ROLE OF SATELLITE SYSTEMS IN THE FUTURE 5G ECOSYSTEM

SPECTRUM / STANDARDS ASPECTS

ESA / DLR 'Space Moves' Conference
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Acknowledgement: ESOA

GENERAL CONTEXT

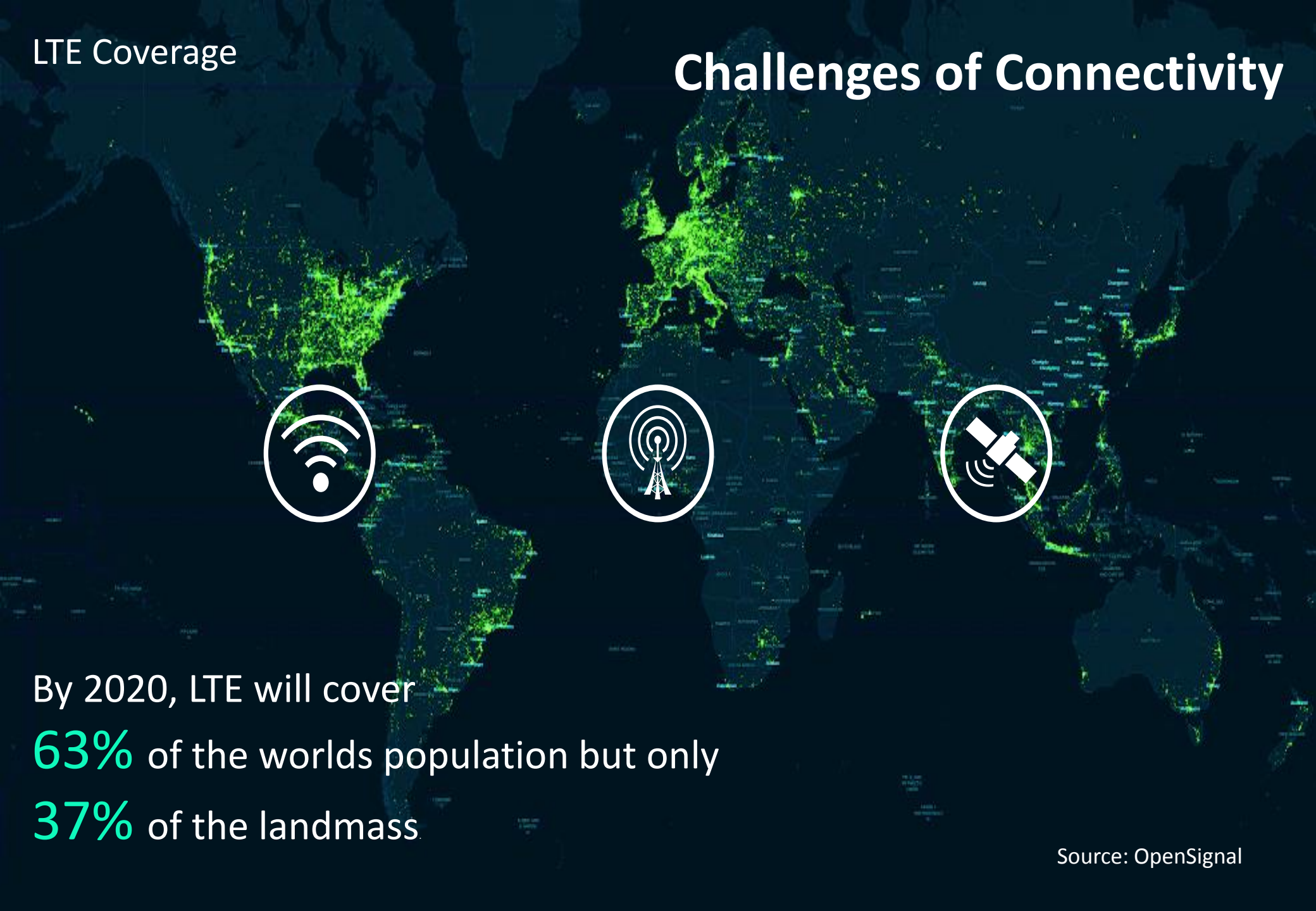
Assumptions Of The Digital Revolution

(The 3 commandments)

Everything **Everywhere** **Always**

LTE Coverage

Challenges of Connectivity



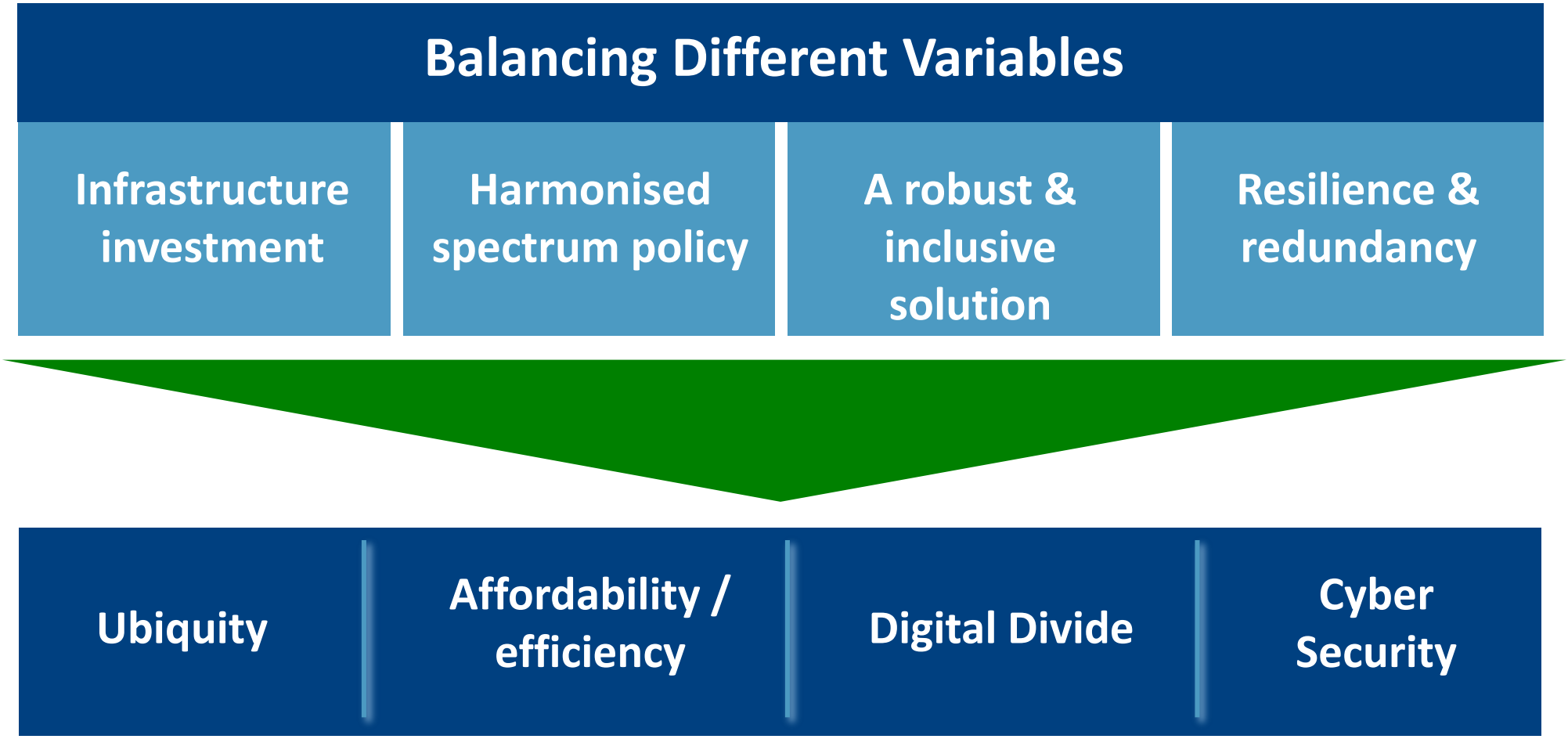
By 2020, LTE will cover

63% of the worlds population but only

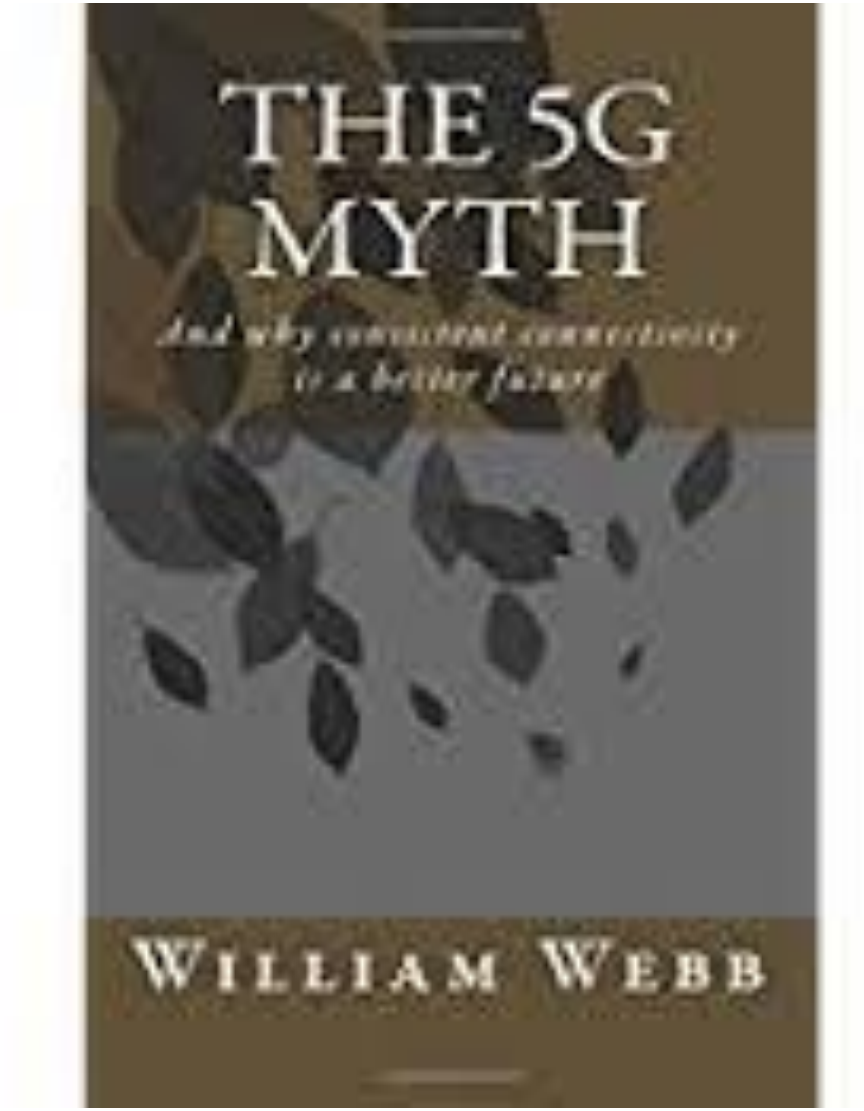
37% of the landmass

Source: OpenSignal

Realising 5G



Question: Is 5G A Myth ?



Professor William Webb, deputy chair at Cambridge Wireless, CEO of Weightless, general all-round wireless communications and regulatory expert (spent seven years with UK regulator, Ofcom)

‘The 5G Myth’

So why has the 5G mission been blown so wildly off-course?

Much of the problem, William says, is that the vision of what’s required for next generation cellular seems to have lost touch with the reality of usage patterns and user behaviour.

“The fact is that in the UK and in other countries, we’ve gradually been making more use of WiFi. My guess is that about 95 per cent of all our traffic is now WiFi and most people have a ‘WiFi first’ (use cellular only when WiFi isn’t available) behaviour pattern.

“The regulators, however, spend most of their time on thinking about cellular - but in the consumer market, that’s not where the action is.”

“I think we need a fundamental rethink of the whole communications environment - instead of thinking that competition comes from the four main operators (in the case of UK), we should take a broader look. The competition comes from a mix of WiFi and multiple operators providing connectivity to the home, the business, the public space and so on - all providing an ecosystem that needs to work nicely together.“

So, he says, indoor high speed data coverage will increasingly be WiFi and self-provided (at home or at work) or amenity based, with cellular picking up where the WiFi signal drops off. That seems unlikely to change - so looking at just one part (the cellular part) in isolation is going to lead to bad results.

One other important mission for 5G might be the delivery of IoT nationwide alongside the delivery of the “consistent connectivity”. That, he judges, would be appreciated by almost all mobile phone and Internet users.

Part of the reason for writing the book, said William, is to see if people in the industry can step back and think carefully about the current 5G direction. The book was published eight weeks ago and, he told me, so far he hadn’t had any vociferous push-back from enraged 5G enthusiasts. He takes that as a good sign. The book is available on Amazon. Search ‘5G Myth’.

http://www.telecomtv.com/articles/5g/busting-the-5g-myth-mobile-users-want-mega-consistency-not-gigabits-14304/

A Framework For Economic Rollout Of 5G Services

4G / 4.5G LTE Networks are already demonstrating ~ 0.5 Gbit/s speed using 4.5G / LTE standard with carrier aggregation using IMT bands up to 2.6 GHz.

4.5 LTE Networks will in near future providing > 1 Gbit/s speeds using:

- 4.5G / LTE standard with carrier aggregation with IMT bands below 3.4 GHz and at 3.4–3.6 GHz in ITU Region 1/ Region 3.
- LAA

3G / 4G / 4.5G devices already have 2.4 GHz / 5 GHz WIFI radios for enabling low cost data off-load service delivery.
Circa 70 – 90 % of mobile data traffic is carried by WIFI networks today.

MNOs top priority seems to be to:

- monetise their huge investments in 3G / 4G / 4.5 G networks.
- achieve economically viable deployment of new '5G-like' networks / services.

It is highly probable that 5G / IMT-2020 networks will be deployed on large scale basis in cm wave bands supported by WIFI and WIGIG.

A Framework For Economic Rollout Of 5G Services

Vodafone Germany launches 4.5G services at up to 375 Mbps

Sunday 18 **September 2016** | 20:59 CET | News Vodafone Germany has announced the launch of 4.5G mobile technology, supporting speeds of up to 375 Mbps. The new technology will be rolled out in 30 cities across the country by end-2016, with new 4.5G base stations now live in 22 of these cities. These include the centres of Berlin, Dresden, Duesseldorf, Cologne, Frankfurt, Hamburg and Hanover. Vodafone deploys triple carrier aggregation in 800, 1800 and 2600 MHz bands.

See: https://www.telecompaper.com/news/vodafone-germany-launches-45g-services-at-up-to-375-mbps--1162788

TIM launches 500 Mbps 4.5G service in 3 Italian cities

Thursday **15 December 2016** | 15:00 CET | News Telecom Italia (TIM) has claimed a European first with the launch of a commercial service offering download speeds of up to 500 Mbps using 4.5G technology. The service is already active in Rome, Palermo and Sanremo and can be accessed with the new Sony Xperia XZ smartphone, available to TIM's business and retail customers as an exclusive. The higher speeds are achieved via carrier aggregation, with TIM bundling spectrum from the 800 MHz, 1800 MHz and 2600 MHz bands, as well as the so-called L band (1500 MHz), and increasing spectral efficiency by evolving antenna transmission systems.

See: https://www.telecompaper.com/news/tim-launches-500-mbps-45g-service-in-3-italian-cities--1176363

Mindsets Must Change !

“Big Challenges Require Many Solutions”

Advances In Satellite

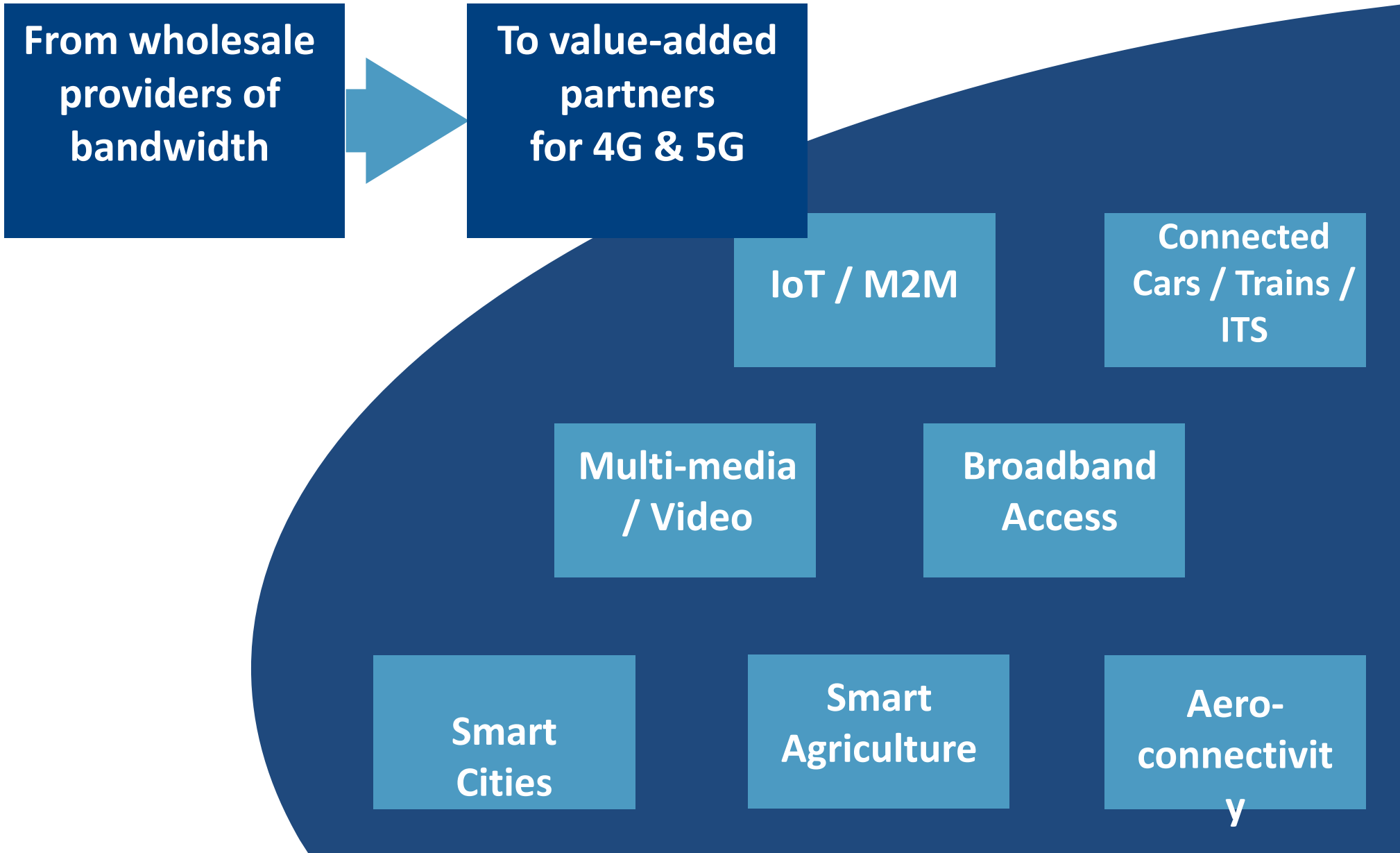
A Revolution in Space

- High Throughput Satellites delivering 50-200 Gbps to 1 TBps by early 2020s
- Innovation happening in all satellite bands: hybrid C/Ku-band; L/S-band systems; Ka-band systems; Q-V band systems under construction
- NGSO (non-geostationary) constellations (1,000+ satellites) emerging
- Increasing focus on mobility / M2M services
- Moving toward open architecture (all-IP & 5G) enabling fully integrated heterogeneous networks
- Higher speeds including exceeding 25/3 Mbps (approaching 100 Mbits/sec broadband)
- Deployment of terrestrial devices at edge of satellite networks for scale/cost benefits

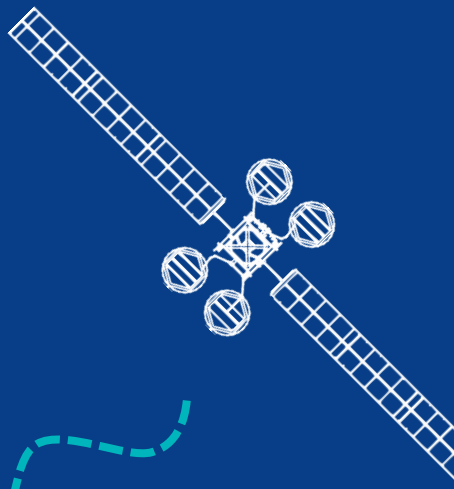
Dramatic Price/MB Decrease

- Highly cost effective - satellites now comparable to terrestrial networks
- Enhanced utility for under-served communities & ubiquitous connectivity on land/air/sea

Evolving Role of Satellite Operators



Example of Satellite Antennae for the Connected Car



Flat panel satellite antennae embedded in car roof to provide continuous connectivity alongside 4G/5G

Example Today – 4G Backhaul via Ka-band Satellite / EE -UK

The Challenge

EE, now part of BT, owns the largest LTE network in the UK. EE also won the contract from Home Office for the new 4G / LTE based Emergency Services Network (ESN). As a result EE was looking for a “Carrier grade” cellular backhaul solution capable of meeting stringent security and operational controls required by the UK government.

Summary

Region: UK

Deliverables: IP satellite backhaul to support 4G / LTE cellular backhaul for Emergency Services

The Solution

- Avanti will provide a carrier grade backhaul solution to provide backhaul to ~ 1000 VSAT fixed units across the UK in time for service launch in 2017.
- EE will have access to a pool of capacity through Avanti’s HYLAS-1 and HYLAS-2 satellites to connect all such LTE sites across the UK. The satellite capacity will help EE reach more remote and rural areas of the UK while boosting the resilience of the ESN network.

Results and Benefits

In Q2 2016 EE collaborating with Avanti to establish dedicated 4G satellite mobile backhaul. The first phase of this multiyear contract has an initial value of $29m, plus options to double the capacity.

Mansoor Hanif, Director of Radio Access Networks at EE, said Avanti "*will play a key part in providing the resilience and increased coverage the operator is seeking to provide through its 4G network.*”

SPECTRUM

Relevance of Spectrum Harmonization

Satellites can roll-out these services in multiple spectrum bands thanks to global frequency allocations made at the ITU

L-Band / S-band

- Global / regional networks enabling mobile satellite services

C/Ku-Band

- New and replacement satellites being launched globally
- C-Band particularly relevant for equatorial regions across the world

Ka-Band

- > US$ 25 billion invested the world over in Ka-band GEO / Non-GEO systems today
- ~ 60+ GEO / Non-GEO Ka-band satellite systems today
- >100 GEO / Non-GEO Ka band systems in place by ~ 2020-2023

Importance of ITU

Worldwide participation at ITU WRCs drive consensus-based decisions that all nations can rely on:

- **WRC15 decisions were made with the participation of up to 193 Member States**
- **Large & small nations; developed & emerging economies - are all placed on an equal footing in taking these decisions**
- **The best chances of achieving globally harmonised spectrum for 5G is by studying bands identified for 5G / IMT-2020 by WRC-15 (Resolution 238)**
  - ⇒ Avoids spectrum fragmentation
  - ⇒ Provides access to shared spectrum where appropriate / feasible; recognizes need for exclusive spectrum access for 2 or more widely deployed services
  - ⇒ Paves the way for economies of scale and customer adoption

WRC decisions balance the needs of different COUNTRIES and different TECHNOLOGIES ensuring that one does not harm the other

5G Requires The Strengths Of Different Technologies

Each technology has its own characteristics & eco-system:

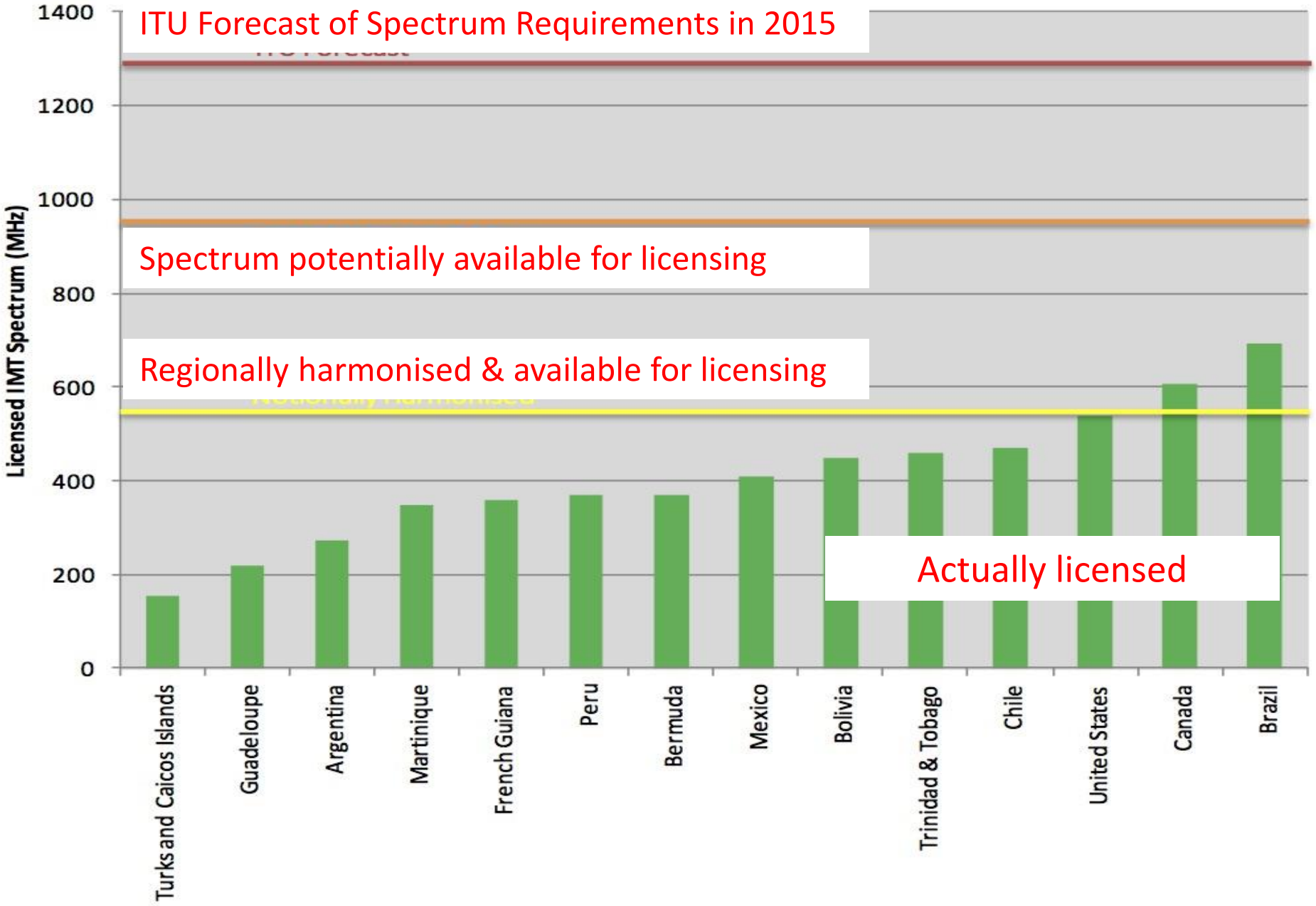
Satellites:

- Inherently global networks, new satellites being launched
- Provides services that other technologies cannot replace
- Efficient use & re-use of spectrum.
- Economies of scale generated for equipment worldwide
- Cost-effective in rural and remote areas & in urban / suburban areas.

Terrestrial Mobile:

- 2G/3G/4G can use different national networks using multiple radios
- Vendors can put multiple bands on a single device at marginal cost
- Huge investments still being made into 4G/LTE
- Allocated spectrum for mobile / IMT still available to be licensed for mobile terrestrial (e.g. ‘4.9G’, 5G)

Mobile Spectrum: The Americas (Source: LS Telcom)



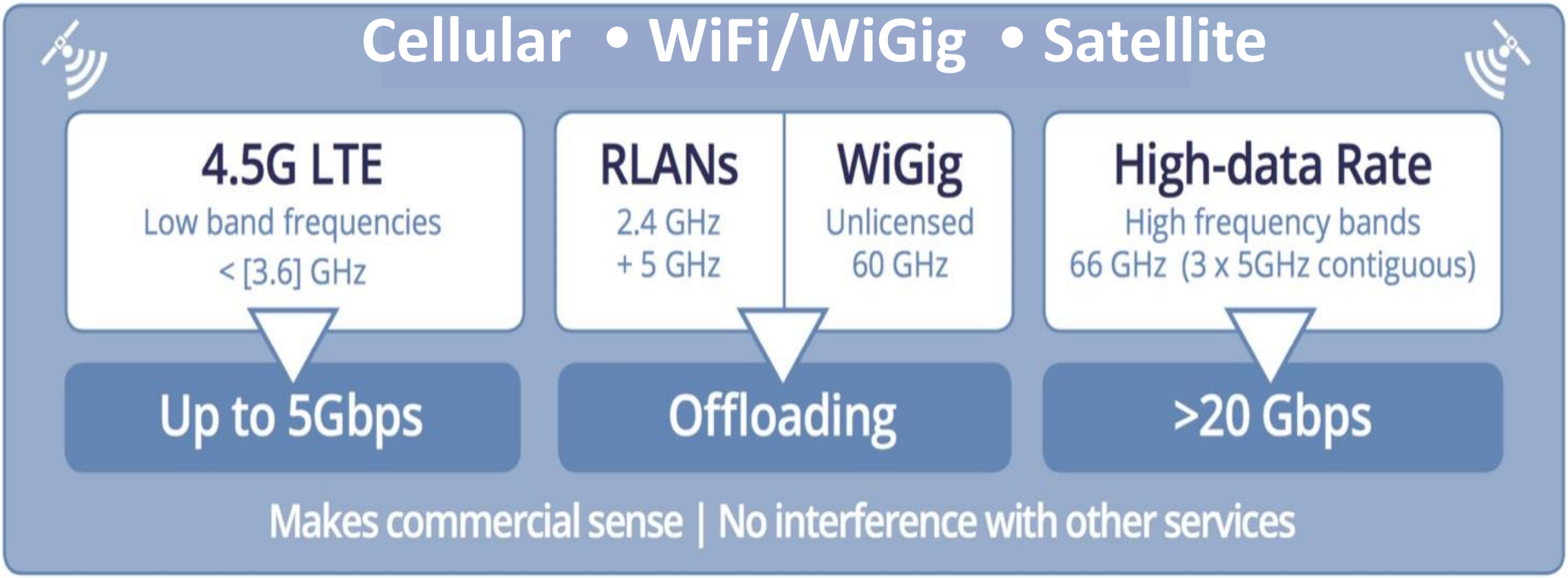
5G - A Network of Networks

MNOs will continue to invest in 4G / 4.9G / LTE

The WiFi Ecosystem continues to evolve with Gigabit WiFi = WiGig

MNOs & vendors successfully trialling high-data rate connectivity in high mmWave bands above 66 GHz

The 5G/IMT-2020 ecosystem will be dominated by 5G mobile devices using MULTIPLE RADIOS



Conclusions

- 5G requires a **Mix of Technologies** to deliver consumer / customer needs
- **Growth of one sector (e.g. terrestrial 5G/IMT) cannot be at the expense of another (e.g. satellite)**
- 5G Spectrum management decisions must **respect ITU WRC-15 decisions (viz Resolution-238):**
  - C-band (3.8 – 4.2 GHz) not identified for study by ITU
  - Ka band (27.5 – 30.0 GHz) not identified for study by ITU
- Working within the ITU framework ensures **regulatory certainty required for future growth of all sectors**

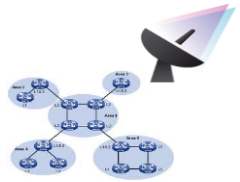
STANDARDS

Satellite 5G Standards

- Standards enable economies scale and market adoption
- Satellite systems did not feature in 2G (GSM), 3G (UMTS or CDMA) or 4G (LTE) standards.
- 5G requires a **Mix of Technologies** to deliver consumer/customer needs.
- 3GPP agreed in March 2017 for work item to develop Satellite 5G standards.
- Draft Technical Report 3GPP TR 38.811 "Study on New Radio (NR) to support Non Terrestrial Networks (Release 15)", The Official Publications of 3GPP are described at this link.
- Opportunity now exists for satellite industry to progress / leverage this to promote accommodation of satellite systems in various **'use cases'** for 5G / IMT-2020.

Four Satellite “Sweet Spots” in the 5G Ecosystem

Source: SES, Thales Alenia Space France



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

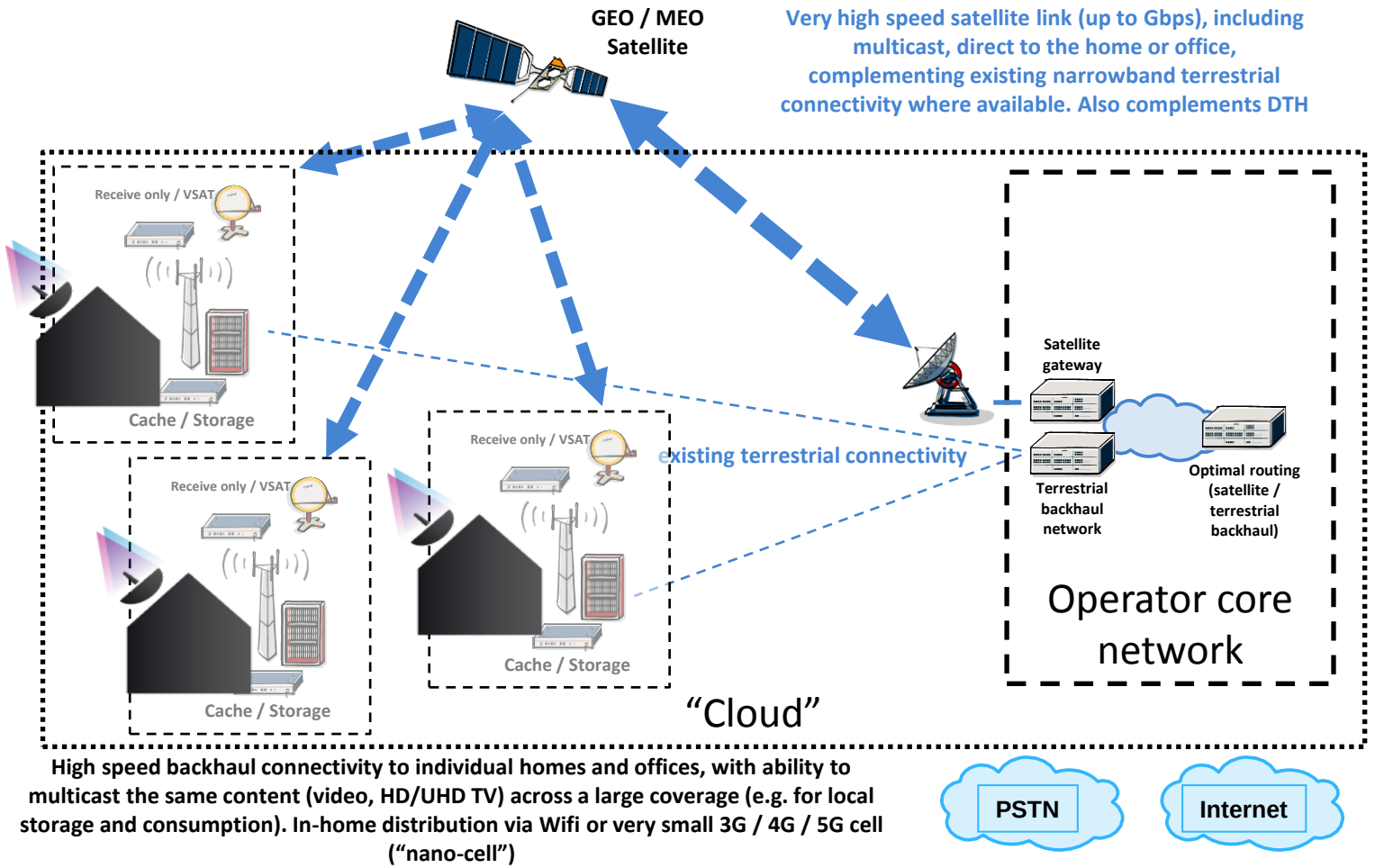
Satellites provide a direct and/or complementary connection for users on the move (e.g. on planes, trains, automobiles and ships)

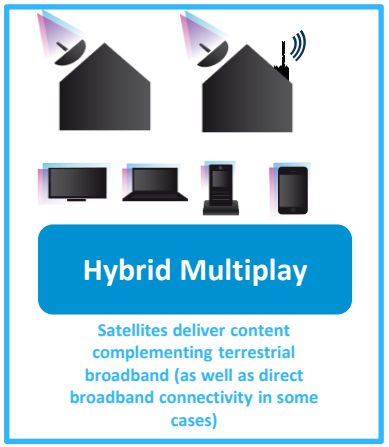
Hybrid Multiplay

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

- These four “sweet spot use cases ” leverage the advantages of satellites – **high bandwidth** and **ubiquitous coverage** – to enable and extend terrestrial 5G networks
- This work cannot be considered in a vacuum, because many of these and other satellite enabled services already are key ingredients in both:
  - existing terrestrial networks (2G, 3G, 4G)
  - others (Disaster relief and Emergency response, Connectivity for remotely deployed battery activated M2M/IoT sensors, IoT devices on containers (e.g., for tracking and tracing)

Integration of Satellite Networks Within 5G
Hybrid Multiplay





Source: SES, Thales Alenia Space France

Satellite coverage allows homogeneous service offering – anywhere.
Multicast and caching/storage enable bandwidth savings and improved quality of service

COOPERATIVE SATELLITE INDUSTRY ACTIVITIES RE 5G

EU

ESA

SaT 5G Project

Satellite and Terrestrial Network for 5G

Project Overview

Georgia Poziopoulou, Avanti Communications

EuCNC 2017

Oulu – 15/06/2017

avanti · ThalesAlenia Space · University of Surrey · SES · AIRBUS · BT · Zodiac Aerospace · Quortus · iDirect · i2cat · University of Oulu · broadpeak · Gilat · imec · TNO · ONEAccess Fast Network Virtualization

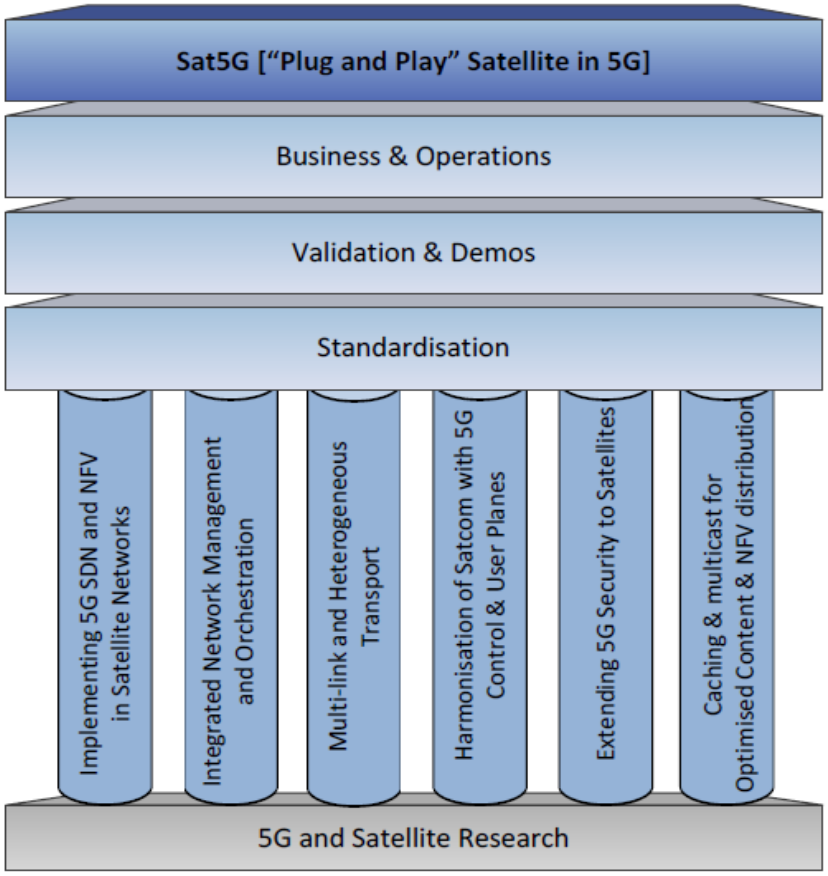
SaT 5G Project

Project Objectives

- Overall objectives
  - Contributing to the 5GPPP use case "**Broadband access everywhere**", SaT5G will foster the implementation of solutions enabling the "plug and play" integration of satcom components into 5G networks.
  - To this aim, SaT5G will **research and validate the key technology enablers through validation and demonstration in live 5G testbeds**.
  - SaT5G impact is for the satellite industry to join the European initiative in the deployment of a competitive and ubiquitous 5G network globally.
- Schedule
  - 30 months duration
- Consortium
  - AVA project coordination, TAS technical coordination
  - 16 partners (satellite/terrestrial operators, vendors, universities and research centres)

SaT 5G Project

SaT5G Concept



Build compelling business cases and commercial models

Validate and demonstrate solution in live testbeds

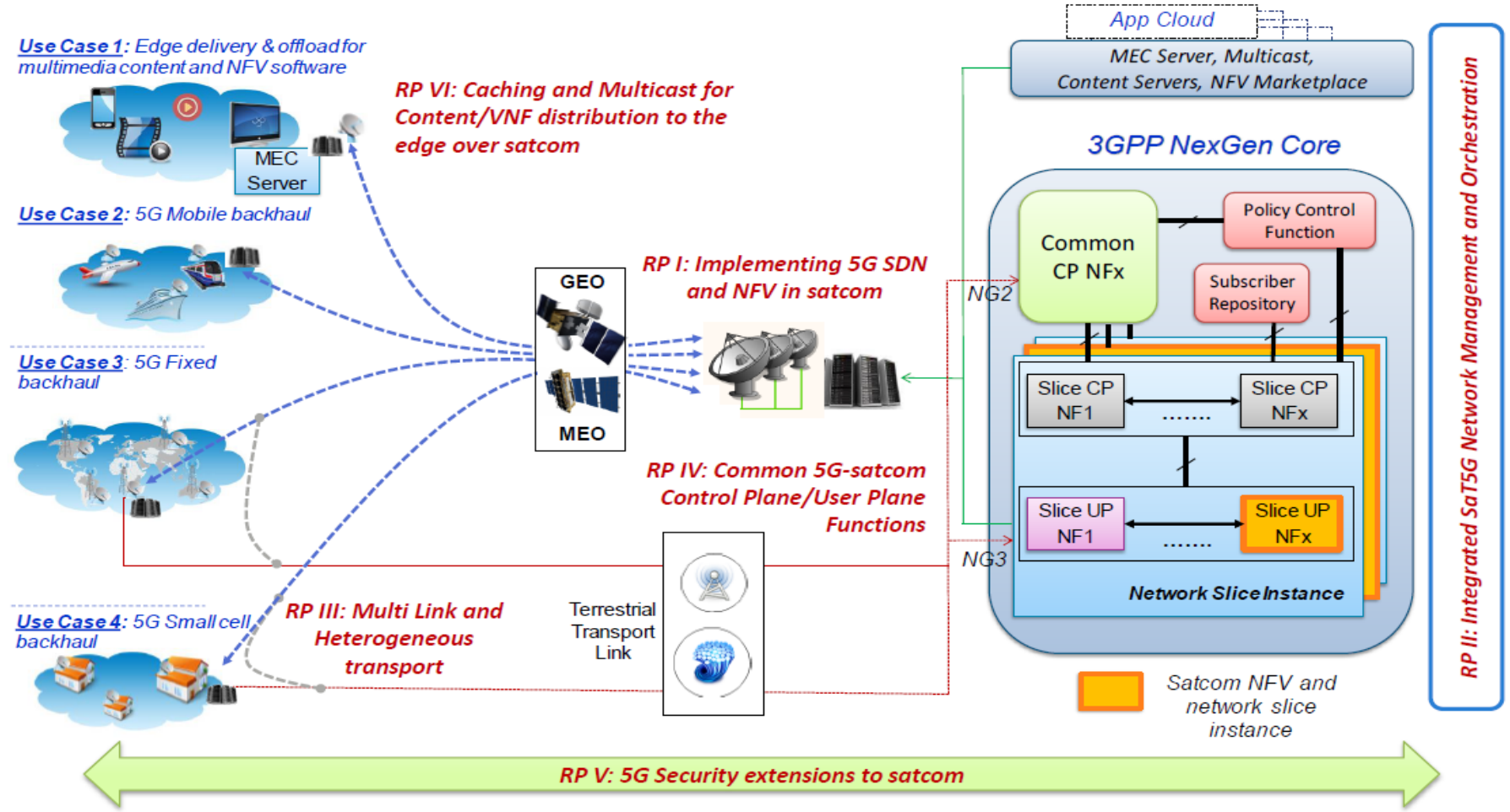
Contribute to standardisation of satcom as an intrinsic element of 5G

Research the key technology enablers for the integration of satellite in 5G

Build on current 5G research and contribute to the 5GPPP WGs

SaT 5G Project

Use Cases & Research Pillars



Project Outputs

- Validation of every research pillar output in the lab
- Demonstration of the SaT5G use cases in 5G live testbeds integrating:
  - Virtualised satellite terminal functions;
  - Management and orchestration functionality;
  - Multilink functionality;
  - An integrated Mobile Edge Computing function with caching and multicast.
- White paper with the reference SaT5G architecture
- Targeted standardisation contributions of the key technology enablers in 3GPP and ETSI
- Develop the commercial value propositions for the SaT5G use cases

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