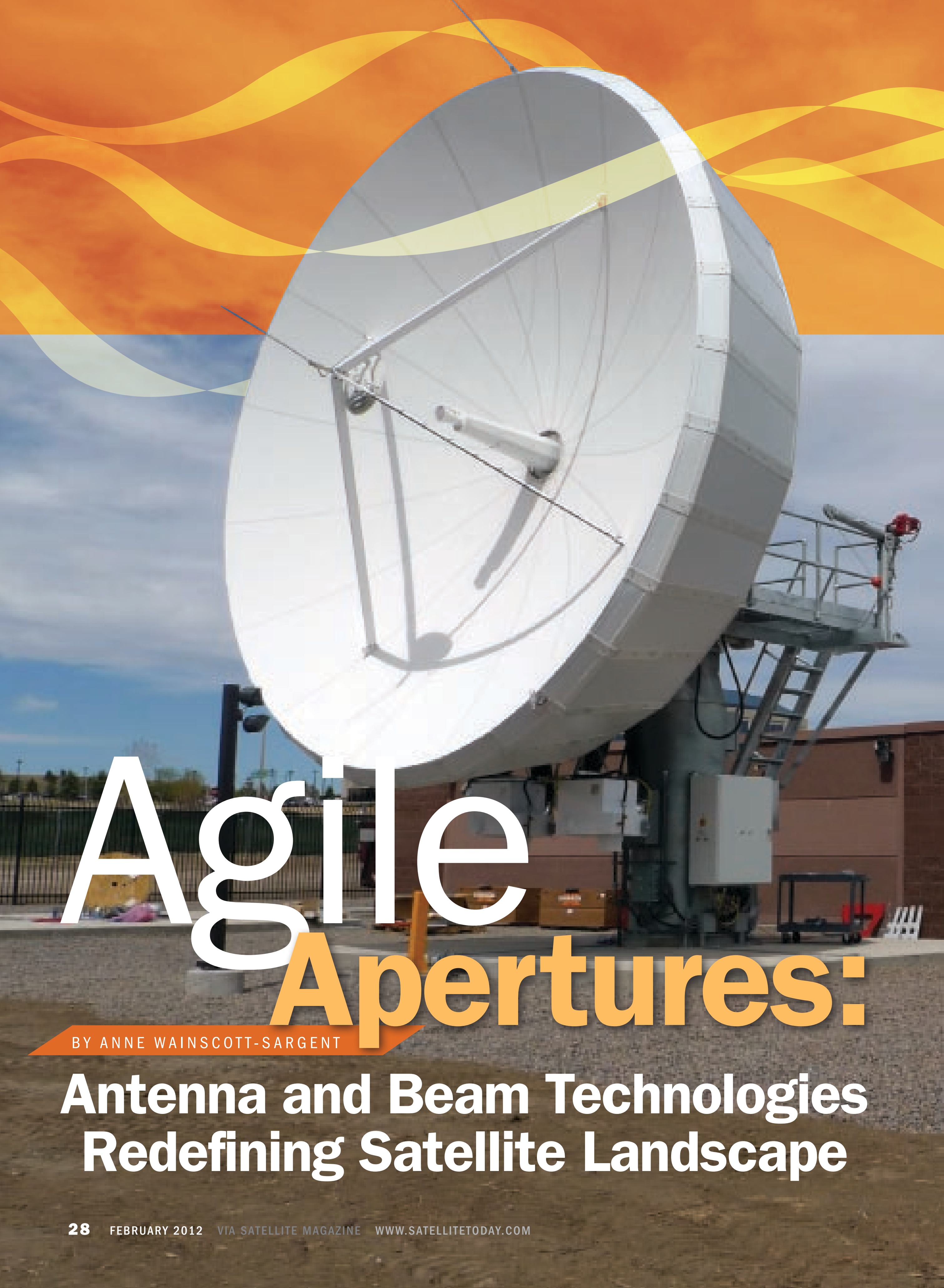

Agile Apertures:

BY ANNE WAINSCOTT-SARGENT

Antenna and Beam Technologies Redefining Satellite Landscape

A powerful new generation of enhanced satellites is placing more stringent requirements on antenna manufacturers as satellite operators look to gain the next-generation of antenna technology without incurring huge extra costs. Are antenna manufacturers able to meet these new multi-faceted demands from government and commercial customers alike?

The launch of ViaSat-1 in October represents the first in a wave of next-generation Ka-band satellites featuring antenna and other system architectures that promise to dramatically alter the economics of delivering broadband Internet and other services to the masses. Specifically, the new systems will make satellite bandwidth and performance competitive with terrestrial services.

Analyst firm NSR estimates that 24 satellites with some type of Ka-band payload are already launched or under construction with five others expected to be ordered soon. They include Inmarsat's Inmarsat-5 constellation, Yahsat IA, Hughes' Jupiter-1, Eutelsat's Ka-Sat, Avanti Communications' Hylas-1 and O3b's 12-satellite Medium-Earth Orbit (MEO) constellation.

The higher frequency Ka-band spectrum offers many advantages, including a narrower beam width, enabling smaller footprints and frequency reuse through a multi-spot-beam architecture. Not only does a Ka-band system use a smaller footprint antenna, but the reflector dish is also 30 percent smaller.

"The new generation of Ka-band satellites is getting a lot of buzz, but perhaps more interesting than the frequency band are the other technologies that these new spacecraft are pioneering. Multi-spot beam architectures for example have the potential to significantly improve the throughput and cost-effectiveness of satellite communications in general," says David Myers, president of government solutions for Harris CapRock.

ViaSat-1's satellite bandwidth spanning 1900 MHz transmit and receive is a "game changer" in the commercial industry, says Don Runyon, antenna engineering lead for ViaSat. Prior commercial systems, including WildBlue-1, span 500 MHz.

> The ultimate antenna will operate in all four frequencies and work in any network. The modem, the HPA and feed will be agnostic. That's what everyone wants.
>
> — Jim Oliver, CEO, AvL Technologies

"What excites me is we are pushing the envelope on performance, cost and functional capabilities. We are producing antennas that have milestone-setting cost points and greater capabilities."

A key difference, Runyon explains, is the highly integrated electronics. ViaSat has an airborne version of its transmit-receive integrated assembly that will go on the operator's JetBlue offering. In addition, the U.S. government recently has engaged ViaSat in a study contract to better understand ViaSat-1 and the possibilities for dramatically reducing their cost of satellite capacity and improving their end-user performance, ViaSat officials said.

"The introduction of Ka-band to commercial users who have primarily used Ku-band is very reminiscent of the introduction of Ku-band to C-band users in the 1980s," says Jim Oliver, who has founded two antenna companies and currently serves as CEO of AvL Technologies, a producer of transportable carbon fiber antennas used by the U.S. military, the American Red Cross and FEMA, among others.

Are Ka-band Antennas Rugged Enough?

Ka-band does have limitations — since it's a higher frequency than C- or Ku-band, it is much more susceptible to rain fade and atmospheric interference. The consumer DTH video or Internet markets might not worry about those issues, but they are a key concern in mission-critical markets such as government and maritime.

"We're finding our customers are raising lots of questions about the reliability and performance of Ka-based satellite communications compared with what they currently experience with Ku- or C-band," says Myers. "You absolutely have to build a set of Ka-band antennas designed specifically for remote and harsh environments. The consumer-grade antennas that are small, lightweight and inexpensive are great, but they won't survive in industrial types of environments."

"A lot of people don't realize that you need a much more accurate antenna for Ka-band. The reflector needs to be better to achieve the gain and, because the beam width has shrunk dramatically, the positioner needs to be stiffer with minimal backlash to remain peaked on the satellite in winds," adds Oliver. "Many operators are unaware of these needs for technical improvements when they buy antennas. They generally ask only one question, 'Do you have a Ka feed for it?'"

Myers says operators of oil rigs, for example, will tend to stick with Ku- and C-band because of proven reliability in adverse atmospheric conditions. "With a high-frequency, like Ka-band, come smaller antennas, but what physics gives it takes away. In regions with heavy precipitation, a higher frequency like Ka-band also means a higher probability of signal attenuation and loss of connectivity, compared with traditional Ku-band services. For truly mission-critical communications, downtime due to weather is a real concern."

Many industrial customers are watching with interest Inmarsat's planned launch of its Inmarsat-5 satellites. The Ka-band system is scheduled to deploy by mid-2013. In October, Inmarsat and prime contractor Boeing announced that they had successfully completed Critical Design Review for the Inmarsat-5 satellites ahead of schedule.

Leo Mondale, managing director of Inmarsat Global Xpress, comments, "Our new satellite fleet-build is proceeding at pace and with purpose. With Global Xpress we will offer up to 50Mbps to a 60 cm antenna, at highly competitive price points."

He added that the service will be supported by multiple steerable beams on each satellite, which will enable us to direct significant capacity, in real-time, to the exact location it is needed. “These beams have been specially designed by Boeing to serve, among other applications, the rapidly growing UAV demand for wideband channels, providing excellent value to governments without the need for capital investment.”

Boeing tapped Harris to build the Ka-band antennas, which are designed to direct 95 Ka-band beams to Earth to provide high-capacity global coverage and adapt to changing usage patterns during the projected 15-year operation of the satellites. These gimbal dish antenna systems are steerable to accommodate user demands.

Low-cost Steerable Antennas Key to Reaching ‘Other 3 Billion’

Steerable capability was also a requirement for O3b Networks, which hopes to bring cheaper, high-speed wireless Internet access to developing countries.

O3b has eight MEO satellites under construction and set for launch in the first quarter of 2013. Nearly 40 percent of the capacity is bought a year before launch, says Brian Holz, executive vice president and CTO of O3b. The company authorized construction for four additional satellites in November.

“The key to our solution was we wanted steerable capacity and a fairly flat gain in the center of our beam with a moderate gain roll-off as we moved off boresight. We are trying to optimize high-performance in the center of the beam for maximizing trunking capacity while being able to offer a good size spot beam for larger area network coverage to backhaul customers,” explains Holz, who leads the design and development of O3b’s constellation space segment. “Maximizing the data rate, being cost-effective and driving a low-latency solution were key requirements.”

The volume of antennas required for a MEO constellation meant that antenna builders needed to spend more time on design and testing of the antenna up front to ensure it would be easy to manufacture. “We have to build 100 of these reflectors in about an 18-month delivery schedule,” says Holz.

More Collaborative Engagements

To get there, O3b spent six months engaging with industry on requirements before beginning its official procurement. The two-way dialogue on capabilities led to a much better development, recalls Holz.

Antennas Play Critical Role on Latest Mars Mission

Antennas, Radios Enable a Five-fold increase in Data Rates compared with Prior Rover Missions

On Nov. 26, NASA reported the successful launch of the Curiosity Rover, which will travel to Mars and touch down on Aug. 6, 2012, before beginning its two-year mission to determine whether the planet was ever habitable, characterize the climate and geology of Mars and prepare for human exploration. The ambitious science mission requires Curiosity to return significantly more data than in prior Mars rover missions.

Chad Edwards, chief telecommunications engineer within the Mars Program Office at JPL, says enhancements to both radios and antenna technology has enabled NASA to attain a five-fold increase in data rates on Curiosity compared with Spirit and Opportunity.

"One challenge for these rover missions is that they are very constrained by both the mass and energy that's available on the surface," says Edwards, noting that trying to communicate directly back to earth with a rover, even with a high-gain antenna, results in a very weak signal because Earth and Mars are so far apart, typically only capable of supporting data rates of less than 10 kilobits-per-second.

That's why NASA relies on orbiters that over-fly the landing site using UHF frequency. An antenna, operating in the UHF band, will communicate with NASA's orbiters overhead for 10 minutes two to three times per Martian day, bringing back the majority of science and engineering data from the rover.

"Even with omnidirectional antennas on the rover and the orbiter, we are able to achieve data rates of up to 2 megabits per second," he says, which will allow returning 250 Megabits of data from Curiosity on average each Martian day.

Curiosity also will feature a new Electra Lite transceiver, a first for a lander mission. This software-defined radio gives the rover more functional capabilities and allows the rover and relay orbiter to continuously monitor the received signal strength at each end of the link, and vary the transmission data rate "so we can always communicate at the maximum possible bit rate that can be supported at that moment," Edwards says.

In addition, NASA will use two X-band antennas — a low-gain antenna and a high-gain antenna approximately a foot in diameter — for direct communication with Earth.

Finally, six Ka-band antennas based on slot array technology will play a critical role in the Terminal Descent Sensor (TDS), providing multi-beam radar imaging which will guide the MSL to the surface of Mars. Unlike previous Mars rovers that used inflatable airbags to bounce the rovers to a halt on the planet's surface, the MSL rover will use precision landing techniques to steer itself toward the Martian surface. The spacecraft will descend on a parachute and then, during the final seconds prior to landing, lower the upright rover on a tether to the surface, much like a sky crane.

"We would like to make this sky crane system a workable capability for future programs," says Edwards. "We are going to great lengths to make sure we can establish communications during entry, descent and landing."

"We gave some general guidelines to manufacturers and they did some studies and came back to us. That allowed us to really assess design and manufacturing drivers and make effective trades to mature specifications enough where we could get very effective bids and responses back from vendors," he says. "We definitely want to keep that kind of spirit of collaboration as we work with vendors as we make investments going forward. Picking the right technology and improving the cost-per-bit of throughput is a clear goal so we can pass those savings onto our customers"

"Our customer worked with us in reducing some of the requirements to keep what they really needed in order to create some room for creativity leading to a lower cost product," recalls Eric Amyotte, director of antennas and electronic products for MDA, which is building 12 O3b gimbaled antennas per satellite. MDA has built the antenna feeds for ViaSat-1 and Jupiter-1 and is also building Ka-band antenna systems for Hylas 2 and Turksat-4B, among others.

Amyotte says when first confronted with the aggressive price target for the O3b antennas, he and his colleagues weren't sure they should even pursue the business. "At first, we thought that the price target was out of our reach, but working with the customer and designing with manufacturing, assembly, integration and testing in mind made us beat that price target by a factor of three," he says.

The commercial operators aren't the only entities looking for closer collaboration to drive requirements and innovation in next-generation systems. U.S. Army Lt. Col. Gregory Coile, product manager for Satellite Communications within PM Win-T, PEO C3T, says that as the Army makes decisions on programs of record or non-programs of record in the future, it would invite industry players to demonstrate their capabilities at the Army's

Network Integration Evaluation (NIE) site located in Ft. Bliss, Texas, and White Sands, N.M.

"As we have requirements for new capabilities, we are going to ask industry partners, including antenna makers, to come out and demonstrate their capability and then we will integrate it into our network to see how that capability performs. It's an opportunity for industry to demonstrate their capability and inform Army decisions going forward," he says.

A Look Ahead — Multiple Frequency Bands

What are the antenna systems of the future going to look like? AvL's Oliver says that in addition to smaller, more agile antennas with less power, military customers increasingly want flexibility — that is, antennas able to handle multiple frequency bands such as X-, C-, Ku- and Ka-band.

"They are combining pretty diverse frequencies — much different wavelengths," he says. "The ultimate antenna will operate in all four frequencies and work in any network. The modem, the HPA and feed will be agnostic. That's what everyone wants."

A key customer of AvL's is the Army WIN-T Program office's SNAP (SIPR/NIPR Access Point) terminal program, which has fielded 600 Ku-band terminals to forces in Iraq and Afghanistan and expects to procure more as needed. Coile expects upwards of 25 to 75 terminals to ship in the coming year.

"SNAP was developed for a specific mission requirement and it has done very well. Our manufacturer has been able to make the antenna smaller by having a collapsible feed boon so that it can be packaged better in transit cases," says Coile, explaining that the biggest drivers in the antenna development were transportability and bandwidth capabilities. The program relies on commercial antennas similar to those used by news organization to file stories over satellite. SNAP terminals recently were certified for Ka- and X-band frequency use.

Coile says Army operators can change out the LNB and feed horn on each antenna to go from X- to Ku- to Ka-band. Coile says having a single antenna to support multiple bands is ideal; however, the technology in his view has not progressed enough to make it a cost-effective option for the military.

"If there was commercial market demand for a multi-band antenna, that would make it more advantageous for all customers," says Coile. He adds that the commercial sector, particularly the cruise line industry, is already looking at multi-band antenna technology since they must use C-band at sea and are looking to switch to Ku-band capacity when they pull into port.

Smaller, More Powerful Antennas on Horizon

Holz says his company is very interested in the potential of phased array technology, which is maturing. O3b may rethink its reliance on mechanically configurable antennas once it begins a new build-out phase in two years. Active phased arrays are electrically steerable, which would allow O3b to transmit more bits with greater reliability. O3b will be evaluating this technology moving forward on both the spacecraft side and for ground antenna systems.

"We will be looking at phased array technology very closely over the next year or two. Being in a MEO orbit, to have uninterruptable service we have to have two tracking antennas on the ground terminals. We would love to get that to a single antenna — one, it takes up less space, and two, it becomes more reliable long-term for the ground users," he says.

ViaSat says technology is evolving, and that future generations of its spacecraft will further exploit the bandwidth gains of Ka-band. "There's going to be more performance with size reductions. That's going to be a general trend — more with less," Runyon says.

Anne Wainscott-Sargent is a communications consultant and writer who brings nearly two decades of writing communications experience in the aerospace, satellite, telecommunications, defense, and government health sectors.