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Broadband satcom

An inside look at the technologies for flexible delivery

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Chasing broadband satcom

Customers around the world are no longer amazed by the sheer communications capacity of high throughput satellites. They want unprecedented flexibility to shift capacity where it's needed most. The question is how to give customers that flexibility. Debra Werner visited a factory in California where one proposed solution is taking shape, and she explores rival concepts.

by Debra Werner
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I'm standing in the world's largest satellite factory, not far from Los Angeles International Airport. This is where the first geosynchronous communications satellite was built 53 years ago, when this facility was part of Hughes Space and Communications. Today, it is Boeing's Satellite Development Center. I'm wearing a bunny suit along with two other reporters, and we're looking up at a three-story 6.5-metric ton behemoth of a satellite that would dwarf that first geo satellite, called Syncom. This new spacecraft will be launched later this year to a position high over the Indian Ocean where it will join a ring of high throughput geosynchronous satellites that Intelsat plans to set up, called the EpicNG constellation.

The executives with us point out the satellite's digital signal processor, a rectangular box about the size of a microwave oven. Crisscrossing it are aluminum tubes, which the executives explain are filled with ammonia to cool the electronics once they are in space. Devices like this one are a twist in high throughput satellite communications, a revolution that began about a decade ago with the goal of transmitting data 10 times faster than with conventional satellites.

Few would question that the high-throughput trend is beginning to pay off. Villagers in the heart of Africa are

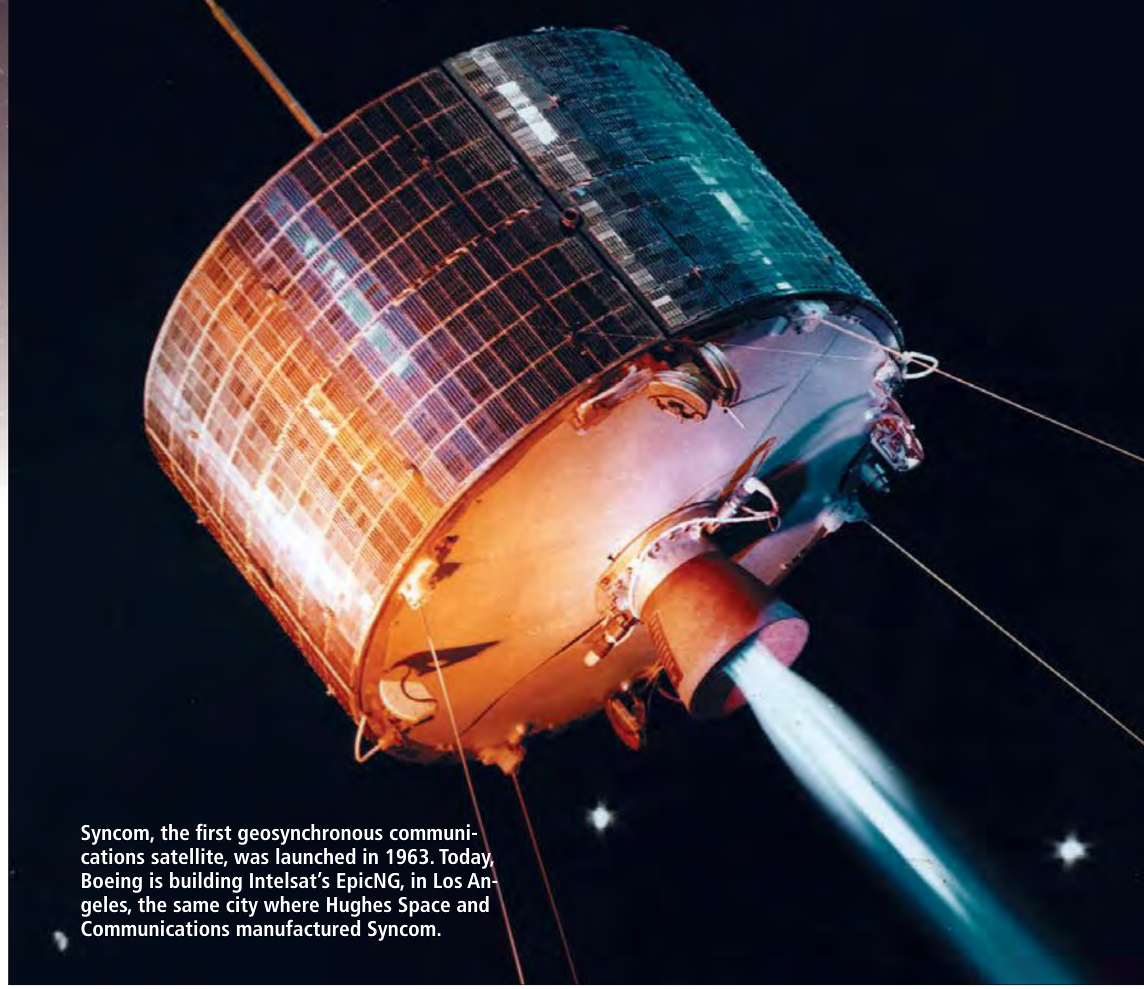
Boeing

Intelsat

Intelsat 29e, the first Intelsat EpicNG high throughput satellite, being loaded with a digital signal processor during testing.

starting to get broadband Internet without waiting for fiber optic cables to reach them. Passengers on cruise ships and airliners are starting to surf the web as they move through a satellite's footprint. The market, however, is a dynamic one. Broadband customers ranging from corporations to networks like Verizon and AT&T are demanding more flexibility than ever. Nearly all want the ability to divert beams to meet a spike in demand. Others want to put multiple regional beams and dozens of spot beams on a single satellite. Still others want the satellite to be able to shift the communications frequency, so that customers with different equipment can communicate. A competition is playing out in the industry over the best technologies to provide this flexibility. What is certain is the company that succeeds in delivering this kind of flexibility at an attractive price could have an advantage in the extremely competitive global market for commercial communications satellites. That market was worth roughly $5.1 billion in 2015, according to Northern Sky Research.

Intelsat is firmly in the digital camp. "It's 2016 and satellites are going digital," says Thierry Guilleman, executive vice president and chief technology officer at Intelsat General, which operates about 50 satellites in geosynchronous orbit from control centers in McLean, Virginia, and Long Beach, California, where the EpicNG



Syncom, the first geosynchronous communications satellite, was launched in 1963. Today, Boeing is building Intelsat's EpicNG, in Los Angeles, the same city where Hughes Space and Communications manufactured Syncom.

spacecraft also will be managed.

Others have a different view. Some geosynchronous satellite manufacturers say onboard processors are too expensive, and these manufacturers say they are providing similar flexibility with analog electronics. Not to be outdone, two new players based in the Channel Islands off the U.K., O3b Networks and OneWeb, plan to set up constellations of smaller satellites in lower altitudes in a strategy to avoid the signal latency of geosynchronous spacecraft. These satellites won't have digital signal processors in orbit either.

High throughput satellites

For decades, geosynchronous satellite designs were strikingly similar. Blueprints called for large dish-shaped antennas to broadcast a unitary analog signal across a region. In fact, most of the communications satellites in orbit still operate that way to some degree. EpicNG satellites, for instance, are equipped with large dish shaped antennas and also cone shaped devices called feed horns that are mounted on an aluminum panel. These feed horns produce multiple spot beams. Power can be modulated to individual feed horns, so that more power can be added where communications capacity is demanded. Digital signal processors on the ground or on the satellite tell these feed horns how to tailor the capacity where it is needed to deliver phone calls, television shows and website content.

Boeing is building five more digital EpicNG satellites in this factory for Intelsat. Over the next four years, these spacecraft will join the first of the EpicNG satellites, called Intelsat 29e, which was boosted into position over the Atlantic Ocean in January.

The cost of digital signal processors has raised eyebrows in some quarters. They make satellites significantly more expensive than their analog counterparts, but advocates of the technology hope that as manufacturers standardize those processors in the years ahead, the cost may come down, making it easier for more satellite operators to adopt the technology. Exactly how widely digital signal processing is being adopted can be hard to judge, because some companies closely guard such innovations in hopes of retaining competitive advantage.

One satellite operator that is willing to speak in depth about its high capacity satellite is Norway's Telenor Satellite Broad-

NASA

casting. Telenor's Thor 7 satellite was built by Space Systems/Loral in Palo Alto, California, and launched last year. Thor 7 does not have an onboard digital signal processor, but its spot beams are "switchable," meaning operators on the ground can adjust the satellite's power levels to boost capacity in areas with high demand. Telenor also can steer one of Thor 7's spot beams to focus on an area with high communications traffic. The spacecraft produces Ku-band regional beams to broadcast radio and television programs in Central and Eastern Europe. It also has 25 Ka-band spot beams to provide Internet access, video streaming and links to corporate networks for Europe and ships in the North Sea, the Norwegian Sea, the English Channel and the Mediterranean Sea.

Inmarsat, the London-based satellite operator that specializes in serving customers traveling around the world, also does not have an onboard digital signal processor on its three Global Xpress high throughput satellites, but they nevertheless produce fixed and steerable beams.

"Around the world, over 200 beams are fixed and staring all the time, which means pretty much anywhere you go, you can point at the sky and have access to wide bandwidth Ka-band communications," explains Peter Hadinger, president of the U.S. government business for Inmarsat. "We have added these steerable beams so we can plus up capacity over an area of high usage."

Inmarsat launched the third satellite in its Global Xpress constellation in August and is now marketing that capacity to both commercial and military customers. "When customers need capacity above and beyond what they can get from military satellites in their area, they can come to us and we can point a steerable beam in that location," Hadinger says. "This is all done to make Global Xpress as flexible and capable as possible."

ViaSat, the Carlsbad, California, company that provides broadband to airline passengers over the continental U.S., Alaska, Hawaii and Canada from its ViaSat-1 spacecraft, has not said whether ViaSat-1 carries a digital signal processor or whether the company will install them on the three ViaSat-3 satellites it plans to buy to create a global Ka-band broadband network.

"We are very sensitive about sharing the things we are doing," says Keven Lippert, executive vice president for satellite systems and corporate development at ViaSat. But generally speaking, ViaSat is upgrading not only its satellite design, but also its transmission and reception devices and fiber networks on the ground. "To get to the capacity and flexibility we have in ViaSat-3, we've had to invest a lot of money in developing technologies ourselves," he says.

Flexibility versus capacity

There are different schools of thought over the best way to deliver flexibility, but no one disputes its importance. "To have the ability to move capacity around and focus it in areas is just as valuable as having a lot of capacity, because otherwise you end up having capacity in areas

The Intelsat 29e satellite lifts off aboard Ariane 5 in January from French Guiana. The Intelsat 29e is the first of Intelsat's high throughput EpicNG-series spacecraft, which is being built by Boeing.

Arianespace

New constellations, new orbits

Two startup companies, O3b Networks and OneWeb, are challenging the conventional wisdom that large, geosynchronous spacecraft positioned 36,000 kilometers over the equator are the preferred way to deliver broadband satellite coverage.

One might have thought that the leading geosynchronous satellite operators would view the upstarts as rivals, but two of the industry's dominant players have decided to work with O3b and OneWeb.

Intelsat General of Luxembourg and McLean, Virginia, has joined forces with OneWeb, whose 700 satellites destined for low Earth orbit will weigh less than 150-kilograms each. In contrast, Intelsat's new EpicNG spacecraft weigh 6,500 kilograms.

Intelsat's rival SES of Luxembourg, which operates 50 geosynchronous satellites, is investing in O3b, which has begun launching satellites weighing 700 kilograms each into medium Earth orbit, an altitude of about 8,000 kilometers. This 20-satellite constellation will provide Ka-band broadband connections in underserved parts of the world.

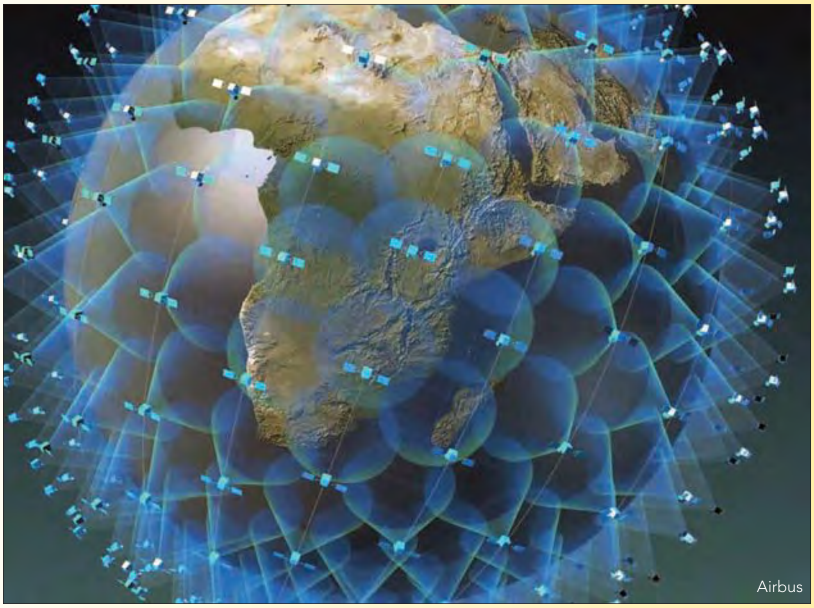
Joining forces offers customers more ways to connect to global networks, says Thierry Guilleman, Intelsat executive vice president and chief technology officer.

In Manhattan or any urban area with tall buildings, satellite antennas often have trouble connecting with satellites in geosynchronous orbit, because they need to be in the satellite's line of sight. Because of orbital geometry, it is easier for antennas to connect with satellites in lower orbits. Also, geosynchronous satellites can reach the polar regions from their positions over the equator. All told, OneWeb's polar orbits and O3b's MEO constellation will expand coverage for their geosynchronous partners.

Intelsat's Guilleman says that working with OneWeb to cover urban canyons and the poles will make Intelsat's service truly global.

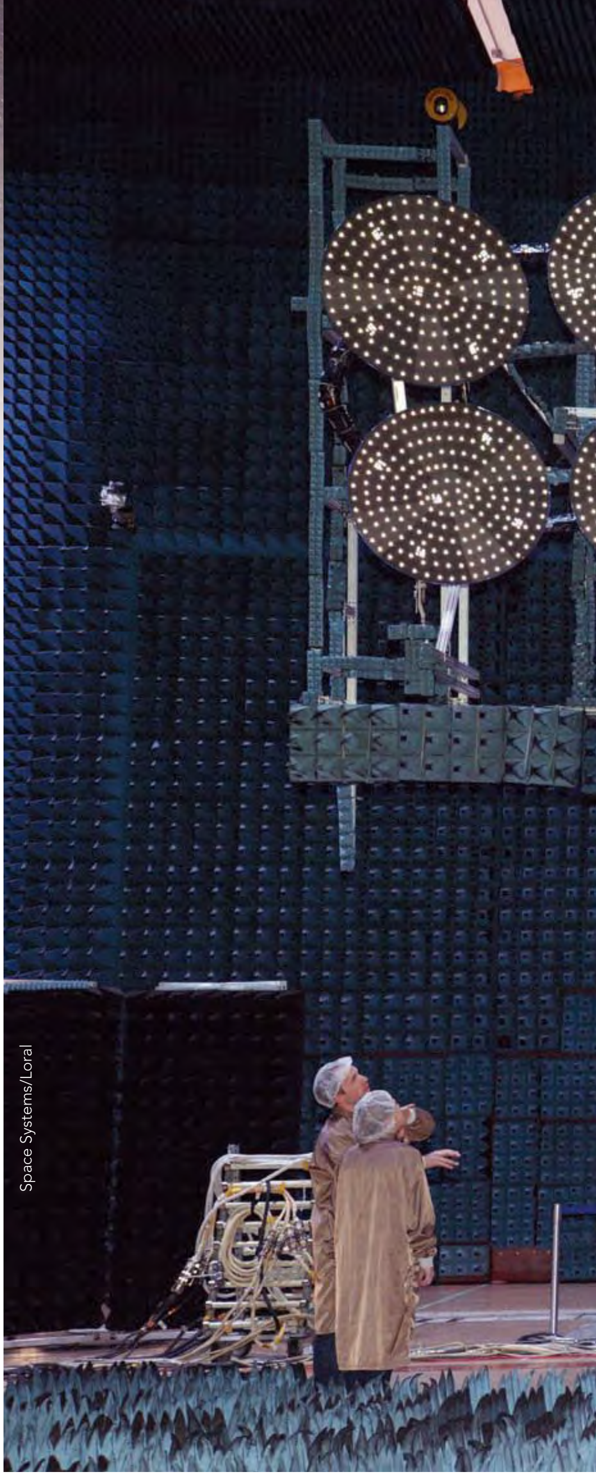
SES says its partnership with O3b will offer its customers similar benefits. For example, Jamaican telecommunications network Digicel is already using the 12 satellites in O3b's current constellation to relay communications in heavily populated parts of its overage area, which includes American Samoa, Fiji, Nauru, Papua New Guinea, Tonga and Vanuatu. Digicel relies on SES's C-band regional beams and uses O3B's spot beams to augment capacity, according to SES's white paper, "GEO & MEO: Proven. Efficient. Scalable."

— Debra Werner



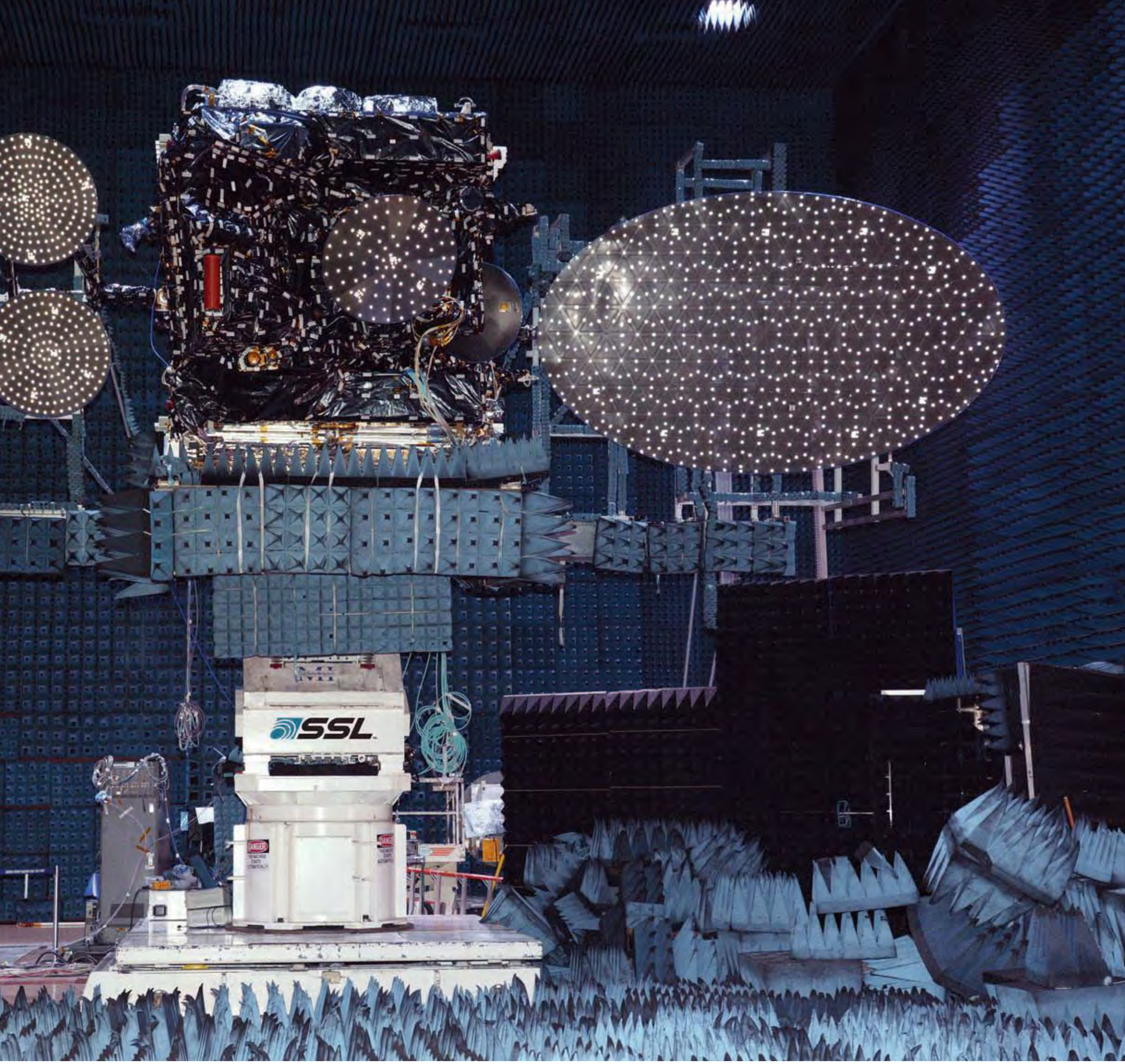
Airbus

Satellite startup OneWeb has picked Airbus Defence and Space to design and build hundreds of microsatellites with the goal of making affordable Internet accessible everywhere around the world.



Space Systems/Loral

where you can't use it," says ViaSat's Lippert. That flexibility is especially important in a market prone to changing rapidly. Communications traffic in Latin America and Africa has lately grown more quickly than in Europe, a traditionally strong market. Consumers have grown so attached to their mobile devices that they want broadband connections on boats, trains and planes. Satcom companies are particularly wary of this kind of shifting geographic demand because they often pay hundreds of millions of dollars to buy, launch and insure spacecraft designed to last 15 years or more.



Thor 7 satellite does not have a digital processor on board, but its beams are still "switchable," allowing ground operators to adjust power levels to boost capacity in high-demand areas.

"They want to make sure a satellite designed today and launched in three years will still be viable in 18 years," says Carolyn Belle, a senior analyst for Northern Sky Research, an international market research and consulting firm based in Cambridge, Massachusetts.

Intelsat, for instance, says that with its EpicNG satellites it will be able to observe how communications traffic patterns vary over a 24-hour period and modify its coverage accordingly, sending signals from the satellite to one set of ground antennas in the morning and a different set in the afternoon. Intelsat also can change the frequency of information sent and received by the satellite. "I can uplink in C-band, go through the digital payload and rather than coming down with a C-band transmission, come down in Ku-band," Guilleman says. That capability would be useful, for example, if one of Intelsat's customers wants to transmit in C-band over two-thirds of Africa, but test the reception for Ku-band communications in another region.

Advocates of digital processors say the devices are worth any expense because of the ease of reacting to changes in

Space Systems/Loral

ViaSat-1, an all-Ka-band satellite, provides broadband connection to residential customers and airlines in North America.

demand. "We like to joke that it may take satellite operators longer to decide what changes to make than to actually do it," says Mark Spiwak, Boeing Satellite Systems president.

Boeing developed the family of digital processors it is installing in EpicNG satellites to help the U.S. military transmit high-resolution imagery and videos through Wideband Global Satcom-1, a U.S. Air Force-operated satellite launched in 2007. Since then, the Air Force has ordered nine more spacecraft in the Wideband Global Satcom series and Boeing has produced six generations of digital processors for military and commercial satellites.

Another major defense contractor, Lockheed Martin Space Systems, is building a digital signal processor for SaudiGeosat-1, a satellite scheduled to launch in 2018 for the Arab Satellite Communications Organization, a communications satellite operator based in Riyadh, Saudi Arabia. With this processor, operators can redirect the satellite's beams to focus on different ground antennas and change the radio frequency of data to eliminate interference and jamming, Lockheed Martin says.

In another trend, the choice between digital and analog is becoming more than an either-or decision. Some manufacturers are combining analog and digital components on the same spacecraft, says Hampton Chan, vice president and chief architect at Space Systems/Loral of Palo Alto, California. Many traditional broadcasting missions are "perfectly suited" for regional beams and analog equipment, Chan says. Those customers can use the less expensive analog service.

Weight watching

High throughput satellites, whether analog or digital, use spot beams to concentrate radio frequency signals on smaller areas. Because the beams focus more power in those areas, customers can communicate via smaller, less powerful ground antennas. Another benefit is that as long as the beams are focused on different areas, satellite owners and operators can relay many different signals in the same frequency band without causing interference. Also, satellite operators are increasingly opting to purchase satellites equipped with both regional and spot beams. The new multi-mission satellites must be packed with electronics and carry dozens of feed horns to shape the signals each beam sends to the ground.

"It's becoming a careful dance because the increase in weight affects the launch price," says Belle, the Northern Sky analyst.

To keep the weight in check, satellite manufacturers are slimming down other satellite components, like replacing nickel hydrogen batteries that provide power when a spacecraft's solar panels are not illuminated with lithium-ion batteries weighing 30 to 50 percent less. Manufacturers also are focusing on the latest propulsion technologies.

When a communications satellite launches, approximately half its mass is liquid fuel that is burned to move the spacecraft from the transfer orbit where a rocket drops it off at its intended location in geosynchronous orbit and to remain there for 15 years. That is the case for the first EpicNG satellite, which carries 16 hydrazine thrusters. On the second EpicNG satellite, Boeing is reducing the fuel load by adding four electric arcjet thrusters, which produce thrust by forcing propellant heated by an electrical charge through a nozzle at supersonic speeds. Intelsat will use the arcjets thrusters on its second EpicNG satellite, Intelsat 33e, to prevent the satellite from traveling too far north or south once it reaches its intended orbit. Arcjets thrusters use about one third as much fuel as hydrazine thrusters to produce the same force, which means EpicNG can allocate that weight to its communications payload, including its digital brain.

As I gaze up at the satellite towering over me, I can't help but wonder whether giant spacecraft with digital signal processors are the way of the future. EpicNG may soon answer that question.