



Transforming Military SATCOM: The Power of SpaceBridge's Next-Generation ESTELLA





SpaceBridge's Next Generation ESTELLA core is a transformative Satellite Communication (SATCOM) solution offering advanced feature sets to support various operational needs critical for modern defense, including secure, reliable, and flexible connectivity. ESTELLA combines our 3D Time Division Multiple Access (TDMA) Waveform, our quasi-SCPC WaveSwitch™ waveform, and our Dynamic Rate Assignment (or Burst Mode-Frequency Division Multiple Access; BM-FDMA) features together to offer a SATCOM solution which meets military requirements everywhere.

Understanding ESTELLA Innovations:

3D TDMA Waveform:

TDMA is a channel access method used in telecommunications to allow multiple users to share the same satellite frequency channel/carrier by dividing the signal into distinct time slots. Each user is assigned a specific time slot or slots within which they can transmit or receive data, thereby sharing the overall bandwidth without interference. Traditional approach often involved trade-offs between performance efficiency and resiliency since the carriers/modulation/coding/block sizes are often fixed and tailored to the user with the most challenging satellite connectivity conditions.

ESTELLA 3D TDMA preserves the structured and interference free communication benefits of traditional TDMA but enhances the efficiency of the satellite channels/carriers by allowing for variable timeslot sizings to accommodate our 3D (3 Decision Factor) independent per remote Modulation/Coding/Block sizes (MCB) selections. The ESTELLA can instruct each remote to select from among 73 MCB options (ranging from spread spectrum Es/No at -15dB to 64QAM Es/No at +18dB) to best meet its connectivity needs and it does so on a per burst basis. This means that multiple users can all share the same carrier with each utilizing their own optimal MCB allowing for best performance and resiliency. Our burst interval can be as low as 20msecs which allows for ESTELLA to rapidly adapt the remote MCB selections providing an inherent protection or adaptive coding modulation (ACM) to protect against link degradations or interference.

Dynamic Rate Assignment (DRA or BM-FDMA)

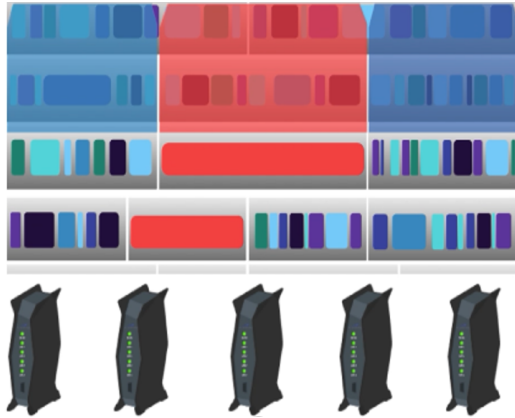
Since ESTELLA 3D TDMA carriers support variable MCB per timeslot per burst, a distinct timeslot profile per satellite channels/carriers must be defined.

DRA is a component of the ESTELLA scheduler which defines return link satellite channels/carriers per burst to accommodate the ever-changing traffic patterns and hence timeslot profiles. This DRA is akin to BM-FDMA in that the carrier definitions are created dynamically every burst interval and so carrier frequency allocations are always changing. This DRA/BM-FDMA inherently makes carrier detection and interception very difficult since carriers are only temporarily allocated for the burst interval.

The ESTELLA scheduler that simultaneously assigns DRA and TDMA carriers can be configured to obfuscate traffic by maximizing the spreading the carrier definition over widest possible frequency ranges to provide a quasi Frequency Hopping Spread Spectrum mode (FHSS) additional level of protection.

ESTELLA supports inherent Interference Detection and Avoidance in that it employs complex digital signaling processing able to detect unexpected changes in channel/carrier performance (due to accidental or intentional interference) and, within a burst interval, dynamically steer carrier definitions away from effected satellite channels/carriers.

WaveSwitch™ Technology



While TDMA is most efficient for shared access to satellite channels due to reuse of the same frequency band that allows oversubscription and hence yields the effective spectral gain due to the statistical multiplexing of the channel between multiple users. The trade off is often lower efficiency due to TDMA related overheads. Single Channel Per Carrier (SCPC), which allocates a

dedicated satellite return carrier to the exclusive use of a single remote, benefits from lower overheads and is often preferred for higher bandwidth or sustained communications links requirements.

WaveSwitch™ is a powerful ESTELLA innovation, which builds upon our 3D TDMA and DRA capabilities, allowing for remotes to be switched between defined shared TDMA satellite carriers to dedicated SCPC satellite carriers dynamically, completely hitless (errorless) and preserving full bit count integrity, on per burst interval. The ESTELLA scheduler determines the return link demands of all remotes and automatically decides if the remotes (and total network capacity) would best be serviced with the remote in TDMA or SCPC mode. The ESTELLA makes these decisions every burst interval to optimize network performance, optimize remote performance, and optimize remote BUC performance. WaveSwitch™ carriers can offer as much as 15% higher throughput at same E_s/N_o vs TDMA carriers.

SpaceBridge ESTELLA for Military SATCOMs

ESTELLA is ideally suited to support military and mission critical applications around the world. It provides the following requirements essential to supporting military SATCOMs:

1. **Coverage and Resilience:** ESTELLA provides multi-military missions profiles across GEO satellites enabling wide reach and coverage. ESTELLA 3D TDMA and DRA combine to define carriers and remote MCB selections to automatically match the capabilities of any remote terminal dynamically (whether it be a small aperture flat panel or manpack antenna). This capability is essential for seamless communication across land, sea, and air, even in isolated or hostile environments. ESTELLA 3D TDMA employs optimal MCB to maximize performance but can fall back to DSSS, spreading the signal to make it less susceptible to jamming, with ESTELLA able to isolate and reconstruct the remote traffic ensuring highest possible resilience of the link.

Operationally, ESTELLA may be deployed in standalone mode, redundant mode, and geographically redundant mode (the latter improving threats resilience from cyber or physical attacks on infrastructure). In case of geographical redundancy, ESTELLA hub may rapidly be replaced by a second or third passive/active or even a mobile HUB with ESTELLA network maintaining secure communication channels between each other (via terrestrial or over satellite itself) allowing for HUBs to maintain the same

synchronized databases and burst time plans. This means any HUB is ready to take over within a short period of time, minimizing critical downtime.

ESTELLA provides assured connectivity and resilience in satellite networks to withstand electronic warfare, cyber threats, and physical attacks on infrastructure.

2. **High Data Throughput and Bandwidth Efficiency:** Military operations need to support secure video, voice and other demanding and data-intensive services for applications like ISR (Intelligence, Surveillance, and Reconnaissance), secure communications, and command/control functions. ESTELLA 3 components, 3D TDMA/DRA/WaveSwitch all combine to provide the most efficient use of bandwidth, whether it is TDMA or SCPC, and provide exceptional adaptability to support high data throughput channels on-the-fly, essential for delivering high-speed data and video transmissions required in support of military operations.
3. **Secure, Encrypted Communications:** Security is paramount when it comes to military SATCOM networks. ESTELLA DRA and FHSS provides a robust physical layer obfuscation of the return satellite channels to defeat anti-jamming and satellite interference/disruption. Additionally, ESTELLA employs robust COMSEC AES256 based encryption at the forward and return satellite channel/carrier traffic to safeguard communications from interception. Military SATCOM must ensure data integrity and confidentiality under adverse electronic warfare conditions.

Conclusion:

The driving attribute in SpaceBridge's ESTELLA development was to provide capabilities unlike any other system in combining the best of TDMA, SCPC and BM-FDMA technologies to provide truly flexible and resilient connectivity.

ESTELLA platform is ideally suited to support today's challenging military missions and operations through unparalleled capabilities based on our advanced 3D TDMA, DRA and WaveSwitch™ features.