Satellites, 5G and the mmWave

PRESENTED BY
Daniel C.H. Mah

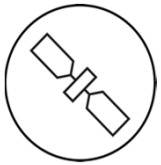
PRESENTED AT
ITU-APT Foundation of India
The 26-28 GHz India 5G Spectrum Workshop
28 September 2018

Outline of Presentation

Introduction to SES

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, e.g., 3GPP, ITU-R, CEPT, ETSI, etc
- 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)

Satellite’s Role in the 5G Ecosystem

What is 5G?
Key Usage Scenarios

SES

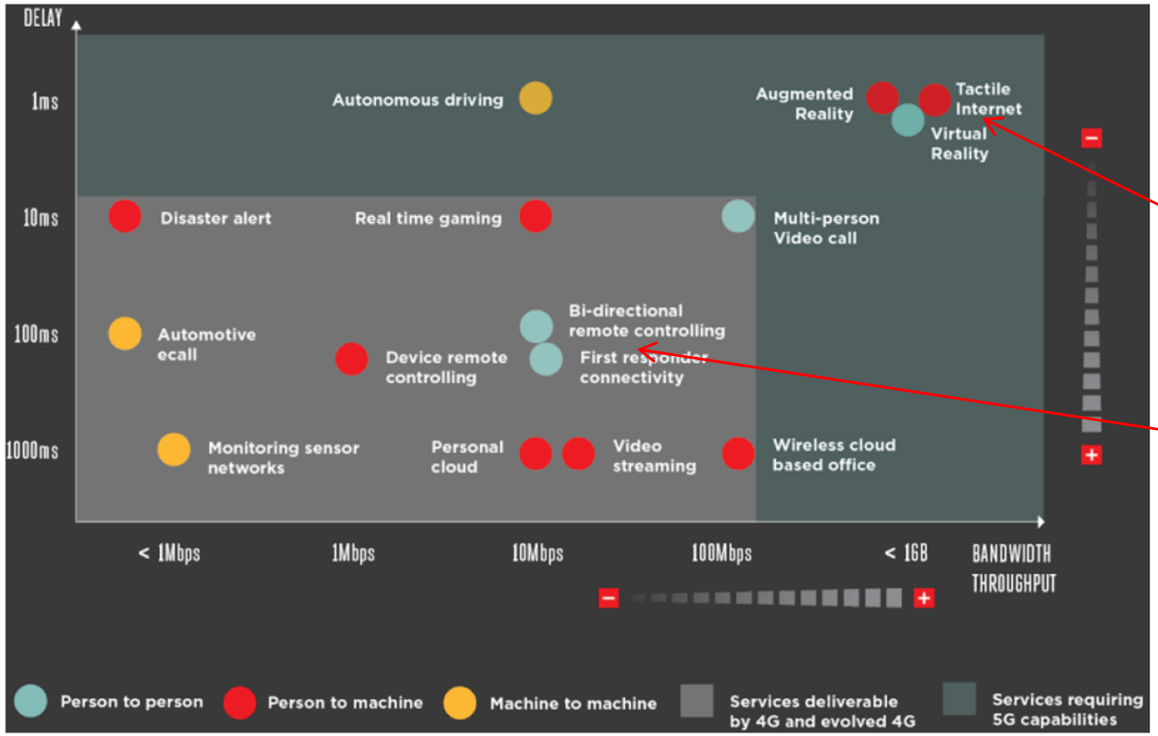
▲ GSMA, “5G Spectrum: Public Policy Position” (Nov. 2016):

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?
Diverse Usage Scenarios

▲ GSMA Presentation, APT Policy & Regulatory Forum for the Pacific (Apr. 2017)



Observations

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

Most use cases are deliverable using 4G and evolved 4G technologies

Satellites Can Support the Key Usage Scenarios for 5G

▲ Enhanced mobile broadband

- Satellites routinely carry high-bandwidth **HD and UHD content** today
- Latest and next-generation **high throughput satellites (HTS)** will support future 5G mobile networks in the same way that current generation satellites support 2G/3G/4G mobile backhaul in many parts of the world today

▲ Ultra-reliable and low-latency

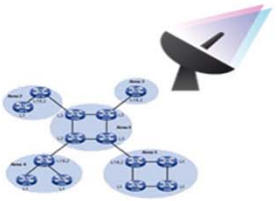
- International broadcasters, MNOs, governments depend on us every day to ensure ultra-reliable communications
- GEO latency is acceptable for many 5G applications, and new MEO and LEO networks will be able to support more latency-sensitive applications
- Satellites can even help 5G networks meet their sub-1ms latency requirements by delivering common content to mobile base stations

▲ 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
- New ground technologies, such as smaller, lower cost, electronically steerable, and/or phased-array satellite transceivers are making ubiquitous deployment for IoT feasible

Four Satellite “Sweet Spots” in the 5G Ecosystem

- Four main use cases for the integration of satellite-based solutions into 5G
  - European Commission, “SaT5G” Project
  - ECC Report 280, “Satellites Solutions for 5G”



Trunking and Head-End Feed

Satellites provide a very high speed direct connectivity option to remote / hard-to-reach locations

Backhauling and Tower Feed

Satellites provide a high speed connectivity complement (incl. multicast content) to wireless towers, access points and the cloud

Comms on the move

Satellites provide a direct and/or complementary connection for users on the move (e.g. on planes, trains, automobiles and ships)

Hybrid Multiplay

Satellites deliver content complementing terrestrial broadband (as well as direct broadband connectivity in some cases)

These four “sweet spots” leverage the advantages of satellites – **high bandwidth** and **ubiquitous coverage** – to enable and extend terrestrial 5G networks

Satellites Can Even Help Achieve Sub-1ms Latency

- Sub-1ms latency is a challenge for 5G mobile networks
  - "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)
- According to GSMA Intelligence, "Understanding 5G" (December 2014):
  - "[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)
- According to NSR, "Wireless Backhaul via Satellite", 11th and 12th Editions (March 2017 & April 2018):
  - "Paradoxically, **the low latency requirement for 5G networks 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**." (2017 report at p. 128)
- This same capability is described in ECC Report 280:
  - "[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]"

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"!

Why Integrate Satellites into 5G?

- Satellite's ability to extend terrestrial networks is **essential for an inclusive digital society**
  - Satellites will help **extend the benefits of 5G** beyond the cities **to rural and other remote areas**
  - Otherwise, 5G will only provide more broadband to those who already have it, and **worsen the digital divide**

- Satellites today **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 – and it is not difficult to see them playing a comparable role in the 5G ecosystem
  - 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

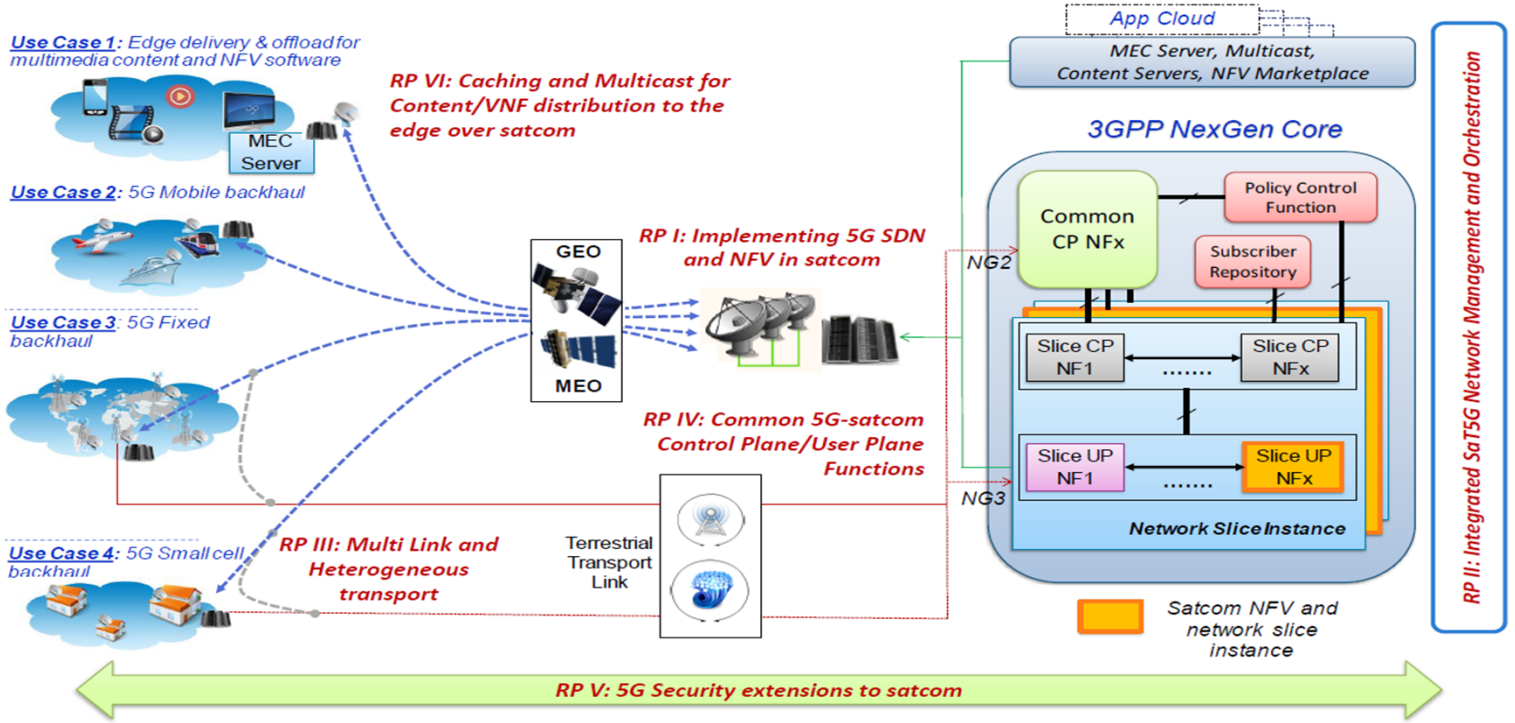
Integrating Satellites into the 5G Ecosystem

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

Project	Timeframe	Description
SaT5G Satellite and Terrestrial Network for 5G	30-month project launched in Jun. 2017	**"SaT5G"** – or Satellite and Terrestrial Network for 5G – is a European Commission funded industry-led consortium consisting of satellite operators, MNOs, equipment vendors, universities and research centers that will research and validate the key technology enablers for integration of satellites into 5G, and demonstrate them in live 5G test beds (http://sat5g-project.eu/)
SATis5	24-month project launched in Oct. 2017	**"SATis5"** is a European Space Agency demonstrator project for satellite-terrestrial integration in the 5G context that considers both mobile backhaul and direct connection architectures (https://artes.esa.int/projects/satis5)
5G-VINNI	36-month project launched in Jul. 2018	**"5G-VINNI"** – or 5G Vertical Innovation Infrastructure – is a European Commission funded industry consortium led by major MNOs, mobile vendors and satellite representatives to build an open large scale 5G end-to-end facility to be used by "vertical industries" to validate and test 5G use cases and KPIs (https://www.5g-vinni.eu/)

Integrating Satellites into the 5G Ecosystem

- **"SaT5G"** is a European Commission-funded industry consortium that will research and validate the key technology enablers for integration of satellites into 5G, and demonstrate them in live 5G test beds (http://sat5g-project.eu/)



Integrating Satellites into the 5G Ecosystem

- European Conference on Networks & Communications (EuCNC), Ljubjana, Slovenia, June 18-21
- First-of-its-kind over-the-air live demo towards integration of satellite into 5G
- Demonstrate key benefits of satellite integration with an SDN / NFV / MEC-enabled pre-5G construction testbed, with an in-orbit geostationary satellite system as a proof-of-concept for integration of those features into a full 5G network
  - SDN and NFV integration into satellite communications
  - Content delivery over Satellite
  - Multi-access Edge Computing (MEC)

Satellite Perspectives on India 5G High Level Forum

India 5G High Level Forum on 26/28 GHz

Tier	Frequency Bands	5G HLF Recommendation	Satellite Perspective
"Announce"	24.25-27.5 GHz	"[D]eclare[] as being made available for 5G rollout, providing certainty to the eco-system." "[M]ost suitable for low mobility and Fixed Wireless Access (FWA) services." "[O]pened free for two years to support rollout trials and indigenous R&D"	• The **24.25-27.5 GHz band** is among those being considered by the ITU for IMT-2020. It is a **promising band for 5G mobile services**, provided that protections are in place to protect co-primary Fixed Satellite Services (FSS) in certain portions of the band. • The **24.65-25.25 GHz uplink band** was recently paired with a new BSS downlink allocation at 21.4-22.0 GHz at WRC-12 and satellites have only recently been deployed in the band (e.g. DIRECTV-14 and 15). BSS spectrum can be used to complement future 5G networks by efficiently distributing common content to edge caches. • The **27.0-27.5 GHz band** is allocated for FSS uplinks in ITU Regions 2 and 3. Modern HTS systems will require large amounts of spectrum to support growing bandwidth demands, and recent HTS systems have turned to this band to meet their requirements (e.g. SkyMuster/NBNCo-1 and 2). • In terms of **sharing conditions**, 5G mobile services should be held to the technical parameters that were used in the ITU-level compatibility studies with FSS. In addition, the regulatory framework should **enable reasonable future deployment of satellite earth stations** in the band, even after the introduction of 5G, consistent with the co-primary status of the FSS.

India 5G High Level Forum on 26/28 GHz

Tier	Frequency Bands	5G HLF Recommendation	Satellite Perspective

"Announce"	27.5-29.5 GHz	"[D]eclare[] as being made available for 5G rollout, providing certainty to the eco-system."
		
		"[M]ost suitable for low mobility and Fixed Wireless Access (FWA) services."
		
		"[O]pened free for two years to support rollout trials and indigenous R&D"
			• **The 27.5-29.5 GHz band is NOT among the bands being considered by the ITU for IMT-2020.** This band was excluded at WRC-15 in recognition of the extensive use of the band by satellites. Few countries (US and Korea) support this band for 5G. Most countries (e.g. 28 countries of the EU, China, Australia) are focused on 24.25-27.5 GHz band instead.
			• **Dozens of satellites are in orbit today using this band** and delivering hundreds of Gbps of throughput, and many more will be launched soon.
			  • IPStar, the first HTS system in the APAC region.
			  • 16 O3b HTS satellites, SES-12, SES-14 and SES-15 GEO HTS
			  • 4 Inmarsat Global Xpress HTS satellites
			  • SkyMuster-1 and -2 (NBNCo)
			  • Hughes's Jupiter 1 and 2
			  • ViaSat 1 & 2, and future ViaSat-3
			  • Bharti-backed future OneWeb constellation
			• **HTS systems** using this band provide direct **broadband access to millions** and **support 2G/3G/4G mobile networks** around the world today, and will support and extend **future 5G networks**.
			• **Ample other spectrum** is being considered for 5G (more than 33 GHz).
			• Providing certainty to a future 5G mobile ecosystem **should not come at the expense of the existing and evolving satellite ecosystem.**

India 5G High Level Forum on 26/28 GHz

Tier	Frequency Bands	5G HLF Recommendation	Satellite Perspective
"Identify"	29.5-31.3 GHz	"[D]esignated for potential 5G use which can be moved to the Announce Tier after coordination with other domestic users."	**No Fixed or Mobile Service** allocation in the **29.5-31.3 GHz band**. **<u>29.5-30.0 GHz</u>** • **The 29.5-30.0 GHz band is NOT among the bands being considered by the ITU for IMT-2020**, and no country has proposed the use of this band for 5G mobile. • This band is **extensively used** for ubiquitously deployed satellite terminals, and is **included in virtually all current and next-generation Ka-band HTS designs**. • The introduction of 5G mobile services in the band will be **incompatible with ubiquitously deployed satellite terminals** in this band. **<u>30.0-31.3 GHz</u>** • **The 30.0-31.3 GHz band is NOT among the bands being considered by the ITU for IMT-2020**, and not even the US or Korea are considering the band for 5G. • The band is used mainly for **government satellite communications** by multiple countries, and the introduction of 5G mobile services in the band is **likely to be incompatible** with such uses.

High Throughput Satellites for the Asia-Pacific Region

Launched

In Service	High Throughput Satellite	Orbit	Frequency bands
2005	Thaicom-4 / IPStar-1	GEO	Ku-band / **Ka-band**
2013, 2014	O3b (Batch 1, 2 & 3)	MEO	**Ka-band**
2015, 2016	Sky Muster I & II (NBN-Co)	GEO	**Ka-band**
2017	Inmarsat GlobalXpress (I5 F4)	GEO	**Ka-band**
	Eutelsat 172B	GEO	C-band / Ku-band
2018	O3b (Batch 4)	MEO	**Ka-band**
	SES-12	GEO	Ku-band / **Ka-band**
	APStar 5C / Telesat 18 Vantage	GEO	C-band / Ku-band
	Horizons 3e	GEO	C-band / Ku-band
	O3b (Batch 5)	MEO	**Ka-band**
2019	Kacific-1 / JCSat-18	GEO	**Ka-band**
	OneWeb	LEO	Ku-band / **Ka-band**
2020	SpaceX	LEO	Ku-band / **Ka-band**
2021	Telesat LEO	LEO	**Ka-band**
	O3b mPower	**MEO**	**Ka-band**

India 5G High Level Forum on Other Bands

Tier	Frequency Bands	5G HLF Recommendation	Satellite Perspective
"Identify"	37.0-43.5 GHz	"[D]esignated for potential 5G use which can be moved to the Announce Tier after coordination with other domestic users." "37.0-43.5 GHz should be opened free for two years to support indigenous R&D"	• The 37.0-43.5 GHz band is among those being considered by the ITU for IMT-2020. • There are **advanced plans by the satellite industry** to deploy the **next-generation of Very High Throughput Satellites (VHTS)** using portions of this spectrum, such as the GEO systems proposed by Hughes and the non-GEO systems proposed by SpaceX and O3b. • As there are 6 GHz of spectrum in this band, it may be possible to find enough frequencies to accommodate both IMT-2020 and VHTS requirements. At the very least, the portions of the band designated for **High Density FSS ("HDFSS") should be preserved** (i.e. not identified for IMT), while establishing **reasonable sharing conditions** in the non-HDFSS portions to ensure compatibility and the continuing ability to deploy **future co-primary FSS earth stations**.
"Study"	3600-3700 MHz	"[E]xploratory studies for 5G use. These bands should be considered as only of potential availability for 5G networks."	• The 3600-3700 MHz band is NOT among the bands being considered by the ITU for IMT-2020. • In recognition of this usage, ITU Region 3 rejected proposals to introduce IMT in this band at WRC-15 in recognition of its extensive use throughout the region for satellite services, such as broadcast and cable distribution, including in India. • There are other bands in the 1-6 GHz band that could be used for 5G that are not yet allocated, assigned or built out (including several mentioned in the 5G HLF Report). • India should provide certainty for the existing satellite ecosystem in this band by not studying the band or establishing conditions for its release for 5G.

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 systems, especially when there is ample spectrum being considered for 5G that is not used or planned to be used by satellites