ENHANCING UAS SATCOM CAPABILITIES

Next-generation network services for BLOS C4ISR missions with O3b mPOWER

Insight Paper

SES | Networks

O3b mPOWER provides the means to deliver unparalleled capabilities to UAS airborne C4ISR applications, ensuring mission success.

EXECUTIVE SUMMARY

Since the successful launch of our O3b Medium Earth Orbit (MEO) satellite system and the introduction of commercial services in 2014, SES Networks has experienced growth and market penetration that are unprecedented in the industry.

Our ability to deliver fibre-like throughput and latency performance to remote and hard-to-reach locations has proven to be a game changer across all market segments, particularly in the government and military sectors. O3b MEO-based services are having a transformational impact on fixed and mobile military communications operations, such as airborne Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) missions.

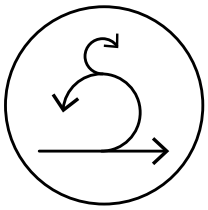
Following the success of our first-generation O3b MEO system, SES has taken the initiative to invest in the design, development and implementation of a second-generation MEO system—O3b mPOWER. The original O3b MEO constellation was the first step in the strategic evolution of our global data services, and O3b mPOWER will facilitate a rapid increase in capability for the markets we serve, to address cloud-computing environments anywhere in the world. O3b mPOWER takes our market-proven MEO satellite technology, greatly extends its capabilities, and increases its capacity by a factor of 10. To meet growing market demand, O3b mPOWER scales the previous O3b model to deliver a ubiquitous, low-latency 'virtual-fibre' network while seamlessly integrating into all other networking infrastructure.

To determine how O3b mPOWER will enable and enhance military airborne C4ISR applications on Unmanned Aerial Systems (UAS) platforms, consider what's possible via virtual-fibre connectivity on a UAS:

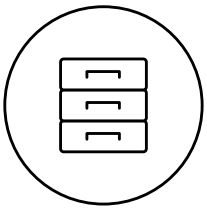
- Having the ability to increase or decrease throughput on demand while flying a mission, as well as a unique higher return link capability
- Providing enough throughput to accommodate all current and foreseeable sensor payloads—simultaneously, and with data in an uncompressed format
- Having the ability to use 'bent-pipe' repeaters, ensuring all current and future modulation and encryption schemes can be transparently supported
- Using a network that is inherently resistant to interception and jamminge
- Having the ability to use customer-defined ground networks, giving access to capabilities that are not permitted on public networks
- Working at all longitudes, and latitudes to ±50°

THE CHALLENGES FOR BEYOND LINE OF SIGHT UAS COMMUNICATIONS

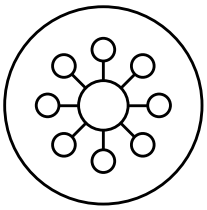
Today, beyond line of sight (BLOS) UAS communications are primarily implemented using Geostationary Earth Orbit (GEO) satellite networks. The inherent characteristics of GEO satellite networks pose a number of challenges when used in airborne C4ISR applications.



Payload complexity
Current and next-generation UAS are being equipped with more advanced and complex sensor payloads that generate ever-growing volumes of data. Yet, the transmission of sensor data and video feeds from aircraft to ground has proven challenging due to the limited throughput capabilities of the BLOS satellite communication (SATCOM) systems currently available. This limitation reduces the ability of a UAS to satisfy its mission requirements. Mission planners are often forced to make trade-off decisions regarding which sensors in the payload to use during a mission due to throughput limitations. These trade-offs may include flying multiple sorties to complete the mission, resulting in higher operating costs and extending the time required to achieve the full mission objectives.



Data compression
To compensate for the throughput limitations of current BLOS SATCOM systems, UAS sensor data and video feeds are often compressed. Depending on the compression technique employed, information is sometimes lost. Lossy compression reduces the amount of information in the data stream, adversely impacting the quality of the intelligence analysis, and resultant intelligence products.



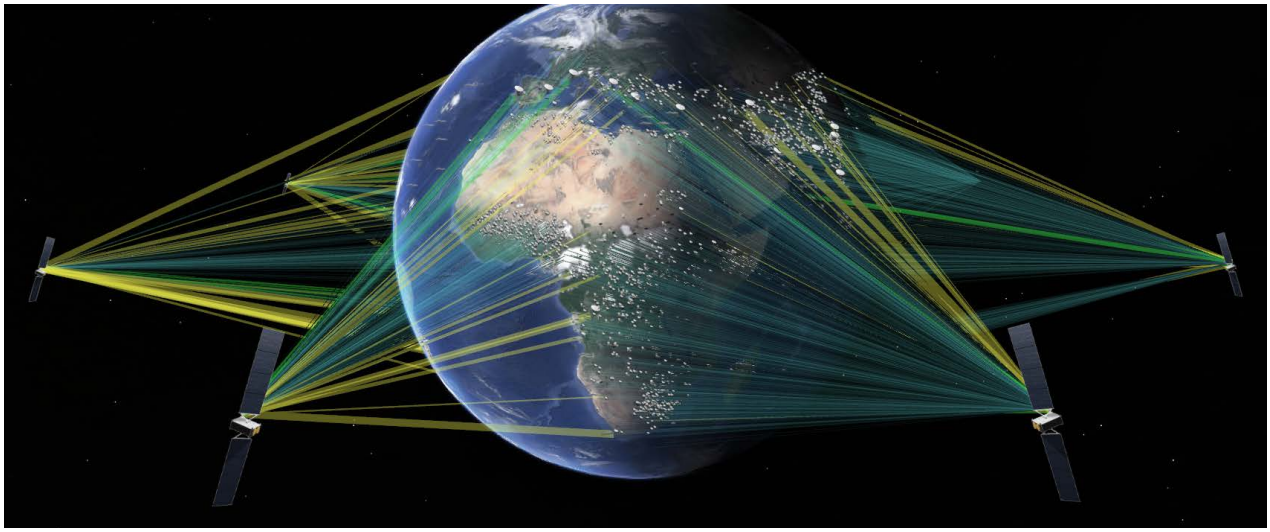
Capacity planning
UAS missions are complex, time sensitive and dynamic operations. Mission success is often dependent upon the ability of a BLOS SATCOM solution to adapt to the dynamics of a mission, to accommodate changes in sensor payload configuration, and resultant changes in connectivity throughput. Current BLOS SATCOM systems typically require planners to pre-set a throughput limit for a mission, leaving operators unable to dynamically allocate or de-allocate capacity as mission needs change. As a result, planners either have to allocate more capacity than is needed—and which may not be used during the mission—to accommodate unforeseen changes in mission requirements, or only allocate sufficient capacity to meet planned mission requirements, with the hope that no additional capacity will be required. The former approach to planning may have an economic impact, and the latter approach may constrain mission success.

Throughput and latency
Actionable information provided by a UAS mission is often time sensitive, and any action to be taken must be coordinated and executed across multiple echelons, including operators, analysts, and command and control elements of the intelligence chain. The throughput and latency limitations of current BLOS SATCOM systems reduce the capability to coordinate the planning, decision making, and execution activities required to respond in a timely manner, thus hindering mission success.

Security
The operational security (OPSEC) and communication security (COMSEC) measures taken to mitigate interception and jamming of GEO SATCOM systems typically impact throughput performance.

THE O3b mPOWER SYSTEM

As the world's most powerful satellite-based telecommunications system, the O3b mPOWER system is a transformative step change in capability.



A unique system built on advanced technologies, O3b mPOWER integrates with the existing SES GEO fleet and O3b MEO constellation, and is the highest-capacity and most flexible system ever, with the broadest available coverage. The system is based on major innovations—a new satellite constellation that builds on the proven success of our first-generation O3b MEO system, next-generation Customer Edge Terminals (CETs), and intelligent control and management software.

The first-generation O3b MEO constellation is interoperable with the upcoming O3b mPOWER constellation, and customers will be able to migrate seamlessly from the previous system to O3b mPOWER as their capacity requirements increase, or their services and applications require the enhanced capabilities of the newer system.

Each of the first-generation O3b MEO satellites provides 12 fully steerable Ka-band beams (two for gateways and 10 for remote terminals), and has an aggregate capacity of 16 gigabits per second. The beams each illuminate an area of Earth's surface measuring 700 kilometres across. In comparison, each of the seven O3b mPOWER satellites provides more than 5,000 beams, which can be combined into fewer, more capable beams as needed.
The satellites are equipped with phased array antennas, and carry advanced digital payloads. The fleet, designed and constructed by Boeing Satellite Systems International, is designed to provide coverage between 50°N and 50°S—almost 80 percent of Earth's surface. Each satellite has a throughput 10 times greater than those in the first-generation constellation, delivering a system-wide terabit capacity. This shift towards targeting individual endpoints in addition to areas containing multiple endpoints, together with the availability of greatly increased data rates, gives customers the freedom to create new classes of applications and services. Targeting individual endpoints improves the efficiency and economics of the system.

O3b mPOWER is scalable, and delivers near-real-time connectivity. The system can be dynamically reconfigured in almost every aspect of its operations, unfettered by the performance constraints of previous systems.
It can also connect and empower those parts of the world that are not well served by competitive systems.
It will scale up to become the first global, multi-terabit satellite communications system, capable of delivering 'virtual fibre' anywhere.

O3b mPOWER ADVANTAGES

The O3b mPOWER system has a number of novel characteristics that make it especially suitable for UAS C4ISR mission connectivity.

Adaptable forward/return ratios
The forward/return ratio for previous generations of satellites is largely fixed by the design of the satellite itself. The flexibility of O3b mPOWER allows the forward/return ratio to be adapted to suit each customer and application—even in near real-time, if needed. This addresses the potential supply/demand mismatch of conventional satellite telecommunications systems by replacing fixed capacity with an on-demand system.

Tailored service packages with more granular coverage and capacity
With O3b mPOWER, users enjoy greater flexibility to set optimal capacity levels for fixed or mobile remote locations, or assets of any size, in a cost-effective way. Users can change allocated bandwidth dynamically from site to site, cutting down on under-used capacity, and improving cost efficiency and asset utilisation. The system also makes it much easier to deliver services to coverage areas determined by the user, a major advantage for mobile applications with frequently changing locations.

Steering traffic to user-selected locations
With O3b mPOWER, we can provide connectivity to a gateway selected by the user. In many cases, this will be an in-country gateway close to the user's fixed location, which reduces end-to-end latency, and improves the user experience. The flexibility of O3b mPOWER, with its vast number of beams, means that it can service many more CETs than the existing O3b MEO system.

This gives users considerably more freedom in selecting the location of a gateway.This level of flexibility in steering data also makes it easier for users to comply with regulations or requirements that mandate that traffic remain within a country or geographical region. O3b mPOWER lets the user steer traffic to locations selected to optimise overall network and application performance.

Independent subnetworks
O3b mPOWER can simultaneously support multiple, completely disparate networks. Federated networking enables O3b mPOWER solutions to be tailored to the application, including terminal, network topologies, and protocol requirements. This capability is particularly relevant for government applications, which often have mission-driven requirements not normally addressed by conventional commercial satellite systems.

Cloud, IoT and 5G ready
O3b mPOWER has been designed from the outset to serve its users' need to transmit data between remote locations, where they have IoT sensors and systems, to central data processing facilities and cloud-computing centres. We're partnering with major cloud service providers to bring services such as Watson and Azure to the very edges of the global internet. We have also attained the certifications needed to interoperate with major telecoms providers for the provision of 5G-enabled services.

Innovative customer edge terminals
Our contracted industry partners are developing smart, high-throughput terminal solutions to serve as O3b mPOWER CETs, important building blocks in the system's ground infrastructure innovation plan. These CETs combine innovative steerable antenna technology with functionality-covering modems and managed networking. Where the latency offered by MEO satellites is not low enough for a specialist application, the CETs can incorporate edge compute capabilities to achieve sub-millisecond response times.

Software defined networking
Thanks to the integration of Software Defined Networking (SDN), the O3b mPOWER system is equipped with intelligent multi-orbit resilience. It also offers the ability to route traffic by application over GEO, MEO, and terrestrial links, supporting the introduction of SD-WAN enabled services—all of which improve efficiency, reliabilit,y, and flexibility for our customers and their end users.

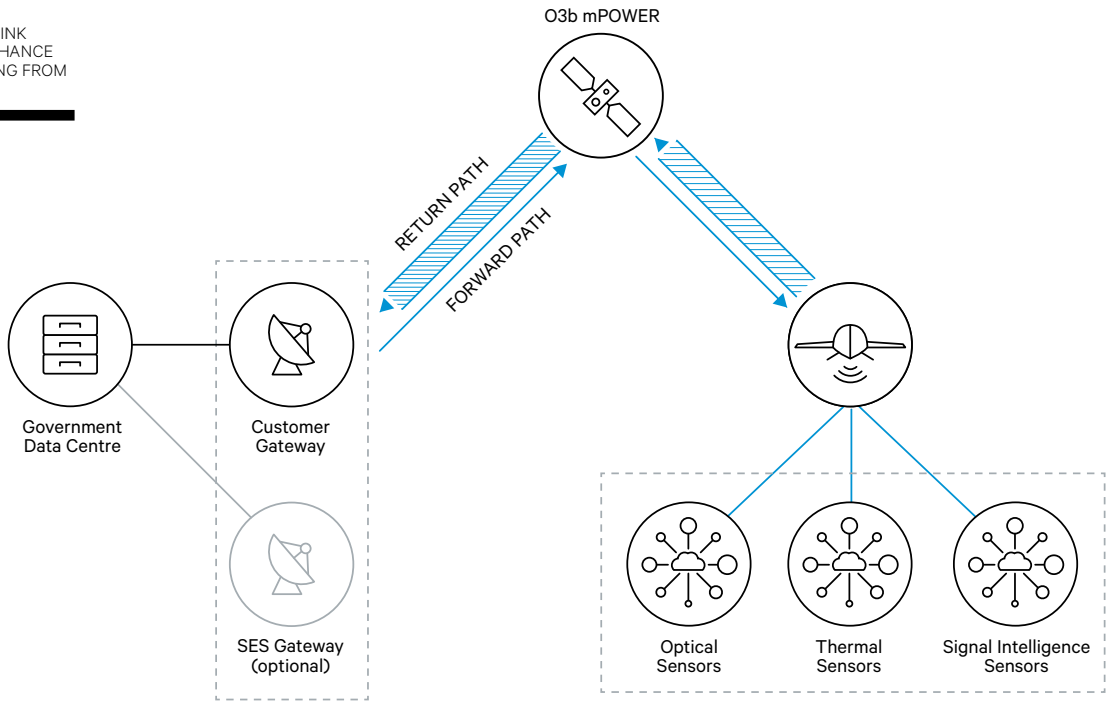
ENHANCING C4ISR PLATFORMS AND MISSIONS ON O3b mPOWER

O3b mPOWER combines high-capacity return-link capability, dynamic capacity and mission planning, and mission-centric link and network requirements. These capabilities translate directly into the operational characteristics of BLOS data links applied to UAS airborne C4ISR applications.

OPTIMISATION OF MISSION SENSOR OFF-BOARDING

O3b mPOWER offers channel capacities from 15MHz to as much as 2.5GHz, enabling mission planners to decide to use all available sensors, or just a part of the payload, as dictated by the mission requirements. Combined with the ability to dynamically allocate bandwidth and power in near-real-time, the system allows users to flexibly determine what capacity is required to meet the assigned objectives, and to adapt to changes in mission operations as the need becomes apparent. Sensors can be brought online or reconfigured inflight, and the corresponding bandwidth increased or decreased as mission requirements change. This enhances mission operations, and minimises the need to fly multiple sorties. High -throughput also enables transmission of C4ISR raw sensor data and non-compressed Ultra High-Definition (UHD) videos. The transmission of raw data, as opposed to compressed data, optimises and enhances the granularity of analysis and the resulting intelligence products, to deliver force multiplier capabilities.

FIGURE 1
UNIQUE RETURN-LINK CAPABILITY TO ENHANCE DATA OFF-BOARDING FROM THE AIRCRAFT



DEDICATED CUSTOMER GATEWAYS

Traffic on the first-generation O3b MEO system normally passes through one of our gateways, located at various sites around the world. O3b mPOWER builds on this capability by allowing customers to locate dedicated gateways at a site of their choosing to provide enhanced information assurance.

LOW LATENCY

O3b mPOWER's low latency—less than 150ms Round Trip Time (RTT)—provides near-real-time distribution of C4ISR data, analysis, and distribution of intelligence products, resulting in better intelligence products delivered in a more timely manner. Using O3b mPOWER's high throughput and low latency reduces the time to complete the intelligence process chain, enabling near-real-time coordination between operators, analysts, and decision makers.

REDUCED SIZE, WEIGHT, AND POWER

The O3b mPOWER phased array antenna system enables the use of smaller and lighter airborne terminals that provide the equivalent throughput performance of far larger GEO terminals. This reduces the size, weight, and power (SWAP), and cost of the UAS airborne terminals. The SWAP reduction can be used to improve UAS platform range and endurance, and/or allow the UAS platform to carry additional or enhanced sensor payloads.

GLOBAL CAPABILITY

The O3b mPOWER network provides high capacity coverage over the full 360° range of longitudes and to ±50° latitude, providing mission support in mission-critical areas of operation, as well as known global areas of conflict.

FIGURE 2
COVERING GLOBAL AREAS OF CONFLICT TO DELIVER MISSION CRITICAL COMMUNICATIONS

OPEN ARCHITECTURE AND MULTIPLE VENDOR APPROACH

Implementing an open architecture offers numerous advantages. The entire system— satellites, terminals, and terrestrial networks—can support multiple vendor platforms and networks, allowing customers far more choice when addressing mission requirements than any previous system.

We are closely engaged with multiple Original Equipment Manufacturers (OEMs) and airborne terminal vendors to ensure a wide range of terminal options are available to access the O3b mPOWER system for both HALE/MALE UAS, and crewed airborne systems. Developments are ongoing to extend the range of airframes supported down to the Group 3 UAS level.

Although implemented as a fully digital architecture, the O3b mPOWER satellites are able to operate as 'bent-pipe' repeaters, ensuring all current and future modulation and encryption techniques can be supported.

INHERENT RESISTANCE TO INTERCEPTION AND JAMMING

MEO SATCOM systems like O3b mPOWER and the first-generation O3b MEO system are inherently interception and jamming resistant due to the motion of the satellites and the use of narrow spot beams. O3b mPOWER further enhances its resistance to interception and jamming by using even smaller spot beams, with a width of 0.5 to 1.0° (with a ground footprint diameter of approximately 140 to 280 kilometres).

In 2015, we conducted rigorous validation of our 1.2 metre O3b terminals through the US Department of Defense's Information Assurance Certification and Accreditation Process (DIACAP, now called the Risk Management Framework). This process provided us with the authority to operate our O3b MEO system on the USS Fort Worth during the US Navy's 2015 Trident Warrior exercise. O3b mPOWER, like the first-generation O3b MEO system, will provide a high degree of resistance to interception and jamming by an adversary. This further enhances the probability of mission success and ensures high performance for UAS applications.

Our O3b mPOWER system has the ability to support advanced anti-jam waveforms. This is made possible by independent subnetworks transmitted using channelised bandwidth. The system is also able to employ frequency hopping and spread spectrum techniques to further enhance TRANSEC, Low Probability of Intercept (LPI), and Low Probability of Detection (LPD). These capabilities are enhanced by O3b mPOWER's ability to steer the narrower satellite beams to follow the UAS. The system has the ability to obfuscate the location of the airframe while doing this.

In addition, the ability to establish government-defined ground networks and government-owned terminals and gateways can allow the use of capabilities that are not permitted on public networks, where the user does not have physical control of the ground locations.

THE FUTURE OF AIRBORNE C4ISR

Optimised and secure satellite-enabled data communications for UAS missions

With O3b mPOWER, we have introduced a paradigm shift in satellite telecommunications. The system offers the speed of fibre, with the reach that only satellite-enabled networks can provide. Through its unprecedented flexibility and advanced technologies, O3b mPOWER opens up a world of new applications and services that cannot be offered with other satellite telecommunications systems.

In response to the evolving demand for telecommunications services, we have created the world's most advanced constellation of equatorial MEO satellites, supported by second-generation ground infrastructure, and advanced management and control software. The result is a portfolio of communications solutions that are more efficient, cost-effective, and versatile than ever before.

The O3b mPOWER system offers a number of compelling advantages for C4ISR UAS missions when compared to previous, purely GEO-based solutions. The most important of these is having much greater capacity for sensor data off-boarding and the ability to vary the forward/return ratio and data rates in near real-time. The system's capacity will be sufficient for all current and foreseeable sensor payloads.

A further advantage is that MEO SATCOM systems are inherently resistant to interception and jamming. This, coupled with the system's ability to implement customer-defined ground networks, and the possibility of locating terminals in secure, customer-selected locations, greatly enhances TRANSEC and COMSEC.

O3b mPOWER offers government and military customers unique new possibilities for UAS intelligence missions.

SES NETWORKS— AN EXPERIENCED PARTNER

Bringing more than 30 years' expertise to government and institutional network services

With a deep understanding of the needs of governments and humanitarian organisations, SES Networks provides end-to-end managed network and application services for security, defence, disaster response, and humanitarian operations. As part of the SES Group, we have the infrastructure and global support to empower governments around the world to meet the increasingly challenging requirements for secure communications networks.

Powered by the industry's only multi-orbit, multi-band fleet, our Signature Government Solutions enable governments and institutions to provision critical communications for missions all over the world—even in the most remote locations. Our Global Government division—together with our dedicated affiliates Redu Space Services, SES Government Solutions, and GovSat—offers a full suite of managed network services for missions on land, at sea, and in the air. Our portfolio includes tailored solutions for a wide variety of government applications, including border control, C4ISR, civil protection and disaster response, and e-government applications.

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