CONNECTING THE DIGITAL WORLD

‘When Networks Collide: Merging of Terrestrial and Non-Terrestrial Networks’

Delivered by The Cambridge Wireless
Non-Terrestrial Networks & Radio Technology SIG’s

Kindly hosted by Institute for Communication Systems (ICS),
University of Surrey

29th October 2024

Event Agenda

11:45 **Dr Mike Short CBE, Chief Architect, Satellite Applications Catapult**, ‘The key markets for Satcom / Telecoms convergence’

12:05 **Rowan Chesmer, R&D Future Technologies Researcher, Vodafone**, - ‘How will satellite connectivity be integrated into Mobile networks?’

12:25 **Professor Barry Evans, Professor of Satellite Communications, Institute for Communications Research (ICS) and 6GIC at the University of Surrey,** ‘Non-Terrestrial Networks (NTN) from 5G to 6G’

12:45 Lunch and networking

13:40 **Richard Moore, Principal, Spectrum Policy & Analysis, Ofcom**, ‘Spectrum for NTNs. A regulator’s perspective

14:00 **Damian Bevan, Wireless System Analyst, Real Wireless,** ‘Can NTN D2D be used to further extend outdoor mobile coverage beyond what the Shared Rural Network will provide?’

14:20 **Glyn Thomas, Payload Product Manager and Senior Expert and Oriol Vidal, Airbus Defence & Space** - ‘The future of NTN in GEO, MEO and LEO’

14:45 Refreshment break

15:20 **Peter Kibutu, 5G NTN Market Lead, TTP plc**, ‘Modern Antennas for 5G NTN User Terminal Applications’

15:40 **Stephane Remy, Director of Connectivity, Cambridge Consultants**, ‘Network Automation for NTN’

16:00 Panel Session: ‘Bursting the hype’, with all speakers and Chaired Steve Clarke, Wyld Networks

Welcome from Cambridge Wireless

Delivered by

Paul Crane,
Board Member, Cambridge Wireless,
& Visiting Professor, University of Surrey

CW INTERNATIONAL CONFERENCE

Building Resilience: Future-proofing the Future

27 March 2025

Hinxton Hall, Wellcome Genome Campus | Hybrid

Special Interest Groups (SIGs) are the backbone of CW activities

- Focus on specific technology and market sectors
- Keep members up to date with industry developments
- Create opportunities for influencing developments
- Explore new business opportunities
- Encourage networking

- Academic & Industry
- Artificial Intelligence
- Automotive & Transport
- Connected Devices
- Content Production & Delivery
- Enhanced Mobile Broadband
- Future Devices & Technologies
- Healthcare
- Industrial IoT
- Location
- Non-Terrestrial Networks
- Radio Technology
- Security, Privacy, Identity & Trust
- Small Cell
- Smart & Intelligent Cities
- Sustainability
- User Experience
- Virtual Networks
- Wireless Heritage

The Non-Terrestrial Network Group

The NTN SIG convenes engineers, technologists and commercial specialists interested in the technology of, and business case for, the use of satellites in telecommunications. It welcomes anyone who wishes to learn from, or debate ideas with, experts in this field.

#CWNTN

Kieran Arnold

Satellite Applications Catapult

Steve Clarke

Wyld Networks

Stewart Marsh

Cambridge Consultants

Paul Morris

EnSilica

Jaime Reed

CGI

Cyril Valadon

MediaTek

The Radio Technology Group

The Radio Technology SIG will aim to increase the awareness of the scientific and engineering limits on radio communications; and the opportunities that could be exploited to improve the state-of-the-art.

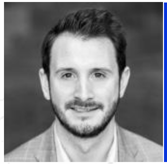
#CWRadioTech

Mark Beach

University of Bristol

Brian Collins

BSC Associates



Dr Paul Harris

VIAVI Solutions

Peter Kibutu

TTP Group

Peter Topham

Qualcomm

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Cambridge Wireless would like to thank our host The University of Surrey

UNIVERSITY OF SURREY

Welcome from;

Professor Rahim Tafazolli FREng,

Head of the Institute for Communication Systems (ICS)

University of Surrey

www.surrey.ac.uk

‘The key markets for Satcom / Telecoms convergence’

Presented by

Dr Mike Short CBE,
Chief Architect,
Satellite Applications Catapult,

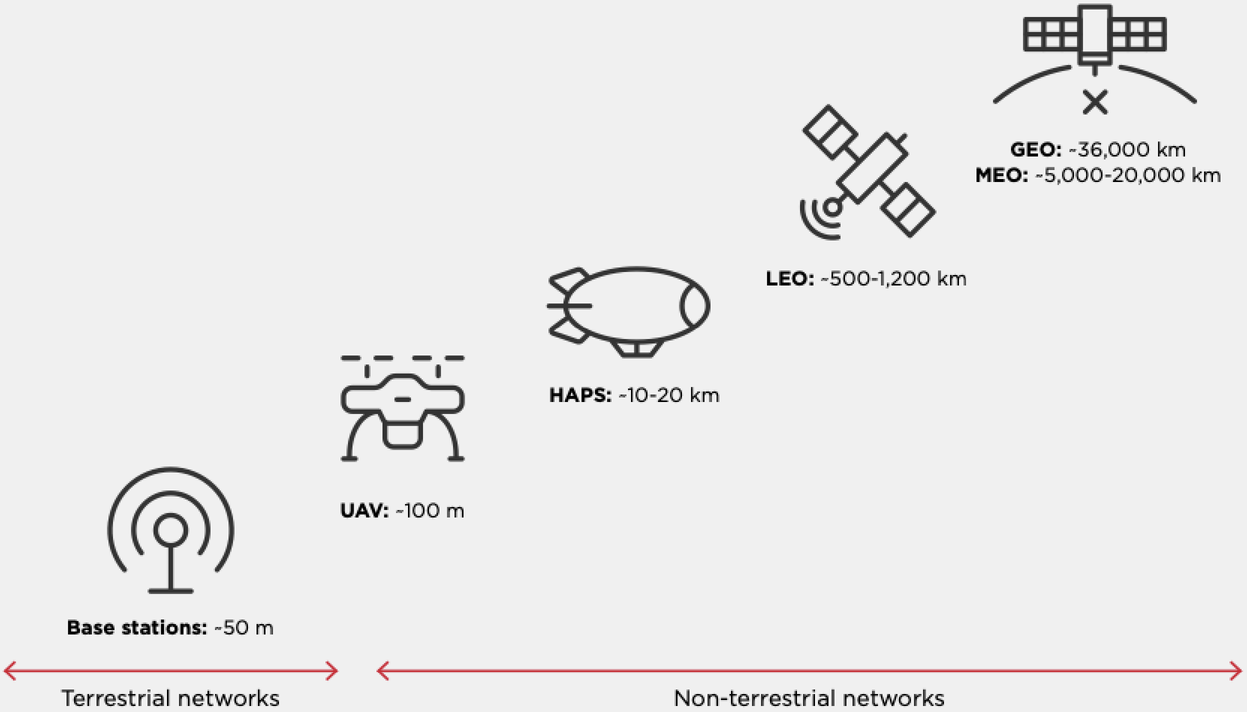
- Satellite Apps Catapult - Michael.Short@sa.catapult.org.uk
- Chair – UK TIN Advisory Board ; Former – CSA – DBT

- SOURCES :
- GSMA Mobile Economy 2024 – Feb 2024
- https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-economy/wp-content/uploads/2024/02/260224-The-Mobile-Economy-2024.pdf

- GSMA Mobile Internet – the unconnected : 23/10/2024
- https://www.gsma.com/newsroom/press-release/new-gsma-report-shows-mobile-internet-connectivity-continues-to-grow-globally-but-barriers-for-3-45-billion-unconnected-people-remain/

Figure 15

Examples of satellite and NTN technologies in the connectivity space



Source: GSMA Intelligence

Figure 16

Examples of partnerships between telecoms operators and satellite/NTN companies

Telecoms operator	Satellite/NTN company	Market	Number of mobile connections (million)
Bharti Airtel	OneWeb	India	**351**
Vodafone	Project Kuiper	Europe, Africa	**341**
Telefónica	OneWeb and Starlink	Europe, Latin America	**262**
MTN	Starlink, OneWeb, AST SpaceMobile and Lynk Global	Africa	**232**
Orange	OneWeb	Europe, Africa, Latin America	**229**
Deutsche Telekom	Skylo and Intelsat	Europe, US	**193**
Veon	OneWeb	Asia, Eurasia, Ukraine	**158**
Vodafone	AST SpaceMobile	Africa	**153**
Verizon	Project Kuiper	US	**144**
T-Mobile	Starlink	US	**119**
AT&T	OneWeb and AST SpaceMobile	US	**114**
KDDI	Starlink	Japan	**67**
Telstra and Optus	Starlink	Australia	**28**
STC	AALTO	Saudi Arabia	**25**
BT	OneWeb	UK	**22**
Rakuten	AST SpaceMobile	Japan	**6**

Note: Market refers only to where the operator is present. Data is correct as of December 2023.
Source: GSMA Intelligence based on company announcements

GSMA

The Mobile Economy 2024

The Mobile Economy

atapult Ope

Unique mobile subscribers

2023 **5.6bn**
69% penetration rate*

2030 **6.3bn**
74% penetration rate*

CAGR 2023-2030 | 1.7%

*Percentage of population

Mobile internet users

2023 **4.7bn**
58% penetration rate*

2030 **5.5bn**
65% penetration rate*

CAGR 2023-2030 | 2.3%

*Percentage of population

SIM connections

(excluding licensed cellular IoT)

2023 **8.6bn**
107% penetration rate*

2030 **9.8bn**
114% penetration rate*

CAGR 2023-2030 | 1.8%

*Percentage of population

4G

Percentage of connections (excluding licensed cellular IoT)

2023 **59%**

2030 **35%**

5G

Percentage of connections (excluding licensed cellular IoT)

2023 **18%**

2030 **56%**

Smartphones

Percentage of connections

2023 **78%**

2030 **91%**

Operator revenues and investment

2023 **$1.11tn**
Total revenues

2030 **$1.25tn**
Total revenues

Operator capex for the period 2023-2030: | $1.5tn

Public funding

2023

$560bn

Mobile ecosystem contribution to public funding (before regulatory and spectrum fees)

Licensed cellular IoT connections

2023 **3.5bn**

2030 **5.8bn**

Mobile's contribution to GDP

2023 **$5.7tn**
5.4% of GDP

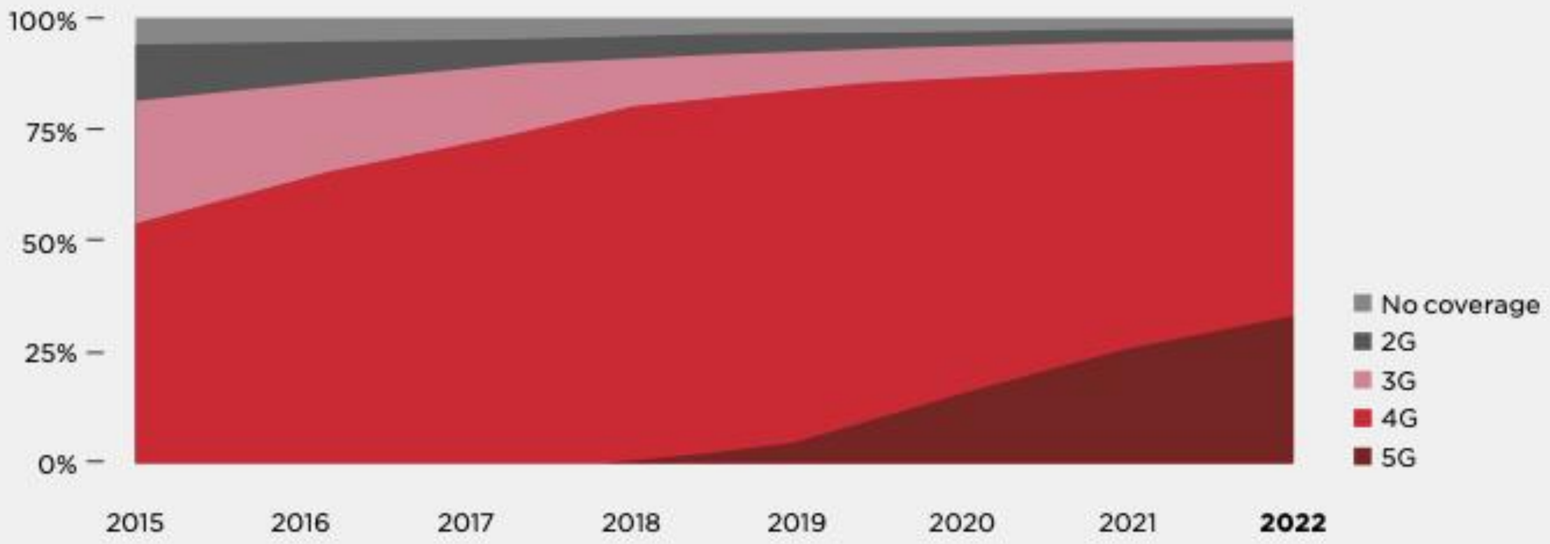
2030 **$6.4tn**

Employment

2023 **19m jobs**
Directly supported by the mobile ecosystem

Plus **16m** indirect jobs

Figure 12
Global population coverage by technology, 2015–2022

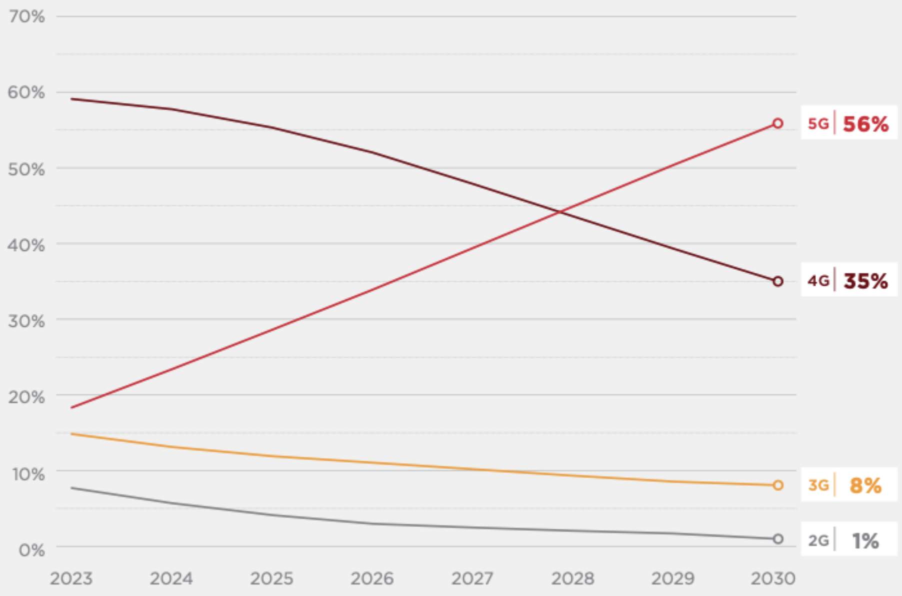


Source: GSMA Intelligence

Figure 2

Mobile adoption by technology

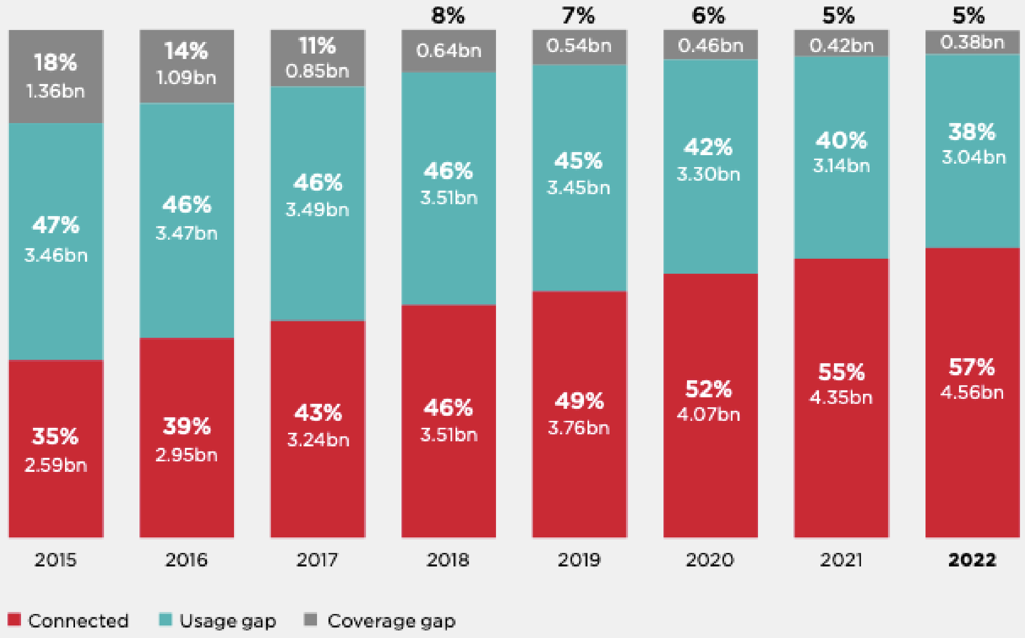
Percentage of total connections



Source: GSMA Intelligence

1. Spectrum: five trends to watch in 2024, GSMA Intelligence, December 2023

Figure 1
Global mobile internet connectivity, 2015–2022



Base: Total population, 198 countries

Note: Totals may not add up due to rounding. Every year, GSMA Intelligence updates its estimates of the number of mobile internet subscribers in each country, incorporating new (and/or updated) data from operators, regulators, national statistics agencies and consumer surveys where available. In some countries and regions, estimates of mobile internet adoption may therefore differ from what was presented in previous editions of The State of Mobile Internet Connectivity.

Source: Unique subscriber data among adults is sourced from GSMA Intelligence. Coverage data is sourced from GSMA Intelligence, combining data reported by mobile operators and national regulatory authorities. Population data is sourced from the UN.

3.45 B unconnected – 23/10/2024

- New GSMA report shows mobile internet connectivity continues to grow globally but barriers for 3.45 billion unconnected people remain - Newsroom
- 4.6 billion people (57% of the global population) now use mobile internet
- 350 million people (4% of the global population) live in largely remote areas without mobile internet networks (the Coverage gap)
- 3.1 billion people (39% of the global population) live within mobile internet coverage but do not use it (the usage gap). The Usage gap is 9X the coverage gap
- Sub-Saharan Africa has only 27% of the population are using mobile internet services, leaving a 13% Coverage gap and a 60% Usage gap
- The biggest challenge remains the Usage gap. Going online would be worth an estimated $3.5 trillion to the global economy during 2023-2030 (incl 90% impact LMICs)
- The coverage gap predominantly exists in rural, poor and sparsely populated areas – often less developed, landlocked, or small island developing states. An estimated $418 billion in investment is needed to build the infrastructure required to achieve universal mobile internet access.

There are two ways people can be **'unconnected'**: either they live in an area not covered by mobile broadband, or they live in an area that is covered but they do not use mobile internet.

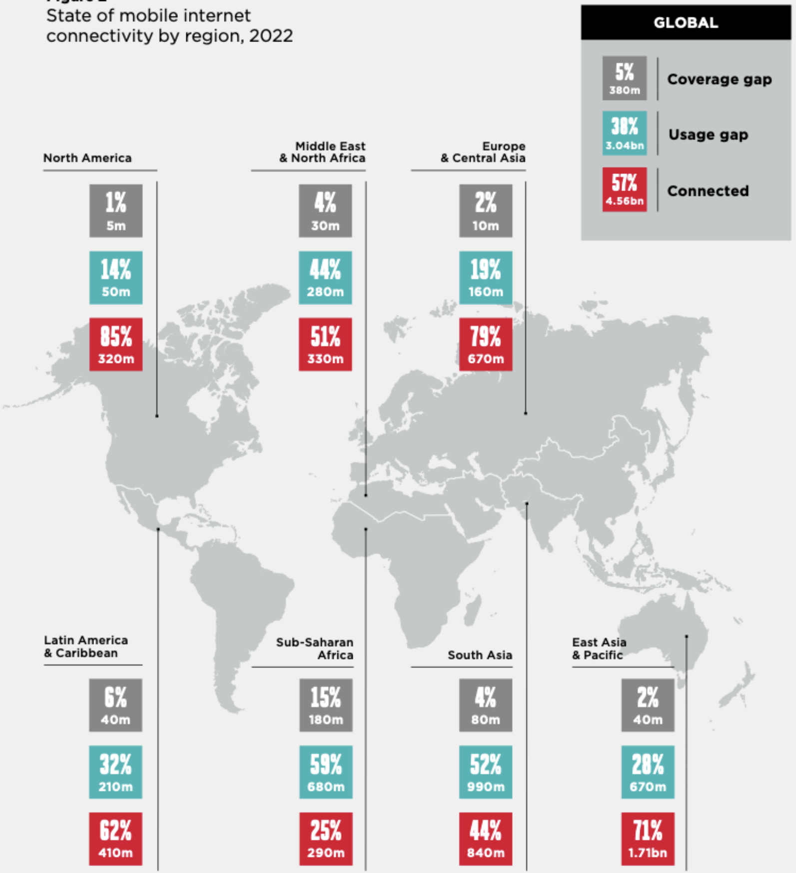
UNCONNECTED

Coverage gap:
Those who live in an area not covered by a mobile broadband network.

Usage gap:
Those who live within the footprint of a mobile broadband network but do not use mobile internet services.

Connected:
Those who use mobile internet.

Figure 2
State of mobile internet connectivity by region, 2022



Base: Total population

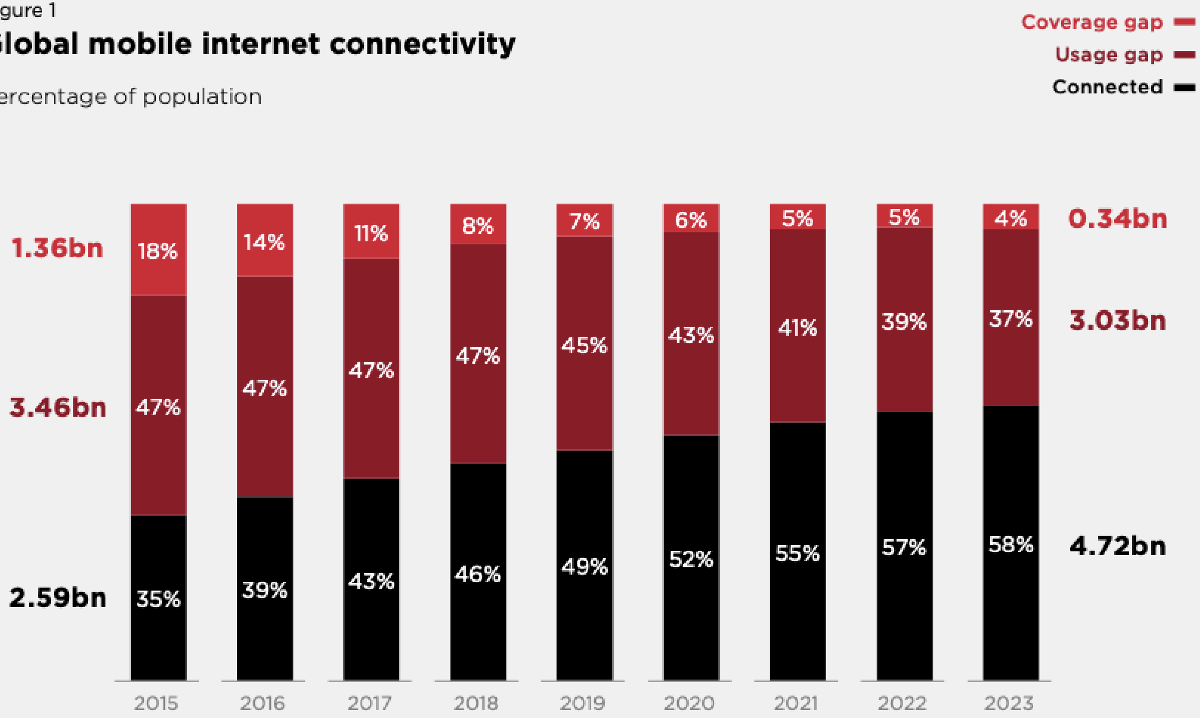
Note: Totals may not add up to 100% due to rounding. Every year, GSMA Intelligence updates its estimates of the number of mobile internet subscribers in each country, incorporating new (and/or updated) data from operators, regulators, national statistics agencies and consumer surveys where available. In some countries and regions, estimates of mobile internet adoption may therefore differ from what was presented in previous editions of The State of Mobile Internet Connectivity.

Source: GSMA Intelligence

Figure 1

Global mobile internet connectivity

Percentage of population

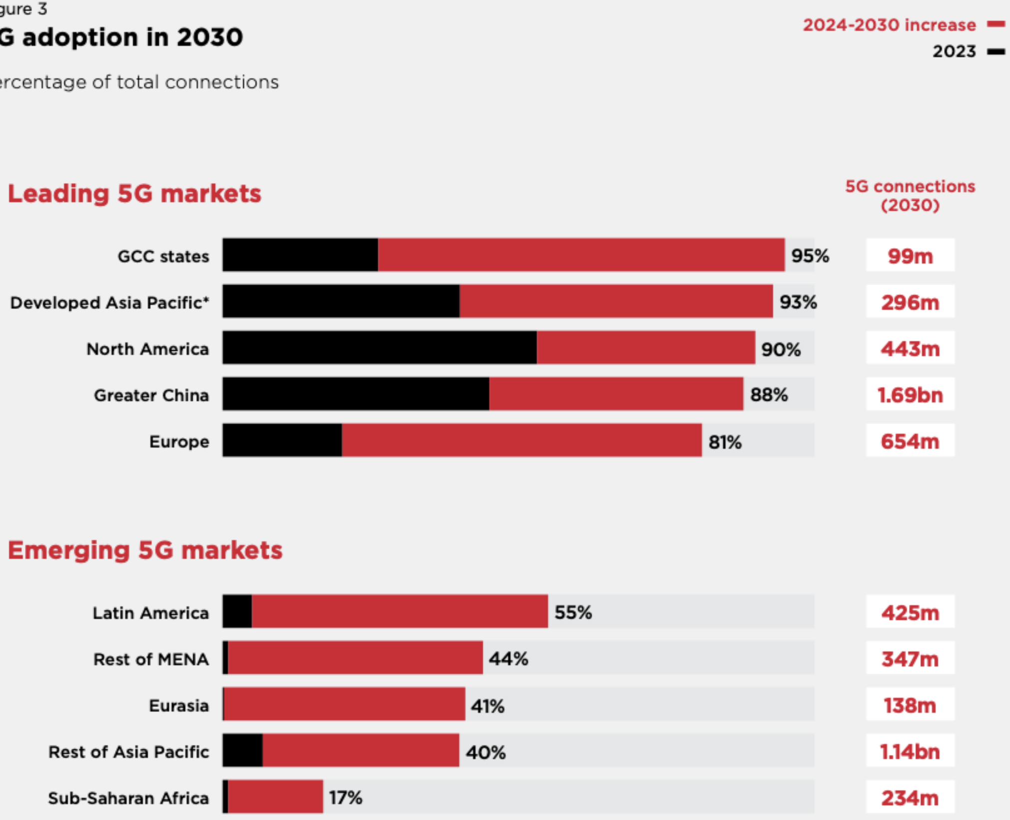


Note: Totals may not add up due to rounding. Every year, GSMA Intelligence updates its estimates of the number of mobile internet subscribers in each country, incorporating new (and/or updated) data from operators, regulators, national statistics agencies and consumer surveys where available. In some countries and regions, estimates of mobile internet adoption may therefore differ from what was presented in previous editions of The Mobile Economy and The State of Mobile Internet Connectivity reports. 2023 is based on estimated data and may be updated later in 2024.
Source: GSMA Intelligence

Figure 3

5G adoption in 2030

Percentage of total connections



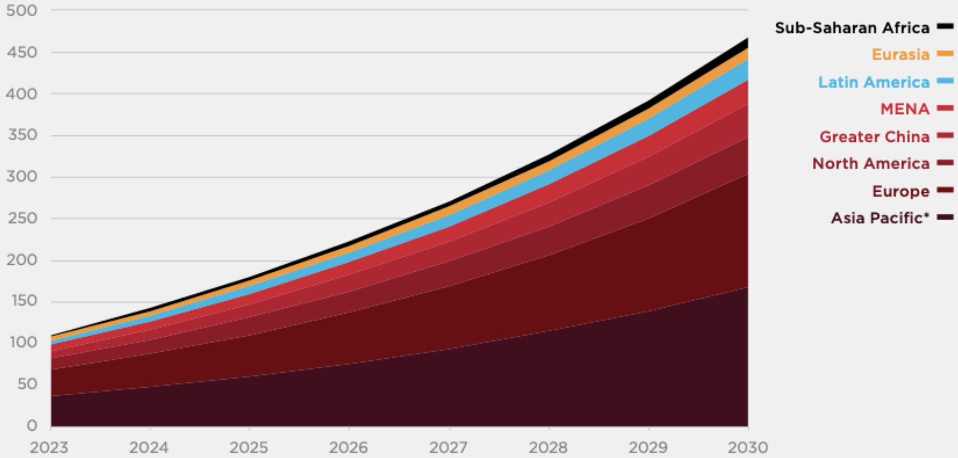
* Australia, Japan, New Zealand, Singapore and South Korea

Source: GSMA Intelligence

Figure 4

Global mobile data traffic

EB per month



Mobile data traffic per connection (GB per month)

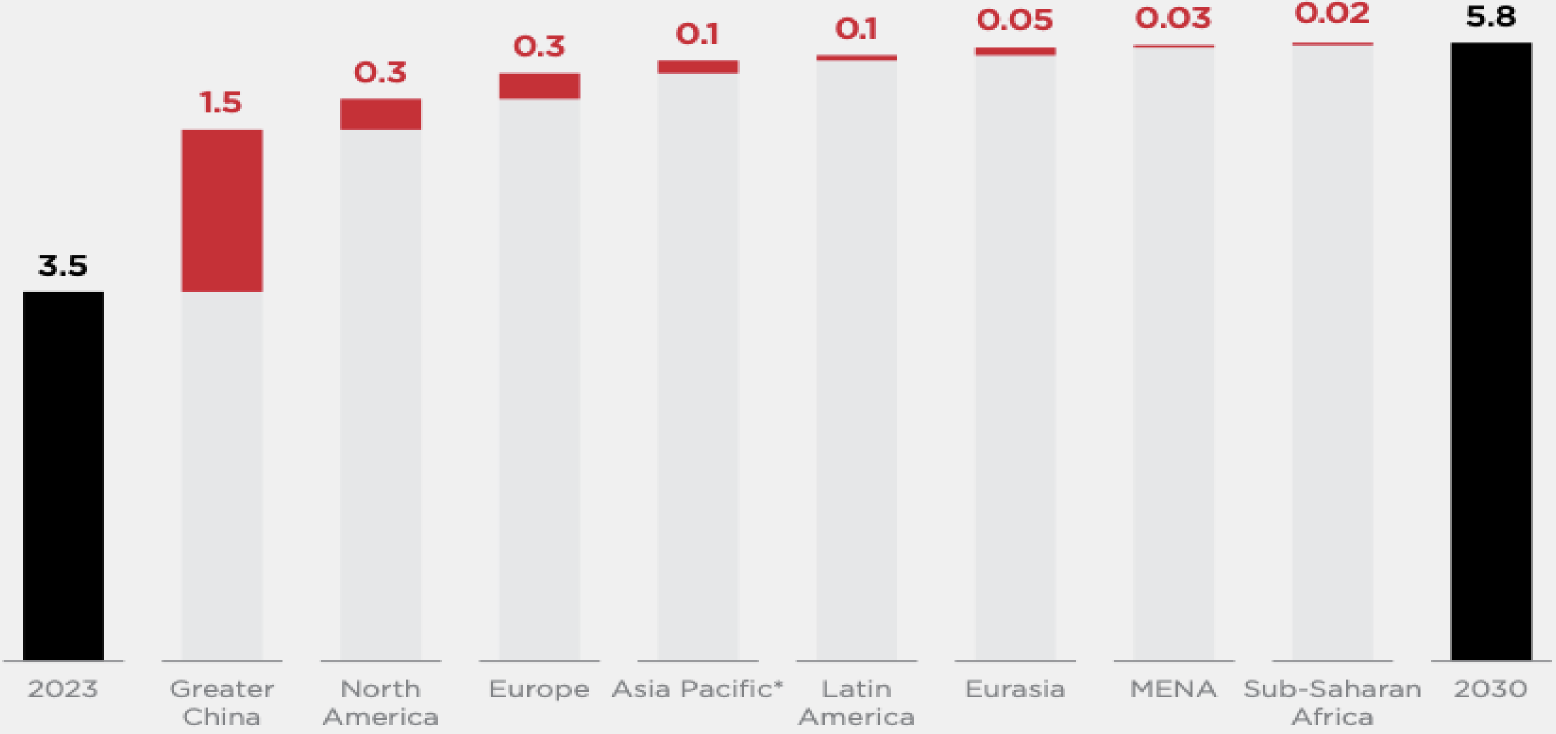
Region	2023	2030	CAGR 2023–2030
Asia Pacific*	14	53	21%
Eurasia	13	41	18%
Europe	17	71	22%
Greater China	13	54	23%
Latin America	7	32	23%
MENA	10	31	18%
North America	29	90	17%
Sub-Saharan Africa	2	9	23%

* Asia Pacific excludes Greater China
Source: GSMA Intelligence

Figure 5

Licensed cellular IoT connections

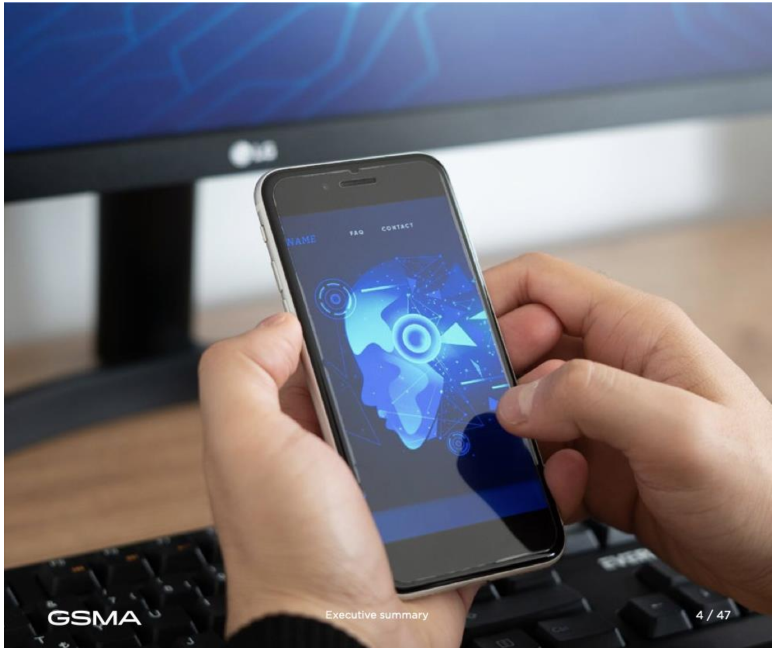
Billion



* Asia Pacific excludes Greater China
Source: GSMA Intelligence

Summary

- Coverage
- Backhaul
- Applications everywhere
- Security and resilience
- PNT evolves for autonomy and new applications
- Data Analytics and AI drives new innovation
- Key dependencies on spectrum , devices and standards
- More than NTN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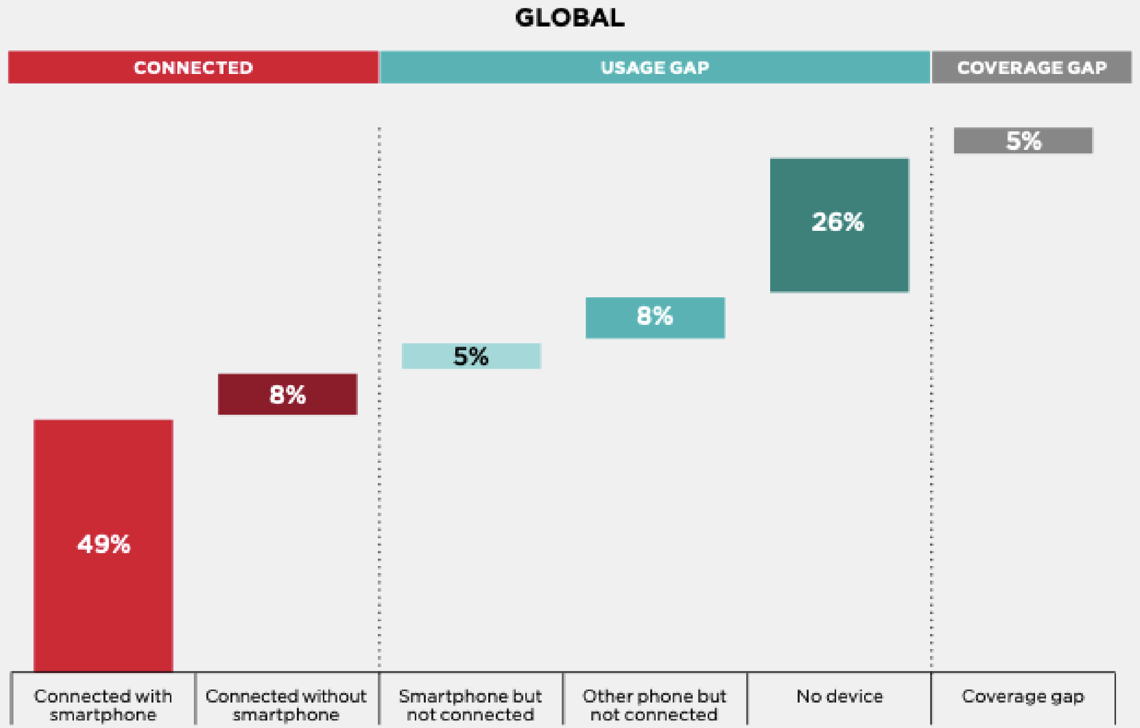
4 / 47

Figure 6

State of connectivity, with connectivity and usage gap broken down by device type, 2022

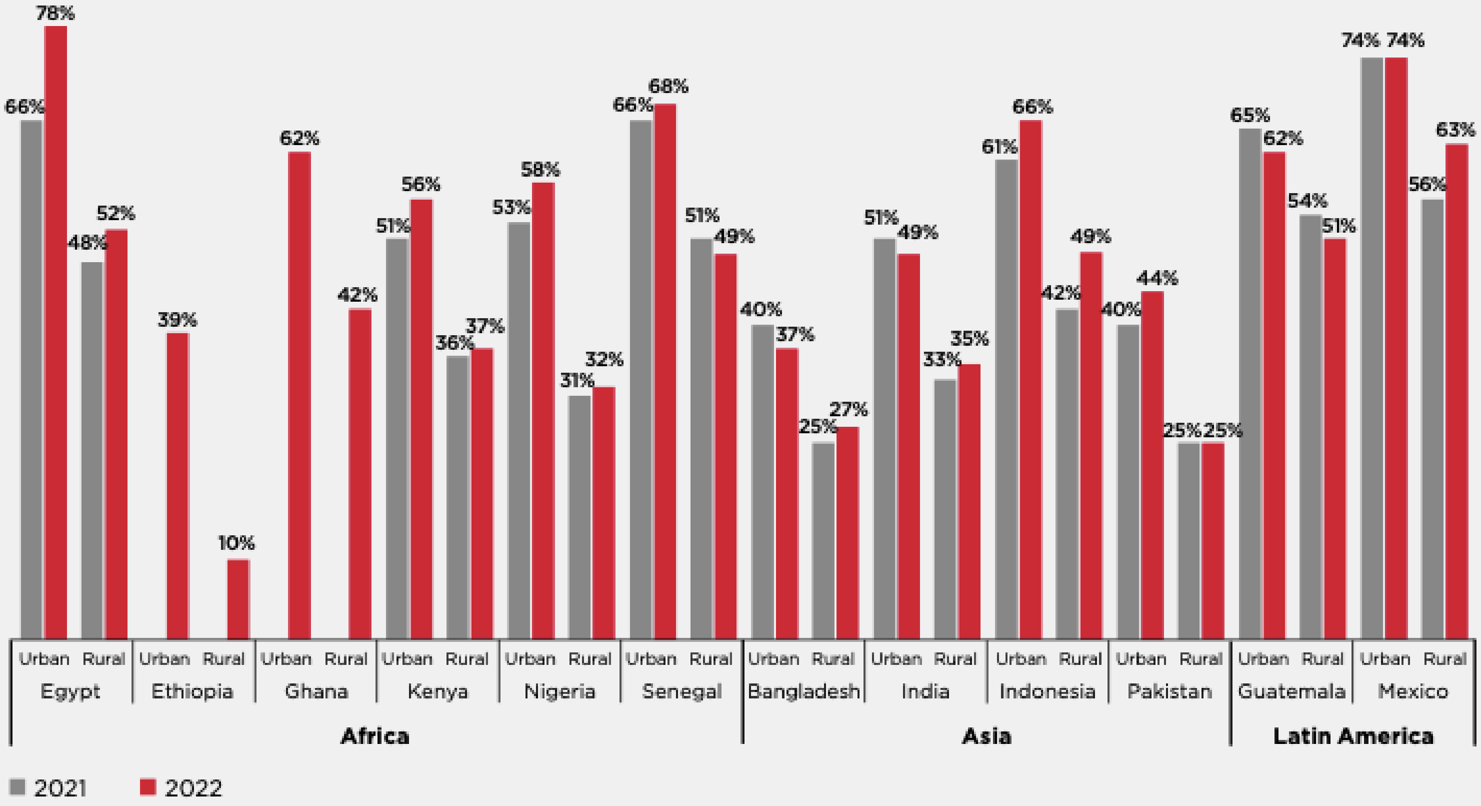


Base: Total population, 198 countries

Note: Totals may not add up to 100% due to rounding

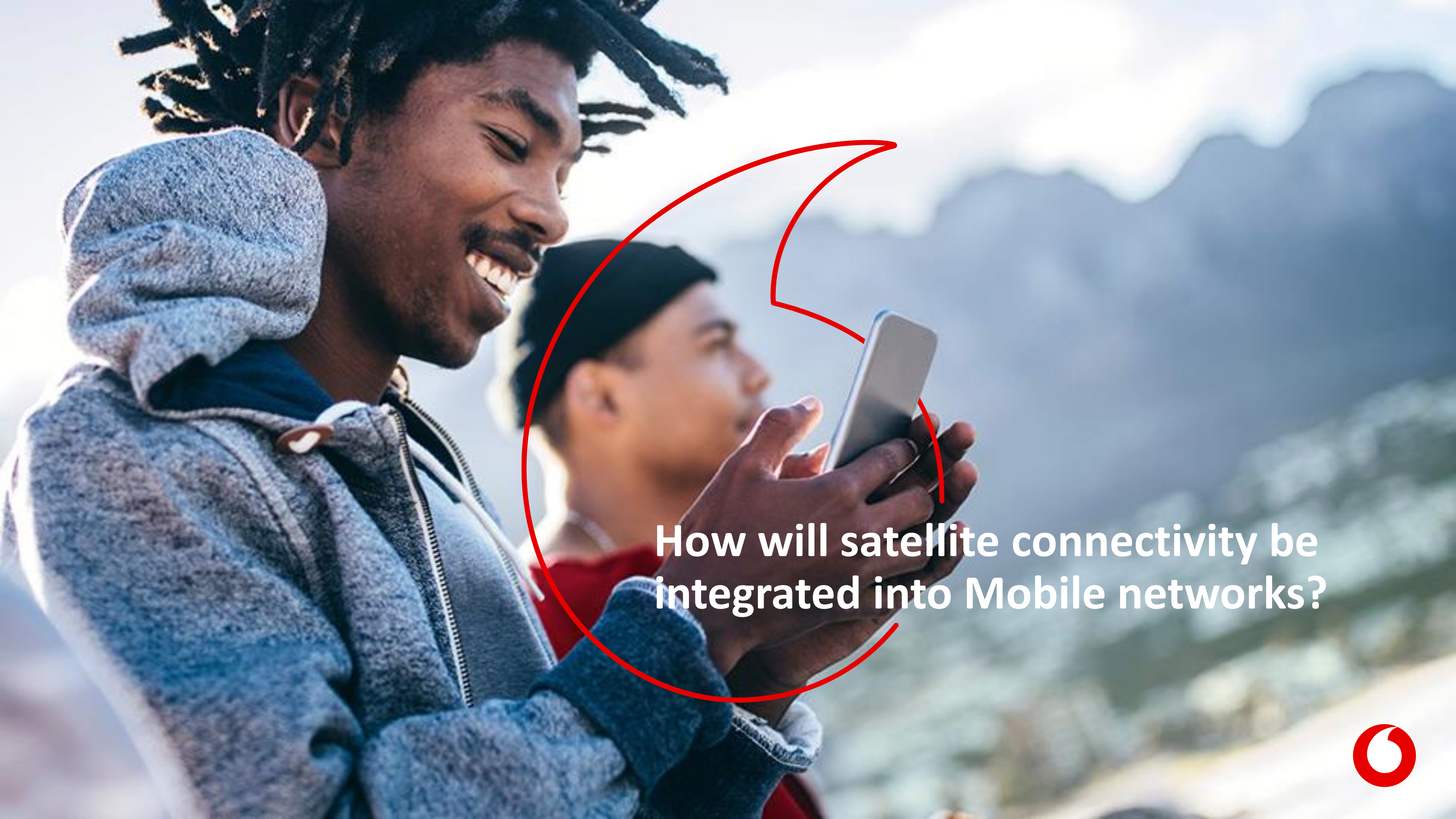
Source: GSMA Intelligence

Figure 10
Smartphone ownership, 2021–2022



‘How will satellite connectivity be integrated into Mobile networks?’

Rowan Chesmer,
R&D Future Technologies Researcher,
Vodafone


How will satellite connectivity be integrated into Mobile networks?

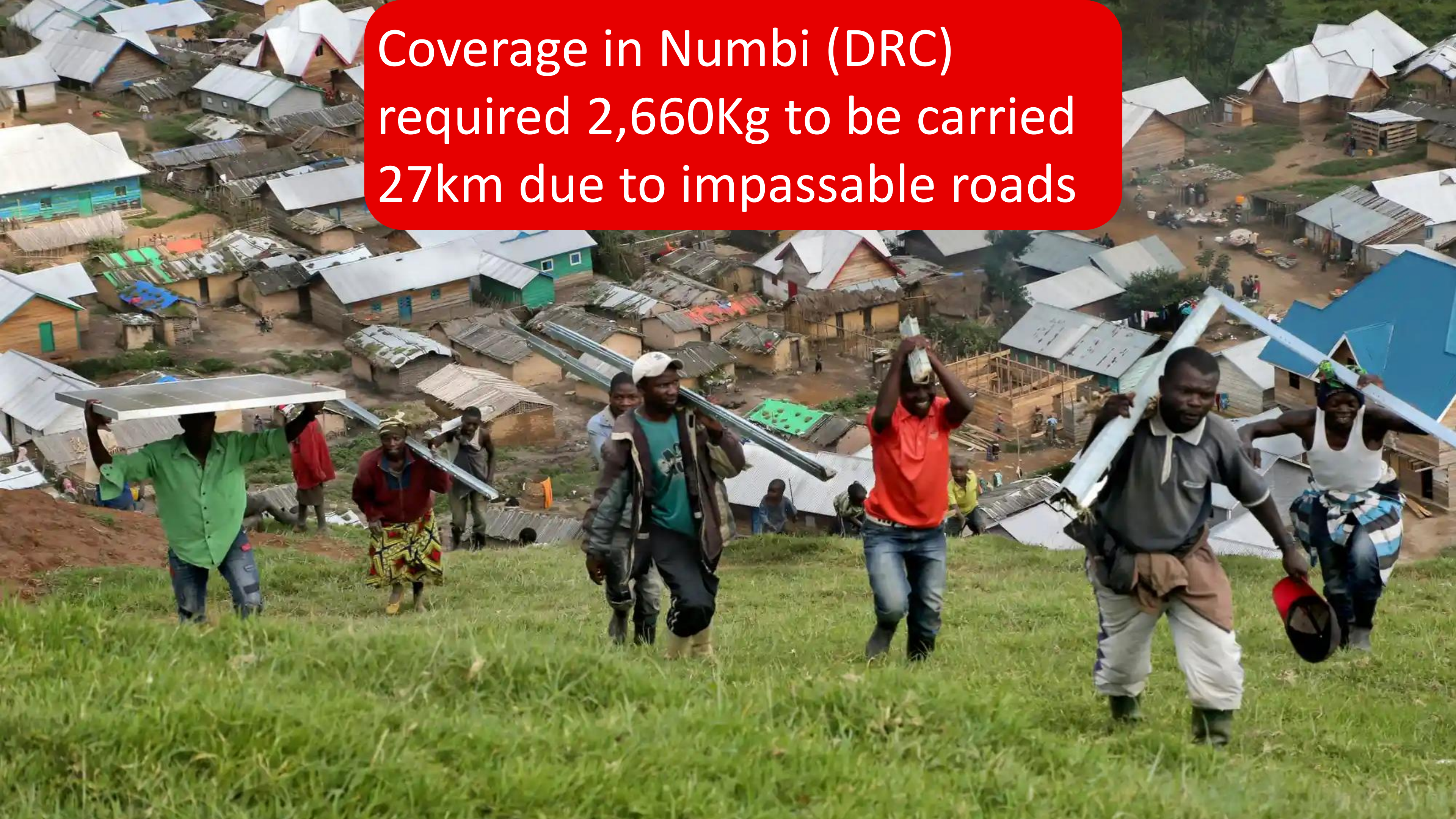
What are we trying to solve with non-terrestrial networks?

1 billion people unconnected

95% live in rural areas

Rural sites have double the cost, and 1/10th revenue of urban sites

- Mobile coverage to date has been based on population coverage rather than geographical coverage.
  - e.g. Kenya has mobile coverage for ~95% of the population but only ~40% of the land mass.


Coverage in Numbi (DRC) required 2,660Kg to be carried 27km due to impassable roads


Natural Disasters cause challenging recovery and costs
Vodafone is purpose led

Satellites are evolving and new generation LEO satellites are emerging with higher capacity & lower latency compared to older MEO & GEO systems

Latest Generation Satellites

Low Earth Satellites (LEO)

600 to 1500km

Smaller Satellites
Large constellation
Lots of Earth Gateways

- Global footprint > 200 satellites
- Highest system capacity
- Lower Latency (50ms *)

AST SpaceMobile, amazon project kuiper, Globalstar, Telesat Lightspeed, Starlink, OneWeb

Medium Earth Satellites (MEO)

8000 to 20000km

Larger Satellites
Small constellation
Regional Earth Gateways

- Global footprint < 10 satellites
- Higher capacity vs GEO
- Moderate Latency (150ms *)

SES, GPS, Galileo

Geosynchronous Satellites (GEO)

~ 35000km

Very Large Satellites
Very small constellation
Few Earth Gateways

Most common legacy system

- Global footprint < 5 satellites
- Lowest system capacity
- Very High Latency (500ms *)

inmarsat, Intelsat, Eutelsat, SES, Viasat, skylo, Telesat

*Latency from Ground Station to Satellite and back to Ground Station

C2 General

LEO Satellite opportunities are lately emerging in 4 main areas:

Direct to Device (D2D)

- 4G/5G services from satellite directly to Smart Phones

Mobile Backhaul

- Satellite backhaul for remote, low-capacity 4G/5G sites or as resiliency

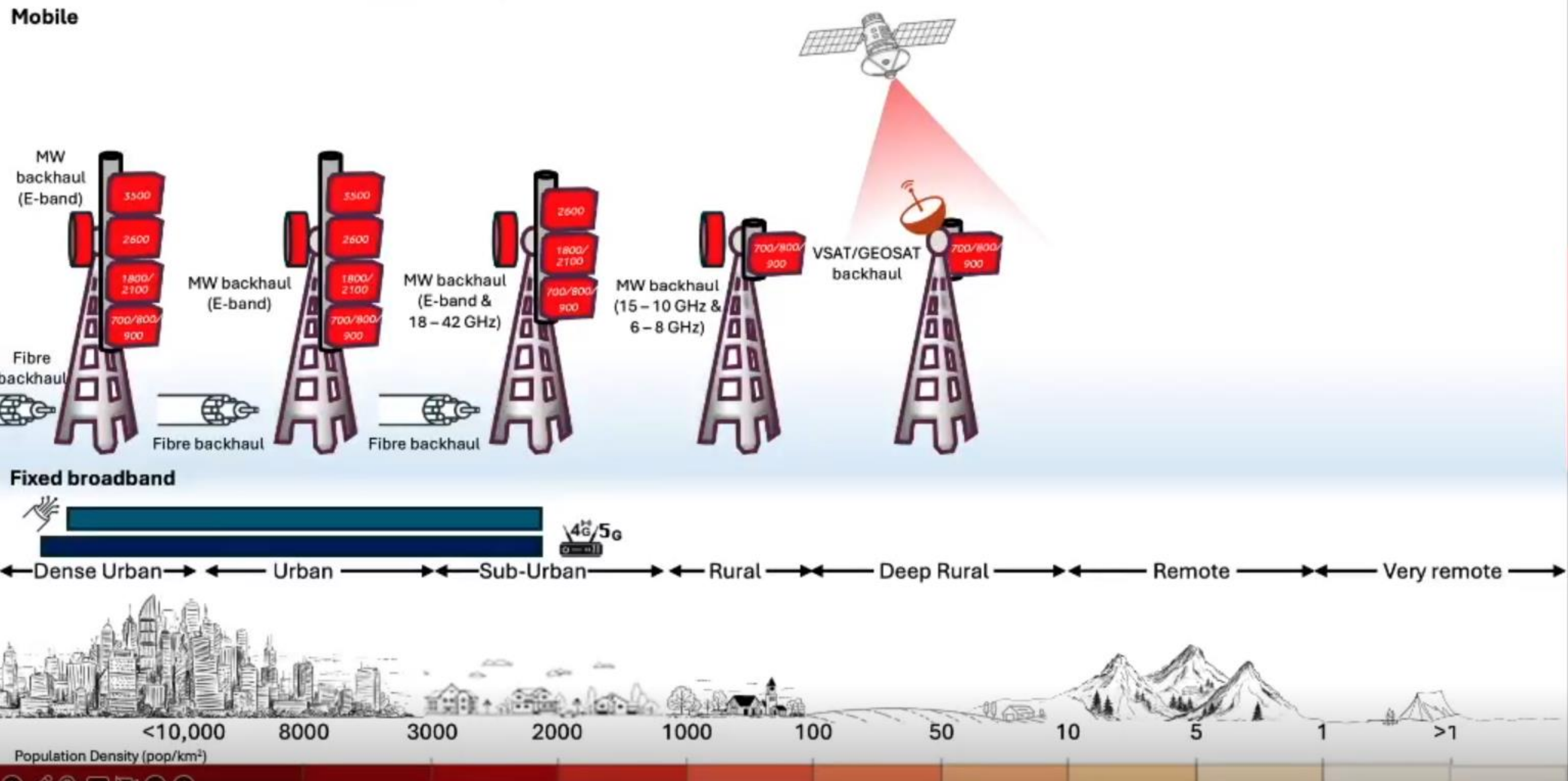
Fixed Broadband

- Satellite Broadband for users outside terrestrial coverage areas

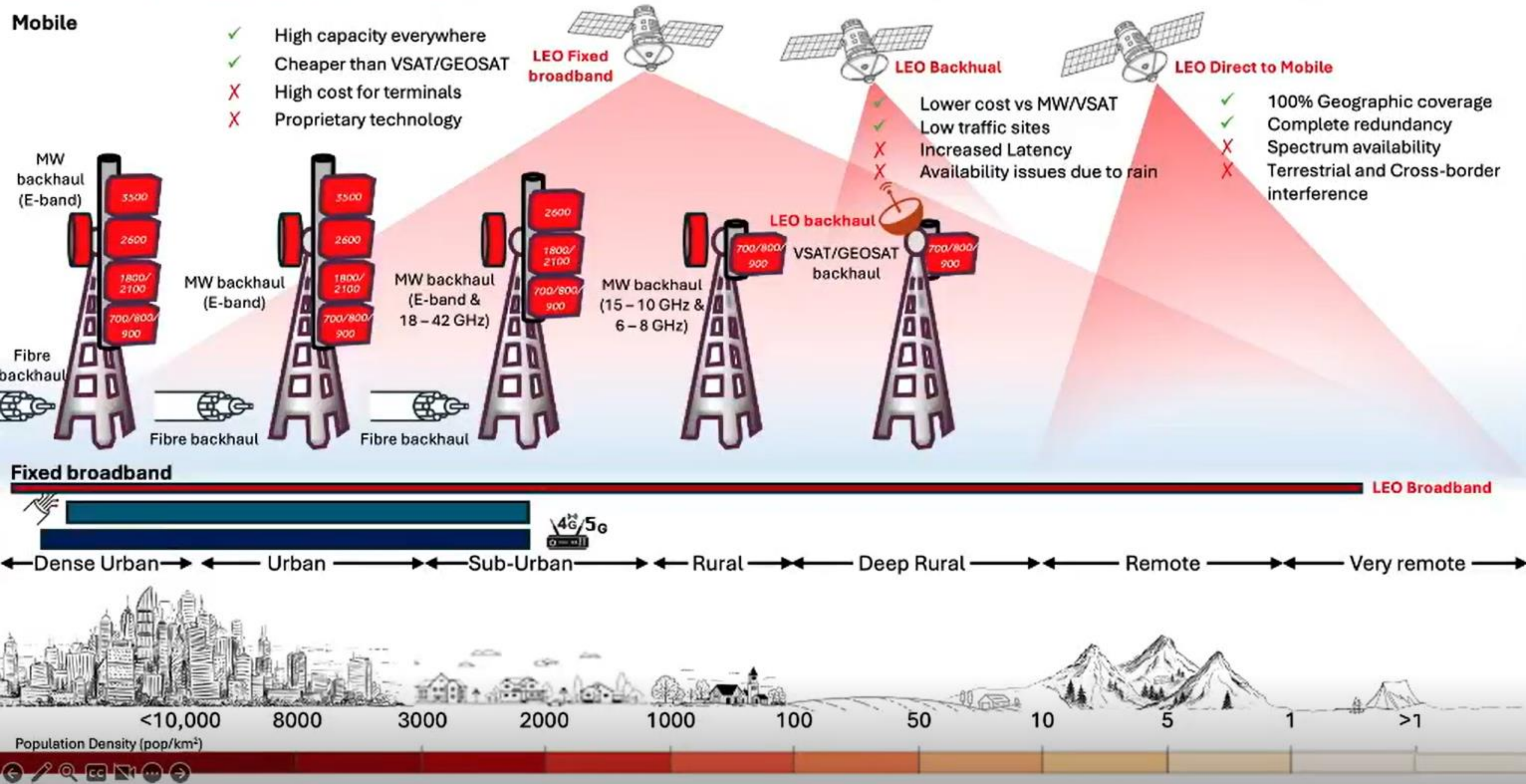
Enterprise/IoT

- Connectivity to remote private networks, VPN, SDWAN, IoT services

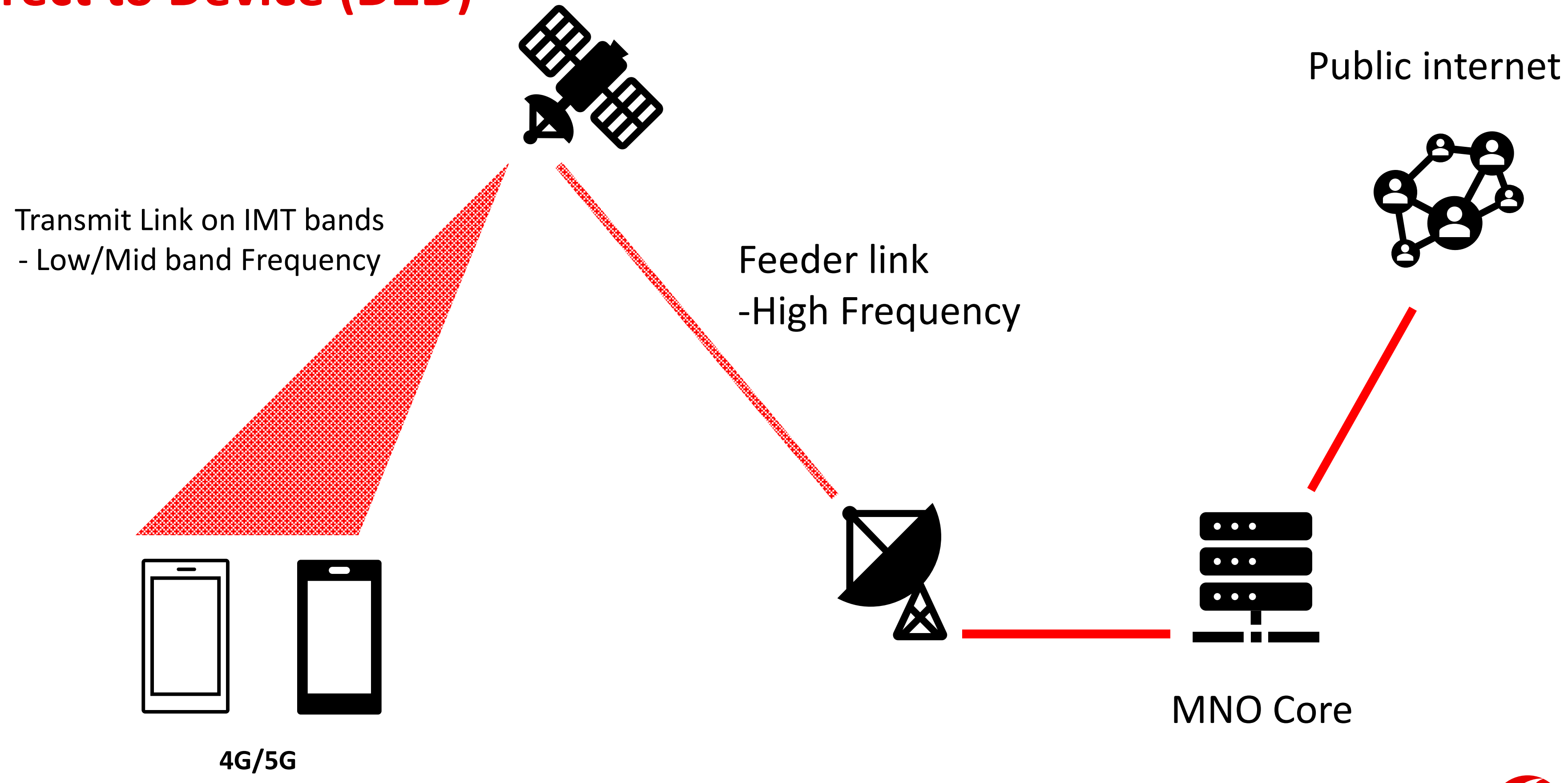
NTN Communications | How does it fit into our bigger deployment plan



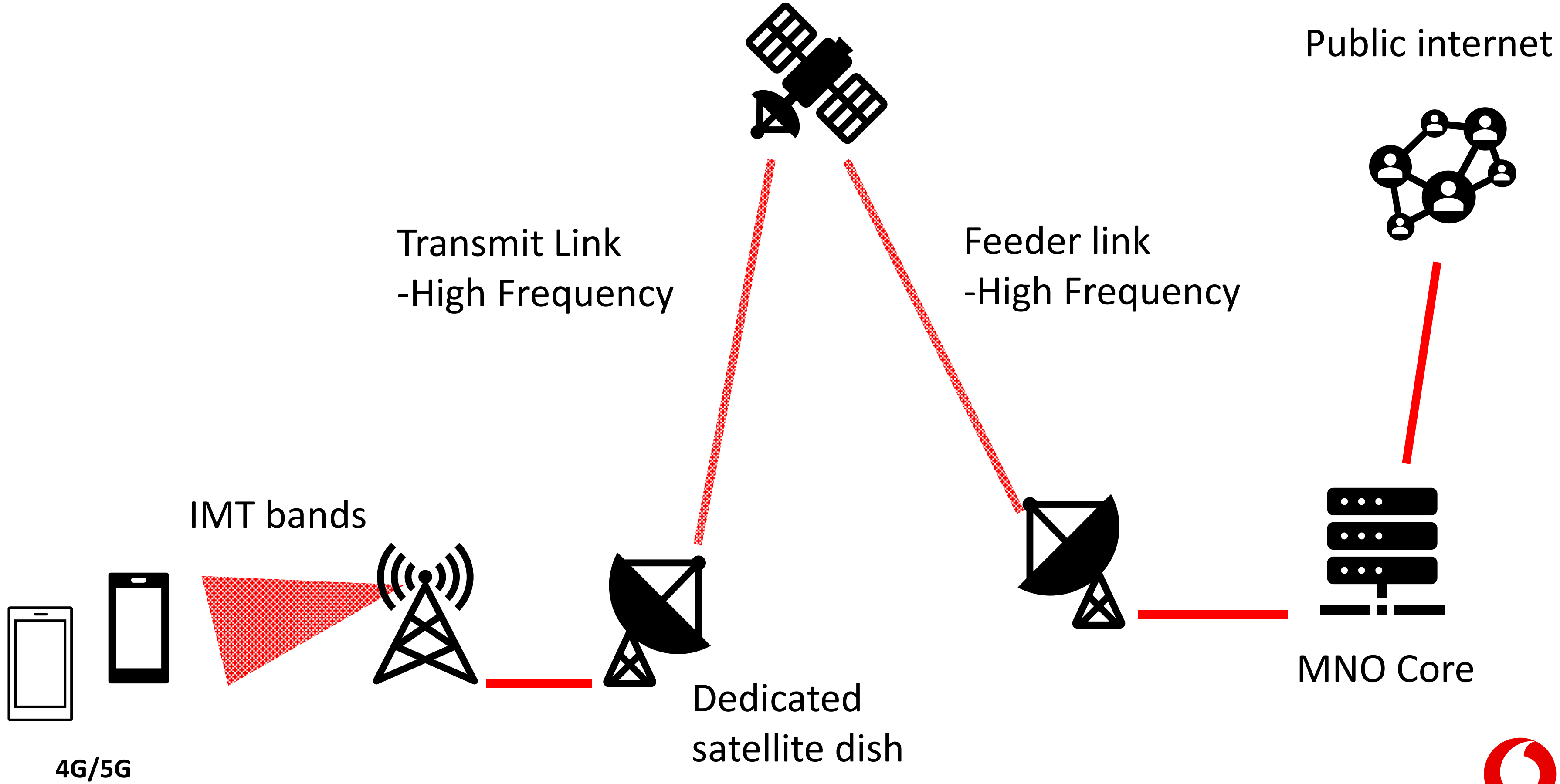
NTN Communications | How does it fit into our bigger deployment plan



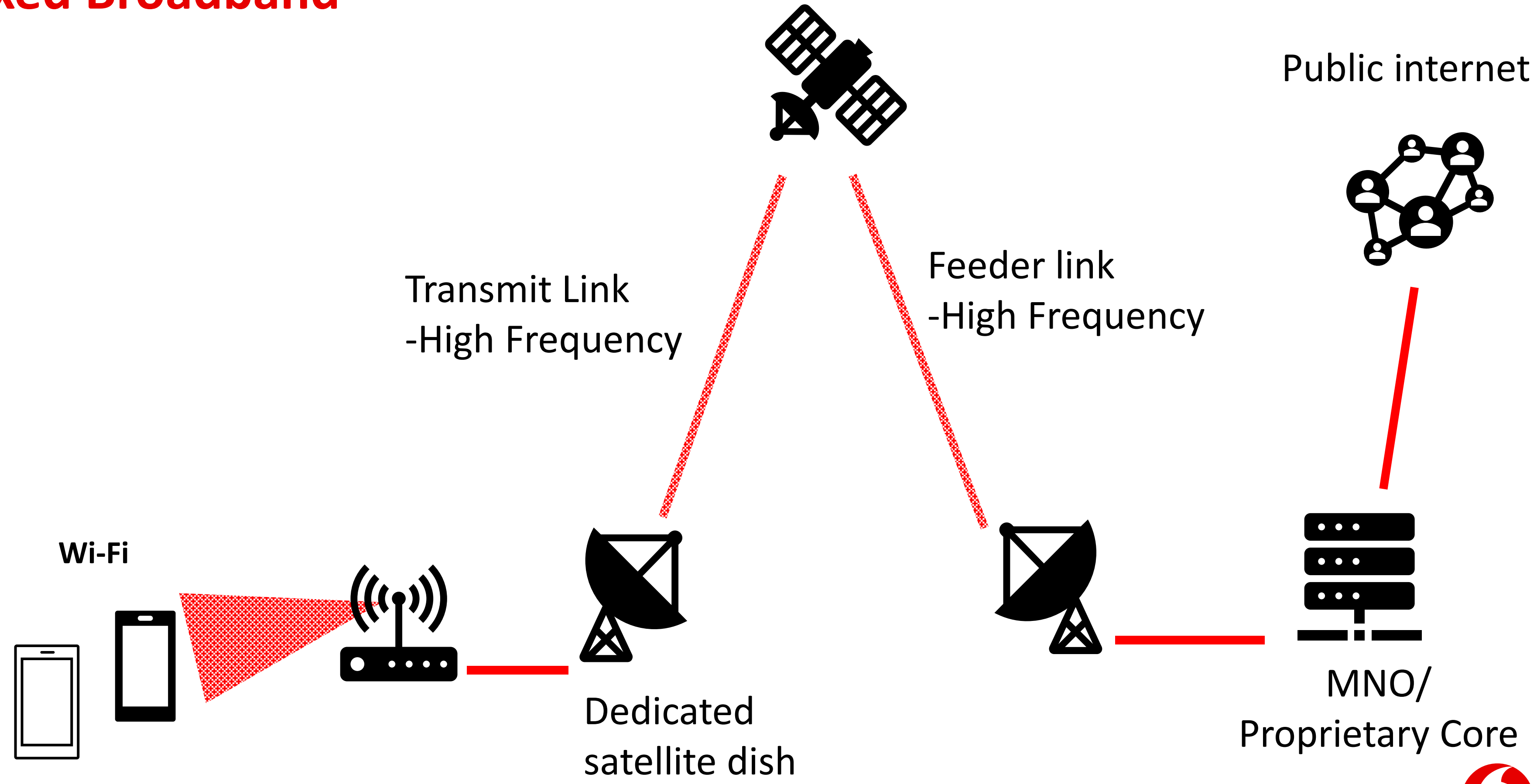
Direct to Device (D2D)



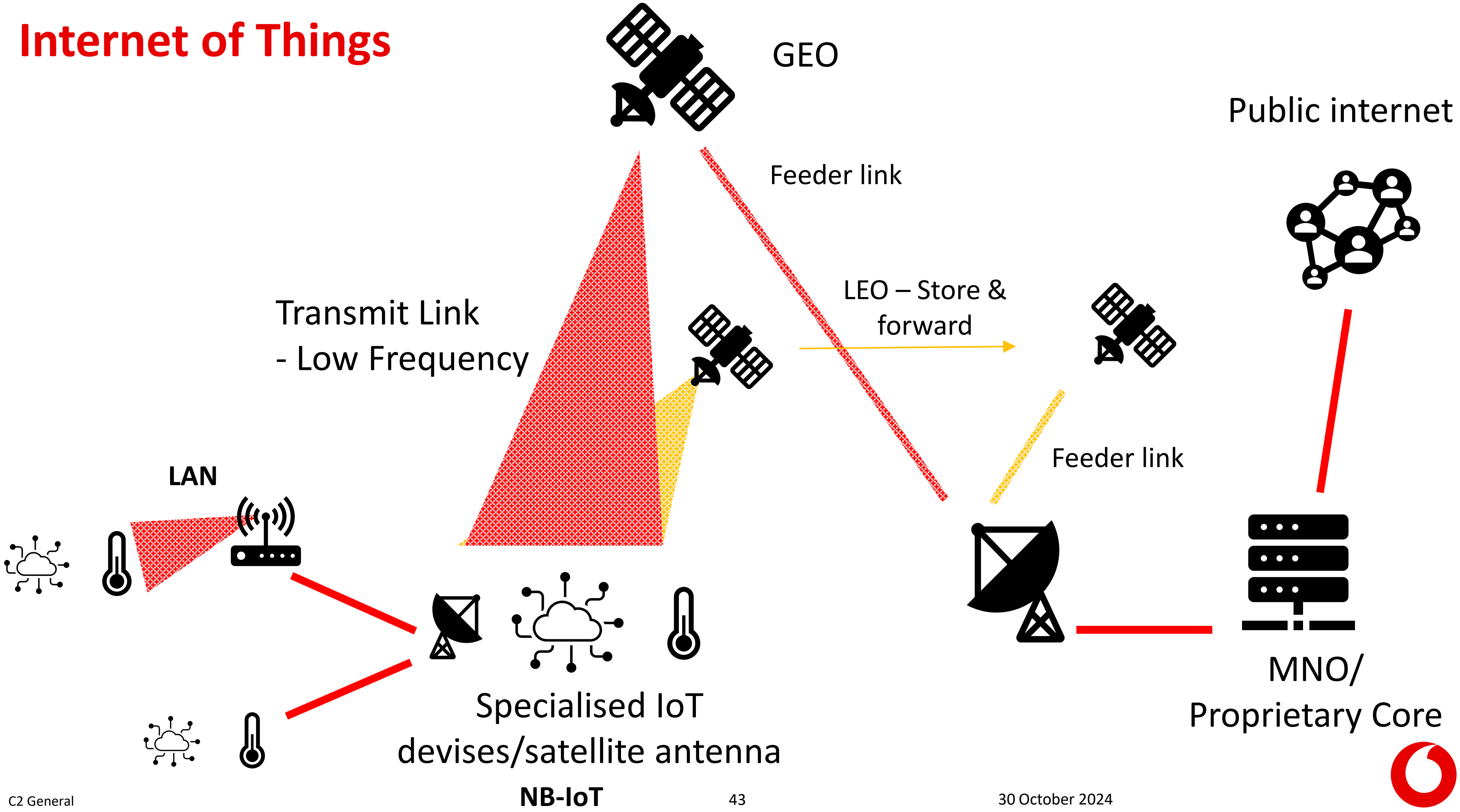
Base Station Backhaul



Fixed Broadband



Internet of Things



Conclusions

- **Terrestrial networks are still the best option** for the following reasons:
  - High throughput
  - Low Latency
  - Large Capacity
  - Constant availability
  - Deploy any Spectrum (Low band, High band, FDD, TDD etc)

- **Satellite** will be a great complimentary and cost-effective use case in providing **100% geographical coverage** for low population density and hard to reach areas.
- Satellite provides some **additional resiliency** to terrestrial networks:
  - Base station backhaul could be used for resiliency in case of Fibre cuts.
  - D2D could provide a “Skelton network” in case of national emergencies/ natural disasters.

Together we can

‘Non Terrestrial Networks (NTN) from 5G to 6G’

Professor Barry Evans
Professor of Satellite Communications,
Institute for Communications Research (ICS) and 6GIC
University of Surrey

When Networks Collide—Merging of Terrestrial & Non-Terrestrial Networks

NTN from 5G to 6G

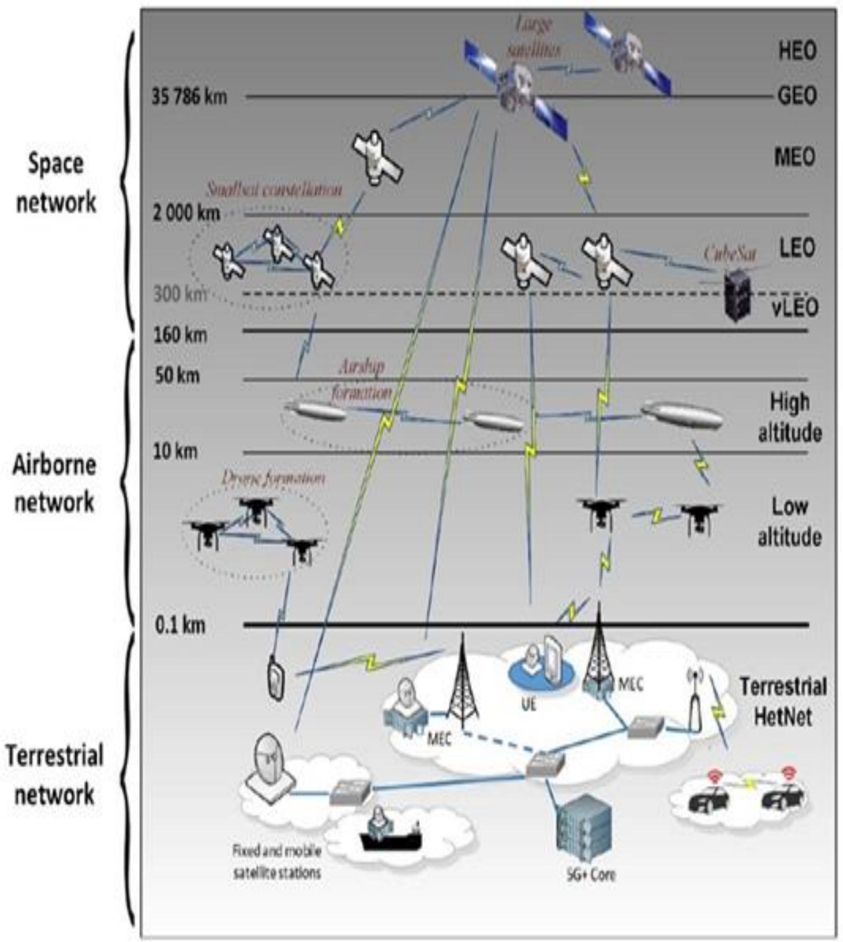
Barry Evans University of Surrey

Worksop University of Surrey 29th October 2024

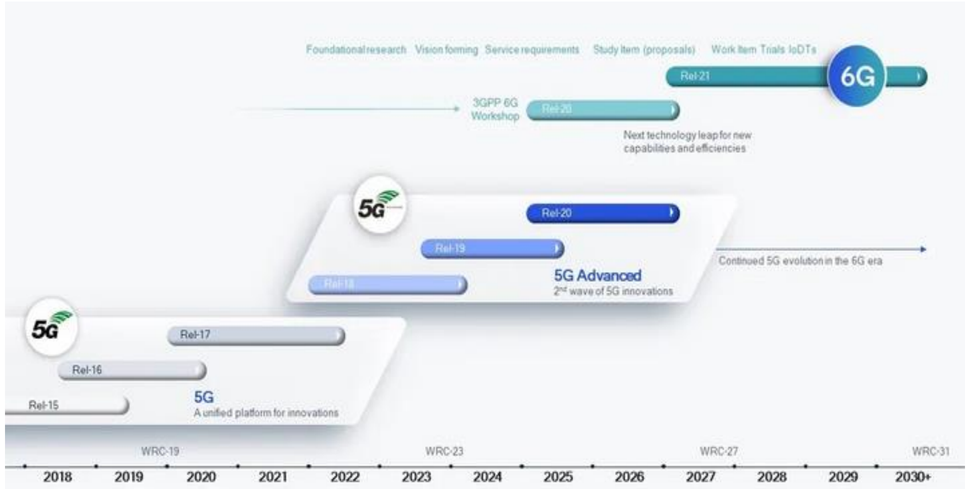
5»6G INNOVATION CENTRE
UNIVERSITY OF SURREY

NTN –TIME SCALES 5G ➞5G+ ➞6G

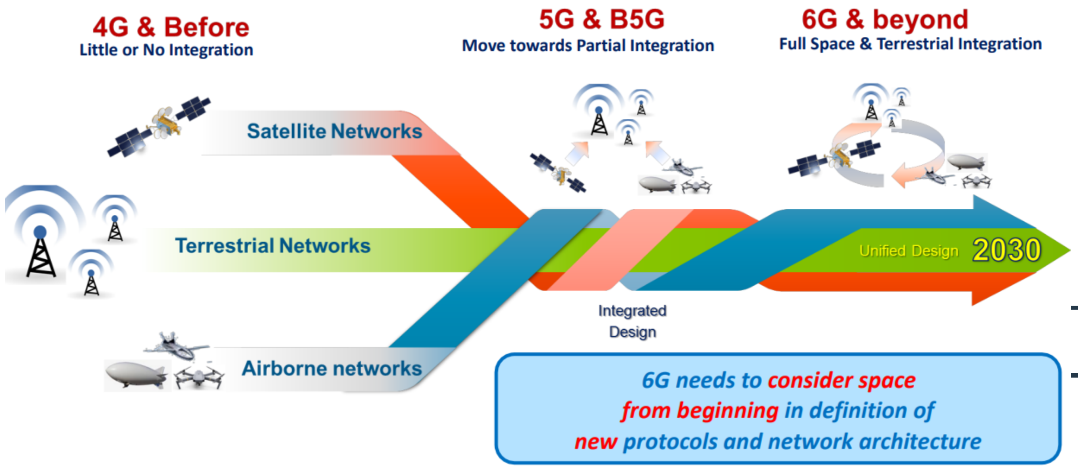
5·6G INNOVATION CENTRE
UNIVERSITY OF SURREY



Convergence NTN-TN



Standards timescales



– interworking

+ --Integration

-- Unified

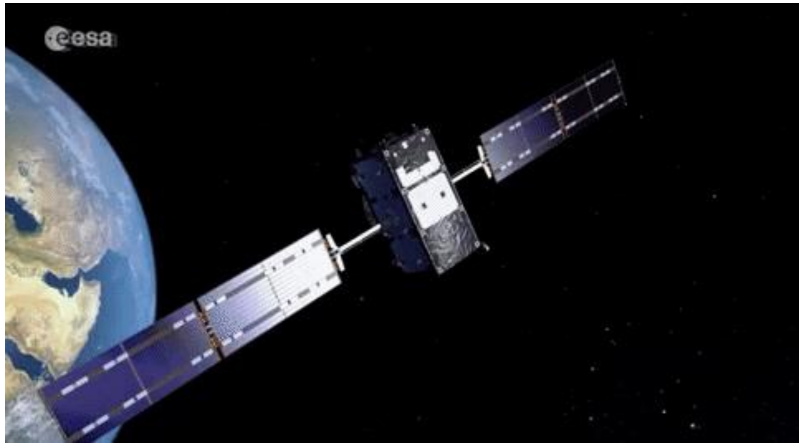
CURRENT SATELLITES

- **GEO/MEO satellites –up to 0.5Tb/s**
  DSP transponders/Beam shaping/ muti-spot beams

- **LEO constellations Operational**
  Starlink 6325 satellites—D2ut model
  1900 Gen2 satellites
  EutelsatOneWeb -650 satellites---B2B model

- **LEO constellations upcoming**
  Kuiper 3,236 satellites—Dut model
  Telesat 198 satellites--- B2B model
  Rivada 600 satellites—Security Mesh model

- GEO operators losing subscribers
  GEO satellite orders down 11→ 3
  Starlink subscribers inc exp (>3m)



SATELLITE MARKETS

Traditional satellite markets—Broadcast, Broadband, Backhaul

5G Backhaul/Broadband –operational with Gen1 constellations

New disruptor –Direct to Device (HH)

"Mobile meets satellite"

First elements of convergence?

- Apple and Globalstar –emergency service in operation in 16 countries.

- Early demonstrators have taken place;
  - -AST Mobile-Demo satellites and launched 5 commercial satellites Sept 24
  - -Lynk demo satellites
  - -Starlink-launched >100 satellites with D2cell capability and early demo's.
  - -Viasat demo L band
- Market size?

  NSR –"largest opportunity in satcoms history" 350-400m subscribers by 2030

  Annual Revenue $68B

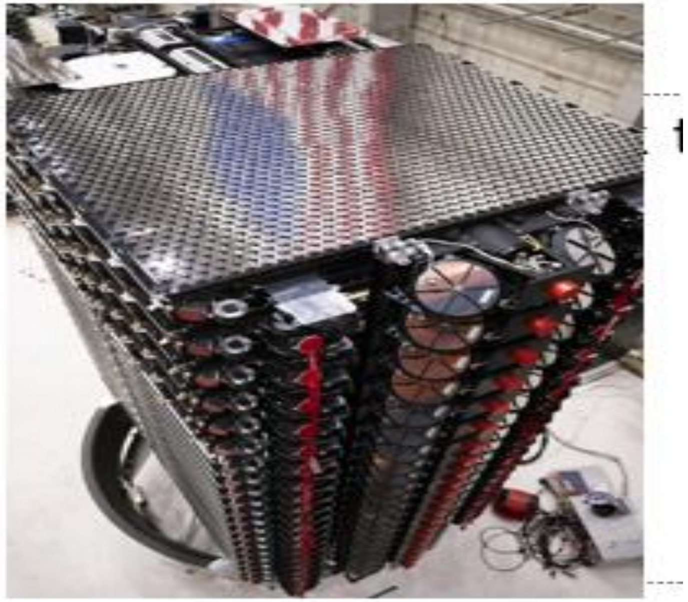
- 3GPP NTN standards Rel17/18

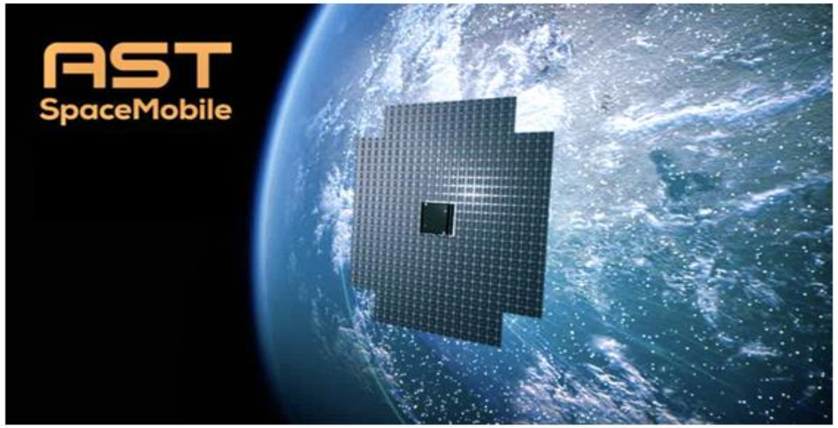
  NR-NTN and NB-IoT-NTN
- Ecosystem developing with chip manufacturers.

- Several new IoT satellite constellations emerging

- Rel 19 studies with processing satellites

WHERE ARE WE TODAY –D2HH





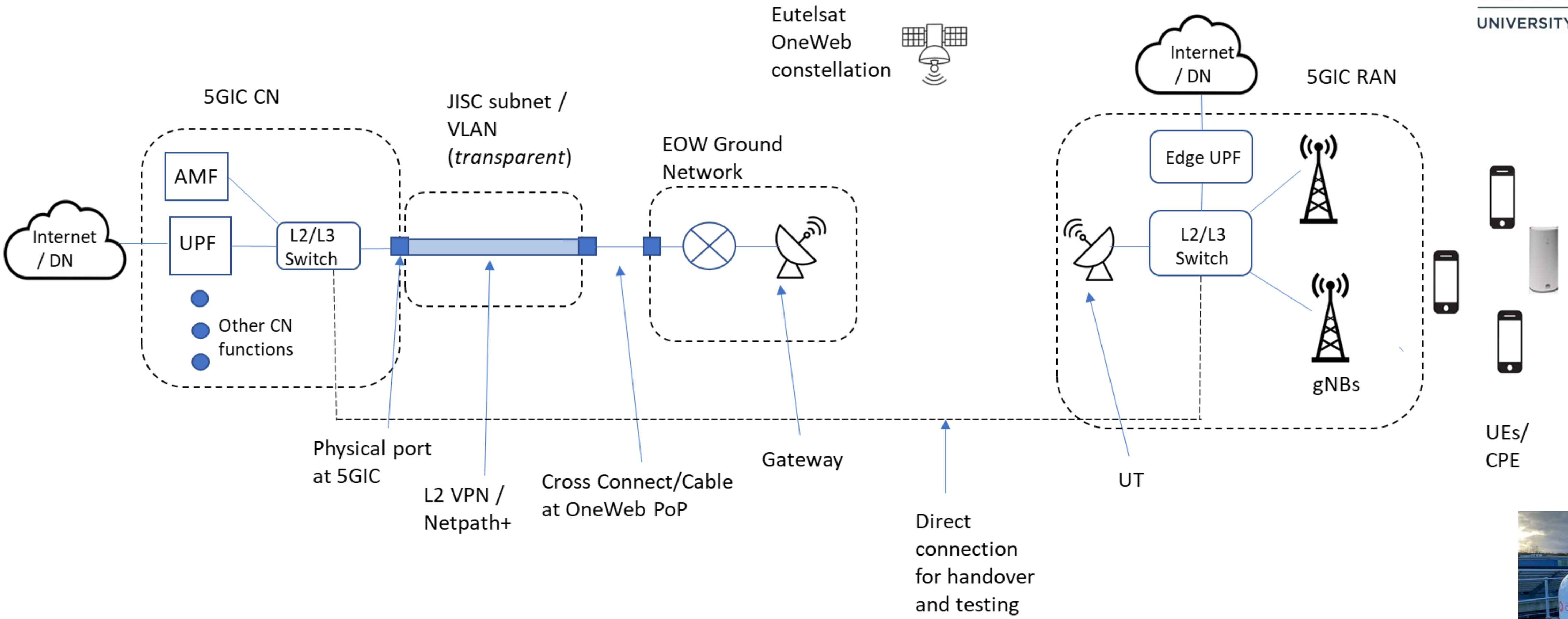
The aim is to have ubiquitous connection anywhere—no more 'Not-Spots' – converged satellite and cellular.

The MSS spectrum camp-Apple/Globalstar –Iridium/Viasat SkyLo.
--Pro's-Globally available
--Cons-Handset needs modifying
--spectrum shortage

The MS spectrum camp-Starlink/AST/Lynk
--Pro's—use existing handsets
--Cons---potential coverage reduction-interference
---limited ubiquity.

Regulation:
2024 FCC ahead of ITU WRC employ 'Supplementary coverage from Space – SCS' in US. Europe has consultations for similar.
Issues—meeting stringent PFD limits to avoid interference.
--borders between countries.
WRC 27—Items to release more spectrum –specific to MSS and satellite delivery.-Key to ubiquity.

Backhaul Connection EoW constellation to 5GIC 5G SA Network



PERFORMANCE EVALUATION

Use cases tested

- Video streaming (Best Effort)
- Video conferencing (Med priority)
- VoIP (High priority, low latency)
- File Transfer (BE)
- Internet Browsing (BE)
- Gaming (Med priority)
- IoT (High priority, low latency)
- [AR / VR] (Edge access only)

- Connections between the constellation and the 5G network were sensitive to satellite hand-over timing.
- With the full constellation all use case performances were indistinguishable from a fibre backhaul connection

SECOND GENERATION CONSTELLATIONS

Payloads

Regenerative OBP –ASIC's from 16—7nm

Digital Beam forming—100's elements and 100Gbps

OISL's—up to 100Gbps

Network functions—gNB/UPF

Second Gen LEO constellations

Starlink Gen1 satellites---16Gbps 4-6KW 0.3T

Gen2 satellites—160Gbps >14KW 1.2T

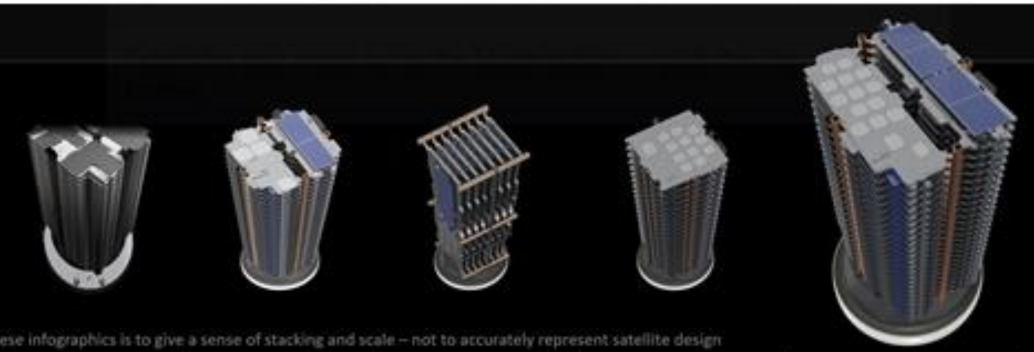
Volume manufacturing

Cost/satellite reducing by factor 10 cf GEO similar capacity

Sec.ond Gen launchers

Falcon 9----3K$/Kg

Starship---- 200$/Kg



The goal of these infographics is to give a sense of stacking and scale – not to accurately represent satellite design

Assumptions

Designation	Starlink V1.5	Starlink V2 F9-1	Starlink V2 F9-2	Starlink V2 mini	Starlink V2 Starship
Status	Launched	FCC filing – may not realize	FCC filing – may not realize	Launched	FCC filing
Mass kg	306	303	800	800	2000
Gbps / sat	15	18	70	60	170
Launch	60 units per Falcon 9	60 units per Falcon 9	16 units per Falcon 9	21 units per Falcon 9	50 units per Starship
Tbps / launch	0.9	1.1	1.1	1.3	8.5
m$ / launch	Sats 18 + launch 30 = 48m$	Sats 18 + launch 30 = 48m$	Sats 11 + launch 30 = 41m$	Sats 15 + launch 30 = 45m$	Sats 60 + launch 15 = 75m$
$ / Mbps	53	45	37	35	9
Direct-to-mobile?	No	No?	Yes	Yes?	Yes

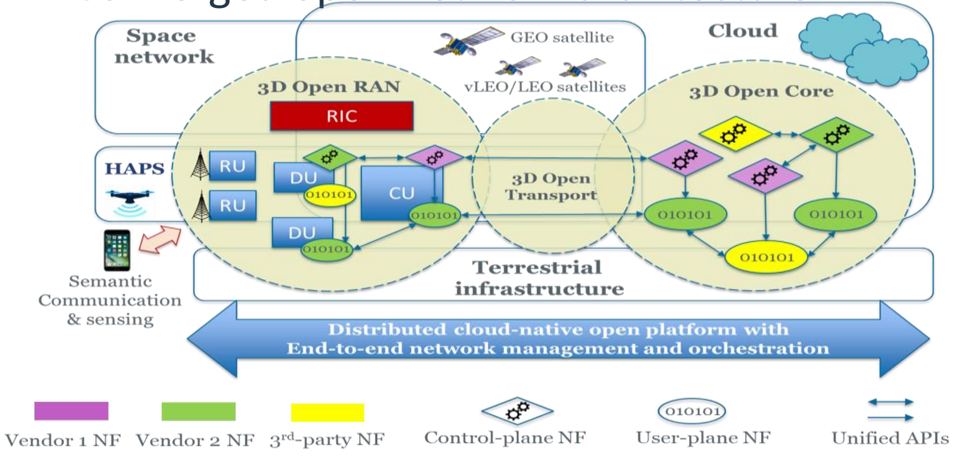
This is not investment advice (just some assumptions)

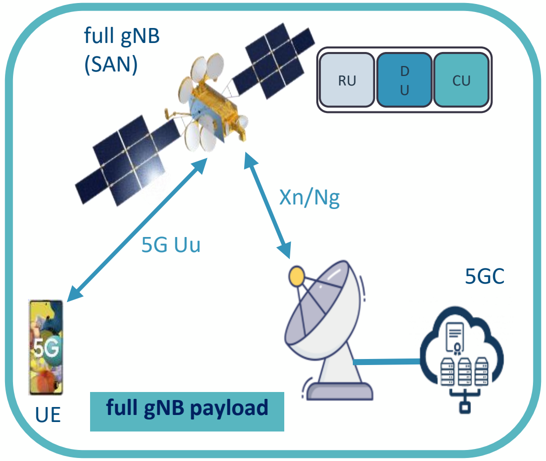
Economies translate to new business models

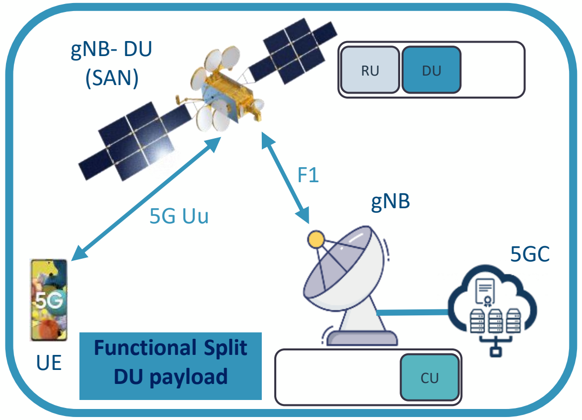
.

SATELLITES IN 5G ENHANCED ERA

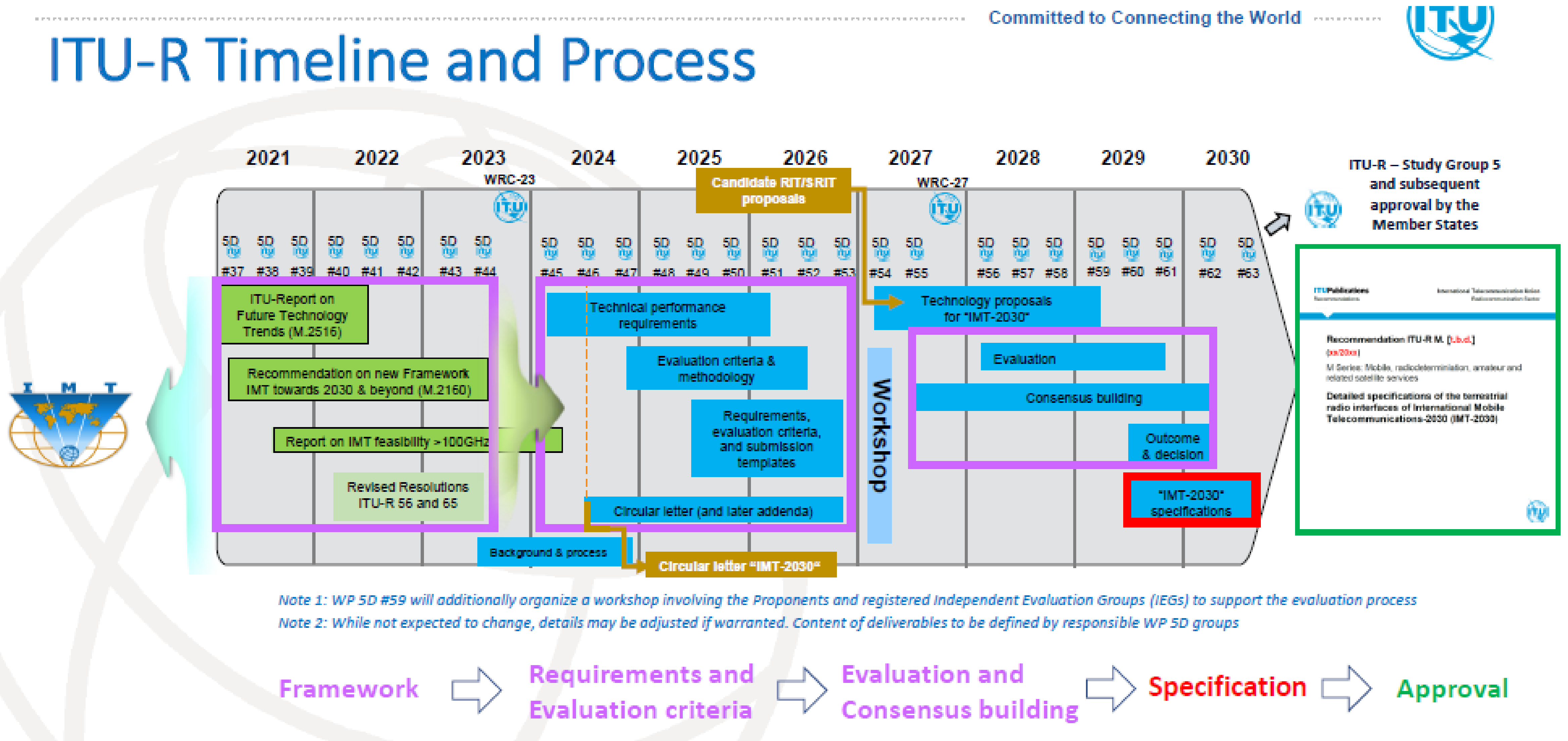
- From bent pipe to Processing payloads
- Regeneration—Dynamic beam shaping-Beam Hopping—oISL's.
- Network functions on board
  - -Full gNB on board
    - -Using ORAN- Du on board and Cu on ground
- Network Slicing & Orchestration
- LEO/GEO and neutral hosting
- Converged open network architecture







TOWARDS 6G-1 STANDARDS TIMESCALES



WHAT IS 6G?

Immersive Communication

- Direct connectivity to smartphones/wearable devices in light indoor/in car scenarios
- High speed broadband connectivity to transportation platforms (Trains, aircraft, vessels)
- Fast set-up of connectivity to an area/theater of operation (for utilities and public safety)

Artificial Intelligence and Communication

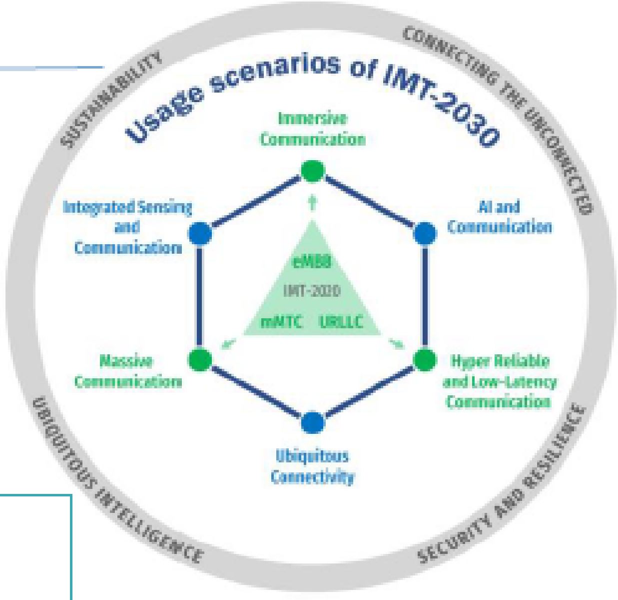
- Content distribution for media applications

Hyper Reliable and Low-Latency Communication

- PNT augmentation to enhance accuracy, reliability, and resilience of location-based services, where GNSS is an issue
- Low latency service over long distance

Integrated Sensing and Communication

- Safety critical applications
- JSAC (Joint Sensing & Communications)



Usage scenarios and overarching aspects of IMT-2030

Ubiquitous Connectivity

Broadband connectivity to:

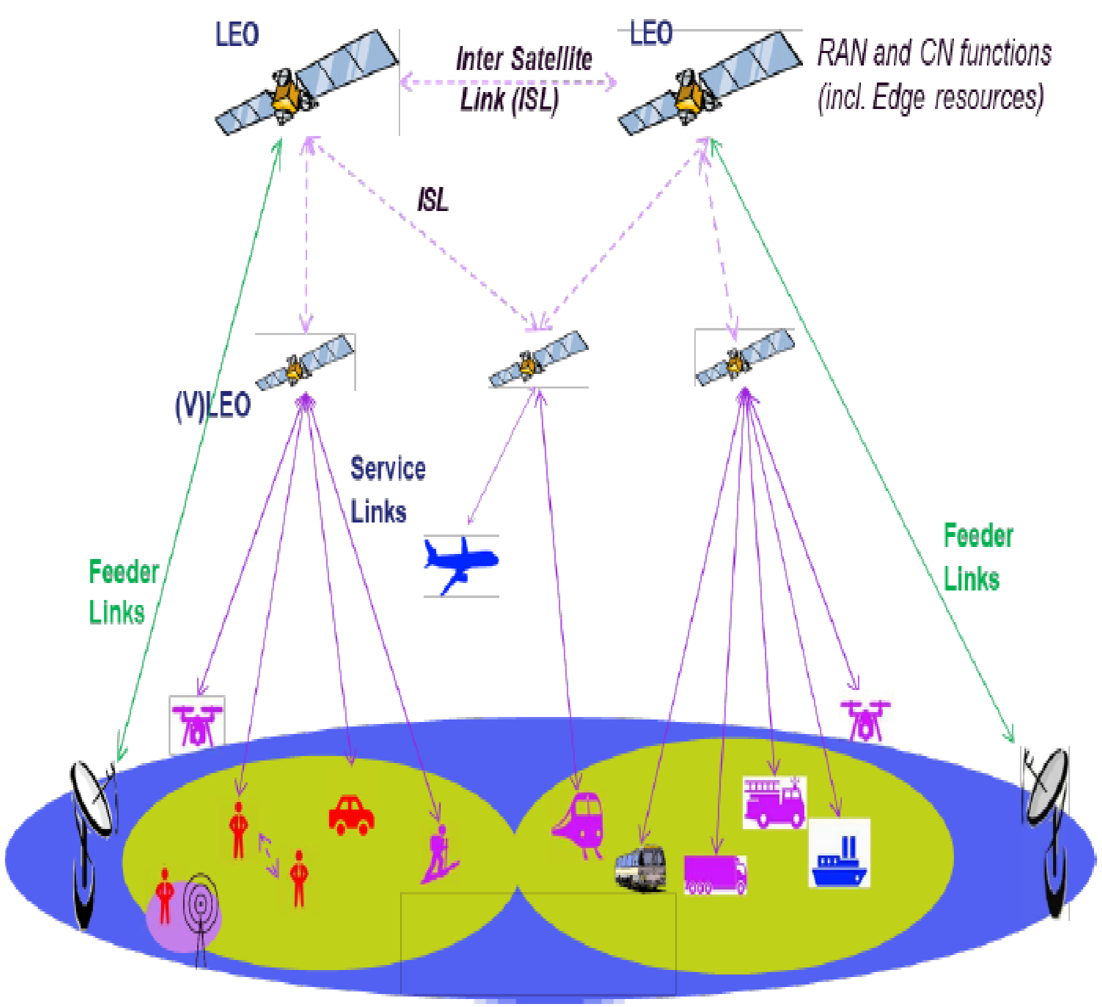
- land vehicles
- drones (or UxV)
- homes and small offices
- aircrafts

Massive Communication

- Data collect from a wide area (e.g. utilities, agriculture, public safety)

ISSUES FOR SATELLITES IN 6G

- Massive LEO networks will have high mobility -multilayer's with oISL's and distributed network functions-Very large numbers of hand-overs.
- Require new approaches to traditional networking-addressing-routing.
- Existing IP networking is hierarchical –IP not suitable for massive networks with high mobility.
- IP does not -provide native support for mobility
  -cannot handle frequent link changes
- Need a new mechanism to support dynamics in NTN
- Network protocols are also affected by node/path changes
- Resource allocation in highly dynamic networks is a challenge-AI?



ISSUES FOR SATELLITES IN 6G-STANDARDS

- Different SDO's have responsibility for NTN-3GPP/ETSI/IETF/CAMRA etc Needs coordination!
- 3GPP have responsibility for the architecture—evolution of 5G Advanced supported by MNO's but has to support mobility NTN.
- 5G Core already has some drawbacks regarding the Service Based Architecture and overloading in access points.
- 6G needs to accommodate 'sensing', AI/ML and NTN which will lead to changes.
- 5G RAN not ideal for satellite but MNO's do not want to change.
- Key is for Satellite Operators to engage more with SDO's to ensure that NTN issues are included in 6G from the start—not as add-on as in 5G.

SOME KEY CHALLENGES FOR NTN IN 6G

- Finding new 6G use cases that need to be enabled by NTN.
- Designing an equitable air interface to allow converged NTN and TN.
- Accommodating high mobility NTN within a 6G architecture-avoiding signalling storms.
- Managing Interference –NTN-TN and between LEO constellations
- Including AI/ML for satellites into the native IP 6G network.
- Including PNT and Sensing with Communications in NTN

‘Spectrum for NTNs. A regulator’s perspective’

Richard Moore,

Principal, Spectrum Policy & Analysis,

Ofcom

Ofcom

NTN :
A Regulator’s Perspective

Richard Moore

Principal, Spectrum Group

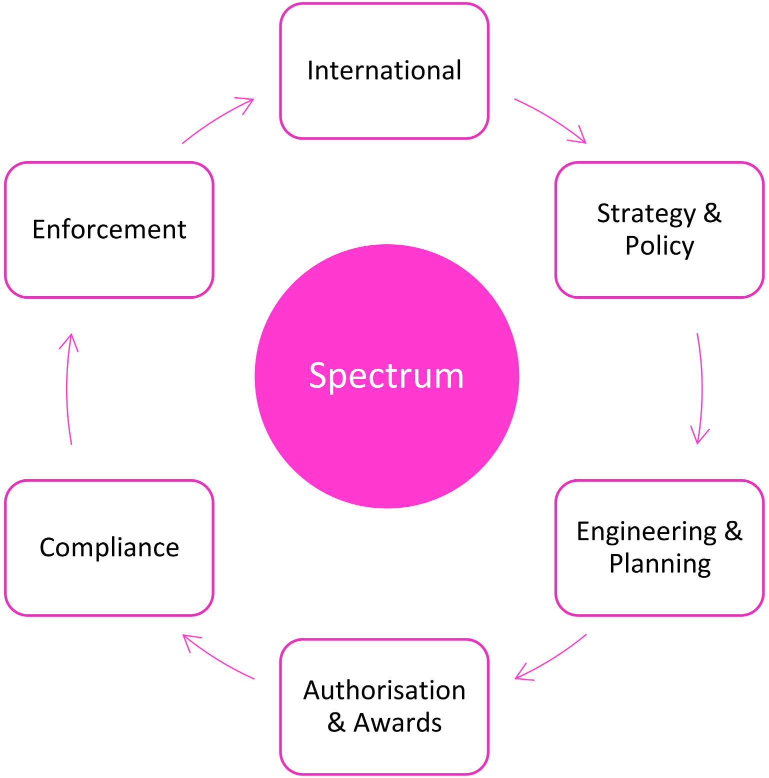
29 October 2024

Heads up…

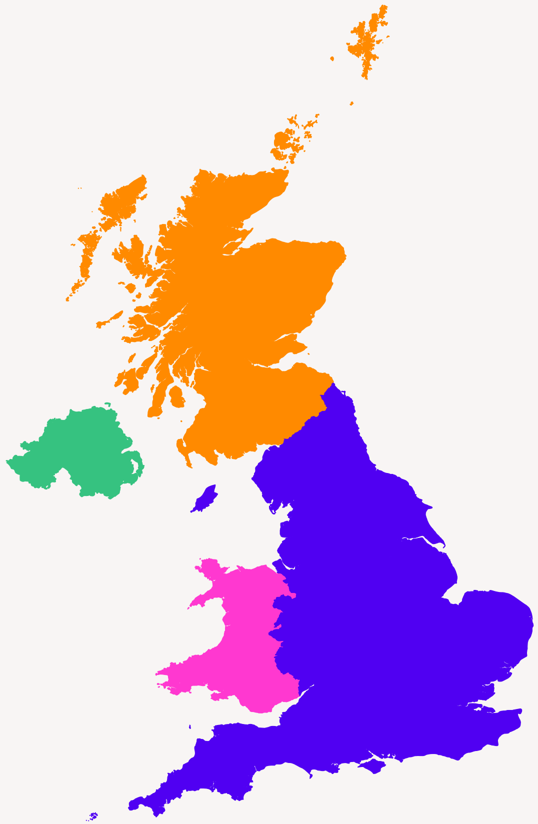
- Ofcom and UK Context
  - Ofcom
  - Connectivity in the UK & the NTN opportunity
- Spectrum for NTN
  - International allocations
  - Spectrum for Direct to Device
- Looking forward
  - Spectrum sharing
  - Capacity and coverage

Ofcom duties and UK context

Making communications work for everyone



The UK connectivity at a glance



Fixed Networks

Homes Passed

62% Full Fibre

80% Gigabit (Full Fibre + Cable)

97% Superfast (> 30 Mbps)

<1% below 10 Mbps

96% Full Fibre by 2027?

Mobile Networks

> 99% 4G outside premises

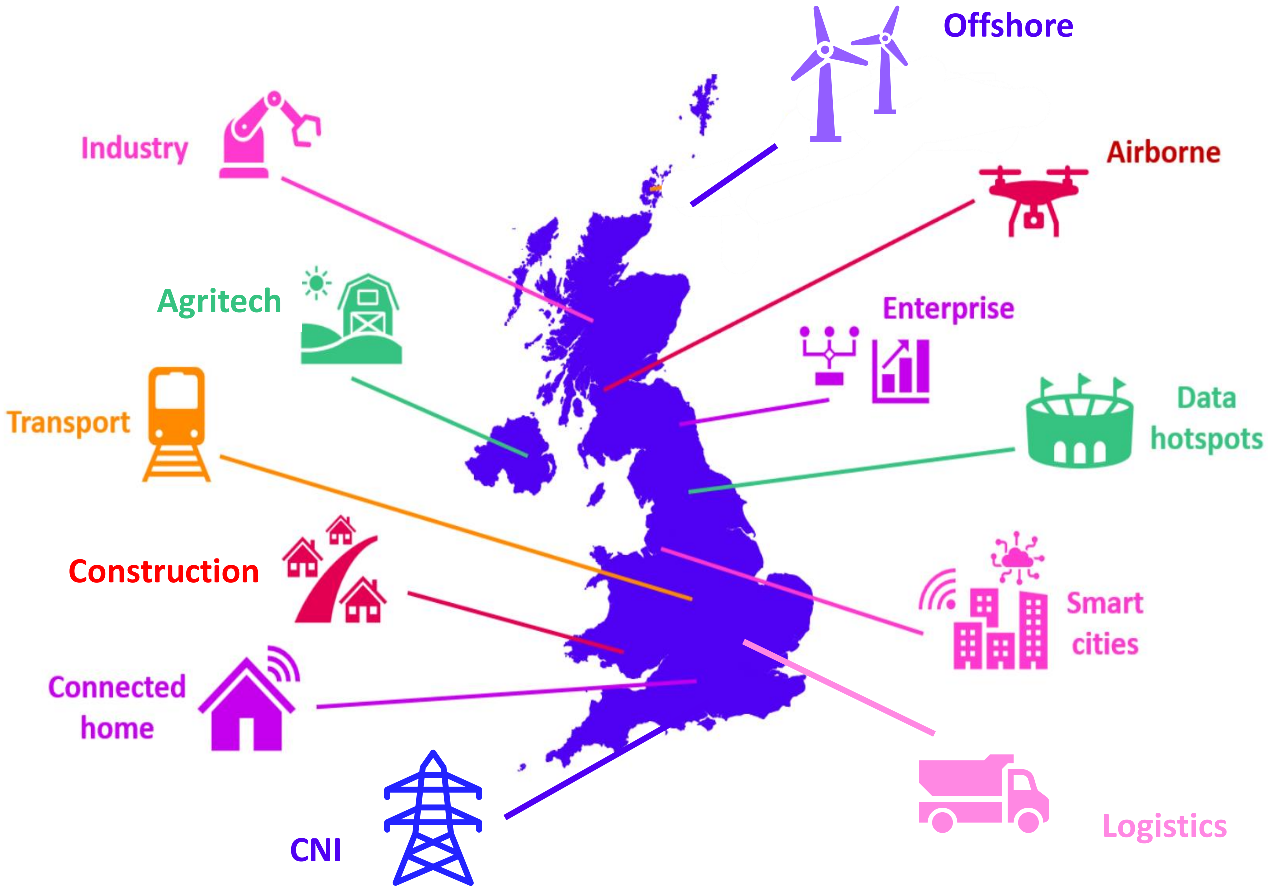
> 92% 5G outside premises

95% 4G geographic coverage WIP

c. 500 C-Band Shared Access Licences

Coverage data as of Spring 2024.

Increasing diversity of demand



NTN opportunities?

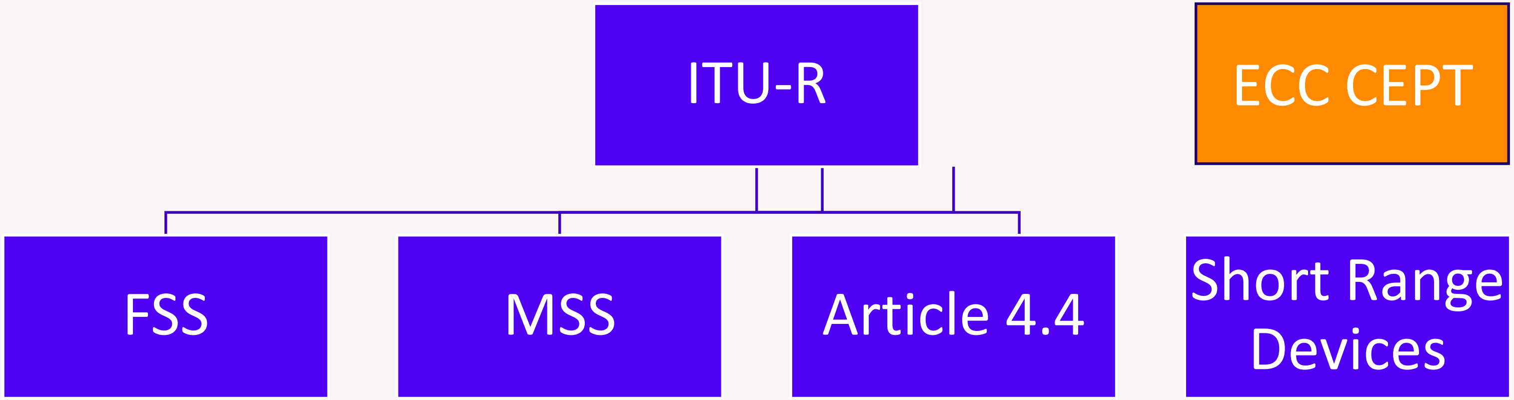
- High speed broadband to the hardest to reach households
- Temporary ‘pop up’ broadband requirements

- Extending mobile coverage, including emergency messaging & calls
- IoT

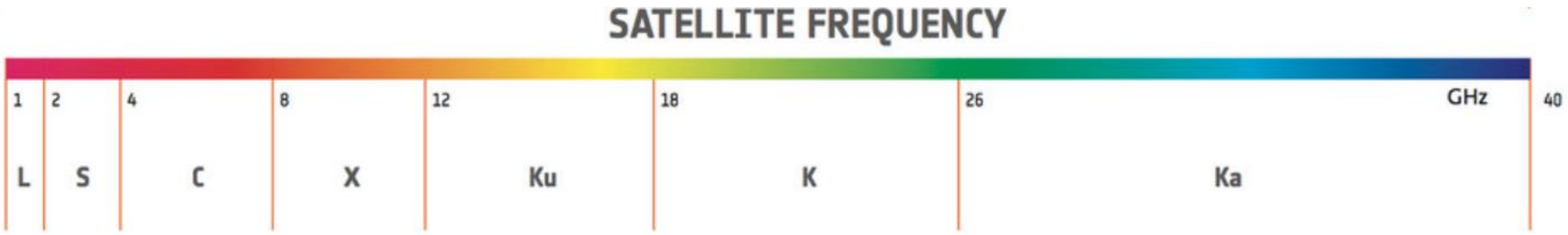
- Aeronautical and Maritime
- Resilience in the event of terrestrial outages
- Backhaul for remote fixed and wireless access networks
- International optical links

Spectrum for NTN

Spectrum Allocations



Satellite Spectrum



MSS

FSS

Less Path Loss

Greater Bandwidth

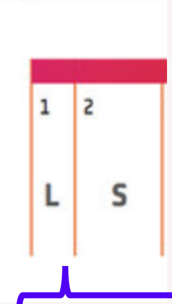
Image from : ESA

Spectrum for Direct to Device

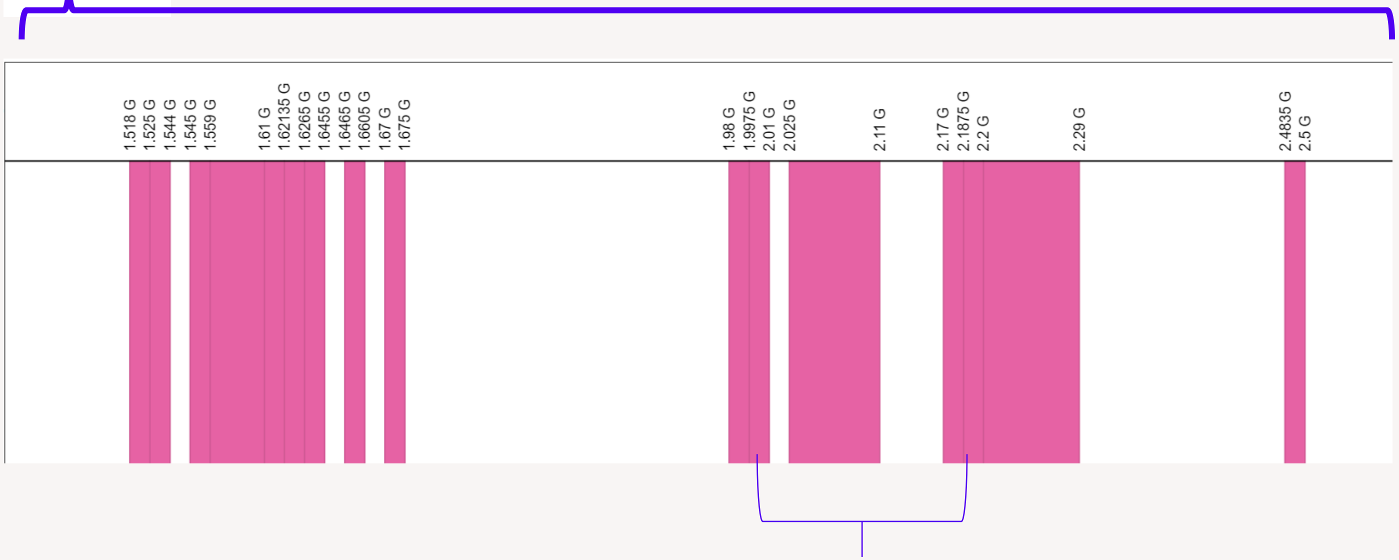
Two broad approaches to D2D

	1. Direct to Device in MSS Spectrum (GEO & LEO)	2. Direct to Device in Mobile Spectrum (LEO)
Satellites	Existing Satellites	Next Gen Satellites
Spectrum	MSS L-Band and S-Band	Mobile 690 – 2700 MHz
Devices	Next Generations Handsets	Existing Handsets

D2D in MSS bands

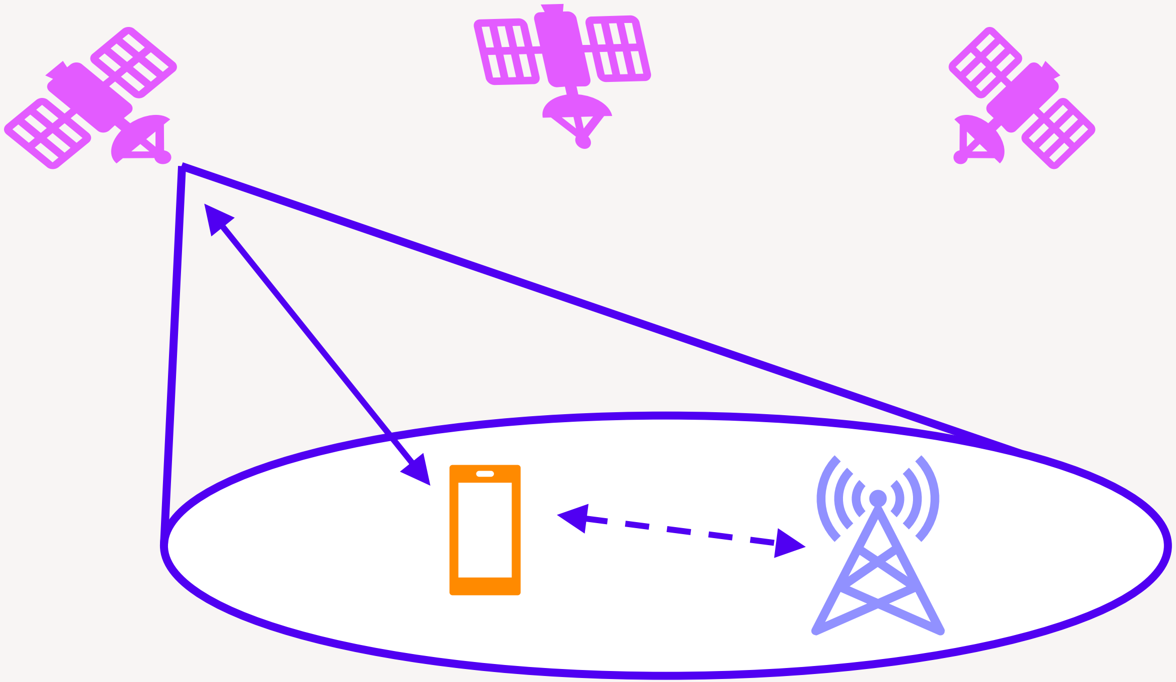


- 3GPP Release 17 and beyond
- L Band and S Band spectrum (above 10 GHz WIP)
- Inter service sharing through frequency segmentation
- Regulatory framework in place



Complementary Ground Component

D2D in mobile bands



Agenda Item 1.13 WRC 27

“Studies on possible new allocations to the mobile-satellite service for direct connectivity between space stations and International Mobile Telecommunications (IMT) user equipment to complement terrestrial IMT network coverage”

IMT bands 694 MHz – 2.7 GHZ

Initial focus on FDD

D2D in mobile bands : Coexistence

Co-Channel
MNO, Local Access, Offshore

Adjacent Channel
PMSE, Broadcasting, Licence Exempt, Business Radio, Public Sector, Space Science*

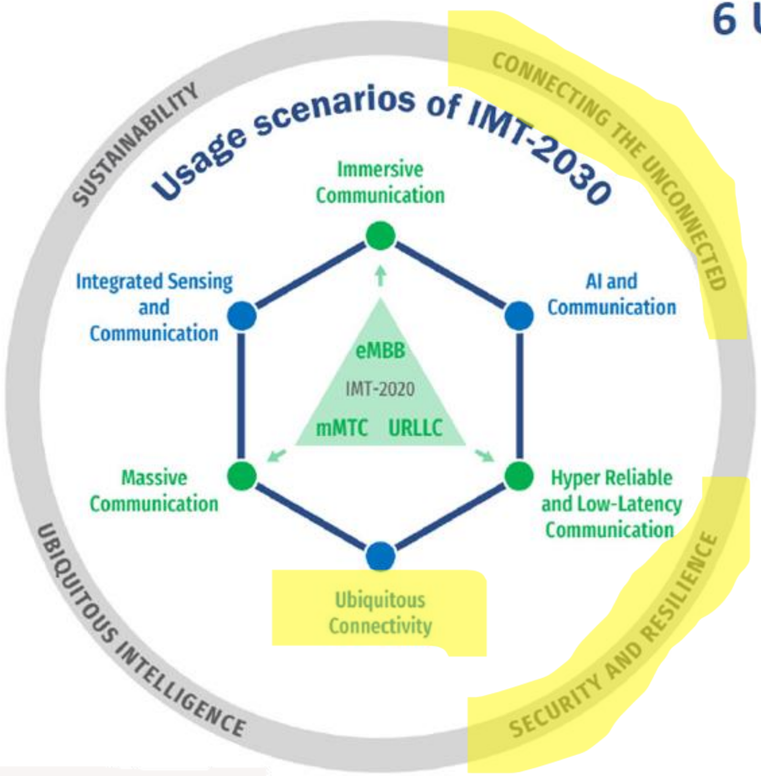
Cross Border
France, Ireland

PFD limits
Beam footprints
Aggregate interference

* Examples from < 1 GHz

Looking forward

The 6G Vision



6 Usage scenarios

Extension from IMT-2020 (5G)

eMBB ➡ Immersive Communication

mMTC ➡ Massive Communication

URLLC ➡ HRLLC (Hyper Reliable & Low-Latency Communication)

New

Ubiquitous Connectivity

AI and Communication

Integrated Sensing and Communication

4 Overarching aspects:

act as design principles commonly applicable to all usage scenarios

Sustainability, Connecting the unconnected,
Ubiquitous intelligence, Security/resilience

Recommendation ITU-R M.2160, “Framework and overall objectives of the future development of IMT for 2030 and beyond”

Potential for better spectrum sharing?

MSS ⟷ FSS

3GPP ⟷ SRD

NTN ⟷ TN

Future capacity and coverage?

- Link-budget & antenna gain
- Bandwidth per beam
- Beam diameter
- Beams per Satellite
- Satellites per Constellation

What's the frequency sweet spot?

Thank You

We will be publishing an update on our next steps in a few weeks

Annex

WRC27
AI 1.13

Current bands of inteterest

Directionality	
Uplink (MHz)	**Downlink (MHz)**
807-849	852-894
880-915	925-960
832-862	791-821
698-716 776-798	716-746 746-768
698-748	753-803
1 427-1 470	1 475-1 518
1 920-1 980	2 110-2 170
1 710-1 785	1 805-1 880
1 850-1 920	1 930-2 000
1 710-1 780	2 110-2 180
2 000-2 020	2 180-2 200
2 010-2 025	1 880-1 920
2 305-2 320	2 345-2 360
2 500-2 570	2 620-2 690

‘Can NTN D2D be used to further extend outdoor mobile coverage beyond what the Shared Rural Network will provide?’

Damian Bevan,
Wireless System Analyst,
Real Wireless

realwireless
independent telecoms experts

Direct-to-Device (D2D) Non-Terrestrial Networks (NTN) for rural coverage

Can NTN D2D be used to further extend outdoor mobile coverage beyond what the Shared Rural Network will provide?

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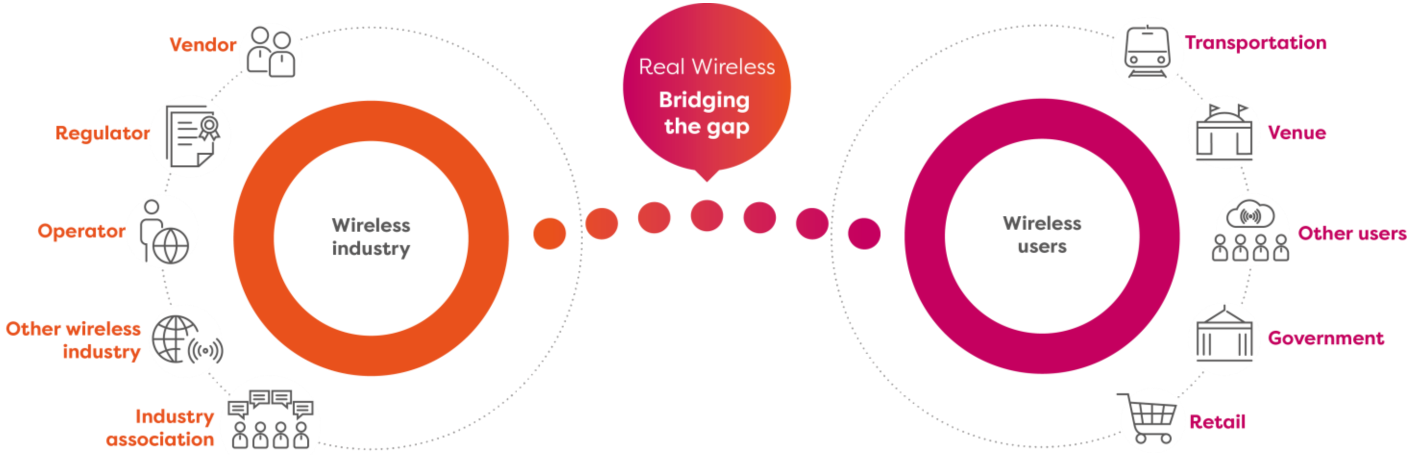
Real Wireless bridges the gap

- Leading independent expert wireless advisory firm
- Technology and business of wireless
- Real Wireless builds bridges between the wireless industry and wireless users



Help the wireless industry to better understand and meet the needs of its customers

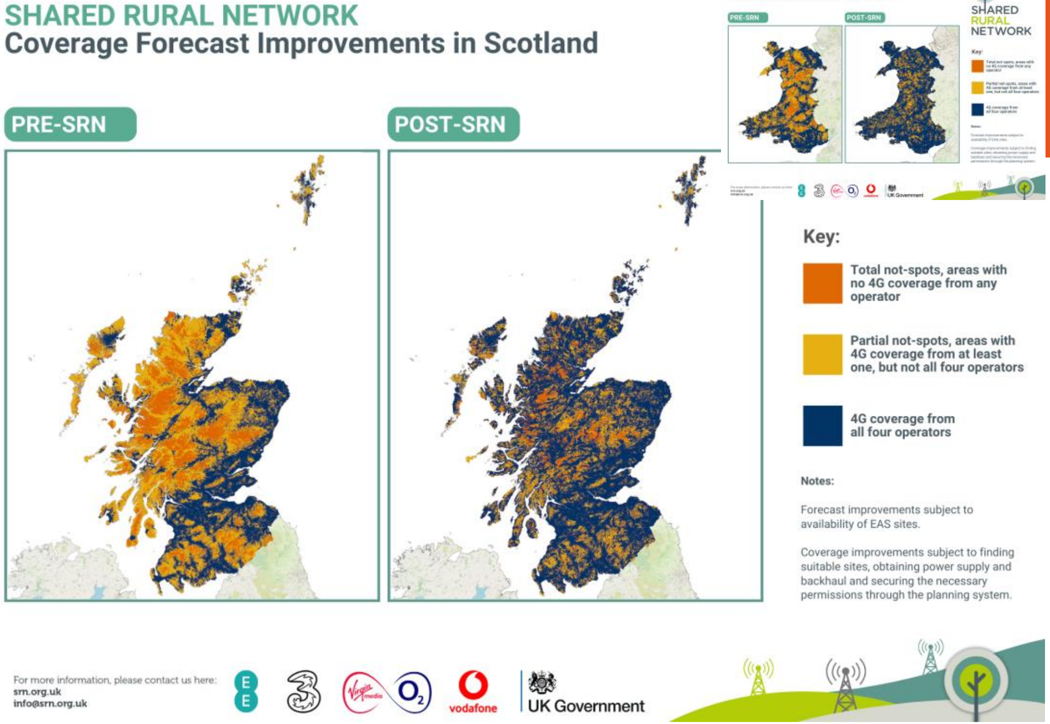
Help wireless users to get the best from wireless technologies to benefit business

Introduction

- We are going to discuss the 'collision of convergence' of **Non-Terrestrial Networks** (**NTN**) and **Terrestrial Networks** (**TN**)
- We will focus on **Direct-to-Device (D2D)** aspect of NTN (*not* nomadic broadband, which competes with *fixed*, not mobile)
  - So the user communicates 'through the sky' using an everyday **handset**
- We are going to consider D2D as an approach to improve **UK 4G rural geographical coverage**
  - We might term this '**UK 4G Rural Coverage 2.0',** whereby we consider **v1.0** to be the **Shared Rural Network (SRN).** We will:
    - Introduce and review the **SRN**, and then…
    - Discuss how D2D could perhaps be used to further **enhance/ extend/ replace(??) SRN**

Section header

[srn] https://srn.org.uk/forecast-coverage-improvements/



The UK's 4G Shared Rural Network (SRN)

'UK (4G) Rural Coverage 1.0'

Introduction to SRN

TNS = notspot for *all* MNOs
PNS = notspot for >=1 MNO

- In agreeing to the **Shared Rural Network** partnership programme, the MNOs have taken on new **4G coverage obligations** [of]
  - Need to distinguish between '**population coverage**' vs. '**geographical coverage**'
  - For geographical coverage we can quantify '**Partial Not-Spots**' (PNS) and '**Total Not-Spots**' (TNS)
- What counts as 'coverage' for the purposes of SRN?
  - *"For **4G networks**, Ofcom defines coverage based on the minimum signal strength required to deliver a 95% probability of making a **90-second telephone call** successfully completed, and a 95% chance of getting a **download speed of at least 2Mbit/s**."* [gov]
- N.B. All coverage figures in this table are geographical and **UK-wide**
  - The numbers in brackets () are the latest reported values

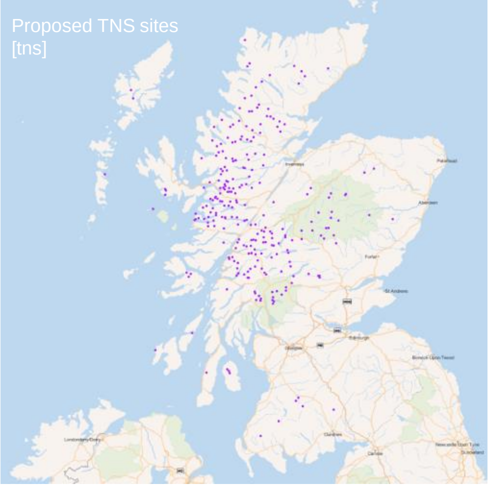
KPI (UK-wide)	Pre- SRN (2020)	Post-SRN (2025/26 targets)
'Worst' 4G network coverage	78% [cn19]	90(88)% [srn][of]
'At least one' 4G network coverage	91% [srn]	95(94.9)% [srn][sr]
'All four' 4G network coverage	66% [srn]	84(78)% [srn][sr]

Target 5% TNS, down from 9%

16(22)% PNS

SRN strategies and funding mechanisms

- We're primarily considering conventional terrestrial rural macro cellsites here
  - '**High Power High Tower**' (HPHT)
  - Presumably predominantly '**low-band**' (<1GHz)
- SRN addresses both '**Partial Not Spots**' (PNS) and '**Total Not Spots**' (TNS)
- **Partial Not Spots**:- MNOs encouraged to share rural cell towers where there is at least one MNO at that site already
  - **£532M** MNO investment to be spent on this
- **Total Not Spots**:- New *shared* sites will be provided where currently none exist
  - Much of the **£500M** UK government investment to be focussed here, on building **new cellsites**
  - But also includes work ongoing to 'beef up' hundreds of **Emergency Services Network (ESN) – 'Extended Area Service (EAS)**' sites so they can also be shared with SRN [cb p.51][sr][tp]



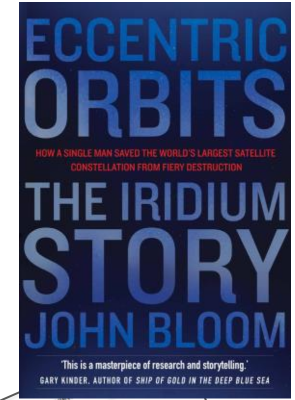
SRN issues and progress

- SRN faces issues, particularly with **planning permission**, **electricity grid**, **backhaul** etc.
  - Involves **installing** some very prominent and visible towers in areas of **outstanding natural beauty**
- Accessing remote rural sites requires **helicopters**, **quad bikes** etc.
  - Both to install and to **service**
- So those remote and **expensive-to-maintain** cellsites will probably be supporting considerably fewer than the ‘many hundreds of UEs’ that would typically be expected for a ‘normal’ cellsite
  - So SRN sites possibly may not really be ‘**paying their way**’ or ‘**washing their face**’ even though CAPEX (e.g. ‘**civil works**’) costs may have been subsidised

Section header

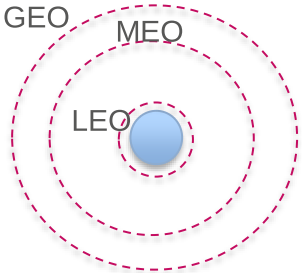
a.k.a. 'Direct-to-Cell' or 'Supplemental Coverage from Space' (SCS)

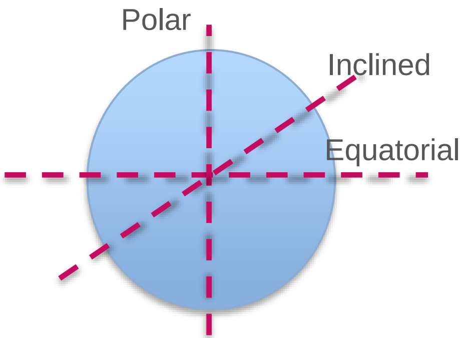
Direct-to-Device (D2D)



D2D introduction

- Direct-to-Device (**D2D**) involves cellphone coverage delivered **from the sky** *directly to the **handset** in your hand*
  - So it isn't rural backhaul, it isn't broadband VSATs etc.
- There are different methods of delivery for NTN
  - **Space Vehicles (SV)** - Low Earth Orbit **(LEO)**, Geostationary Orbit **(GEO)**, etc.
  - Also **HAPs**, **Aerostats** etc., although we won't discuss those further here
- Waveform could be **proprietary** (e.g. Apple+Globalstar) or **standards**-based (e.g. Skylo, Starlink-D2C, AST etc.)
  - More advanced NTN features are continually being incorporated into **3GPP** standards
- There are different **spectrum** options
  - See next slide…





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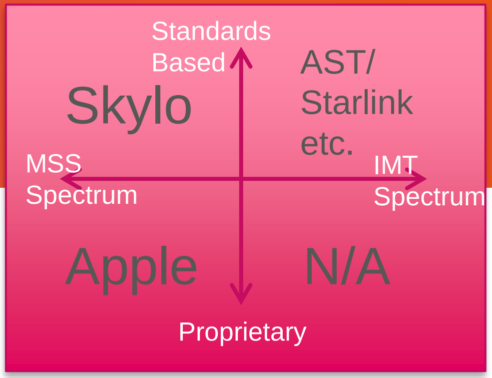
D2D spectrum – two main options



- **Terrestrial** or ‘**IMT**’ spectrum
  - All handsets (**UEs**) *already* have the radios, but…
    - Need to avoid ‘metro’ areas due to danger of interference, so…
    - Typically restricted to the more **rural areas**, where less TN coverage, and potentially underused IMT spectrum (but that’s where we most need it!)
- **Mobile Satellite Service** (**MSS**) spectrum (if given 3GPP band designations)
  - Avoids interference with Terrestrial Networks, but…
    - MSS spectrum typically in shorter supply than IMT
    - UEs will need equipping with extra radio band(s)
      - Most existing devices not compatible, although some new **high-end phones** (e.g. latest Apple iPhone, Samsung S-series, Google Pixel etc.) already are

D2D for ‘UK 4G Rural Coverage 2.0’?

So can we use D2D technology to satisfy public policy objectives?

- For D2D to count as SRN-like, it would need to meet the same definition of ‘**coverage**’
  - So **text-messaging-only** presumably wouldn’t ‘cut the mustard’, even though 2-way messaging could still be a very useful service
    - Note that the latest iPhone users have this already, as well as top-end Android (via **Skylo GEO**), at least now or soon
  - Maybe **voice** is also quite do-able, even with the Skylo-style **NB-IoT via GEO**
  - **eMBB** – SRN-style i.e. ‘2Mbps downlink datarate with 95% reliability’
    - This is more challenging – it remains to be seen whether actually technically feasible, although various players such as **Starlink** and **AST** appear to be claiming that it *will* be

How will users pay for it?

If users have to pay extra (unlike for SRN), then does that still count as 'coverage'?

- One big question could be the **mechanisms of customers paying for it**, to help (both terrestrial and non-terrestrial) MNOs recoup the cost
  - Note that for SRN, the users don't even know that they are paying for it (i.e. it is included in **ARPU**, or **taxes**)
    - So it is **invisible to users**
  - Would MNOs do the same for D2D, or would they require some explicit opt-in from users?
    - e.g. **supplementary PAYG charges** for satellite-based usage
      - A few pence per message/ minute/ MB
    - **Bundled usage** through extra per-month charges (e.g. £2-5 per month extra?)
- Could MNOs at a stroke easily meet and exceed (up to **100%**) their **geographical coverage obligations** by signing up to a D2D deal with a satellite operator?
  - This potentially could even save them some OPEX by allowing **decommissioning** of some expensive-to-service SRN HPHT cellsites?

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Summary

- The **Shared Rural Network** was the chosen route by UK gov and MNOs to significantly increase **geographical coverage** ('UK 4G Rural Coverage 1.0') and reduce Partial and Total Not Spots (**PNS** and **TNS**)
- SRN requires **>£1B of investment**, and is not without its issues
  - **Planning permission** and **logistical** issues make deployment slower than planned, and possibly even more expensive than expected
  - **Ongoing OPEX** for rural sites that don't inherently 'pay their way'
- D2D offers one possible route to '**UK 4G Rural Coverage 2.0**', which could allow MNOs to meet their **4G coverage obligations** 'at a stroke', albeit with technical issues:
  - e.g. **IMT spectrum coexistence** vs. **MSS spectrum scarcity** vs. **UE compatibility** etc.
- And some as-yet-unresolved **questions**:
  - Can D2D *really* provide the required **coverage** service (e.g. at what eMBB datarates and reliability)?
  - What would be the mechanism for the users to **pay** for the service?
- Discuss…

Thank you for listening!
Any questions?

Can D2D *really* provide the required 4G coverage (e.g. at what eMBB datarates and reliability)?

What would be the mechanism for the users to pay for the D2D service?

realwireless.
independent telecoms experts

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Backup slides

Abstract

The four UK Mobile Network Operators (MNO) and the UK government have jointly committed (in March 2020) to a project called the ‘Shared Rural Network’ (SRN). Around £500M of MNO investment, plus a matching amount of government investment, has been committed to deploying additional (shared) terrestrial infrastructure. The aim is to improve so-called coverage ‘partial not-spots’ (PNS) and ‘total not-spots’ (TNS), particularly in remote rural regions such as much of Scotland, Wales, North Eastern England and Northern Ireland. In this talk we will first of all introduce the UK's SRN programme, before going on to assess whether or how interventions like SRN would benefit from future NTN and D2D capabilities. Perhaps this technology can be exploited by the MNOs and government to close even more post-SRN coverage gaps, to bring the U.K. closer towards full 100% UK (outdoor) geographical coverage of mobile services with improved costs due to network convergence.

References and further reading

[gov] https://www.gov.uk/government/news/shared-rural-network

[srn] https://srn.org.uk/forecast-coverage-improvements/

[cb] A. Clark and C. Baker, "Rural mobile coverage in the UK: Not-spots and partial not-spots", *House of Commons Library Research Briefing*, 1 March 2024 (https://commonslibrary.parliament.uk/research-briefings/sn07069/)

[cn19] https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/multi-sector/infrastructure-research/connected-nations-2019/connected-nations-2019-uk-final.pdf?v=321686

[sr] https://www.gov.uk/government/publications/shared-rural-network-srn-progress-update-september-2024/shared-rural-network-srn-progress-update-september-2024

[tp] https://www.gov.uk/government/publications/shared-rural-network-transparency-commitment-publication/shared-rural-network-srn-transparency-commitment-publication

[cn] https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/multi-sector/infrastructure-research/connected-nations-2023/connected-nations-2023-uk-report/?v=330642

[tns] https://srn.org.uk/about/srn-tns-site-locations/

[of] https://www.ofcom.org.uk/siteassets/resources/documents/spectrum/spectrum-information/mobile-coverage-obligation/shared-rural-network-coverage-obligations.pdf?v=379965

[jb] J. Bloom, *Eccentric Orbits - The Iridium Story*, Grove Press UK, 2016

Version Control

Version	Date	Owner	Comments
0.1	2024-10-09	DDNB	First (storyboard) draft, for review by JO
1.0	2024-10-25	DDNB	First issue, sent to CW

realwireless

‘The future of NTN in GEO, MEO and LEO’

Glyn Thomas
Payload Product Manager and Senior Expert
Airbus Defence & Space

Not yet available

‘Modern Antennas for 5G NTN User Terminal Applications’

Peter Kibutu,
5G NTN Market Lead,
TTP plc

Modern Antennas for 5G NTN applications

Nima Razavi-Ghods, Peter Kibutu

29 October 2024

About TTP

We help clients rapidly develop and scale up new technologies

- Based near Cambridge, UK
- ~320 engineers/ scientists
- ~200 projects a year
- Extensive facilities
- Track record (+35 years)
- Employee owned

Core business:

- Fast track engineering: design to manufacture
- New technology development and licensing

Our core service offerings:

- Innovation Strategy
- Technology Development
- Product and System Development
- Technical support & troubleshooting

Multidisciplinary expertise applied across multiple industries

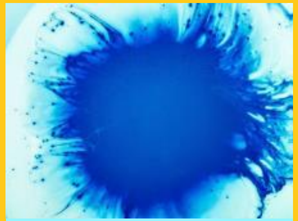
Satellite and Space

5G NTN

Aerospace and Defence

Autonomous Vehicles

Energy transition



Medical Devices

Life Sciences and Biology

TTP 5G NTN Activities

5G NTN End to End System & Services Specification

- NTN Business case analysis
- NTN Services and product classes definition
- NTN System Engineering, Modelling, Analysis
- Satellite network architecture specification, payload specification and RFPs
- 5G RAN, UE, Core Requirements specifications and RFPs

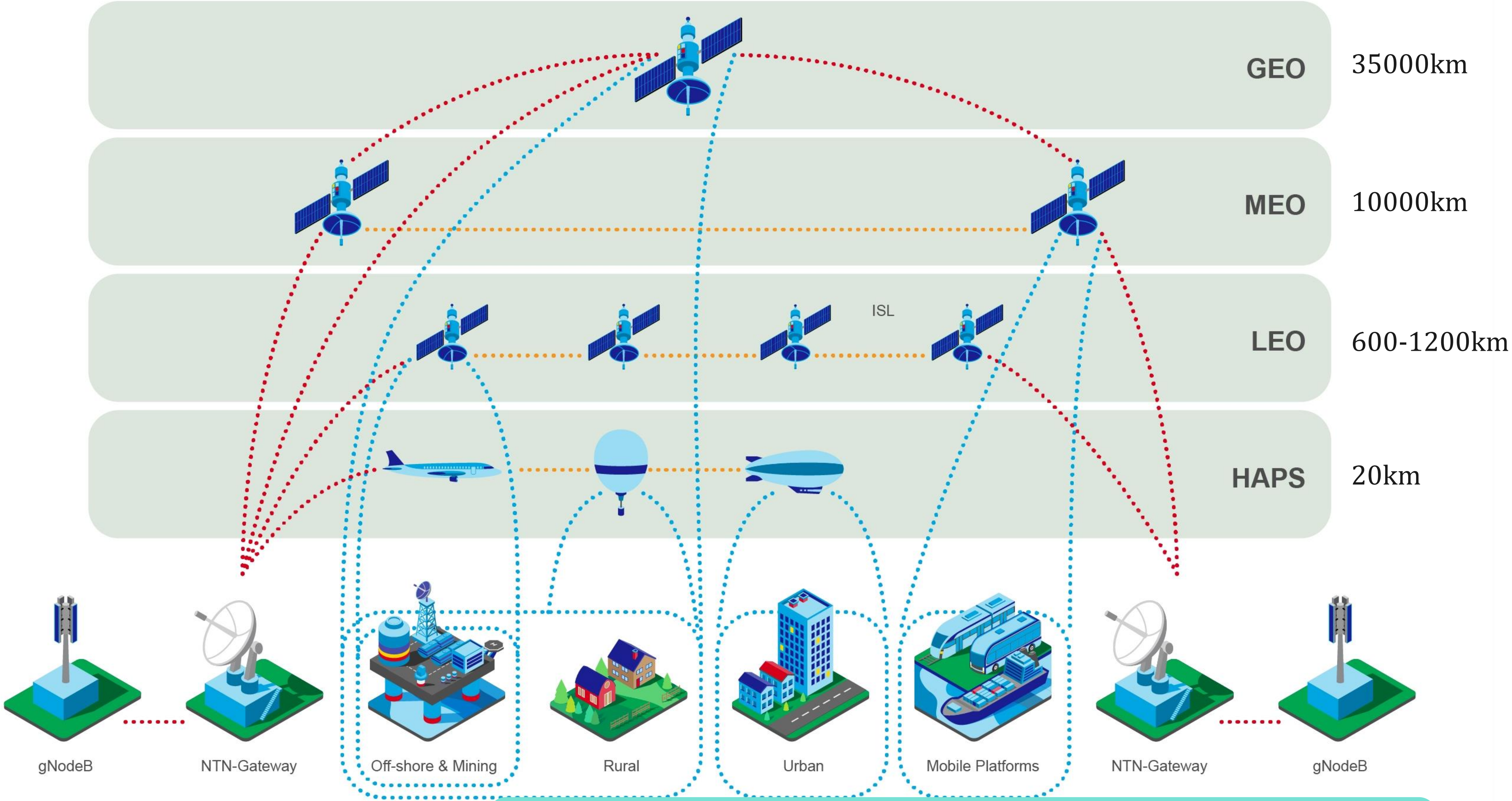
5G NTN Key Technology Development, Test and Integration

- Early concepts prototyping and demonstration
- 5G NR FR1/FR2 Terminals
- 5G NR regenerative gNodeB (POC)
- 5G NTN RAN Emulation Lab deployment

3GPP NTN Ecosystem Development

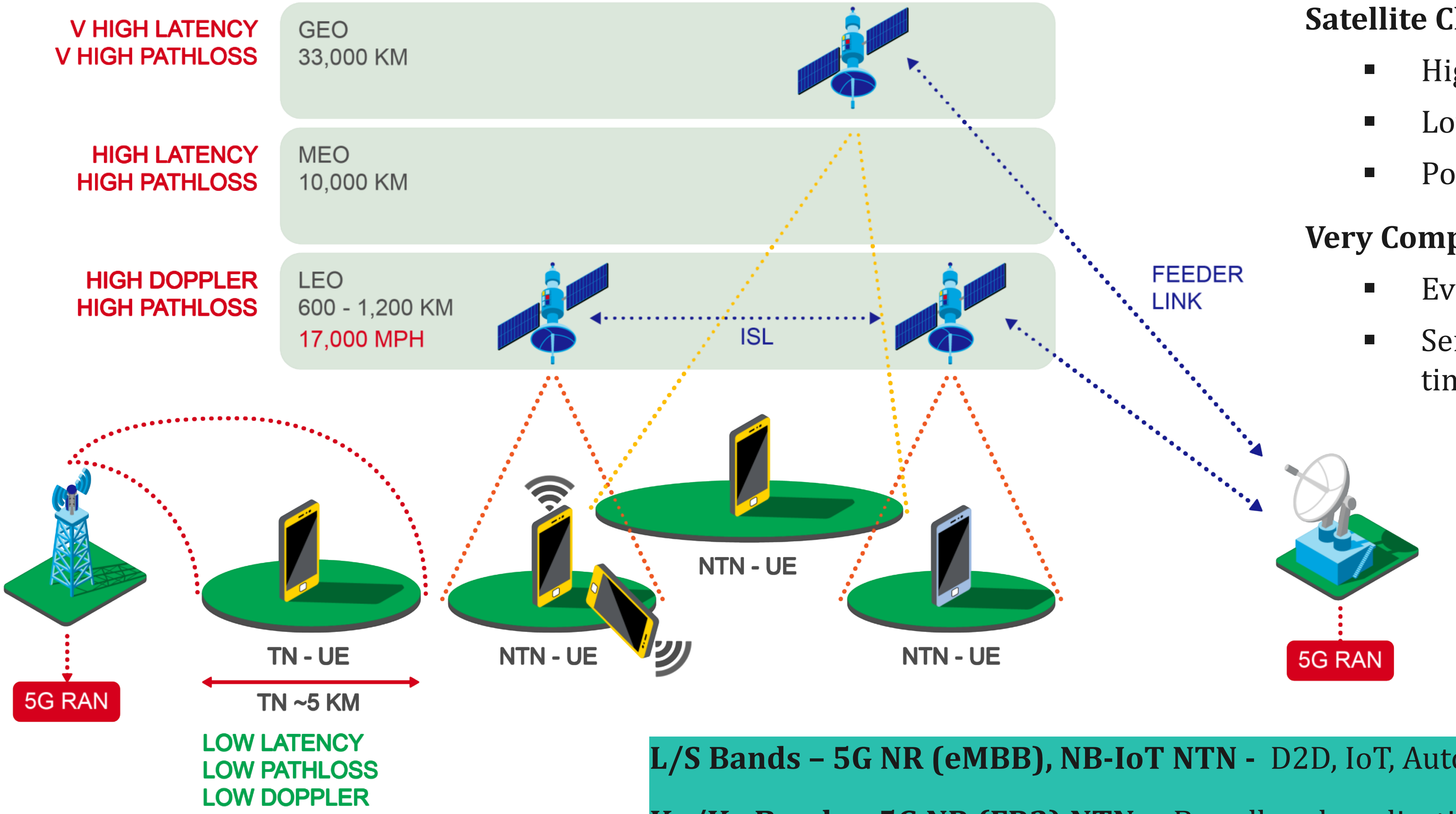
- 3GPP NTN standardization , vendor and supply chain engagements
  - Chipset, UE, Infrastructure, Test and assurance etc..

5G NTN Deployment Use-Cases



- All the use-case require specialised antennas
- NTN antenna requirements are different from TN

5G NTN is very different from TN



Complex Architecture

- Transparent vs Regen, multi-orbit

Satellite Channel

- High Path loss /High Doppler
- Low Elevations Coverage
- Poor penetration - Out-doors

Very Complex LEO Handovers

- Every ~3min, make before break ?
- Service continuity/interruption time

L/S Bands – 5G NR (eMBB), NB-IoT NTN - D2D, IoT, Automotive

Ku/Ka Bands – 5G NR (FR2) NTN – Broadband applications - Home, Enterprise, Aero, Maritime

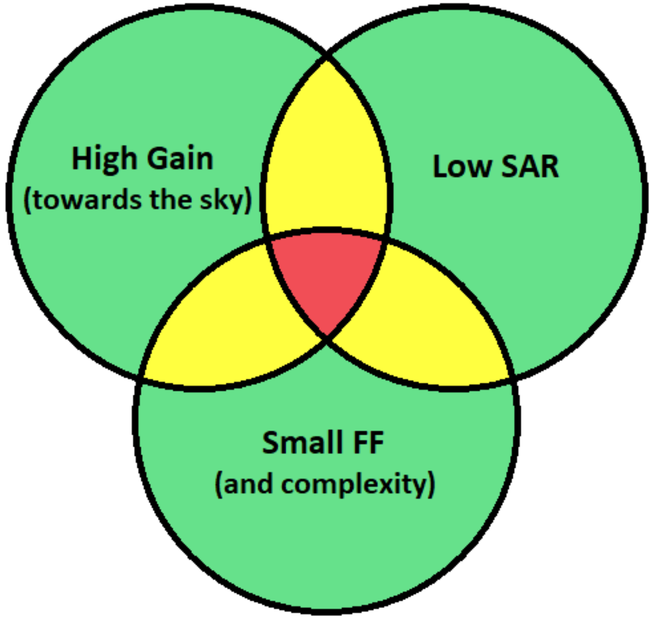
5G NTN – D2D Optimised Handset Antennas (L/S bands)

LEO & GEO NTN use-cases

- Optimised Antenna and RF-FE
- High Gain towards Satellite
  - Rel19 HP-UE >26dB
  - Beam steering
- L/R Circular Pol
- SAR and Heating issues

User-Application

- Manage Messaging, data ,Voice
- Assist in pointing

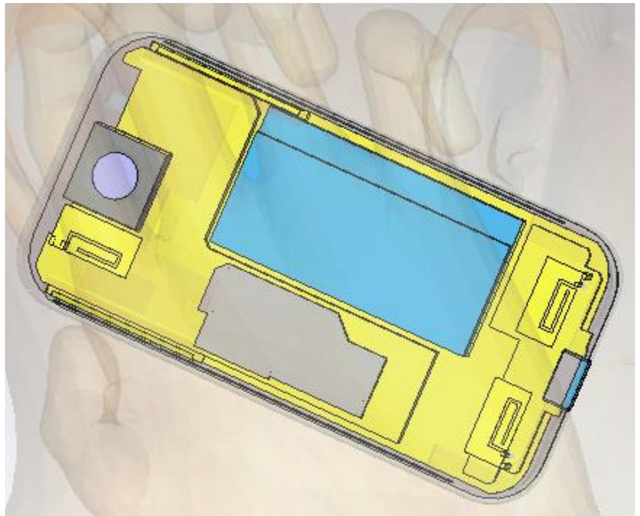


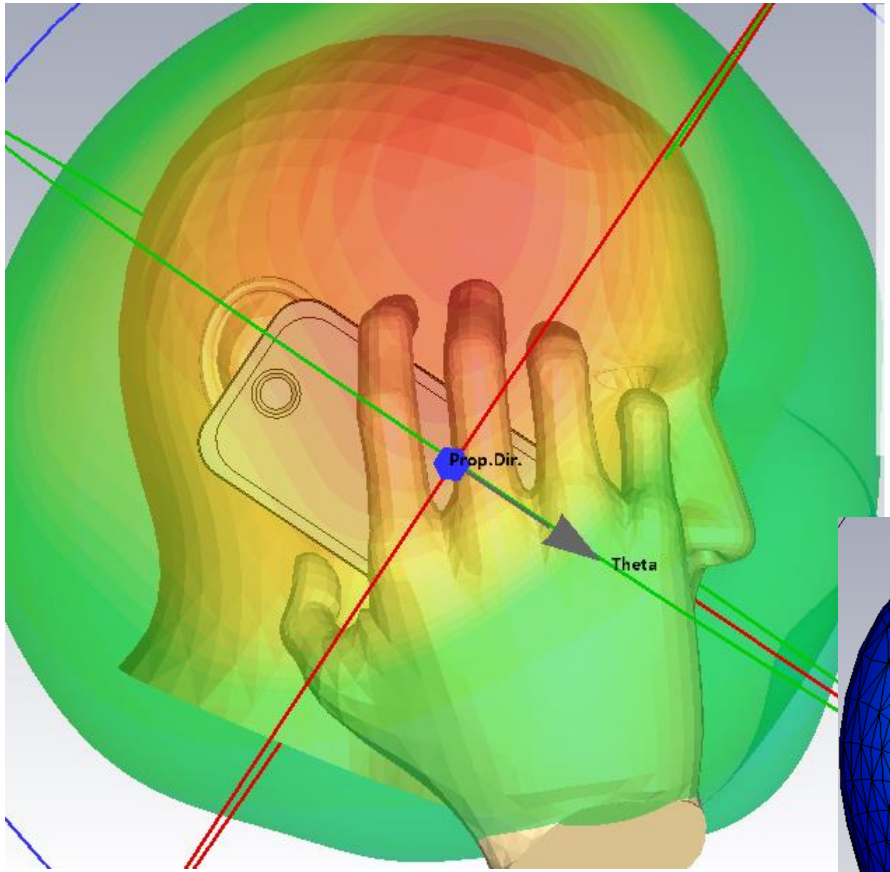
finding a solution is a direct trade off, e.g. increasing gain towards the sky also results in increasing SAR into the head

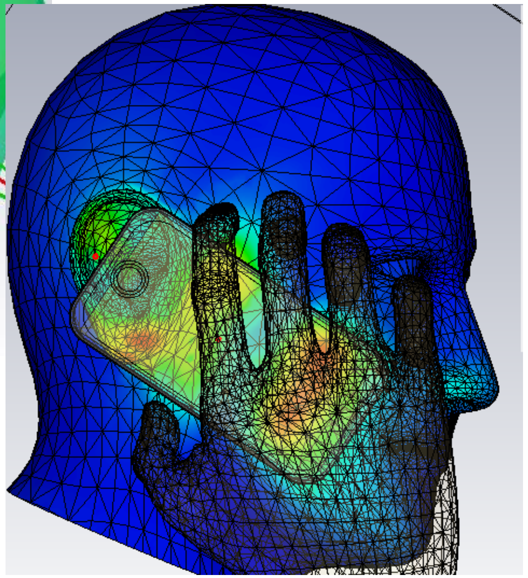
5G NTN - D2D Optimised Handset Antennas (L&S Bands)

handset antenna must offer

- Much higher antenna gain, typically >2-3dBi+
- Higher TX power levels, well above the standard 23dBm
- Offer small formfactor for handset integration







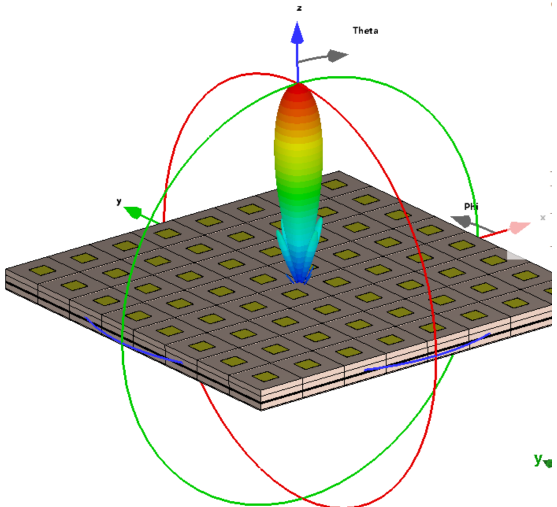
5G NTN NR – FR2 ESA Antennas (Ku/Ka Bands)

Use-cases -

- Home Broadband (Starlink equivalent)
- Enterprise
- Automotive
- Aero
- Maritime

Challenges

- LEO Beam acquisition and tracking
  - Multiple Beams
- Support high EIRP
- Low Elevation performance
- Low SWAP(Size , Weight, Power)
  - Compact form factor
  - Low Power vs High EIRP ?
- Low Cost
- **Multi- Orbit, Multi Freq**



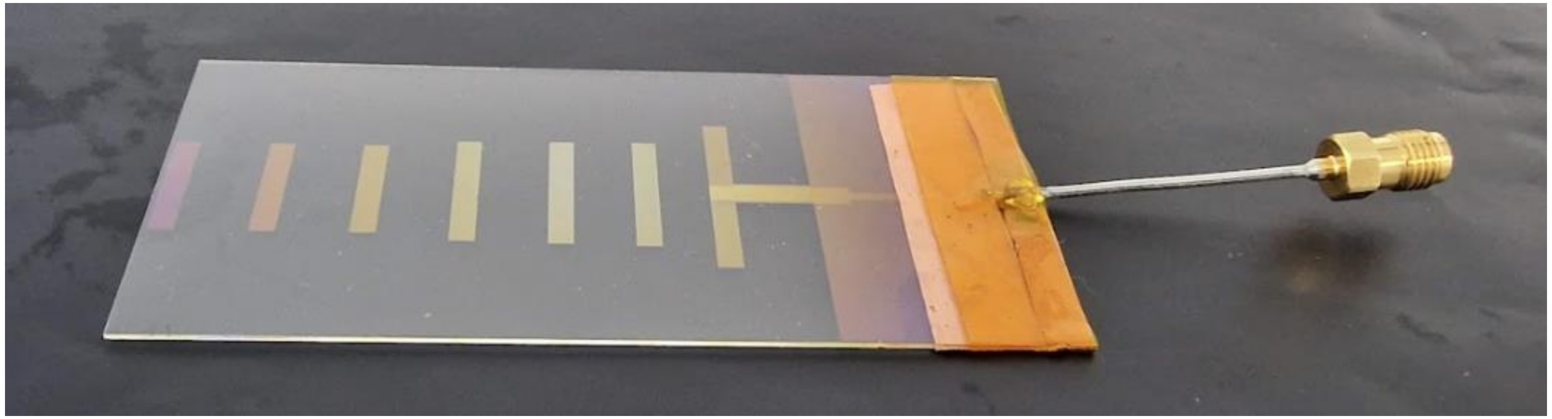
Emerging Technology: Transparent Antennas

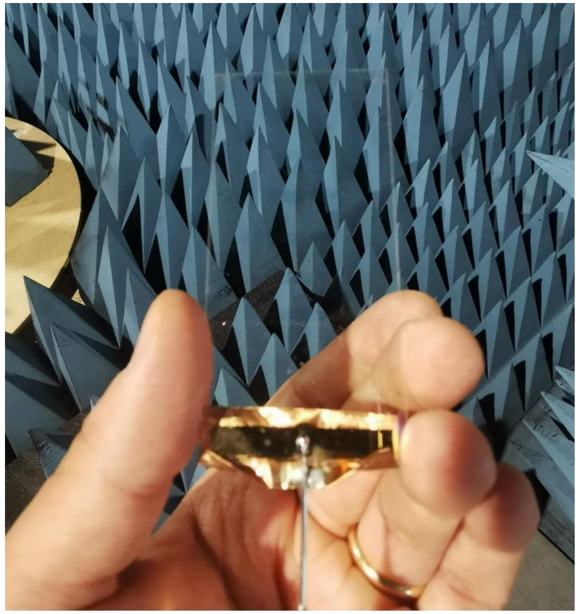
Use-cases

- **Handheld devices screens :** Handset ,Table/Laptop screens
- **Home broadband :** Windows, Solar Panels
- **IoT Devices**

Challenges:

- Reliability of flexible materials
- Power handling
- Mass fabrication technologies
- Multi Bands - L/S, Ku/Ka

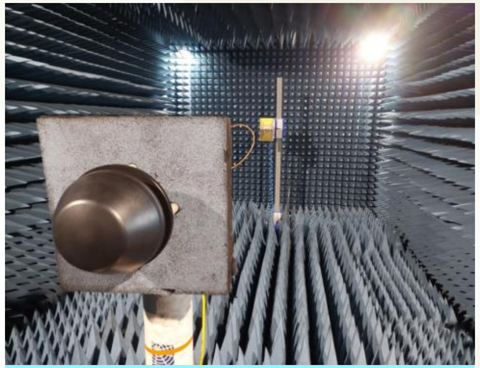




TTP L/S Band Antenna Development

Helical Phased Array Antenna

LEO – GEO IDRS Antenna



MilCom L-Band Antenna

UAV BVLOS Antenna

Thank you

The Tech Barn

Our large-scale and industrial technology development and pilot manufacturing space.

The Hive

Designed for interaction, creativity and innovation. The open-plan layout mixes engineering and science with working, meeting, and breakout spaces.

The Exchange

Our social and event space, for us and our clients – where we gather to exchange ideas, eat, work out, and relax.

Our labs and facilities:

- Dedicated project and client collaboration labs
- Electronics lab
- Engineering labs
- Optics and laser labs
- Metrology lab
- Microfabrication
- Rapid prototyping and machining centre
- Controlled manufacturing areas (500m^2)
- Cleanrooms (ISO6, ISO7 and ISO8)
- Wet chemistry and materials science
- Biology labs (nucleic acid, protein analytics, sequencing, cell culture)
- Bio-engineering integration labs
- RF and communications labs including anechoic chamber
- AI lab
- 5G NTN test lab

From opportunity to reality

TTP plc

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+44 1763 262626

ttp.com

‘Network Automation for NTN’

Stephane Remy,

**Director of Connectivity,
Cambridge Consultants**

Network Automation for NTN

When Networks Collide: Merging of Terrestrial and Non-Terrestrial Networks

Stephane Remy – Cambridge Consultants

University of Surrey, October 2024

Stephane Remy

Terrestrial Networks, Enterprise Communications, Connectivity

I lead the commercial activities and oversee next stages of development of connectivity, specifically on terrestrial networks and enterprise communications, across multiple regions and sectors, setting the future strategy to help clients create breakthrough innovations.

Reach out: stephane.remy@cambridgeconsultants.com | 07973 716519 | LinkedIn

Resources:

- Whitepaper - Get ahead in the race to network automation with deep tech
- Whitepaper - Advancing autonomous networks: mastering AI in the multi-G era
- Webinar - Navigating the transition to autonomous networks
- Podcast - Telecoms.com

Introducing Cambridge Consultants

About us

CC is a leading global deep-tech product and service development consultancy, part of Capgemini Invent. We spearhead high-impact, transformative and societally beneficial projects for the world's biggest brands and most ambitious start-ups.

Our vision

A future unconstrained by current thinking

Our purpose

We unite an extraordinary breadth of talent to expand the boundaries of technology innovation, and together we overcome the toughest, most urgent and essential challenges to make a difference. **To people. To business. To the world**

Our values

- Service
- Excellence
- Teamwork
- Care
- Integrity
- Deliver Impact

A world-leading innovation partner

800+ People
90% multidisciplinary engineers, technologists designers, scientists and consultants

35+ Countries
Local presence across Europe, North America and Asia

140+ Laboratories
More than 200,000 ft^2 of world-class design and development facilities

5000+ Patents
Creating intellectual property assets for clients

500+ Projects/year
Across the fastest-moving and most disrupted industries and technology areas

60+ Years
Experience in delivering world-changing innovation

Non-Terrestrial Networks are a game changer. And AI will boost their performance, to meet increasing demand for ubiquitous connectivity.

NTN plays a vital role in modern communications to deliver ubiquitous coverage

Definition

- Satellite, airborne and other non-ground-based platforms.
- Various orbits (GEO, MEO, LEO, HAPs, UAVs) provide connectivity.
- Global coverage, crucial for bridging the digital divide.
- Broadband, IoT, emergency services, navigation.

Modern communications

- Complement TN for ubiquitous coverage.
- Connectivity in areas where TN is impractical or impossible: remote regions, oceans, natural disasters...
- Resilient and reliable.

Landscape

- Evolving rapidly with advancements in satellite technology, and AI/ML.
- Low-latency broadband services from Starlink and OneWeb.
- HAPs and UAVs provide flexibility and scalability.
- Ongoing work on standards and regulations towards TN and NTN integration (spectrum, interop, cost).

The need for improved efficiency, reliability and scalability drives automation adoption

Managing challenges

- Dynamic and complex environment.
- Satellites move rapidly.
- Varying atmospheric conditions.
- Diverse platforms and technologies.

Automation benefits

- Leverage AI/ML for optimal resource allocation and efficiency.
- Quickly respond to changes.
- Detect and resolve anomalies to minimize service disruption.
- Reduce overhead.

Key drivers

- Efficiency, reliability, scalability.
- Demand for high-speed internet and IoT services.
- Predictive maintenance.

What is an autonomous network?

- A network that anticipates bottlenecks, self-configures for optimal performance and heals itself from outages – all without human intervention.
- Autonomous networks are built to independently monitor their status while performing maintenance and reconfiguration tasks with minimal human intervention.
- This enables optimized performance, reliability and cost-efficiency across an array of applications, from cellular, fixed and fibre optic networks to satellite constellations and HAPs.

Network Automation for NTN

Using AI to drive network transformation

To solve complex problems with ML models trained using data or through simulations

To deliver operational and resource efficiency, experience excellence and enabling monetization

A CSP cannot simply start work on a Level 5 tomorrow from scratch, and shall expect that different components of the network may be at different levels of automation

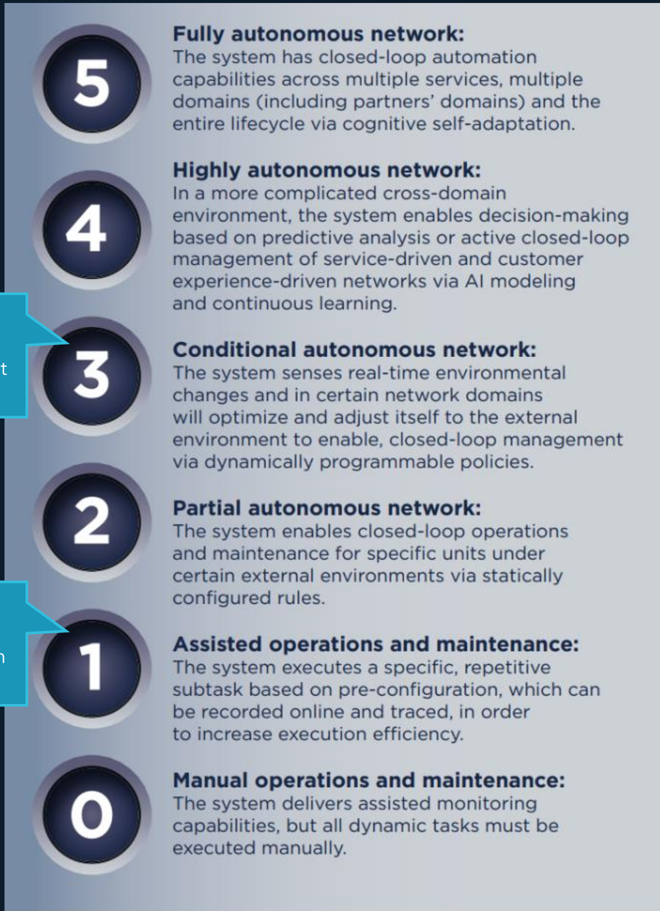
At CC, we

- use our domain expertise to identify problems and/or where improvements can be made
- help clients prioritize use cases (DVF)
- implement scalable frameworks (e.g. assurance, AIOps) to support ongoing transformation

Link to podcast

About half of Communications Service Providers expected to be at Level 3 by 2026

About half of Communications Service Providers were at Level 1 in 2023



AI and ML facilitate intelligent decision-making processes

Role of AI and ML

- AI analyses vast amounts of data, identify patterns and predict potential issues.
- ML enables continuous learning and adaption.
- Intelligent decision-making.

Examples

- Dynamic resource management.
- Predictive maintenance.
- Intelligent traffic routing.

Benefits of AI-driven automation

- Enhanced operational efficiency.
- Improved service availability.
- Reduced opex.

AI helps optimize resources allocation and management

Resource optimization

- Continuous analysis of network conditions and user demands.
- Patterns prediction.
- Realtime adaptability.

Dynamic resource allocation

- Realtime adjustment of network parameters.
- Informed decisions to maximise resource utilization and improve user experience.

Enhanced resource management

- Improved bandwidth allocation.
- Reduced latency.
- Better power distribution in a constellation.

AI helps maintain stable connections in dynamic environments

Stable connections

- Realtime analysis and predictive modelling.
- Pre-empt changes.
- Mitigate interferences.
- Manage handovers.

AI in dynamic environments

- Optimize satellite beam steering.
- Manage traffic congestion and reroute data through most efficient paths.
- Predict equipment failure.

Service quality and reliability

- Continuous monitoring.
- Continuous optimization.
- Predictive capabilities.
- Efficient use of resources.

The integration of TN and NTN delivers a unified network, but it's not without challenges

Challenges

- Interoperability.
- Latency differences.
- Spectrum management.

AI for seamless integration

- Dynamic handover management.
- Traffic routing optimization.
- Usage pattern and interference prediction.

Benefits

- Global coverage.
- Network resilience and redundancy.
- Efficient use of resources.
- Meet diverse user needs.

Network Automation for NTN

Deep tech adoption helps accelerate automation and its benefits

Phased array antenna

- Electronic beam steering.
- Dynamic adjust coverage.
- Multiple beams for improved spectrum management.
- High-capacity links.

Adaptive beamforming

- Adjust direction and shape based on real-time conditions.
- Improved signal strength.
- Reduced interferences.
- Higher data rates.
- More reliable connections.
- Better customer experience.

Realtime signal optimization

- AI/ML analyse real-time data to make informed decisions about resource allocation, power level, and signal modulation.
- Higher quality connectivity, lower latency, enhanced overall network efficiency.

Deep tech adoption helps accelerate automation and its benefits

Imagery and network calibration

- Insight into environmental conditions and potential obstacles that affect signal propagation.
- Calibrate networks in real-time.
- Disaster response.

AI assurance

- Have you got the right framework?
- Data privacy.
- Responsible AI

Automating NTN will drive business growth and operational efficiency

Good for business

- Increased revenue.
- Reduced opex.
- Enhanced customer satisfaction.
- Efficient use of resources.

Operational efficiency

- Real-time insights into operations.
- Optimal performance.
- Anomalies detection, correct actions in real-time.
- Proactive maintenance, reduced downtime, extended lifespan.
- Superior service to end users.

RoI

- Predictive maintenance.
- Optimized resource allocation.
- Better bandwidth management.

Summary

The move to autonomous systems brings many advantages

Optimizing resource allocation & management

- NTNs operate in a constantly changing environment.
- AI can adjust how the network works in real time, making sure that the signal is as strong and clear as possible, even in hard-to-reach places.
- Hence, the network uses its resources more efficiently to serve more users better, without wasting resources.

Consistent connectivity in dynamic environments

- Maintain a stable connection, even as conditions change to deliver reliable service.
- AI plays a key role here, constantly adjusting the network to keep the connection smooth, whether you're on the move or in a fixed location.

Enhanced coverage and service quality

- With AI managing the network, hard to reach areas enjoy better coverage and a stronger connection.
- People in rural or remote areas get access to high-quality internet and communications services.

And there are a few options within AI towards automation

Adaptive beamforming and better targeting

- Phased array antennas can already enhance network capabilities, optimizing signal direction and power dynamically to improve bandwidth and reduce interference.
- AI/ML models can help manage the dynamic conditions of NTN's environments, aiming at maintaining service integrity.

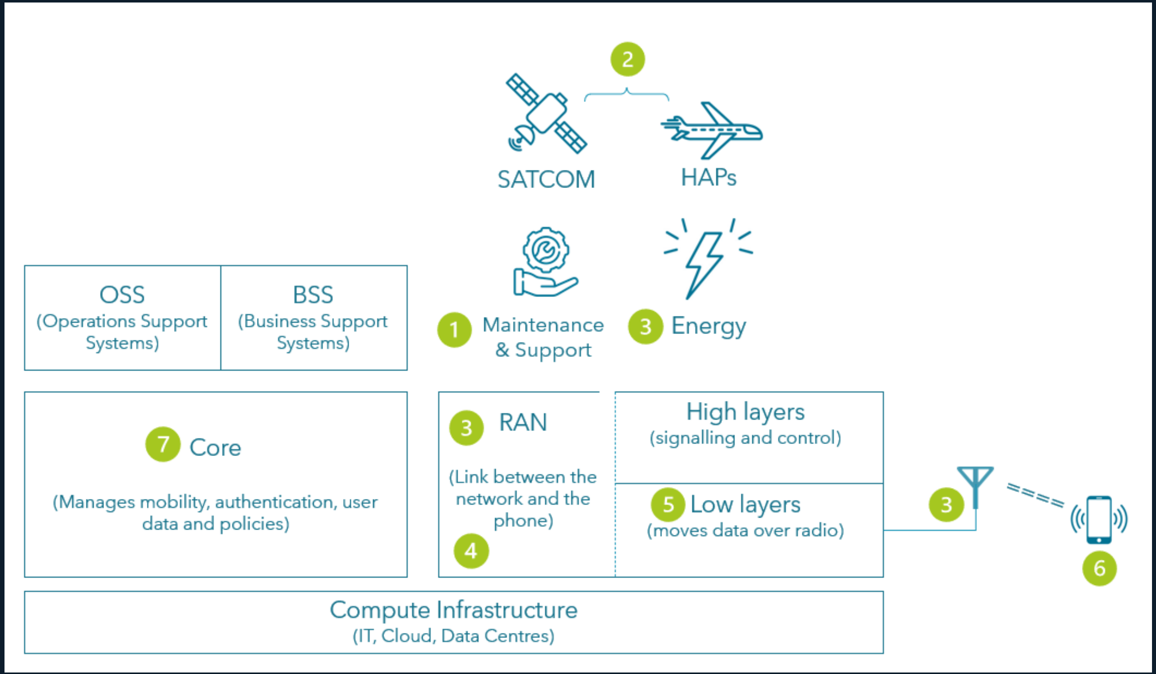
Routing & prediction

- Real-time resource allocation managed by AI ensures optimal performance, dynamically adjusting bandwidth and power based on user demand and network conditions.
- Efficiency analytics provide insights into network performance, helping operators to cut waste and redirect resources towards areas with higher ROI.

Optimization

- Anomaly detection to rectify issues, ensuring continuous service availability.
- Optimize network traffic to balance load and prevent congestion.
- AI-upscaled NTN imagery analysis (SuperRes)
- Automating calibration and maintenance of equipment, improving operational longevity and performance.

Examples of AI-driven transformation (mix of clients and internal projects)



1. AI for root cause analysis on unstructured log files
2. AI to compensate for failed elements in phased array antennas
3. Cell load predictor for energy Saving
4. AI agent inferring user QoE standard network performance parameters only
5. Efficiency optimisation
6. Multi-Agent Reinforcement Learning (MARL) for cybersecurity
7. MARL for distributed network routing

Take away

Don’t miss out on the transformative power of autonomous NTN

- NTNs are set to transform communications, connecting diverse environments, but they must deliver superior connectivity without user experience compromises.
- AI-driven autonomous NTN can address this, enhancing control, cost-efficiency, and performance.
- Achieving high level of network autonomy is complex and requires collaboration.

Developing a winning strategy for AI-driven NTN transformation

Be ambitious… with clear objectives

- Think big
- Start small with repetitive tasks (e.g. what could be automated?)
- Iterate, gathering data and e.g. moving to predictive
- Deliver true value

Establish a culture of automation

- Integrate automation deeply into teams and daily operations
- Be clear on the objectives
- Early wins will lay the groundwork for long term success

Invest

- [Deep] technology will make sense of advanced software, complex hardware, cutting-edge applications, and more - towards full autonomy
- Bold strategic investment will adapt and transform your infrastructure

Embrace a robust AI framework

- Prioritize a foundation of reliability, ethics and compliance
- The right blueprint will ensure security, transparency, explainability, fairness and regulatory adherence to achieve successful, long-term AI integration and societal acceptance

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Panel session; Bursting the Hype

Chaired by

Steve Clarke

Wyld Networks

Mike Short

Satellite Applications Catapult

Barry Evans

University of Surrey

Damien Bevan

Real Wireless

Peter Kibutu

TTP plc

Rowan Chesmer

Vodafone

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