Now Is A Perfect Time To Talk 6G!

Prof Mischa Dohler, *FIEEE FRAEng FRSA FIET*

Chief Architect, Ericsson Inc, Silicon Valley

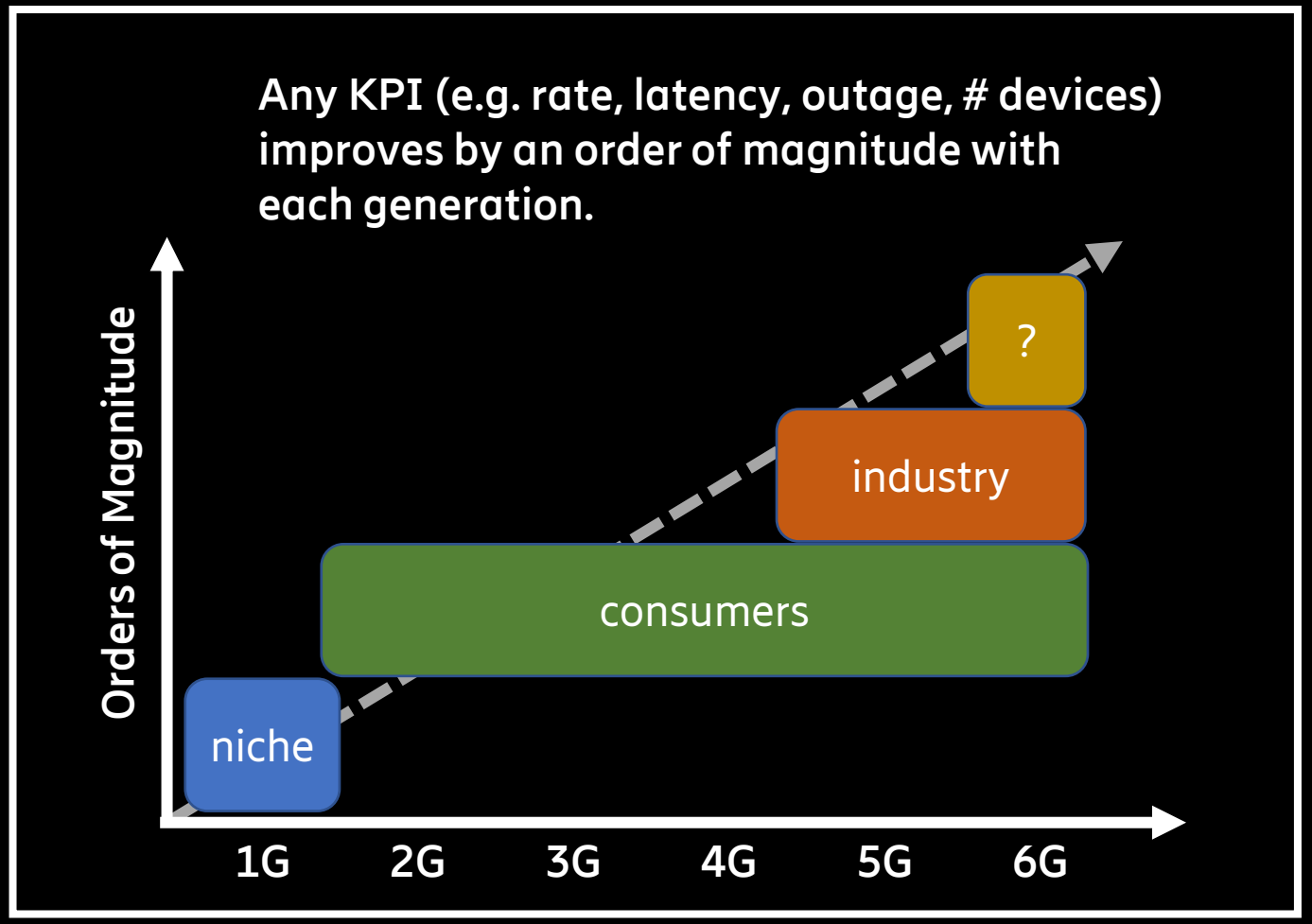
Visiting Professor, King's College London

IEEE Next G, 14 June 2022

01
Five Important Trends In Telecommunications

Fundamental trends in telecoms which help us guide in designing the next-generation systems.

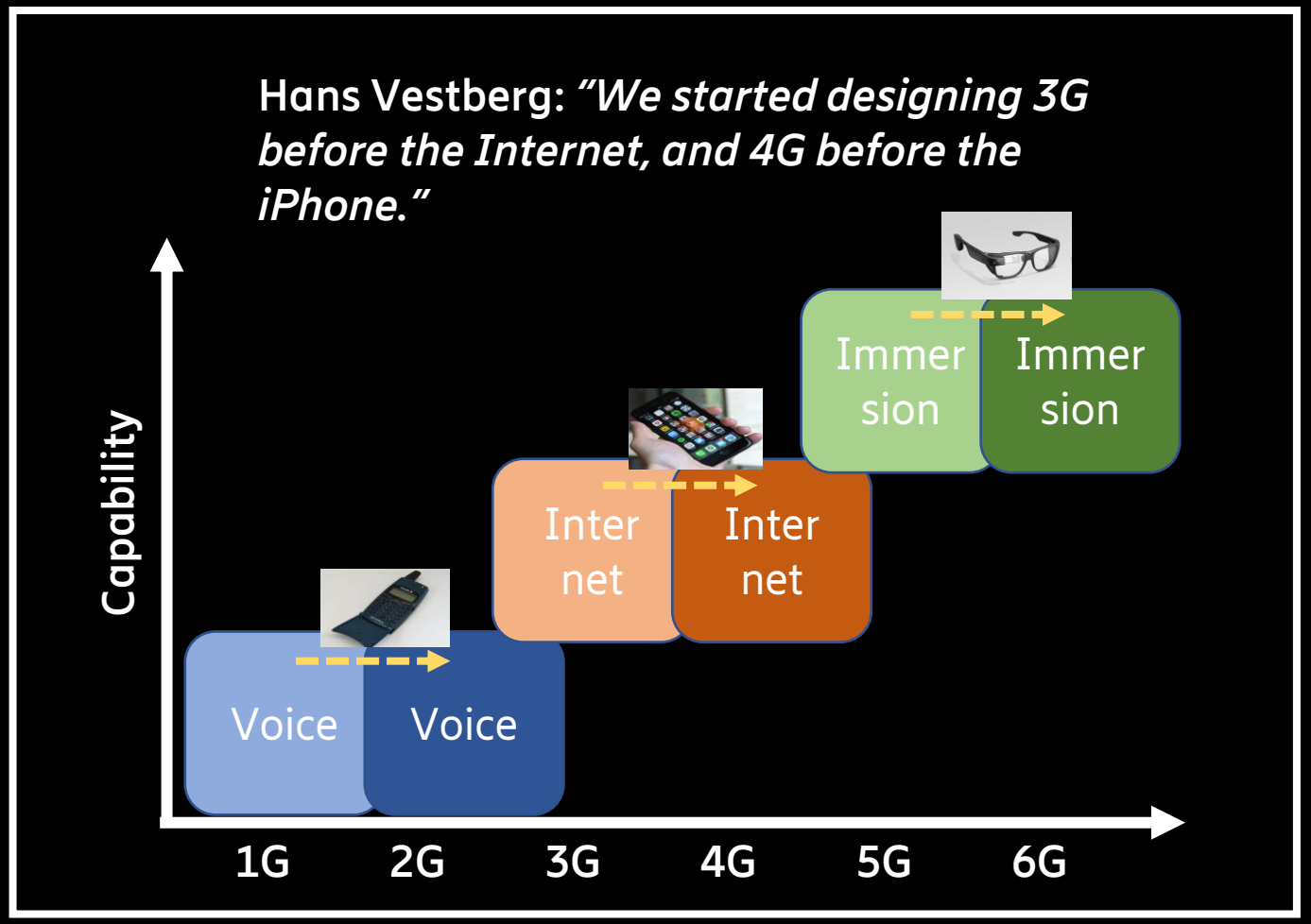
#1 "Growth Trend" (what)



Fairly consistently, the transition from G-1 to G has always yielded an approx. 10x improvement over a given key performance indicator, e.g. rate.

Implications: We know what 6G will be able to achieve, but not yet how and why; nor do we have fundamental system limits.

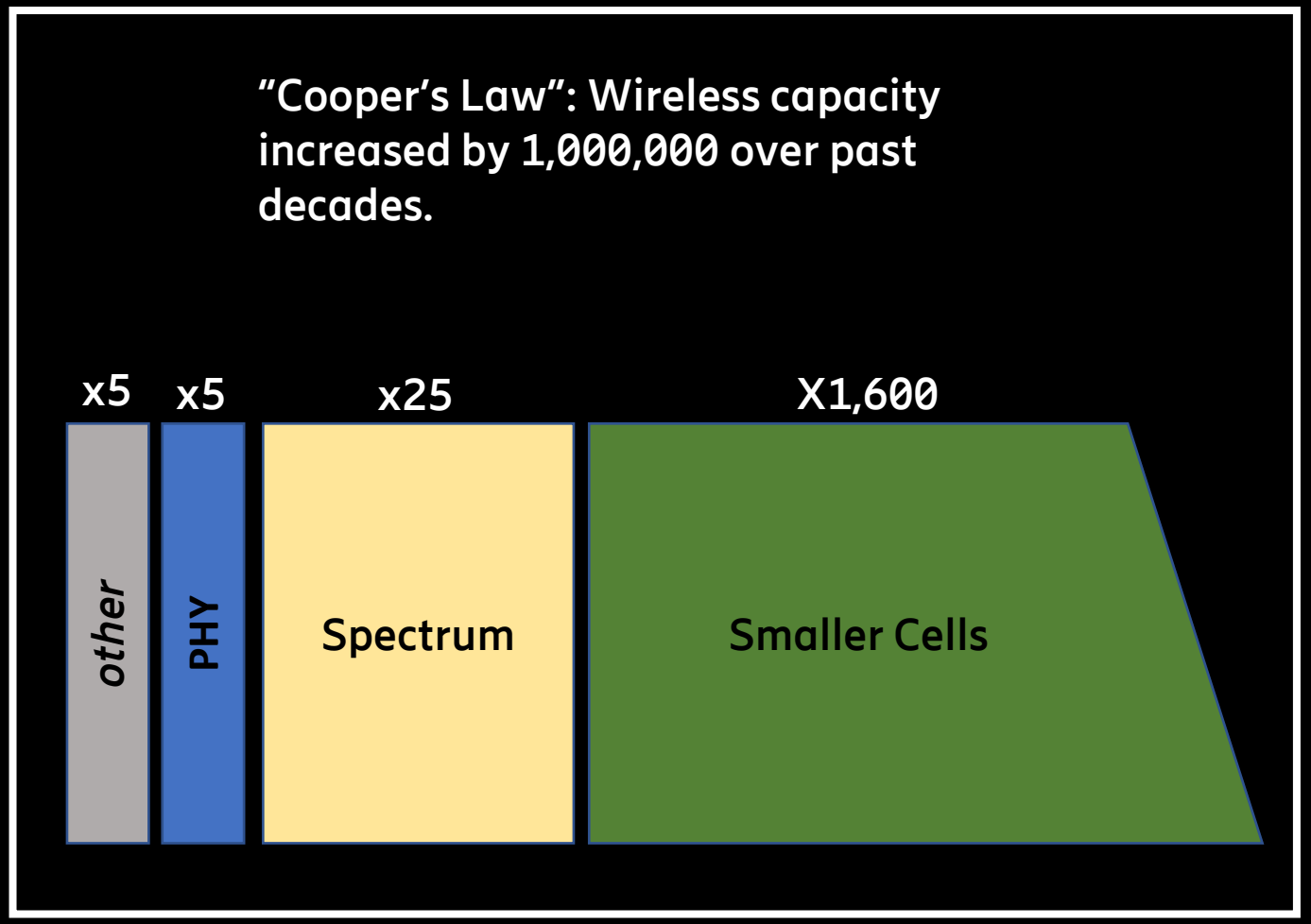
#2 "Consolidation Trend" (why)



Fairly consistently, a pioneering telco usecase needed one generation to consolidate; and often took off with the arrival of a new device.

Implications: Synch telco roadmap with consumer device roadmap; and accept that "killer app" will eventually appear.

#3 "Atomization Trend" (how)



The large bulk of capacity increase has been delivered via smaller cells and more spectrum; both were supported by an appropriate physical layer.

Implications: Holistic system thinking across architecture, spectrum and radio access is required to keep up with trends.

#4 "Tech Enabler Trend" (who)

Hardware
Generic HW acceleration, new materials (meta/neuromorphic), and quantum technology

Open Source
Higher reliance on open-source components; see e.g. Linux Open Source Foundation

Integrated AI
Widespread use of AI for automation and cost-efficiency in cognitive and data-driven networks

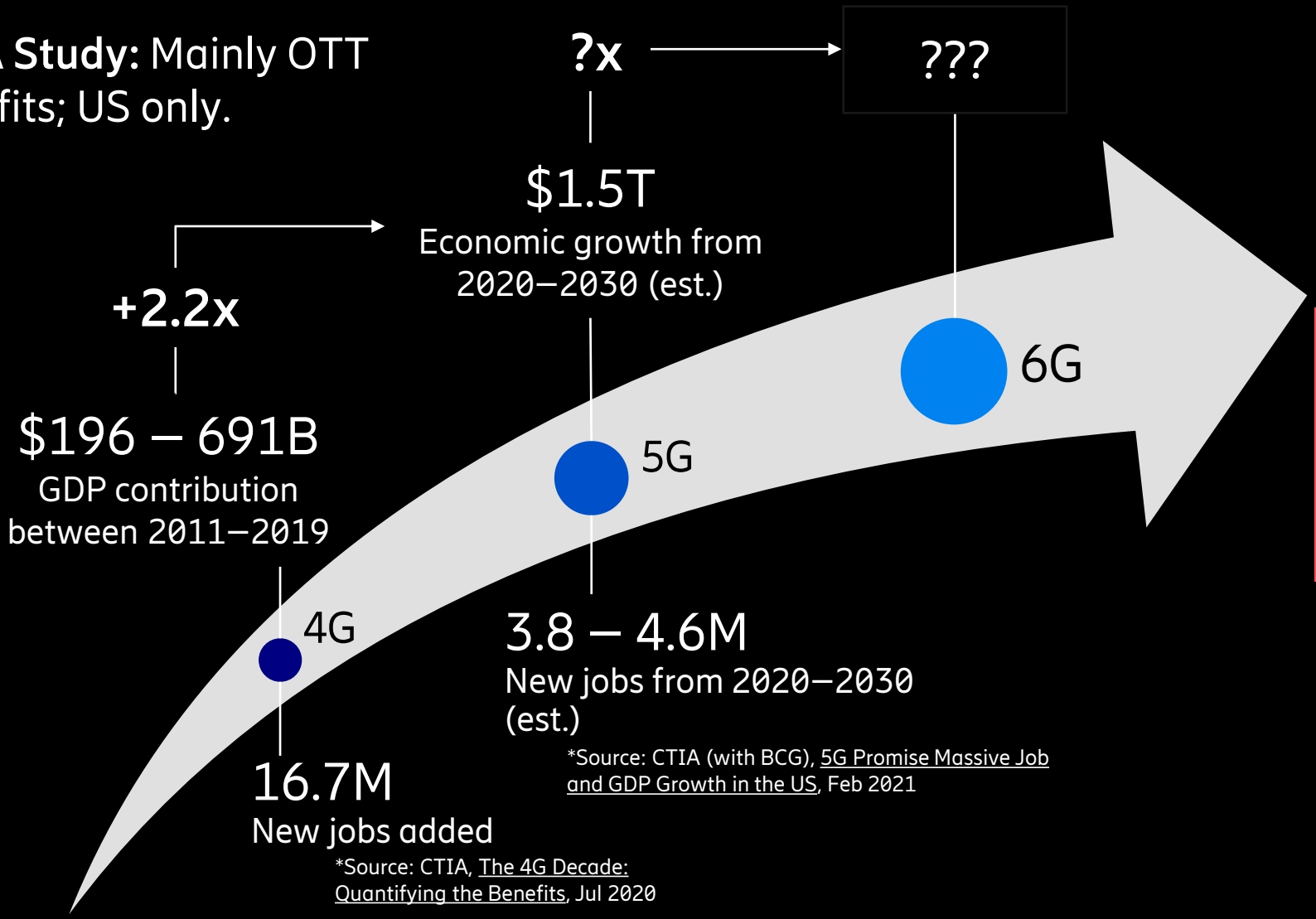
Cloudification
Continued cloudification for cost/efficiency, now also in RAN and in form of edge-cloud;

Accelerated Evolution
Fast evolution of underlying tools and development (DevOps) at a higher pace

Internet Evolution
Distributed resilient services, evolving multi-path tailorable transport and security

#5 "Economic Trend" (how much)

CTIA Study: Mainly OTT benefits; US only.



*Source: CTIA (with BCG), 5G Promise Massive Job and GDP Growth in the US, Feb 2021

*Source: CTIA, The 4G Decade: Quantifying the Benefits, Jul 2020

$???B

Loss in benefits for every 1-month delay in 6G rollout

$12B

Loss in benefits for every 1-month delay in 5G rollout

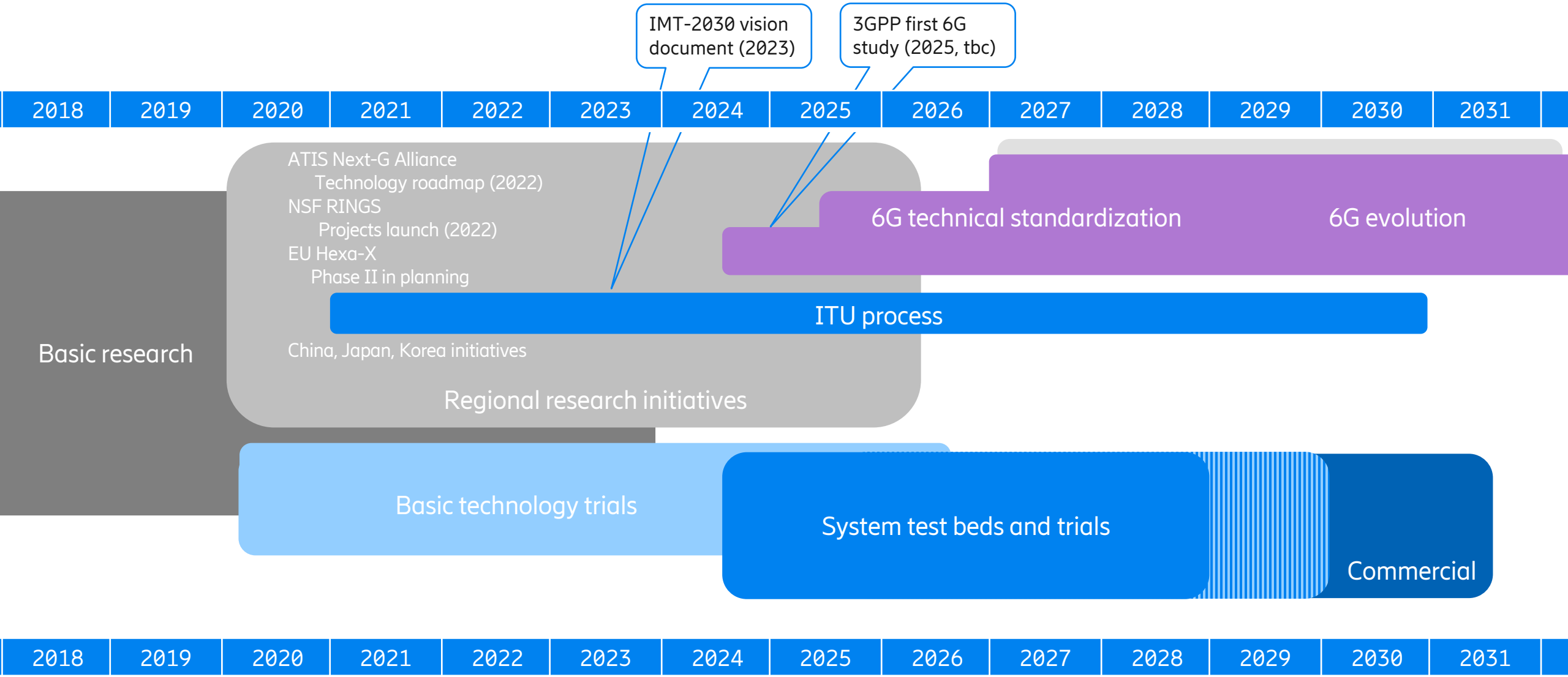
>$2B

Loss in benefits for every 1-month delay in 4G rollout

02
6G Use-Cases and Standards Roadmaps

Let’s understand the currently anticipated 6G industry and standardization roadmaps.

6G Ecosystem Timelines



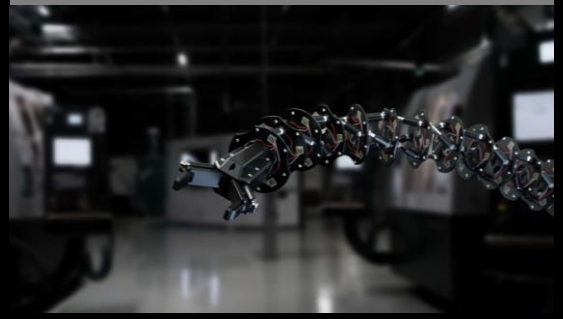
Ericsson's 6G Use-Cases

2022 update to E///'s 2020 6G Vision:

Human and Societal Needs

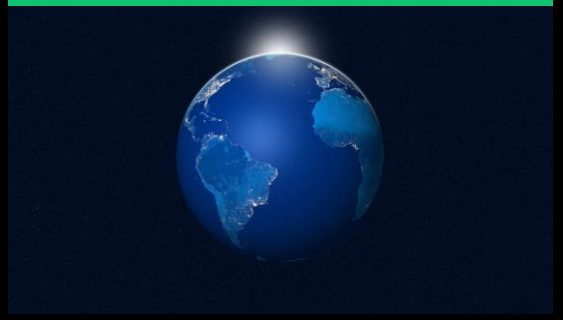
The Internet of Senses

Connected Intelligent Machines



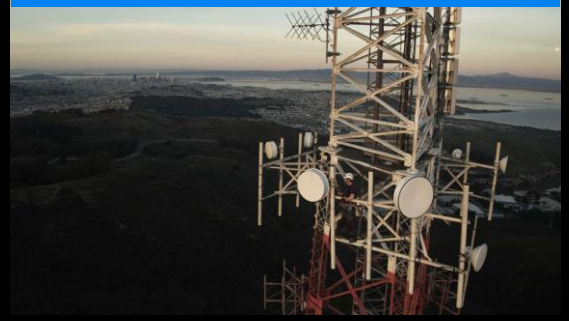
Digitalized & programmable physical world

Connected sustainable world



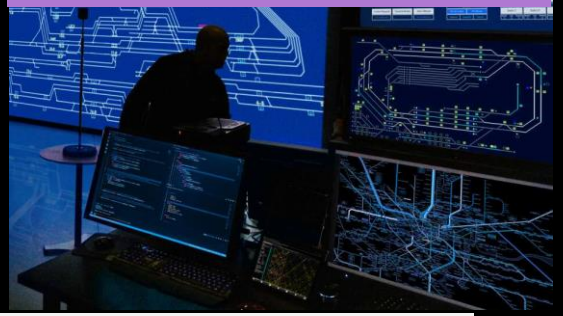
Use case focus

Limitless connectivity



Trustworthy Systems

Cognitive network



Network compute fabric

Technology focus

Fundaments of a 6G Network Platform

Example: World's First Holotaring (MWC22)

Imagine Live Kick Off 2022 - Ericsson

ATIS 6G Use-Cases

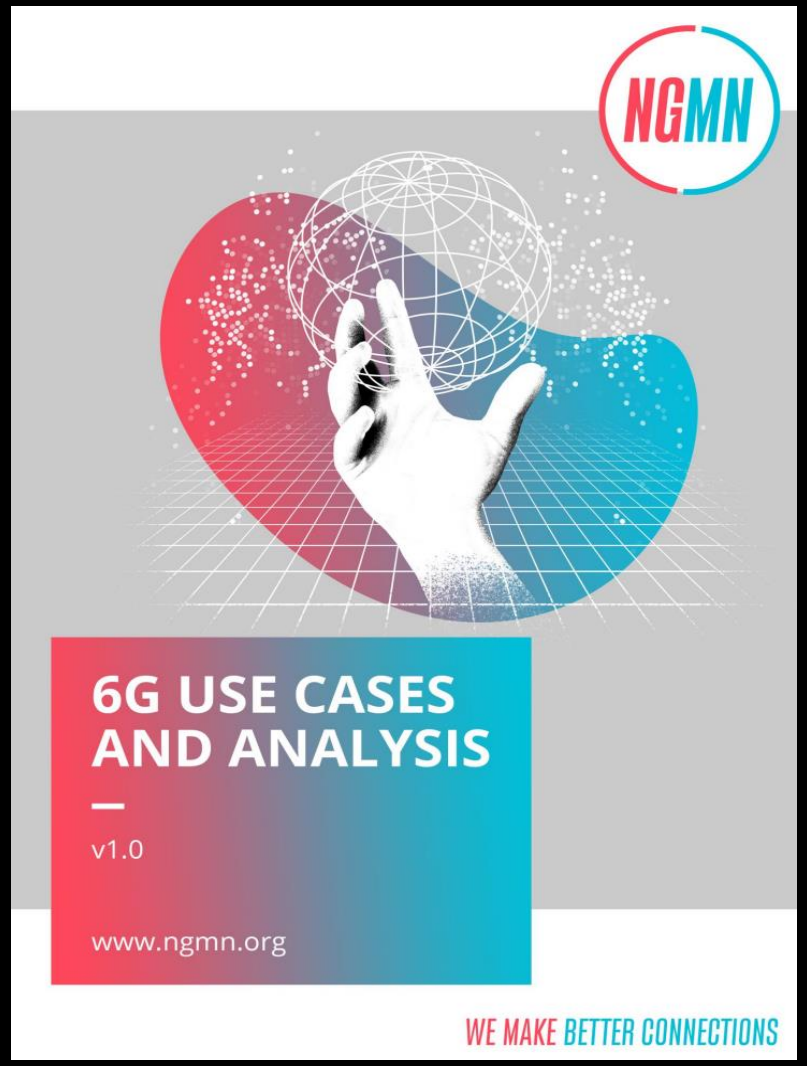
1. Networked-Enabled Robotic and Autonomous Systems

2. Multi-Sensory Extended Reality

3. Distributed Sensing and Communications

4. Personalized User Experiences

NGMN 6G Use-Cases



Examples:

USE CASE	CONTEXT	6G IMPLICATION	
		DELIVERABILITY	DIFFERENTIATION TO 5G
XR Telepresence	Services are aligned with new devices/HMI technology, and sensing technologies.	Early XR capabilities can be delivered over 5G and fixed networks. The more demanding applications foresee new HMI, devices, sensing, and compute capabilities.	The highest data rates would require the bandwidth associated with higher frequency bands, and a new air interface, for localised coverage and short-range communications.
Multimodal Teleoperation	Aligned with the ability to deliver information related to human senses, necessitating intelligent transfer and prediction of sensory and/or ambient information. Extensions include operation of machines or robots at a distance.	Dependent on the ability to capture sensory information. Industrial and mobile private networks may be necessary to support dedicated industrial use cases.	New requirements may emerge related service delivery to multiple devices and need for to synchronized multi-modal communication and control.
Robot Network Fabric	Enables robots to coordinate mobility by using sensing and mapping data, improve traffic flow for vehicles.	Peer-to-peer communication and protocols required for vehicles, possibly extending V2X type capabilities.	Enabled by joint sensing and communications that improves resolution and high-speed communications.

Use-Cases to KPIs @ ITU

Parameter	IMT-2020 (5G)	* My personal estimates: Networks-2030 (6G)
Peak data rate	DL: 20Gbps UL: 10Gbps	DL: 10x 20Gbps UL: 10x 10Gbps
User experienced data rate	100Mbps	10x 100Mbps
Peak spectral efficiency	DL: 30bps/Hz UL: 15bps/Hz	DL: UL:
Mobility Support	500km/h	
User Plane latency	1ms	100us
Connection density	1 000 000 devices/km^2	10x of 5G
Energy consumption	1 (normalized)	1/10x of 5G
Mobile data volume	10Tb/s/km^2	10Pb/s/km^2

Table not by ITU, but you can follow work on https://www.itu.int/en/ITU-T/focusgroups/net2030/Pages/default.aspx

KPIs to Standards @ 3GPP

*6G releases and dates are my personal guestimates based on past 4G & 5G design cycles:

6G	Rel-24	Release 24	2028	2032
	Rel-23	Release 23	2026	2030
	Rel-22	Release 22	2025	2028
	Rel-21	Release 21	2024	2027
	Rel-20	Release 20	2023	2025

Release Code	Name	Status	Start date	End date	
5G Rel-19	Release 19	Open	2021-06-18		
Rel-18	Release 18	Open	2019-09-16	2024-03-22 (SA#103)	
Rel-17	Release 17	Frozen	2018-06-15	2022-06-10 (SA#96)	
Rel-16	Release 16	Frozen	2017-03-22	2020-07-03 (SA#88-e)	
Rel-15	Release 15	Frozen	2016-06-01	2019-06-07 (SA#84)	
Rel-14	Release 14	Frozen	2014-09-17	2017-06-09 (SA#76)	
Rel-13	Release 13	Frozen	2012-09-30	2016-03-11 (SA#71)	
Rel-12	Release 12	Frozen	2011-06-26	2015-03-13 (SA#67)	
Rel-11	Release 11	Frozen	2010-01-22	2013-03-06 (SA#59)	
Rel-10	Release 10	Frozen	2009-01-20	2011-06-08 (SA#52)	
Rel-9	Release 9	Frozen	2008-03-06	2010-03-25 (SA#47)	
Rel-8	Release 8	Frozen	2006-01-23	2009-03-12 (SA#43)	
Rel-7	Release 7	Closed	2003-10-06	2008-03-13 (SA#39)	2014-09-17 (SA#65)
Rel-6	Release 6	Closed	2000-03-28	2005-09-28 (SA#29)	2014-09-17 (SA#65)
Rel-5	Release 5	Closed	2000-05-01	2002-09-12 (SA-#17)	2014-09-17 (SA#65)
Rel-4	Release 4	Closed	1998-08-01	2001-06-21 (SA-#12)	2014-09-17 (SA#65)
R00	Release 2000	Closed	1999-03-30		1999-12-17 (SA-#6)

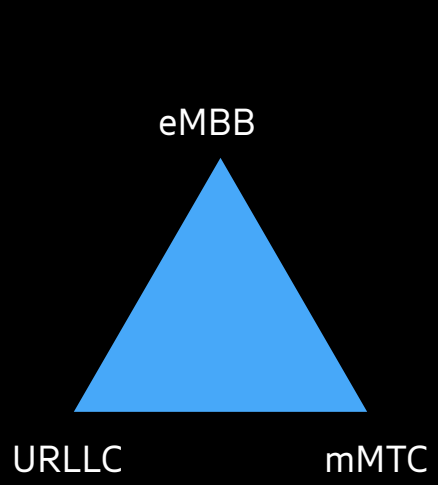
3GPP Feature and Study Item list: Rel-19

Feature or Study Item - click for details
Study on Supporting of Railway Smart Station Services
Study on Network Sharing Aspects
Study on Localized Mobile Metaverse Services
Study on Integrated Sensing and Communication
Study on FRMCS Phase 3
Study on Ambient power-enabled Internet of Things
Study on AI/ML Model Transfer Phase2

www.3gpp.org/DynaReport/FeatureListFrameSet.htm

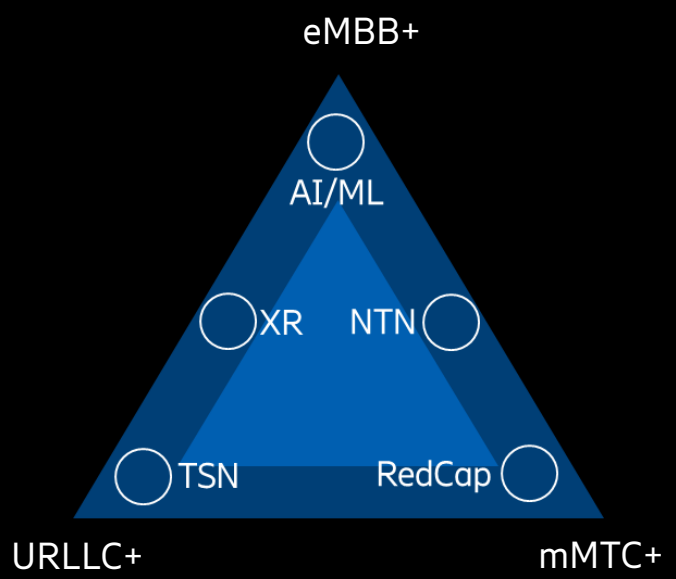
https://portal.3gpp.org/Releases.aspx

Ericsson's View on 3GPP's 6G Roadmap



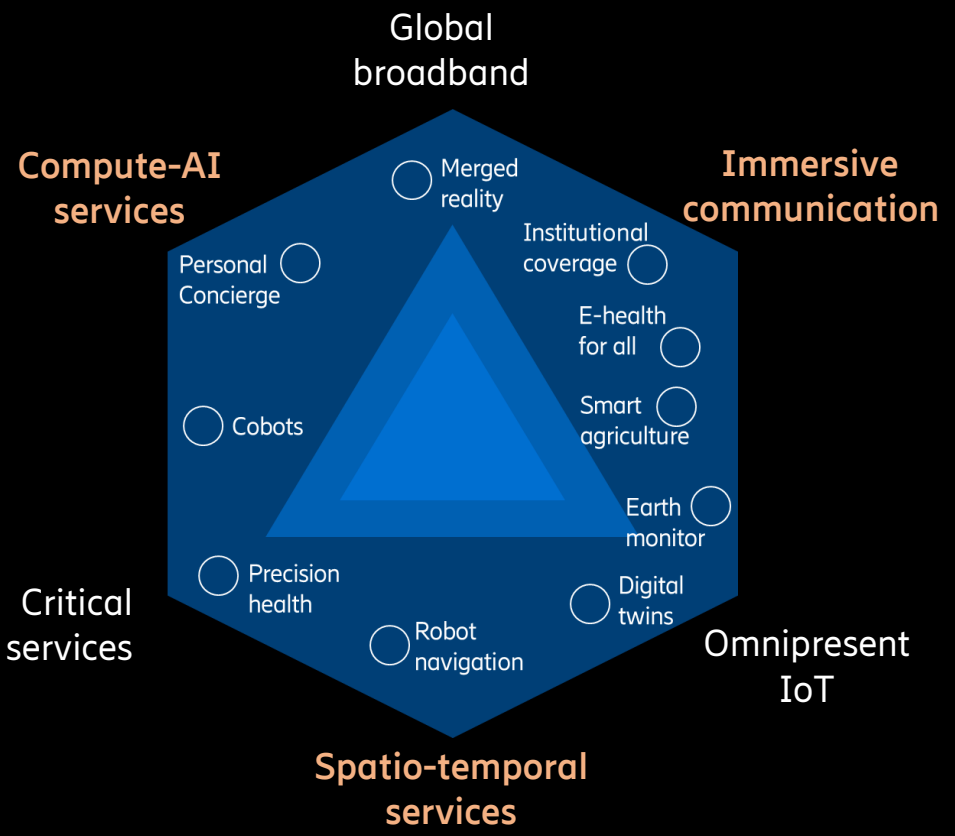
5G

enhance



5G Advanced

expand



6G

03
6G Challenges That Require Solutions

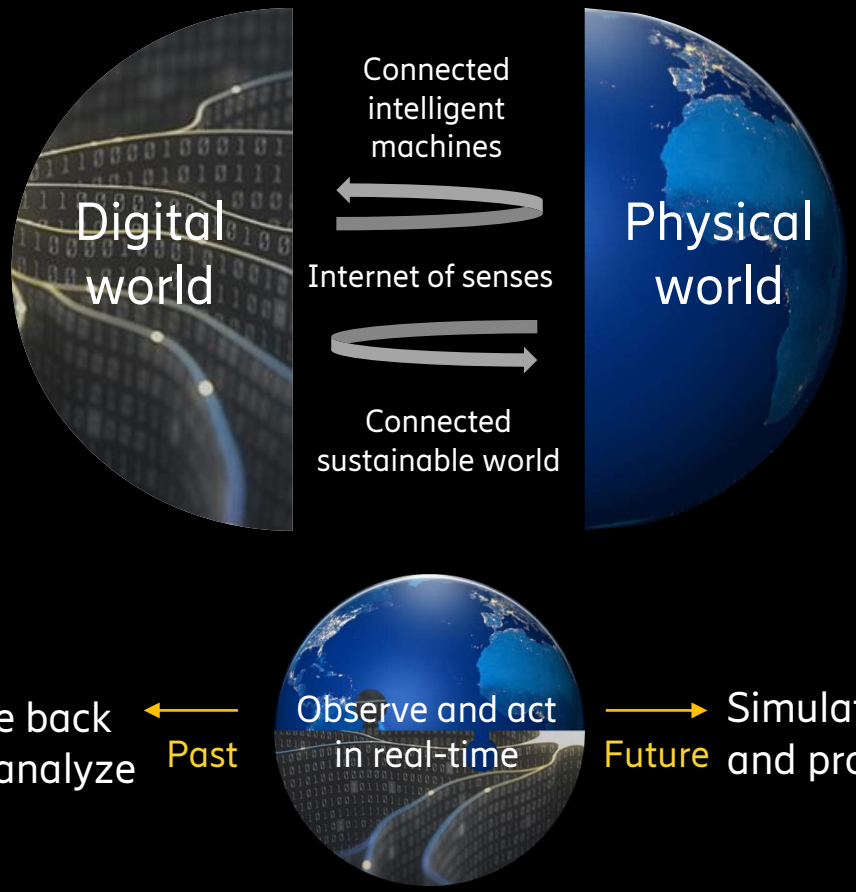
Let’s focus on important 6G technical challenges that require fundamental solutions.

#1 – Enable A Cyber-Physical Continuum

Programmable digital representation of the physical world

The network provides intelligence, limitless connectivity, and full synchronization of the physical and digital worlds

Cyber-physical continuum



The physical world of sensing, action, and experience

Vast amounts of sensors embedded in the physical world send data to update the digital representation in real time

Actuators in the real world carry out functions that are programmed in its digital representation

#2 – From "5G LAN" To "6G Internet"

A <u>global</u> wireless Internet requires a truly global ultra-low latency; however:

1. Network Congestion
2. Application Delay
3. Speed of Light

Human Cortex 10ms

Slicing++, IP++, etc

London - LA

Standardized AI (Mobile Edge Cloud)

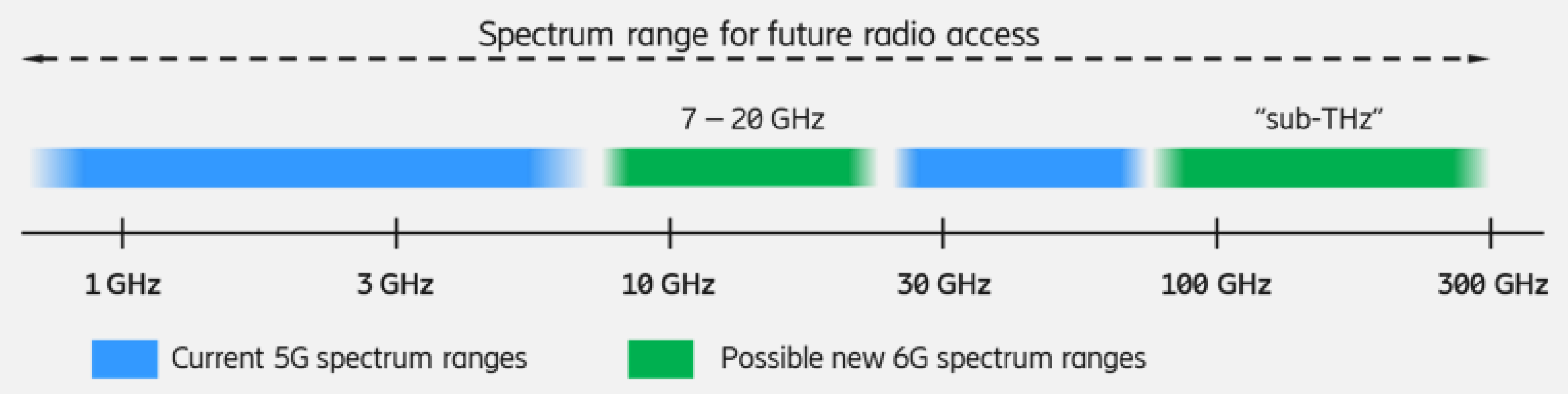
Low-Latency Volumetric Codecs

#3 – Avoid The "Spectrum Trap"

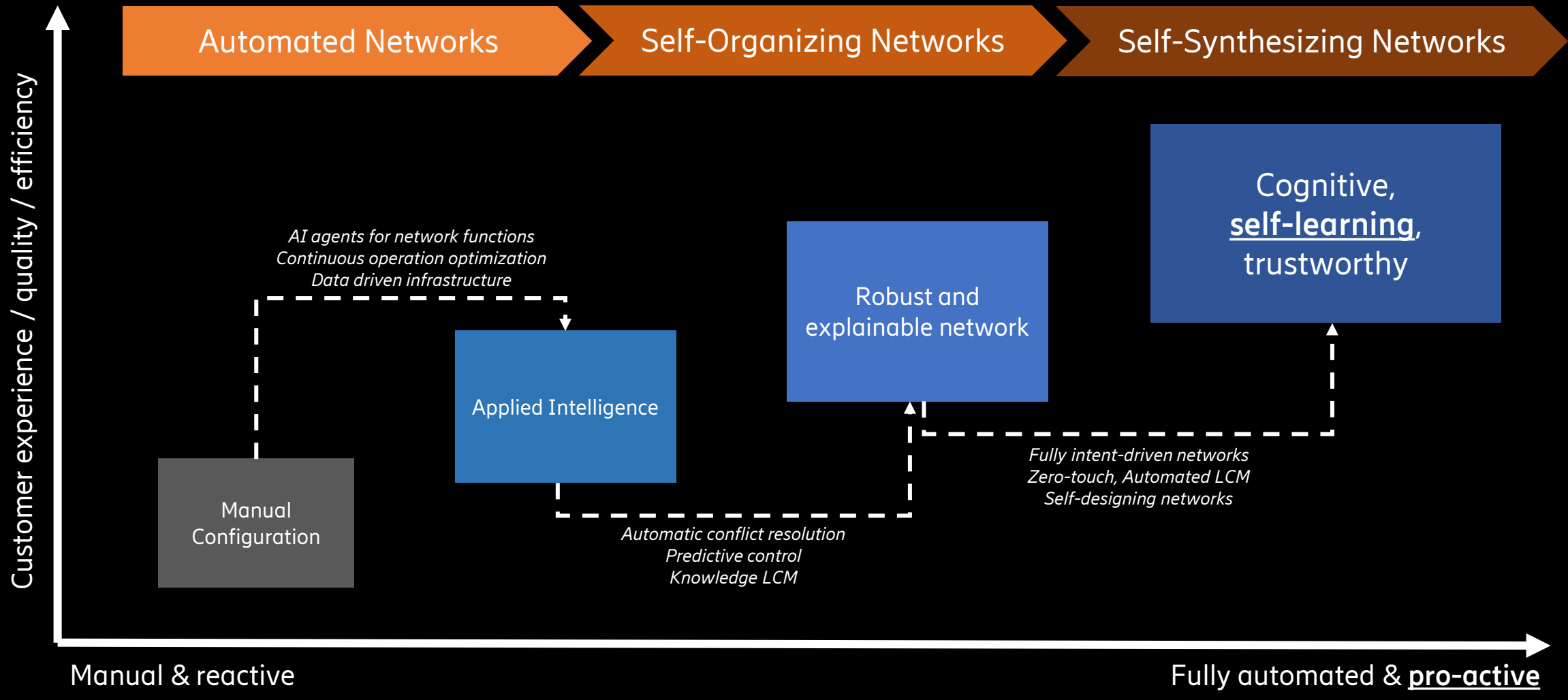
6G radio should be able to communicate over wide range; however, the main value is in the mid bands.

Spectrum cannot be viewed independently anymore from real-estate, fiber backhaul, and the environment.

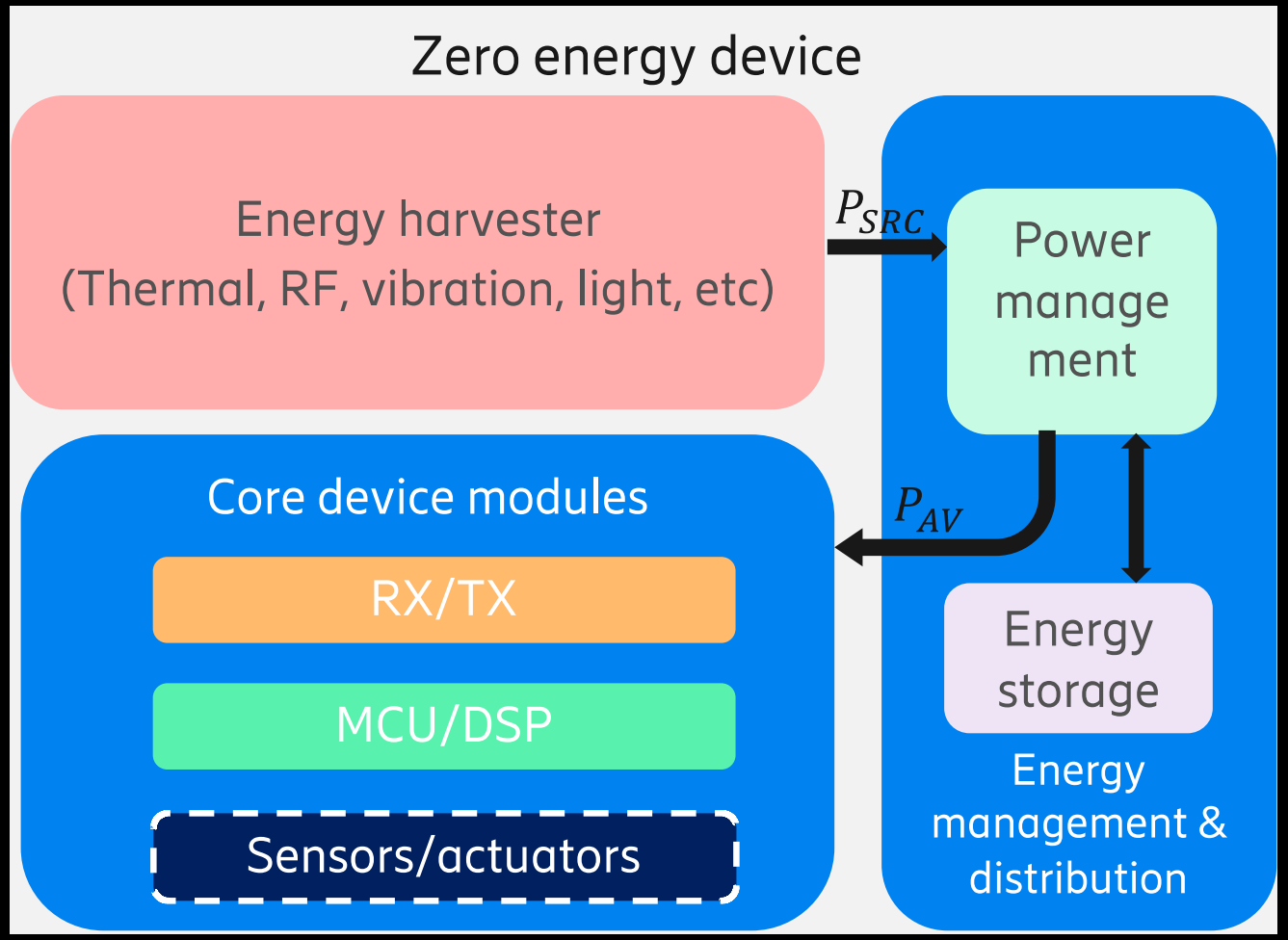
Ensure radio systems coexistence and consumer education prior rather than posteriorly to deployment.



#4 – Beyond Cognitive Networks



#5 – Zero Energy & Carbon Neutral



Zero-Energy Devices

- Complements more traditional "mainstream" IoT/MTC devices
- Typically uses energy harvesting, i.e. often battery-less devices

Carbon-Neutral Networks

- Most energy efficient air interface and RAN possible
- Optimize for asynchronous energy availability

#6 – Privacy by Engineering Design

© Washington Post | Privacy Problems with the Metaverse

References

[1] https://www.ericsson.com/en/6g

[2] https://www.ericsson.com/en/blog/2022/6/6g-spectrum-why-its-fundamental

[3] https://www.ericsson.com/4927de/assets/local/reports-papers/white-papers/6g--connecting-a-cyber-physical-world.pdf

[4] https://www.ericsson.com/en/blog/2021/10/joint-sensing-and-communication-6g

[5] https://www.ericsson.com/en/blog/2021/9/zero-energy-devices-opportunity-6g

[6] https://www.ericsson.com/en/blog/2022/4/why-metaverse-needs-5g

[7] H. Tataria, M. Shafi, Mischa Dohler, S. Shu, "Six Critical Challenges for 6G Wireless Systems," IEEE Vehicular Technology Magazine, accepted 13 December 2021.

[8] H. Tataria, M. Shafi, Mischa Dohler *et al*, "6G Wireless Systems: Vision, Requirements, Challenges, Insights, and Opportunities," in Proceedings of the IEEE, 30 March 2021.

ericsson.com/future-technologies