Integrating Satellites and 5G

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Introduction
**SES & O3b**

Who we are

**SES** worldwide

- **World-leading satellite operator and dynamic market leader**
  - ▲ Global satellite fleet operator
    - Over 50 satellites in GEO covering 99% of the globe
    - 12 O3b satellites in MEO
  - ▲ Partner of choice for major global broadcasters, telcos, enterprises, governments and institutions
    - Technical reach of 325 million households in 2016
  - ▲ Global reach, regional support
    - Over 2,000 employees around the globe
    - 25 locations worldwide

**SES** in the Asia-Pacific

A strong base of quality video & data customers in the region
SES & O3b
Combined Fleet Map

SES's GEO SATELLITES
Delivering extended coverage
- In orbit
- To be launched

O3b's MEO SATELLITES
Delivering low latency

MEDIUM EARTH ORBIT
(8,000 km from Earth)

GEOSTATIONARY ORBIT
(36,000 km from Earth)

Fleet configuration is based on current planning and is subject to change. SES holds a 70% interest in Ciel Satellite Limited Partnership and a 100% ownership interest in QuetzSat. Yahsat 1A's Ku-band payload is owned by YahsatLive, where SES holds a 30% ownership interest. *GovSat – Joint venture with Luxembourg government.
August 2015
SES & O3b
SES Ground Network
Global reach 45 degrees North and South

Nine gateways connect customers to the Internet

Fiber-like latency and capacity:
- Under 150 ms roundtrip
- 2 Gbps per beam
What is 5G (IMT-2020)?
What is 5G (IMT-2020)?
Key Usage Scenarios


5G is expected to address three key usage scenarios:

1. **Enhanced mobile broadband**: Including multi-gigabit per second (Gbps) data rates for applications like virtual reality and the ability to support extensive data traffic growth.

2. **Ultra-reliable communications**: Including very low latency (sub-1ms) and very high availability, reliability and security to support services such as autonomous vehicles and mobile healthcare.

3. **Massive machine-type communications**: Including the ability to support a massive number of low cost IoT connections with very long battery life and wide coverage including inside buildings.
What is 5G (IMT-2020)?
Diverse Usage Scenarios

▲ GSMA Intelligence, “Understanding 5G” (Dec. 2014)

Observations

“5G-only” use cases are few and challenging even for mobile networks
Most use cases are achievable using existing technologies

Figure 1: Bandwidth and latency requirements of potential 5G use cases
Source: GSMA Intelligence

Legend:
- Services that can be delivered by legacy networks
- Services that could be enabled by 5G
- Fixed
- Nomadic
- On the go
- M2M connectivity
Satellite’s Role in the 5G Ecosystem
Satellites Can Support the Key Usage Scenarios for 5G

▲ Satellites can support **multi-gigabit per second** data rates for **enhanced mobile broadband**

- 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 **ultra-reliable communications**

- 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 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

▲ Satellites can support **massive machine-to-machine communications**

- Satellites already support SCADA and other global asset tracking applications today, and can scale to support future machine-to-machine (Internet-of-Things) 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
Why Integrate Satellites in 5G?

▲ Satellite’s ability to extend terrestrial networks is **essential for an inclusive digital society** to ensure that the benefits of 5G (or even 4G) are made available beyond the urban cores

- Otherwise, 5G and 4G will only be providing more broadband to those who already have it

▲ Satellites today already **complement** and help **extend terrestrial networks** to places they would not otherwise reach – 2G/3G/4G mobile backhaul, rural Wi-Fi backhaul, aeronautical and maritime broadband

- New **High Throughput Satellite (HTS) systems** – both geostationary and non-geostationary – will bring even higher speeds, lower cost-per-bit, and lower latency (when needed) to **support current 4G and future 5G/Wi-Gig networks**

- In order to meet the **low latency (sub-1ms) requirements of future 5G applications**, commonly accessed content will need to be efficiently distributed and stored at the base of every 5G cell site – a multi-cast or point-to-multipoint function at which satellites excel

- Satellites also **support many IoT networks** today (e.g. global asset tracking and SCADA) and can scale to meet expanded IoT requirements of the future, e.g. connected cars, planes and ships
Four main use cases for the integration of satellite-based solutions into 5G (IMT-2020)

These four “sweet spots” leverage the advantages of satellites – high bandwidth and ubiquitous coverage – to enable and extend terrestrial 5G networks.
A very high speed satellite link (up to 1 Gbps or more) from geostationary and/or non-geostationary satellites will complement existing terrestrial connectivity to enable:

- High speed trunking of video, IoT and other data to a central site, with further terrestrial distribution to local cell sites (3G/4G/5G cellular), for instance neighboring villages.
A very high speed satellite link (up to 1 Gbps or more), direct to base stations, from geostationary and/or non-geostationary satellites would complement existing terrestrial connectivity and enable:

- Backhaul connectivity to individual cells with the ability to multicast the same content (e.g. video, HD/UHD TV, as well as non-video data) across a large coverage area
- Efficient backhauling of aggregated IoT traffic from multiple sites
Very high speed, multi-cast enabled, satellite link (up to 1 Gbps or more) direct to plane, train, car or vessel, from geostationary and/or non-geostationary satellites would enable:

- Backhaul connectivity and multicasting of (video, HD/UHD TV and non-video data) where it may not be otherwise possible
- Direct connectivity and/or efficient backhauling of aggregated IoT traffic
Very high speed (up to 1 Gbps or more) satellite connectivity to individual homes and offices, with the ability to multicast the same content (video HD/UHD TV, and non-video data) across a large coverage area (e.g. for local storage or consumption)

- The same capability allows for efficient broadband connectivity for aggregated IoT data
- Further in-home or in-office distribution via Wi-Fi or very small 3G/4G/5G nano-cells
Satellites Can Even Help Achieve Sub-1ms Latency

▲ Sub-1ms latency is very difficult to achieve, 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)

• Illustrated by Figure 3 (at p.13):

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”!
Satellite industry is actively engaged in developing the key technologies and standards needed to enable seamless integration of satellite solutions into future 5G networks.

“SaT5G” – or Satellite and Terrestrial Network for 5G – is an industry-led consortium funded by the European Commission that will research and validate the key technology enablers for integration of satellites into 5G, and demonstrate them in live 5G test beds.

- 16 partner companies consisting of satellite and terrestrial operators, equipment manufacturers, universities and research centers
- 30-month project that will run from June 2016 to November 2019
Integrating Satellites into the 5G Ecosystem
Satellite and Terrestrial Network for 5G

SaT5G Use Cases and Research Pillars

- **Use Case 1**: Edge delivery & offload for multimedia content and NFV software
- **Use Case 2**: 5G Mobile backhaul
- **Use Case 3**: 5G Fixed backhaul
- **Use Case 4**: 5G Small cell backhaul

- **RP VI**: Caching and Multicast for Content/VNF distribution to the edge over satcom
- **RP I**: Implementing 5G SDN and NFV in satcom
- **RP IV**: Common 5G-satcom Control Plane/User Plane Functions
- **RP III**: Multi Link and Heterogeneous transport

- **RP V**: 5G Security extensions to satcom

3GPP NexGen Core

Satcom NFV and network slice instance

**App Cloud**
- MEC Server, Multicast, Content Servers, NFV Marketplace
- Policy Control Function
- Subscriber Repository

**NG2**
- Slice CP
- NFx

**NG3**
- Slice UP
- NF1

**Network Slice Instance**
- Satcom NFV and network slice instance

**RP II**: Integrated SaT5G Network Management and Orchestration

**RP III**: Integrated SaT5G Network Management and Orchestration
Satellite Use of the mmWave Spectrum
Satellites Already Use mmWave Spectrum

▲ Satellite spectrum requirements must also be taken into account in 5G spectrum planning

▲ Many of the current High Throughput Satellite (HTS) systems already make use of mmWave spectrum, for example:
   • IPStar – one of the very first HTS systems – operates in Ku- and Ka-band frequencies
   • Inmarsat’s GlobalXpress satellites operate in the Ka-bands (4 in-orbit)
   • Australia’s NBNCo’s satellites operate in the Ka-bands (2 in-orbit)
   • O3b’s Medium Earth Orbit constellation operates in the Ka-bands (12 in-orbit, 8 more to be launched in 2018)
   • Others include: ViaSat-1,2; Jupiter-1,2; KaSat; Hylas satellites

▲ Next-generation Very High Through Satellites (VHTS) will use even more mmWave spectrum
   • At least six next-generation, global non-geostationary constellations have been proposed using the Ka- and Q-/V-band frequencies
World Radio Conference 2019 (WRC-19) Agenda Item 1.13 will consider over 31 GHz worth of spectrum as potential bands for terrestrial mobile 5G (IMT-2020) services

26 GHz Band (24.25-27.5 GHz)

24.65-25.25 GHz is an FSS uplink band intended to feed the 21.4-22 GHz BSS downlink band

- ITU affirmed and expanded this allocation as recently as WRC-12. Without access to this uplink band, the ability to efficiently feed the 21.4-22 GHz BSS band is lost
- Satellite operators have only just started to deploy in this portion of the band (e.g. DTV 14 & 15)
- Potential SaT5G use case is to use BSS to efficiently multicast common content to multiple 5G base stations

27.0-27.5 GHz is an FSS uplink band used on NBN satellites in Australia

Consider prioritizing portions of band not shared with satellite and establishing sharing conditions in the shared bands based on ITU-R TG 5/1 studies
mmWave Spectrum for Terrestrial Mobile 5G
Satellite Perspectives (cont’d)

28 GHz Band (27.5-29.5 GHz)

▲ Not included in WRC-19 Agenda Item 1.13, and therefore is unlikely to be internationally harmonised

• Europe is opposed to using this band, China is not prioritizing this band, and only a small number of countries are targeting this band for terrestrial 5G

▲ Key uplink band for GEO and non-GEO systems, including HTS systems

▲ Already deployed on many satellites, over 20 of which were launched just in the last four years

• NBN satellites; IPStar; Inmarsat GlobalXpress (x4); O3b MEO constellation (x12); Viasat-1,2; Jupiter-1,2; Hylas-1,2; JCSat-16; Amazonas-3; Spaceway-3; Wildblue-1; Superbird 4; AMC-15,16; and several DIRECTV satellites

▲ No need to consider the 28 GHz band as there is ample other spectrum (more than 31 GHz worth) identified as potential 5G bands
32 GHz Band (31.8-33.4 GHz)

▲ Good prospect for international harmonisation as it was proposed for study by all three ITU regions at WRC-15

▲ Similar propagation characteristics as other lower mmWave bands, but without the heavy existing and planned uses

Q-/V-Bands (37-52 GHz)

▲ Multiple satellite companies have announced plans to deploy next-generation VHTS systems using portions of the Q-/V-bands
  • Including six global non-GEO constellations: Boeing, O3b, OneWeb, SpaceX, Telesat and Theia

▲ WRC-19 Agenda Item 9.1.9 seeks additional uplink spectrum for future VHTS systems

▲ Careful review of the planned satellite uses and the available spectrum will be necessary to determine the extent to which future 5G mobile deployments can be accommodated

▲ Sharing studies are currently underway
66 GHz Band (66-76 GHz) and 81 GHz Band (81-86 GHz)

▲ Good prospects for international harmonisation given limited existing and planned uses
▲ About 15 GHz of spectrum in contiguous blocks of at least 5 GHz available
▲ Suitable for high-density indoor and outdoor 5G deployment scenarios, e.g. in stadiums, campuses, and shopping malls
▲ Potential synergies with Wi-Gig at 61 GHz
Conclusions
Conclusions

▲ Satellites will play an important role in digital inclusion such as by extending 5G networks to hard-to-serve, under-served and un-served areas of the world

▲ Regulatory and technical decisions should enable, and not preclude, satellites from playing a role in the 5G ecosystem

▲ Spectrum decisions relating to terrestrial mobile 5G should not and need not be mutually exclusive of current and next-generation HTS and VHTS satellites, especially when there is ample other mmWave spectrum available in bands not used or planned to be used by satellites