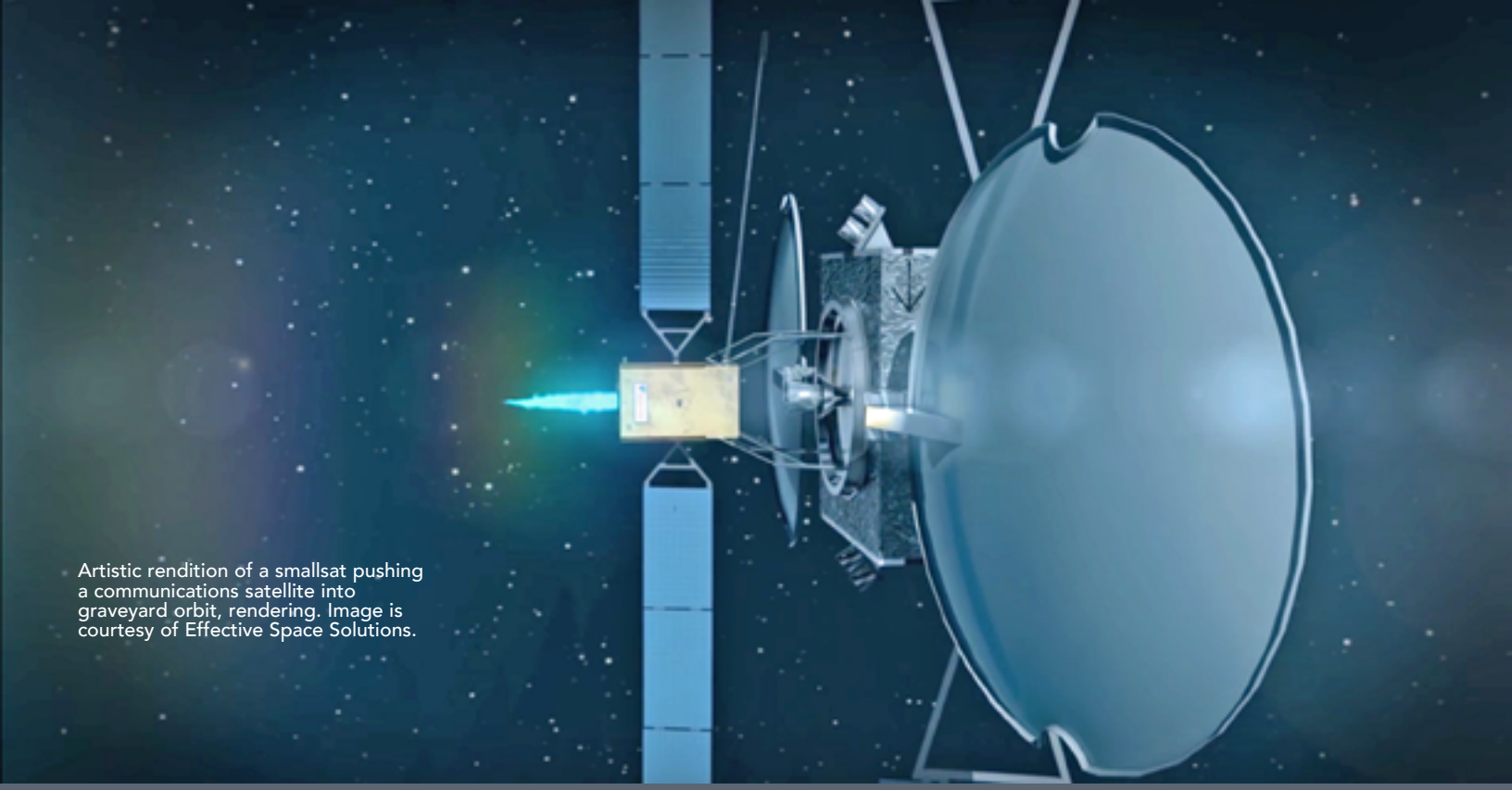
Life Extension is the most widespread market and will be the bread and butter of IoS providers in the near term. With 240 satellites reaching End-of-Life (EOL) in the next decade, and an estimated 90 as candidates for servicing, *the addressable market already exceeds near-term supply*.

As commercial operators continue to struggle with declining capacity prices and uncertain growth in revenues, if IoS providers can hit the correct price point the *appeal of deferring or reducing CAPEX* and decision making will drive an average of nine life extension missions per year.

While Life Extension drives demand, Salvage drives revenue: with only percent of total market demand, salvage is expected to generate as much as 32 percent of revenue.







Artistic rendition of a smallsat pushing a communications satellite into graveyard orbit, rendering. Image is courtesy of Effective Space Solutions.

Salvage of a satellite following maldeployment by the launch vehicle or other inability to reach the operating orbit presents the most opportunistic, but most compelling, value proposition for IoS.

With the satellite operator and insurer otherwise facing a full satellite loss (+3-year delay for a replacement) and payout, IoS providers will be able to charge a premium to recover the asset.

The Robotics market demonstrates more long-term potential, expected to be slow to develop since satellites in orbit today are not designed to be robotically manipulated or augmented.

Early use cases will be fixing mal-deployed antennas and solar arrays, but as operators look to more flexible, next-generation satellite designs and space architectures enabled for such manipulation, demand will diversify.

As this dynamic evolves in the 2020s with new satellite orders, by the end of the decade, the addressable market and revenue will grow above the forecasted 13 percent share for the intervening period to be a much more robust segment of the market.

De-orbiting offers only a limited revenue opportunity, attractive more for the incremental business to keep IoS vehicles busy between other contracts than as a business case of its own. Few operators will be interested in trading OPEX for the couple months of station-keeping fuel that would otherwise be used to place a satellite in the graveyard orbit.

Onboard failures that make orbit raising impossible, or delays in launching a replacement satellite that obligate an operator to dip into the fuel reserve, will drive occasional use of this service.

As the space industry works to sustain profits and remain competitive in the evolving global economy, innovative solutions that enable more flexible use of in-orbit assets are increasingly appealing.

The prospect of satellite servicing offers value on multiple levels to operators and will only grow as more complex capabilities are integrated into space architectures.

While many satellites in orbit today will not be candidates for servicing, between sustaining life extension contracts and opportunistic, high value salvage contracts, there is a solid near-term market opportunity for emerging IoS providers to grasp.

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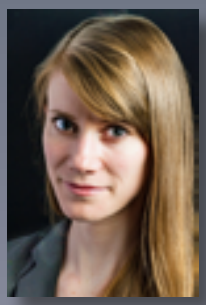

Carolyn Belle focuses on satellite manufacturing, launch, and in-space activity, and in particular the trends surrounding creation of diversified space architectures. She participates in commercial, civil, and government projects, serving as NSR's lead analyst for manufacturing and launch market dynamics. She built NSR's practice in small satellites and emerging markets like satellite servicing, engaging with start-ups globally to create a robust research base on new applications and ways of leveraging space. Ms. Belle regularly contributes to diverse tailored consulting projects in these areas, lending expertise to feasibility studies, analysis of competitive dynamics, satellite procurement assessments, and addressable market sizing for both start-ups and industry leaders.

Ms. Belle has been with NSR since 2014, coming from the D.C.-based Research and Analysis team at the Space Foundation. Her research efforts focused on new and emerging space products and services, as well as an exploration of the policy considerations and efficacy of collaborative space endeavors such as the International Space Station.

Ms. Belle has previously engaged in astrobiology research at the NASA Ames Research Center. She holds a Bachelor's degree from The Colorado College with a focus in Biology and Chemistry and completed the International Space University's multidisciplinary program in Space Management. Ms. Belle has been active in leading STEM outreach initiatives such as Yuri's Night and Cool Science as well as efforts to strengthen women's roles and recognition within the space industry.

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Revolutionizing the Use of LEO Satellites and Drones

A GateHouse Perspective

SB-SAT technology is still at its early stages of adoption and could spread massively to LEO satellites — the technology could also find widespread applications in military-grade drones.

Lars Christensen, Chief Architect at SATCOM test company **GateHouse Telecom**, looks at the possibilities of SB-SAT technology and how an already proven Protocol Stack could open up many new opportunities and applications for the satellite industry.

The use of smallsats in LEO have, for many years, been limited by the short ground station overpass time (around ten minutes per overpass). The use of LEO satellites for real-time applications have, therefore, been restricted.

Delayed data may be acceptable in some cases, but in other situations, the delay invalidates the use and relevance of transmitted data. The limited overpass time causes satellites to store and prioritize large amounts of data until they can be transferred to a ground station and then on to the user.

However, both the issue of time-sensitivity and amounts of data to be transmitted can be addressed by enabling longer or more frequent overpass times and increases the opportunity for satellites to 'dump' collected data.

If higher connectivity was to be obtained by establishing more ground stations, this would be an overwhelming investment. How can connectivity be increased purely with software within the boundaries of an existing physical network?

What is SB-SAT?

With **SwiftBroadband for Satellite** (SB-SAT), LEO satellites gain data connectivity via L-band frequencies on the **Inmarsat I4** satellite constellation in Geostationary Earth Orbit (GEO). The Inmarsat I4 satellites relay data through Inmarsat ground stations to users or operators making full use of Inmarsat's mobile broadband system infrastructure.

SB-SAT technology enables new use cases for LEO satellite missions by providing connectivity in all of Inmarsat's I4 near-global coverage. Smaller and cheaper LEO programs can leverage satellites that stay in frequent communications contact without the cost of building an extensive ground station infrastructure around the globe. By significantly increasing connectivity, the use of LEO satellites will undeniably increase both in terms of volume and variety.

How Does SB-SAT work?

SB-SAT is an on-board satellite modem based on the **SwiftBroadband** satellite connectivity solution by Inmarsat for aeronautical use.

A variant of the SwiftBroadband specification has been built as a joint effort between Inmarsat and partners that enable use in LEO. The satellite modem provides IP data connectivity when the satellite is under coverage of one of the currently four Inmarsat I4 satellites.

The Inmarsat I4 satellites relay data through Inmarsat ground stations to users or operators making full use of Inmarsat's mobile broadband system infrastructure.

The terminal uses a steerable antenna and GPS data to point to the visible I4 satellites, logs on and activates a data connection. Now the terminal is on-line and can provide IP data connectivity up to 492 kbps.

The terminal seamlessly handles handover between the 200 narrow spot beams of each Inmarsat I4 satellite. As the relative velocity of a LEO satellite is much higher than the normal aeronautical use case for Inmarsat terminals, the terminal intelligently predicts when the handover is required and initiates negation with the ground station ahead of time such that the handover is done successfully before the signal of the previous spot beam is lost.

When the terminal enters coverage of a new GEO satellite, a re-pointing is required. This, again, is a predictive process, but will take a few seconds while the antenna is rotated, signal re-acquired and terminal logs on to the new satellite and ground station.

While the existing Inmarsat SwiftBroadband terminal already has provisions for handling Doppler shift and precise burst timing, conditions are relatively much more challenging in LEO.

The SB-SAT terminal has been built and extensively tested under worst-case conditions of Doppler shifts up to 50 kHz and burst clock timing shift rates of 54 microseconds per second. Under these conditions, the satellite terminal requires special predictive handling of Doppler compensation and burst link timing, compared to an aeronautical terminal.

How Can SB-SAT Create Value?

In an Earth imaging mission with a limited number of ground links, a traditional LEO mission will have only ground connectivity for 10 to 15 minutes each time a ground station is passed.

This can happen as rarely as only a few times a day with at least 90 minutes between each pass in the best case if just one single ground station is available. This limits the ability to react to new data from the satellite and best utilize the limited on-board storage capacity and downlink capacity.

With real-time access to the satellite provided by SB-SAT, low resolution data can be downloaded continuously via the SB-SAT link.

A ground operator can decide which data is the most interesting and command the satellite to take high-resolution imagery of an area of specific interest. This could be downloaded via the high-speed dedicated ground link when the ground station is passed.

This completely changes the reaction time window and ability to best utilize a satellite's orbit and storage capacity, enabling entirely new use cases that were previously not possible.

Addressing New Opportunities in SB-SAT

Over the years, GateHouse Telecom has been a significant contributor to the development and realization of SB-SAT technology through the company's **BGAN Protocol Stack**.

Currently, more than 80,000 BGAN terminals use GateHouse software. By using the company's widely used BGAN Protocol Stack, the satellite industry can address new opportunities and applications in space.

SB-SAT technology enabled by the GateHouse Protocol Stack will provide unprecedented connectivity for LEO satellites and drones faster, at much less cost and with less risk compared with developing a custom communications solutions from scratch.

gatehouse.dk/

GateHouse Telecom A/S is a wholly-owned subsidiary of the GateHouse Holding Group. For more than a decade, the company has provided the satellite communications industry with a range of testing and software products for commercial, government and military use. GateHouse Telecom also offers consultancy services for software, hardware and system integration, as well as for the preparation and evaluation of international tenders.

Training 12,000 Employees Via the Cloud

A GLOBECOMM case in point

By Paul Scardino, Senior Vice President, Sales Operations/Engineering and Marketing, GLOBECOMM

The challenge — to replace a legacy satellite distance learning platform with a state-of-the-art system that would make training content available anywhere at any time, mix live and pre-recorded content in an easy-to-navigate format and deliver significant cost savings.

The Solution

The GLOBECOMM Tempo enterprise cloud platform provides managed video as a service (MVaas) for secure delivery of live and on-demand content across corporate networks and the public internet, with modules supporting content management, media assets, event scheduling and production, encoding, delivery, metrics and network management. The are a number of benefits incorporated into the Tempo system:

- *25 percent annual savings on a platform capable of reaching all 12,000 employees on any device*
- *Greater employee engagement in live and on-demand content*
- *Flexibility to manage live events on-the-fly up to the time of the event*
- *Major improvement in the speed and ease of content re-purposing and creation*

Moving Training to the Cloud

You may not have heard of **Rollins Corporation**, but you probably know their brands. From Orkin and HomeTeam to Western Pest Services, the company provides pest control and protection to more than two million customers from more than 700 locations worldwide.

The company's success is based in part on a deep commitment to employee training delivered by Rollins University, which the company considers a strategic resource that gives it a competitive advantage in the market.

Until 2006, Rollins University used a combination of classroom instruction, pre-recorded content on disk and printed material to keep its employees up to date.

In that year, the university launched a live distance-learning network over satellite, which was the only technology that could deliver enough bandwidth to branch locations. It did the job — but it required costly terminal equipment at each location, had limited interactivity and was rapidly falling behind newer distance-learning technologies reaching the market. The company was also growing internationally, reaching 12,000 employees, and faced a decision to either expand their system or find something better for their training processes.

Four-Screens, Greater Engagement

The university wanted to stop letting technology dictate how employees could consume training content. They wanted a multi-screen approach: consumption and interaction with content via big-screen TVs in training and break rooms but also on desktop computers, laptops, tablets and smart phones. They knew that training is not about pushing content at employees; training is about what employees actually learn. The more accessible the content, anywhere and at any time, the greater the impact.

The university staff had other items on their wish list. They wanted to mix live and prerecorded content in a single, easy-to-navigate platform that delivered significant cost savings over the legacy satellite network. The search for a vendor that could take their training to the next level led them to one product: the Tempo enterprise learning and corporate communications platform from GLOBECOMM.

Complete Cloud-Based Solution

Tempo is an enterprise cloud platform that offers MVaaS for secure, delivery of live and on-demand content that is accessible by authorized users from any screen or device located anywhere in the world. Tempo can integrate into existing enterprise networks or leverage Globecomm's global content distribution network (CDN), consisting of satellites, teleports and fiber. For university staff, however the network technology was incorporated was secondary, but what mattered was Tempo's ability to provide full control of a powerful, easy-to-navigate platform for content delivery to any screen or device.

Tempo consists of modules that meet every requirement of corporate training and communications:

- *A Learning Content Management allowing for cross-platform content creation using templates to ensure portability and high re-usability. A Media Asset Management system that stores and indexes approved content for search and distribution*
- *An Event Scheduling interface for managing live and on-demand class sessions*
- *Live Event Production with the ability for users to call or use text chat to ask questions, and interactive polling to test skills and retention*
- *Near-real-time calculation and display of metrics, which enables the university to quickly improve training effectiveness*
- *Digital encoding of content for best performance on multiple devices*
- *Content delivery with audience tracking and metrics*
- *Network and device management across the network*

The university implemented Tempo as a cloud service, in which the Tempo software modules and all content is securely hosted on GLOBECOMM's private cloud, available to university staff with a single sign-on. Cloud implementation eliminated up-front capital costs and the risks of equipment obsolescence.

Delivery to Rollins' employees occurs over the corporate MPLS network, where advanced multicast streaming technology minimizes bandwidth consumption. That reduces strain on the network for live sessions and lets users efficiently stream content from the library at any time. Locations that are not on the core network can access the same content over the internet through GLOBECOMM's CDN.

Flexibility, Engagement and Savings

"*We now have a platform to reach the entire Rollins population,*" said ***Craig Goodwin***, director of training. "*The company can leverage economies of scale, and improve uniformity and consistency of learning throughout the organization.*"

The Tempo system also provided Rollins with the flexibility and engagement that were at the top of its priority list. "*We do more than 600 live events in a single year,*" said ***Ramiro Banderas***, Director of Media Services. "*If you do live events, you know that things change up until the last minute. This system is dynamic enough that we can make changes on the fly right before the event starts. That's huge for us. GLOBECOMM also created two IOS apps for us, one for live and one for on-demand. Employees can watch an event on their device as well as on TV, and that drives real employee engagement.*"

What about cost savings, the final item on the list? "*Tempo let us make two technology changes that made a difference,*" said Mr. Banderas. "*We were able to start using off-the-shelf display devices in our branch locations instead of proprietary hardware. More important was the decision to take all the processing that we used to do at our headend and move it to the GLOBECOMM cloud. Those changes let us reduce our annual cost by 25 percent.*"

www.globecomm.com/broadcast-video/enterprise-learning-corporate-communications/

Author Paul Scardino is GLOBECOMM's Senior Vice President, Sales Operations/Engineering and Marketing.

A Conversation With...

Rob Alexander, Executive Director, International Institute of Space Commerce (IISC)

Rob Alexander assumed the role of IISC's Executive Director in June of 2017. He has worked in various human space flight projects for the last 20 years, including the Space Shuttle and International Space Station programs in various capacities. He has also worked at United Space Alliance (a joint venture between Boeing and Lockheed Martin), McDonald Dettwiler (the Canadian space robotics company), and Science Applications International Corporation (an international engineering and science contractor).

Rob was in the private space sector for several years as a member of the NanoRacks team in Houston, Texas. Most recently, he has been involved with the secondary payload cubesat deployment system on the Space Launch System as an employee of Bastion Technologies at the Marshall Space Flight Center in Huntsville, Alabama, USA.

Mr. Alexander has a Bachelor's degree in Aerospace Engineering from the University of Texas at Austin, as well as a Master of Space Studies degree from the International Space University.

Rob Alexander, the Executive Director of the International Institute of Space Commerce (IISC), discussed the upcoming 35 Under 35 Awards with _SatMagazine_.

For the first time, the IISC is recognizing 35 individuals in the space industry who are under the age of 35. Nominations are open now and may be submitted via the IISC website located at ***http://iisc.im***.

How did the idea for the 35 Under 35 come to fruition?

Rob Alexander (RA)
The idea materialized when I became Executive Director last year. The IISC has been around for more than 10 years and has existed as a think tank tasked with furthering the cause of the commercial space sector.

As I got my head wrapped around my new role in the organization, it became apparent to me that we needed more than a think tank; we needed an organization at the center of it all to provide support to those who are trying to make a business in space without competing for their own share of the profits. Hence our rebranding

of the Institute as "*the Chamber of Commerce to the Cosmos.*"

We're still fulfilling the think tank role. In fact, we're very proud of the **Lunar Economic Action Plan** (LEAP) that we just published. We're just doing so much more.

To take on this new role, we needed to expand our footprint, including growing and adding further value to our members and the marketplace. This is our next major effort after LEAP and I suspect that this is going to be the first time a lot of people will be introduced to the IISC.

What is the goal of the 35 under 35 award?

RA
The primary goal is to give a spotlight to the younger people in our industry. The space sector is not exactly brimming with recognition and awards — many of the awards that we do have are focused on lifetime achievement. That's a great thing in and of itself; we all would love to get such an award some day. The **35 Under 35** will give the honorees some strong confidence that they are on the correct path.

With that in mind, we would like to receive nominations for persons in all facets of the space sector. Despite the IISC's placement on the commercial side, we would like to recognize the young people on the government side, as well. I started out on the government side, myself, and here I am at the center of commercial space. Recognition during those earlier years would have given me a great platform to stand on when I made the change over to my commercial career.

Most importantly, we want to be sure that we get nominations for young people fulfilling all the roles in the industry. Yes, the IISC is an organization that loves business plans and profit analysis. We do want to recognize the young space financiers — a group that especially lacks recognition in our industry. That being said, we want a list that included engineers, researchers, educators, and anyone that I may be leaving out.

Do you have a young science-fiction writer that you've especially enjoyed? Nominate them.

How about a technician that manages to get your space hardware wired correctly? Nominate them.

Do you have a human resources representative that has helped to build your company? They deserve to be nominated, as well.

With this being the first year of the awards, the path is open. We're taking any and all comers.

How will the candidates be judged?

RA
The 35 Under 35 is going to list a group of people to watch in the coming years. To that end, we're going to take a look at the candidate for two aspects: what have they accomplished, and, just as importantly, what is their potential?

Given that most people in the space industry actually enter the workforce at age 23 or so at the soonest, we have — at most — 12 years of work in order to rate one's accomplishments. What one accomplished during this period will get serious consideration. As so many of us really only came into the industry after getting advanced degrees, this aspect cannot be the only criterion.

This means we're looking at a nominee's potential, as well. Where is their career going? A young project manager who is taking on a new project would be one to watch. Teenage ISS researchers — such as the **HUNCH** program — might be worth considering for nomination as well.

Both of these aspects will be taken into consideration when we're finding the most "complete" candidates.

Who are the judges and how were they chosen?

RA
We've got a panel of six judges for this year. I am very proud of the team that we have put together for this; it's one of the best teams that I have ever assembled.

I started with *Chris Stott* and myself. Our positions with the IISC, and our respective roles in the space industry, give us the perspective that the judges will need. We're going to be the "anchor" of this group, as it were.

The next person that I was able to sign on was *Noah Rhys*, the CEO of **YetiSpace** in Huntsville, Alabama. I was privileged enough to tour his facilities and was impressed by the efficiency and capability that his company uses. As so much of their work is in fabrication, Noah will keep an eye for the "hands on" side of thing. It's so rare that we give our techies recognition, and Noah could be the balance to that. Plus, with Yeti Space qualifying as a "small business," he has the correct perspective for the emerging space industry.

The final three members of the committee — *Suyeon Yi*, *Chris Hadfield*, and *Jose Hernandez* — are all former astronauts. They're not just media darlings — we invited each of them because of their work in international outreach and, more importantly, education. Each of them have done a good amount of work toward blazing a path for others to follow.

How many people are expected to apply?

RA
As this is the first year of the award, we are expecting about 250 nominees in total. I think that once people see the first recipients — and then start noting people list this recognition on their resumes — we will see more and more in the future. If I were a CEO right now, I would be wanting to see as many of my employees as possible on this list each year. It's a certain signifier of the company going forward, with potential for the future.

Whats the IISC role in the award?

RA
This is our award, through and through. We're handling the outreach, the nominations and the final determination of who will be on this list. We are reliant on our membership and the space community as a whole to give us the best possible nominees. Anyone can make a nominations via our website (***http://iisc.im***). **The deadline for submissions is April 20**. From there, we are taking it forward to make our decisions.

Once the final recipients are selected, we will publish the list — first on our website, and then via a poster or hardbound book that will be given to each recipient and key people who have helped us with this effort.

The recipients will also be honored at an IISC fundraising event that will be held later this year.

Would you tell us about the organization that is IISC?

RA
The International Institute of Space Commerce is the world's leading nonpartisan think-tank dedicated to the study of the business, economics and the commerce of space.

The organization's goal is to transform the global discussion on space commerce working to solve the issues it faces today and tomorrow by driving forward the conversation with a marketplace of new ideas by providing this home for the exchange, discussion, and creation of new ideas in space commerce.

Being international in its reach and a non partisan 'Think Tank,' IISC draws upon new ideas and solutions to existing and future problems that the space industry faces by bringing together experts from academia, government, the media, business, international and non-governmental organizations, most notably those from the ISU and its extended network of people and resources.

Why not join IISC and contribute to the conversation? Thanks to the various sponsors and partners, membership is free.

Members are drawn from around the world and include private citizens and policy makers from academics and students to industry leaders. All are contributing to the growing conversation and ideas about space commerce today and its future for all tomorrow.

Every nation in the world, every economic sector, and nearly every human being today, depends upon the products and services of the space industry.

Since the launch of Sputnik in 1957, the global space industry has grown enormously to encompass the annual $300 billion satellite communications industry[1], itself supporting the $4.3 trillion a year telecommunications industry[2], on through to the provision of weather satellites and global positioning systems changing the way the world feeds itself through to the revolution in remote sensing changing the way we see our lives and further to the cutting edge frontier of the commercialization of human spaceflight with space tourism, the International Space Station, asteroid mining, and so much more.

How is all of this evolving and growing in this age of exponential technology, of industry disruption, this second renaissance, this digital renaissance? Help us in answering these and other questions. IISC publishes papers, holds workshops and events, and supports conferences around the world.

To date, the Institute has published more than 40 papers from industry and academic leaders — these papers have been delivered by invitation at venues ranging from the U.S. National Academy of Sciences in Washington DC to the International Space University (ISU) in Strasbourg, to the International Astronomical Congress (IAC) in Toronto and Jerusalem, covering topics as diverse as the commercial use of the International Space Station to the use of private capital for the provision of public science missions.

The Institute was founded in 2007 as a Not for Profit Isle of Man Company and is located at the Nunnery in Douglas on the Isle of Man, drawing from the Isle of Man's growing role and importance in the world's space industry.

INTERNATIONAL INSTITUTE OF SPACE COMMERCE

References

[1]*Space Foundation: www.spacefoundation.org*

[2]*Satellite Industry Association: www.sia.org*

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Insight: Recruiting Advice for the Satellite Industry

By Ian Stammers, Founder and Managing Director, Satellite Talent

Satellite companies of all sizes have contributed to an improving global economy, with unemployment at record lows.

In the satellite industry, this bullish environment is being driven by Space 2.0 companies such as SpaceX, OneWeb and Blue Origin, as well as by established operators such as Intelsat, Inmarsat and SES.

Over the course of a typical month, Satellite Talent works with dozens of hiring managers seeking to bring top professionals into their organizations. Based on these interactions, the company estimates that more than 80 percent of employers in the satellite industry will increase headcount this year. In this competitive environment, both employers and candidates are constantly seeking helpful advice to achieve their goals. Here are some guidelines to help ensure hiring success.

Helping Employers Increase Their Appeal

No matter a company's size or industry, employers are up against greater odds when hiring the best talent.

Employees are now switching jobs more often, leading to an increase in the frequency of vacancies within a company. Today's best talent now possess an abundance of options.

While bigger salaries and bonuses and more flexible work are obvious ways to attract candidates, these are not always the most practical enticements — at least not from a budgetary perspective. To enjoy a wealth of qualified applicants, organizations of all shapes and sizes need to consider ways to improve their employer brand.

Perhaps the most important step toward improving your employer brand is to improve interviewing skills. Hiring managers spend little time learning the skills and theory behind effective interviewing — yet hiring is the most important element of one's job as a leader.

The ability to interview and assess a person's intellectual potential and cultural fit for the firm takes practice. Companies must invest in training those responsible for hiring how to spot the quiet superstars and potential future leaders during the interview process.

Social Media Presence Optimization

Just as employers often check the social media feeds of their candidates before extending a job offer, many candidates similarly check out the employer's social media channels before submitting an application, making it a prime opportunity to gain (or lose) applicants.

No matter which platform you choose and no matter how many (or few) followers you have, it's important that your company's channels represent the type of work environment that would appeal to your ideal candidate. Posting employee testimonials, footage of team building exercises, or simply showcasing staff accomplishments tells candidates that you're an employer who recognizes and values its employees.

In today's strong growth environment, many top candidates believe they have the upper hand as well as the opportunity to control the hiring process and they take the extra time necessary to land the perfect position. As a result, candidates seek employers who will provide an enhanced candidate experience.

Employers can ensure an enhanced experience for an interviewee by implementing a strict recruitment procedure that includes Key Performance Indicators (KPIs) that relate to response times and a hiring timeframe. Employers should also consider steps that will make the interview process fun and memorable. Such steps can include offsite as well as virtual-reality interviews and facility tours. When a company successfully builds a reputation for innovation in the hiring process, the word spreads out quickly among top candidates.

Helping Candidates Stand Out

For management positions, employers are looking for candidates who can demonstrate superior communication skills, including listening, speaking and writing. They also look for candidates with experience demonstrating strong teamwork skills.

Perhaps most of all, candidates need to demonstrate analytical and problem-solving skills if they wish to gain a satisfying position within the satellite industry. Employers want professionals who demonstrate creativity, reasoning and a history of past experiences that reveal they can effectively identify and solve problems.

For engineering positions, the most obvious requirement is the ability to provide case studies as to how complex engineering challenges were successfully solved. Employers are also looking for proof that a candidate has a strong analytical mind, pays attention to detail and the ability to work as part of a team.

Regardless of the position being opened for hiring, employers are seeking professionals who can adapt quickly to the changing face of technology and to rapid economic shifts, especially within the satellite and space industries.

These employers are most impressed when candidates put maximum effort into differentiating themselves from the "pack." One notable method is by using online candidate videos streamed from their own websites and portals, such as LinkedIn.

When both employers and candidates dedicate maximum effort to the hiring process, the result will undoubtedly be a far more resilient satellite industry, which will result in the incorporation of the most viable and strongest candidates into the industry talent pool.

Ian Stammers founded Satellite Talent in 2012. It is now one of the leading recruitment firms for the global satelite and space industries. He has more than 20 years of tech-industry recruiting experience. He can be reached at ***ian@satellitetalent.com****.*