Satellite Use Cases and Solutions for 5G

PRESENTED BY
Konstantinos LIOLIS

PRESENTED ON
15 October 2018
Aim:
- To present the most promising satellite use cases for 5G with focus on eMBB and mMTC
- To present GEO/MEO satellite solutions for 5G roll-out

Outline:
- SES Overview
- Intro to 5G & Satellite Role
- Selected Satellite Use Cases for eMBB and mMTC
- GEO/MEO Satellite Solutions for 5G Roll-Out
- Conclusion
About SES
World’s Leading Satellite Operator

70+ satellites covering 99% of the globe and world population

Unique GEO-MEO constellation complemented by a ground segment, together forming a flexible network architecture that is globally scalable

Driver of INNOVATION in building a cloud-scale, automated, “virtual fibre” network of the future

LEADING IN THE INDUSTRY’S MOST INFLUENTIAL STANDARDS GROUPS
□ Active proponent of integration of satellite into 5G
□ Co-founder and Vice-Chair of the 5G Infrastructure Association (5G-IA)
□ Collaborative standards, studies and open-source initiatives
□ Member of the SB and relevant WGs of NetWorld2020 ETP
□ Member of the ESA “Satellite for 5G” Task Force
□ Ecosystem and technology development, e.g. SaT5G, 5G-VINNI (EU H2020), SATis5 (ESA)
What is 5G?

Key Usage Scenarios

"5G-only" use cases are few and challenging even for mobile networks

Many use cases are achievable using existing technologies and their evolutions

Source: ITU-R M.2083

Source: GSMA Intelligence, “Understanding 5G” (Dec. 2014)
Key Satellite Features that Enhance the Networked Society

Ubiquity
Mobility
Broadcast (Simultaneity)
Security
Satellites Can Support the Key Usage Scenarios for 5G

▲ Satellites can support multi-Gbps data rates for enhanced mobile broadband (eMBB)
  • Satellites routinely carry high bandwidth HD and UHD content
  • Satellites already support 2G/3G mobile backhaul in many parts of the world, and high-throughput satellites (HTS) in GEO, MEO and LEO will support 4G and 5G mobile networks

▲ Satellites can support massive machine-type communications (mMTC)
  • Satellites already support SCADA and other global asset tracking applications today, and can scale to support future M2M/IoT communications
  • Investments in new ground segment technologies, such as smaller, lower cost, electronically steerable, and/or phased-array satellite transceivers are making ubiquitous deployment for IoT feasible

▲ Satellites can support ultra-reliable communications (URLLC)
  • Our customers – international broadcasters, MNOs, governments – depend on us every day to ensure ultra-reliable communications
  • GEO latency of 250ms (500ms round-trip) is acceptable for many 5G applications, and new MEO and LEO networks will be able to support even more latency-sensitive applications
  • Satellites can even play a role in helping 5G networks meet their sub-1ms latency requirements by delivering commonly accessed content to mobile base stations
Sub-1ms latency is a challenge, even for 5G mobile networks

According to GSMA Intelligence, “Understanding 5G” (December 2014):

- “Achieving the sub-1ms latency rate … will likely prove to be a significant undertaking in terms of technological development and investment in infrastructure.” (at p.12)
- “[S]ervices requiring a delay time of less than 1 millisecond must have all of their content served from a physical position very close to the user’s device. … possibly at the base of every cell, including the many small cells that are predicted to be fundamental to meeting densification requirements.” (at p.12)


- “Paradoxically, the low latency requirement for 5G network is a big ally in this vertical for satcom as many new locations for content servers will be required. In the transition to 5G, content needs to be moved to the edge and many new locations will be required, densifying CDN networks and making satellite multicast a viable option.”
- “The emergency and growth of applications like virtual reality, augmented reality, tactile Internet or video streaming will only accelerate this requirement to move capacities to the edge.”

This same capability is described in ECC Report 280 “Satellite solutions for 5G” (May 2018):

- “[N]ew edge-focused network infrastructure that IMT 2020 will demand means that satellites can play a role in connecting and updating the large number of edge servers [required]”

Thus, satellites can help 5G networks achieve sub-1ms latency by multi-casting content to caches located at individual cells, even in places without fiber. This is one of the satellite “sweet spots”!
Four Satellite “Sweet Spots” in the 5G Ecosystem

These four “sweet spots” leverage the advantages of satellites – high bandwidth and ubiquitous coverage – to enable and extend terrestrial 5G networks.
**Satellite Use Cases for eMBB and mMTC**

Selection Methodology Developed by SES in SaT5G and SATis5 Projects

▲ **SaT5G:** Satellite and Terrestrial Network for 5G

- European Commission H2020 ICT - 5G PPP Phase 2
- Aim: To research, develop, validate and demonstrate key technology enablers for “plug-and-play” integration of SatCom into 5G networks, with focus on 5G use cases for enhanced mobile broadband (eMBB)
- Further info: [http://sat5g-project.eu/](http://sat5g-project.eu/)

▲ **SATis5:** Demonstrator for Satellite-Terrestrial Integration in 5G Context

- European Space Agency ARTES Advanced Technology
- Aim: To build a large-scale real-time live end-to-end 5G integrated network PoC testbed that enables the satellite terrestrial convergence into the 5G context. Focus on both eMBB and mMTC use cases
- Further info: [https://artes.esa.int/projects/satis5](https://artes.esa.int/projects/satis5)
<table>
<thead>
<tr>
<th>Satellite Use Case Categories</th>
<th>Satellite Use Cases for eMBB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trunking and Head-end Feed</strong></td>
<td>Broadband connectivity to areas where it is difficult or not (yet) possible to deploy terrestrial connections to towers, for example, coverage on lakes, islands, mountains, rural areas, isolated areas or other areas that are best or only covered by satellites; across a wide geographic region.</td>
</tr>
<tr>
<td></td>
<td>Broadband connectivity for network head-ends.</td>
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<td></td>
<td>Secondary/backup connection (limited in capability) in the event of primary connection failure.</td>
</tr>
<tr>
<td><strong>Backhauling and Tower Feed</strong></td>
<td>Providing efficient multicast/broadcast delivery to network edges for content such as live broadcasts, ad-hoc broadcast/multicast streams, group communications, MEC VNF update distribution.</td>
</tr>
<tr>
<td><strong>Communications on the Move</strong></td>
<td>Broadband and content multicast connectivity to moving platforms such as airplanes, vessels, high speed trains/buses and other road vehicles, in conjunction with terrestrial-based connectivity link to base stations or relay on-board moving platforms, to ensure service continuity and service reliability.</td>
</tr>
<tr>
<td></td>
<td>Infotainment to connected cars: real-time information, entertainment and connectivity enhance passenger experience.</td>
</tr>
<tr>
<td><strong>Hybrid Multiplay</strong></td>
<td>Connectivity complementing terrestrial networks, such as broadband connectivity to home/office small cell in underserved areas in combination with terrestrial wireless or wireline.</td>
</tr>
</tbody>
</table>
### “Global” List of Satellite Use Cases for mMTC

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<tbody>
<tr>
<td><strong>Trunking and Head-end Feed</strong></td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Backhauling and Tower Feed</strong></td>
<td>Broadcast service to end users, etc (e.g., video, software download), <strong>support of low bit-rate broadcast service</strong> e.g. for emergency messages and synchronisation of <strong>remote sensors and actuators</strong>.</td>
</tr>
<tr>
<td><strong>Communications on the Move</strong></td>
<td><strong>Connectivity for remotely deployed battery activated (M2M/IoT) sensors, or handset devices with messaging/voice capabilities via satellite</strong> (e.g. fleet management, asset tracking, livestock management, farms, substations, gas pipelines, digital signage, remote road alerts, emergency calls, mission critical/public safety communications, etc).</td>
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<td></td>
<td><strong>Two-way telematics capability enabling automotive diagnostic reporting on connected cars</strong>, user base insurance information, safety reporting (e.g. air-bag deployment reporting), advertising based revenue, remote access functions (e.g. remote door unlocking), increased coverage and reliability for e-Call services, stolen vehicle tracking and vehicle telemetry.</td>
</tr>
<tr>
<td></td>
<td><strong>IoT devices on containers (e.g. for tracking and tracing) connected via a Relay UE on a transport vehicle</strong> such as a ship, train or truck.</td>
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<tr>
<td></td>
<td><strong>Autonomous Shipping</strong>: Low- and high- data rate SatCom services for improved onboard connectivity in autonomous vessels mainly for deep sea operations.</td>
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<tr>
<td></td>
<td><strong>Secondary/backup connection (limited in capability) for connected cars</strong>: Enabling Firmware/Software Over-the-Air (FOTA/SOTA) services to get information updates, such as information regarding Points of Interest (POIs), real-time traffic, and parking availability.</td>
</tr>
<tr>
<td></td>
<td><strong>OTA (Over-the-Air) updates with acknowledgement for connected cars</strong>: Efficient and secure broadcast service to update software in TCU (Telematic Control Unit), ECUs (Electronic Control Units), and Head Units.</td>
</tr>
<tr>
<td></td>
<td><strong>Cyber and Managed Security Services for connected cars</strong>: Alternate secure channel for global certificate and key management; managed service for OEMs and Tier 1s patching latest vulnerabilities and attacks by updating firewall and IDS (Intrusion Detection Systems) systems.</td>
</tr>
<tr>
<td><strong>Hybrid Multiplay</strong></td>
<td>N/A</td>
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Market Verticals and Market Size Assessment Methodology

Market Verticals
- Media & Entertainment
- Transportation
- Manufacturing
- Health
- Utilities
- Agriculture
- Public Safety

Qualitative Market Size Assessment
- Proposed criterion employed: **Global Satellite Services Market Size in 2030**
- Proposed scoring employed:
  - €: 1-10 M€
  - €€: 10-100 M€
  - €€€: 100-1000 M€
  - €€€€: >1 B€
- Notes:
  - Assumed timeline for the forecast is 2030 as 5G is highly unlikely to generate anywhere near the numbers mentioned as early as 2025
  - Reported qualitative market size assessment is based on experts’ judgement assessment from the satellite operator’s viewpoint and based on the development seen in the industry
<table>
<thead>
<tr>
<th>5G Usage Scenario</th>
<th>Satellite Use Case Category</th>
<th>Satellite Use Case for 5G</th>
<th>Correspondence to 3GPP SA1 Use Case (3GPP TR 22.822)</th>
<th>Media &amp; Entertainment</th>
<th>Transportation</th>
<th>Manufacturing</th>
<th>Health</th>
<th>Utilities</th>
<th>Agriculture</th>
<th>Public Safety</th>
<th>Global Satellite Services Market Size in 2030</th>
</tr>
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<tr>
<td>eMBB</td>
<td>Trunking and Head-end Feed</td>
<td>Broadband connectivity to areas where it is difficult or not (yet) possible to deploy terrestrial connections to towers, for example, coverage on lakes, islands, mountains, rural areas, isolated areas or other areas that are best or only covered by satellites; across a wide geographic region.</td>
<td>5G Fixed Backhaul between NR and the 5G Core</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>€€€€</td>
</tr>
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<td></td>
<td>Backhauling and Tower Feed</td>
<td>Providing efficient multicast/ broadcast delivery to network edges for content such as live broadcasts, ad-hoc broadcast/multicast streams, group communications, MEC VNF update distribution.</td>
<td>Broadcast and multicast with a satellite overlay</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>€€€€</td>
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<td>Communications on the Move</td>
<td>Broadband and content multicast connectivity to moving platforms such as airplanes, vessels, high speed trains/buses and other road vehicles, in conjunction with terrestrial-based connectivity link to base stations or relay onboard moving platforms, to ensure service continuity and service reliability.</td>
<td>5G Moving Platform Backhaul</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td></td>
<td>Hybrid Multiplay</td>
<td>Connectivity complementing terrestrial networks, such as broadband connectivity to home/office small cell in underserved areas in combination with terrestrial wireless or wireline.</td>
<td>5G to Premises</td>
<td>✓</td>
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**Selected Satellite Use Cases for mMTC**

**Mapping to Market Verticals and Market Size Assessment**

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<tbody>
<tr>
<td>mMTC</td>
<td>Backhauling and Tower Feed</td>
<td>Broadcast service to end users (e.g., video, software download), <strong>support of low bit-rate broadcast service</strong> e.g. for emergency messages and synchronisation of remote sensors and actuators.</td>
<td>Internet of Things with a satellite network</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>€</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mMTC</td>
<td>IoT devices on containers (e.g. for tracking and tracing) connected via a Relay UE on a transport vehicle such as a ship, train or truck.</td>
<td>Indirect connection through a 5G satellite access network</td>
<td>✓</td>
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What is Satellite into 5G?

Short/Mid-Term: Operational Integration and Satellite Backhauling Solutions

▲ Short/Mid-term: Fully-fledged implementation for operational integration of satellite into the heterogeneous 5G “network of networks” through plug & play approach with focus on higher layer enablers (e.g., NFV, SDN, Network Slicing, MEC, etc) under common network management and orchestration.

Satellite into 5G is mainly about the higher layers, not about 5G waveforms, ultra-low latency, or cell towers in space.

▲ Short/Mid-term: Reference GEO/MEO satellite backhaul architectures.
EuCNC 2018 Demo Setup Overview
First-of-its-kind over-the-air live demo towards integration of satellite into 5G

Demonstrated key benefits of satellite integration with an SDN / NFV / MEC-enabled pre-5G construction testbed, with an SES GEO in-orbit satellite system as a proof-of-concept for integration of those features into a full 5G network

Objectives

▲ Satellite integration into standard 3GPP network architecture
▲ SDN and NFV integration into satellite communications
▲ Content delivery over Satellite
▲ Multi-access Edge Computing (MEC)
ENABLING GLOBAL CONNECTIVITY

- MULTI-TERABIT CAPACITY
- ULTIMATE FLEXIBILITY
- GLOBAL COVERAGE
- LOW LATENCY, VIRTUAL FIBER NETWORK

LAUNCH 2021
O3b Next Generation MEO Constellation
The Most Powerful Satellite System Ever

- SES Networks already operates the only MEO satellites for the lowest-latency service from space
- In 2021, seven next-generation MEO satellites will be added to the O3b fleet
- Setting new industry benchmarks across multiple performance metrics

**CAPACITY**
- Multi-terabit Scalable to 10s of Tbps globally

**FLEXIBILITY**
- Shape, moderate, route, shift & switch
- 4,000+ beams per satellite

**COVERAGE**
- ~400M Square kilometres covered

**PRODUCTIVITY**
- 100% productive
- Beams go to customers, not empty territory
Our Vision: A Software-defined, Automated, Cloud-scale Platform

Planning for the future

As your customers demand more, we chart a clear path to cloud-scale, software-defined networks.

SD-WAN  Analytics  Security  IoT  Video  AR/VR  VNFs  Connected Car

End-to-end service orchestration

Network and service automation

O3b mPOWER, GEO-HTS

Customer Edge Terminal

Customer Edge

Turnkey tower & power

5G

MEC Apps

Customer Edge

SES Gateway

Cloud Apps

SES PoP

Peering & content partnerships

Management & Orchestration

SES, partner & customer applications

Colloquium "Satellite for 5G", 15 October 2018
Conclusion
SES has leading role in promoting satellite integration in 5G

▲ Satellite can deliver secured high bandwidth and ubiquitous coverage to connect fixed and on-the-move 5G network sites as well as to enable highly scalable content distribution capabilities, accelerating 5G roll-out.

▲ Satellite industry is investing in global network infrastructure which can be used to support 5G roll-out worldwide.

▲ Satellite integration into 5G requires certain technology development, validation & demonstration as well as standardisation efforts (e.g., 3GPP, ETSI). Projects such as SaT5G, 5G-VINNI (EU H2020), SATis5 (ESA), support these initiatives. Further projects in the pipeline.

▲ Fully-fledged implementation for operational integration of satellite into 5G through plug & play approach with focus on satellite backhauling and higher layer enablers (NFV, SDN, Network Slicing, MEC, etc) is possible in short/mid-term.

▲ First of its kind live demonstration at the EuCNC 2018 conference in Ljubljana, Slovenia; further demonstrations over GEO/MEO foreseen in 2018, 2019 (aero, mobile van, customer premises).

▲ SES has deep expertise in delivering tailored backhaul solutions with the industry’s only multi-orbit, multi-band GEO/MEO fleet.
Acknowledgement & References

▲ SaT5G
• Part of the presented work was conducted within the SaT5G project, which has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement no. 761413.

▲ SATis5
• Part of the presented work was conducted within the ESA ARTES project SATis5 – ESA Contract No.: 4000120663/17/NL/CLP. The views expressed herein can in no way be taken to reflect the official opinion of the European Space Agency.

▲ References
• K. Liolis, “Overview of SES's Innovation Activities on Satellite Integration into 5G”, in Proc. 16th BroadSky Workshop, within 24th Ka and Broadband Communications Conference and 36th International Communications Satellite Systems Conference (ICSSC), Niagara Falls, Canada, 16 October 2018.