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Governments across the world have employed the use of satellite communications across Geosynchronous satellites dating back to the 1960s. In the last 20 years, the amount of traffic that the government users pass across satellites has skyrocketed from around 1-2 GBPS in 2001 to around 30 GBPS in 2020.

That trend is expected to not only continue but to explode. NSR projects that MILSATCOM will grow to more than 480 GBPS by 2028 – more than 10x what is used today.

At the same time that the need for bandwidth is growing, the threat to military satellite communications, or MILSATCOM, satellites is also growing. Several nation states have repeatedly demonstrated their ability to eavesdrop, jam, harass, manipulate, and potentially even shut down the most vital portion of these networks – the satellites themselves. By employing a number of techniques both on the ground and in space, adversaries in a conflict have the ability to disable the critical communications that takes place between tactical users and their command structures of their enemies.

GEO Satellites are Big, Juicy Targets

General John Hyten, former head of US Strategic Command and now Vice Chairman of the Joint Chiefs of Staff of the US Department of Defense, is famously quoted as saying that he "won't support the development any further of large, big, fat, juicy targets", referring to the large GEO satellites that take years (and vast sums of money) to develop, launch and deploy, be they military or commercial in nature.

GEN John Hyten, Vice Chairman of the US Joint Chiefs of Staff, speaks at the 2017 Halifax International Security Forum. Credit: Spacenews

While High Throughput Satellites (HTS) and Very-High Throughput Satellites (VHTS) in GEO orbit will always play a critical role in military and government communications – primarily as data backhaul and broad distribution systems – it is very likely that many critical data links will migrate away from these constellations and towards more resilient and robust Non-Geostationary Orbit (NGSO) constellations.

The Benefits of NGSO Constellations

The closer to the battle edge a military unit gets, the more critical the communications become on a moment-to-moment basis. Losing the only connection to headquarters via satellite can make a real difference in an active conflict. In the case of GEO satellites, the adversary needs only target one chokepoint – the satellite itself – to disrupt the communications infrastructure for a fighting force.

If, however, military units are able to access multiple satellites in multiple NGSO constellations, their adversary's ability to harass, jam, or degrade their communications network becomes significantly smaller. The sheer number of satellites required to create ubiquitous coverage over a geographical area range from a handful in High Earth Orbit (HEO), to a dozen in Medium Earth Orbit (MEO), to hundreds or even thousands in Low Earth Orbit (LEO). This means the adversary must impact not one, but dozens or even hundreds of satellites simultaneously.

SpaceX Starlink (US) has deployed more than 1,000 satellites to date, and SES O3b mPower (Luxembourg) is on station, with 11 new MEO satellites planned to launch in 2021. NGSO broadband constellations are in development by OneWeb (UK/India), Honyan (China), Amazon Kuiper (US), Telesat Lightspeed (Canada), and potentially dozens of others in the planning stages, each planning global reach of their constellations. At least one company, Mangata Networks (US), is planning to develop a hybrid architecture that would be designed specifically for one geographical region – a model that would serve the AsiaPac region well.

And these are just the commercially available networks. At some point it stands to reason that governments will begin to launch NGSO constellations of their own. Indeed, the US has been working to launch a NGSO constellation to test the merits of use in a battlefield environment. The DARPA project called "Blackjack" has already awarded Blue Canyon Technologies a contract to develop and launch 20 satellites to test various technologies ahead of the military-grade mega-constellation being developed by the newly formed Space Development Agency. The US Army has also said that they want to be actively operating on MEO constellations in the 2025-2027 timeframe.

Blue Canyon Technologies is using the 150-kilogram X-SAT bus for DARPA's Blackjack program. Credit: Blue Canyon Technologies.

The benefits of NGSO constellations in military networks extends beyond just resiliency. NGSO satellites are closer to the ground, therefore the latency typically experienced with GEO satellites (around 500 milliseconds round-trip) would be reduced to around 100 milliseconds on average, meaning that latency-sensitive applications would be more realistic to operate via satellite, such as drone / UAV remote control and real-time data collaboration activities.

Additionally, NGSO constellations allow for smaller aperture antennas to connect with the satellites, meaning tactical users no longer need to lug around trailer-mounted SATCOM equipment and deploy very obvious parabolic reflectors. And consider that these very small – in some cases 30 cm. in diameter – user terminals will generate hundreds of megabits per second of throughput as compared to the 5-10MBPS military links using 2.4M antennas get today.

Starlink User Terminal. Credit: Erc X @ErcXspace via Twitter.

Finally, a significant advantage of several new NGSO constellations being deployed is their spectral efficiency. Many new constellations are cramming more bits per second (BPS) per Hertz (Hz) of frequency, or BPS/Hz, than ever before. Typical satellite links pass 1-3 BPS/Hz, whereas these new constellations are striving for 6, 7, and even 8 BPS/Hz. The more BPS/Hz, the more data per satellite that can be passed.

The Downsides of NGSO Constellations

While NGSO constellations will certainly provide significant benefits to military users – especially tactical users – these benefits will come with some new challenges.

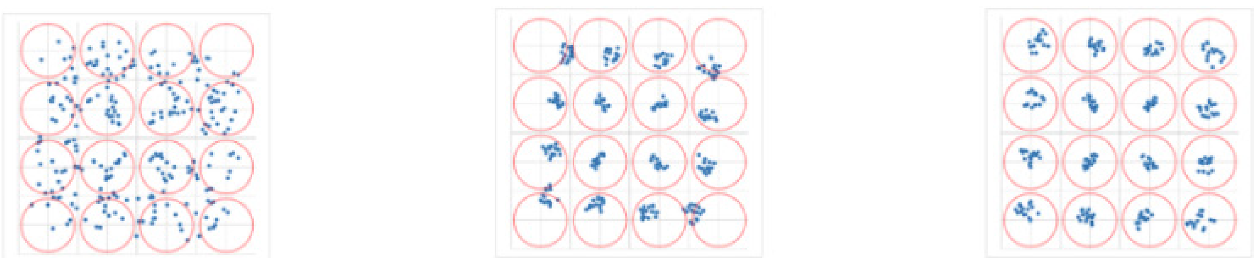
By far the biggest challenge is the fact that these satellites move – and in most cases relatively quickly – across the sky. That means that the user terminals need to be able to track the satellites as they move from one horizon to the other. Using a parabolic reflector to do this would require a rather expensive positioner like the ones currently used for Comms-on-the-Move (COTM) military applications. Current COTM terminals can cost 10x that of a non-tracking Very Small Aperture Terminal (VSAT).

SATCOM-on-the-Move terminal built for military applications. Credit: General Dynamics Mission Systems.

Additionally, the terminal will need to be able to switch from one satellite to the next simultaneously to avoid dropping the network connection. This requires either a phased array antenna capable of communicating in two directions simultaneously, or two antennas side-by-side. Otherwise, the terminal will have a multi-second network drop every time it has to leave one satellite and acquire another every 20 minutes or so.

And unless the user intends to carry around a separate modem for each network, a new global open standard for virtualizing the functionality of a satellite modem is needed so that waveforms can be easily ported as software files to a common hardware device. This is how the adoption of the 5G open standard for terrestrial networks is being implemented around the world. Unfortunately, we are already starting to see some companies create closed, proprietary solutions for virtualizing multiple waveforms, which is just as bad as the problem it attempts to solve. Creating a single gatekeeper that charges a toll for every waveform implemented decimates innovation and destroys value for the end users.

Finally, the spectral efficiency of these new constellations will require that the RF subsystems be designed to provide the cleanest signal possible. This means the RF subsystems used in current systems won't be high enough quality to maximize the throughput of these new constellations. At Wavestream, we have been working for years to optimize the Error Vector Magnitude, or EVM, of our RF products in order to meet the coming demand for high spectral efficiency satellite networks. Using multiple leading-edge techniques, we have developed RF products for Gateway and Edge terminals that make these very high order modulation schemes being considered by NGSO operators possible. We believe this is the area of greatest growth in our industry as bandwidth demand grows exponentially and pricing pressure moves downward.



Uncorrected amplifier response | **Response with EQ correction to gain flatness** | **Response with EQ and correction to amplifier distortion**

Comparison of uncorrected vs. corrected gain flatness and distortion, leading to higher spectral efficiency. Credit: Wavestream.

The Very Bright Future of NGSO Military Networks

Multiple satellite constellations in varying orbits. Credit: Thales.

Ultimately the 2020s will be the decade we saw a global shift from GEO to NGSO constellations being the primary link for tactical users at the edge of their military networks. GEO satellites, especially new HTS and VHTS satellites, will absolutely continue to play a critical role in military communications, primarily for backhaul between theater command posts and headquarters as well as broadcast of high-bandwidth data to multiple domains. But the technical and price advantages of NGSO will ultimately carry the day for tactical edge users.

The technical challenges ahead – especially on the end user terminal front – are not insignificant, however they are manageable with time and money invested by the industry that serves our warfighters and peacekeepers.

The resiliency, redundancy, anti-jam capabilities of these networks will leave global military satellite networks in a far less precarious environment we currently find ourselves today. And the opportunities to communicate more data more effectively with less latency and smaller terminals will further reduce the material burden on users as militaries around the world become more and more expeditionary in nature.

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