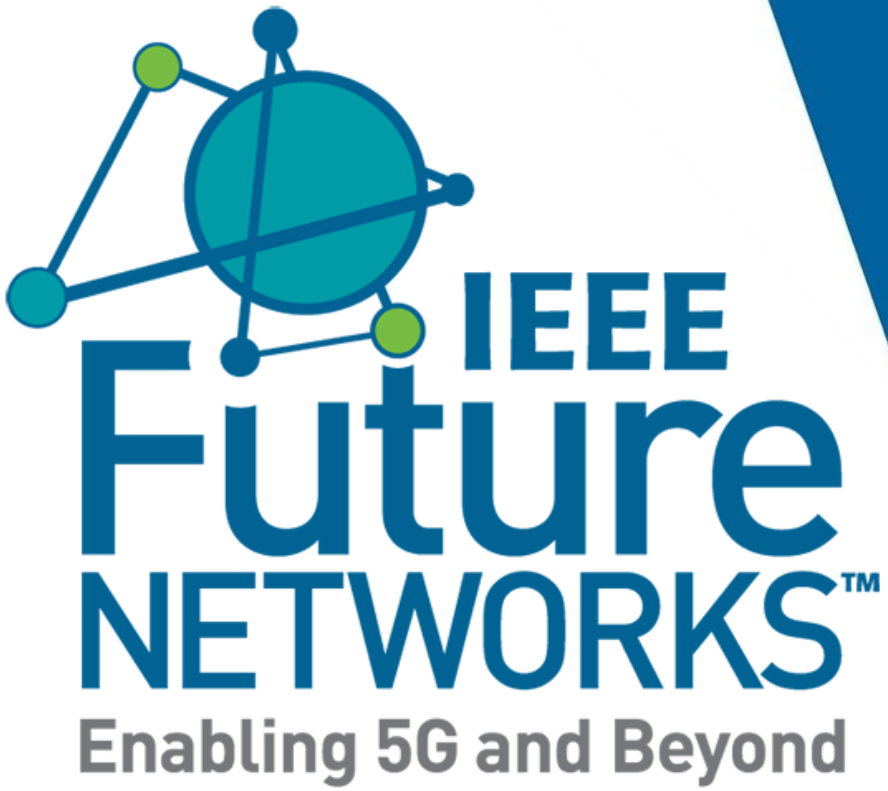


Distinguished Lecture

The Three As of the Future of Telecoms: AI, API and AR

13 September 2023

IEEE

IEEE Future Networks – FutureNetworks.ieee.org

Collaboration

IEEE Antennas and Propagation Society · CAS · IEEE ComSoc IEEE Communications Society · IEEE Electronics Packaging Society · ITSS · MTT-S · IEEE Reliability Society · SSCS · IEEE VTS Connecting the Mobile World

Content

+ technical newsletter, podcasts, videos, articles

Events

IEEE Future Networks WORLD FORUM • 2022 · IEEE Connecting the UNCONNECTED SUMMIT An IEEE Future Networks Program

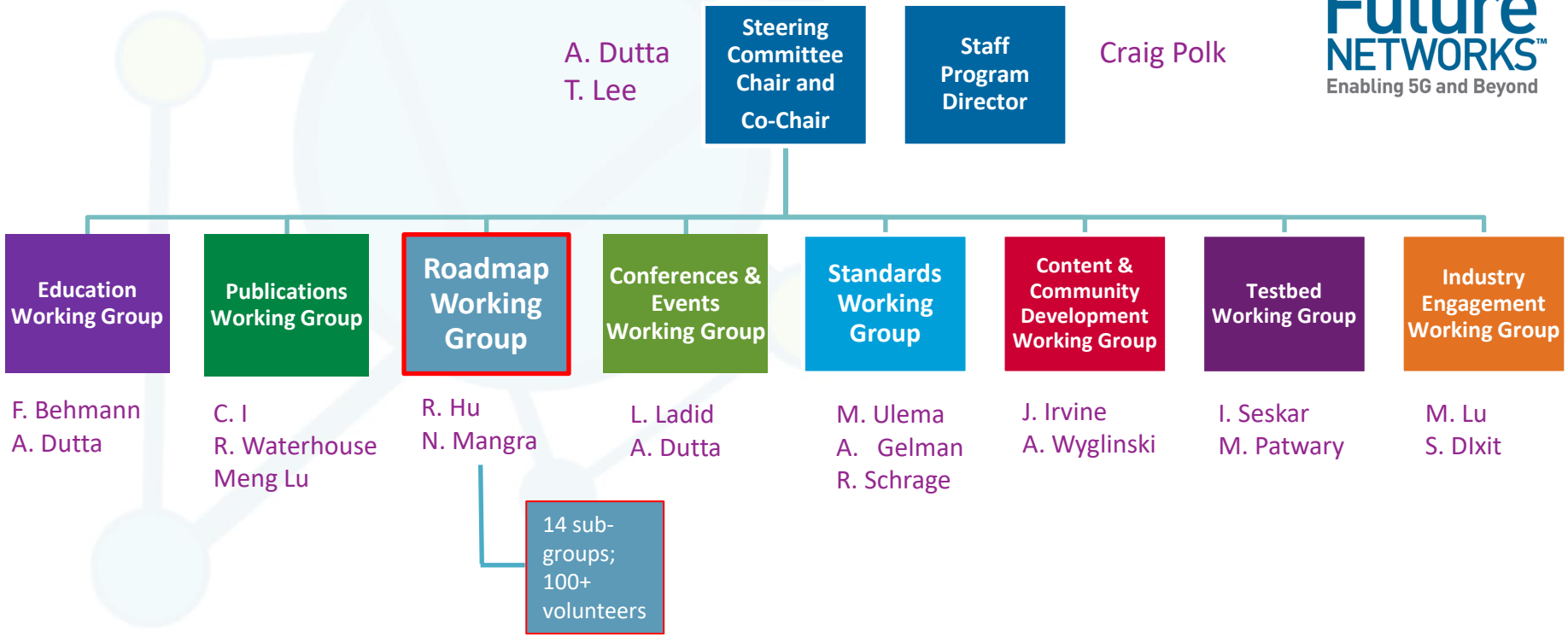
+ more!

Research & Education

IEEE INGR International Network Generations Roadmap

+ eLearning, webinar series, white papers, tutorials

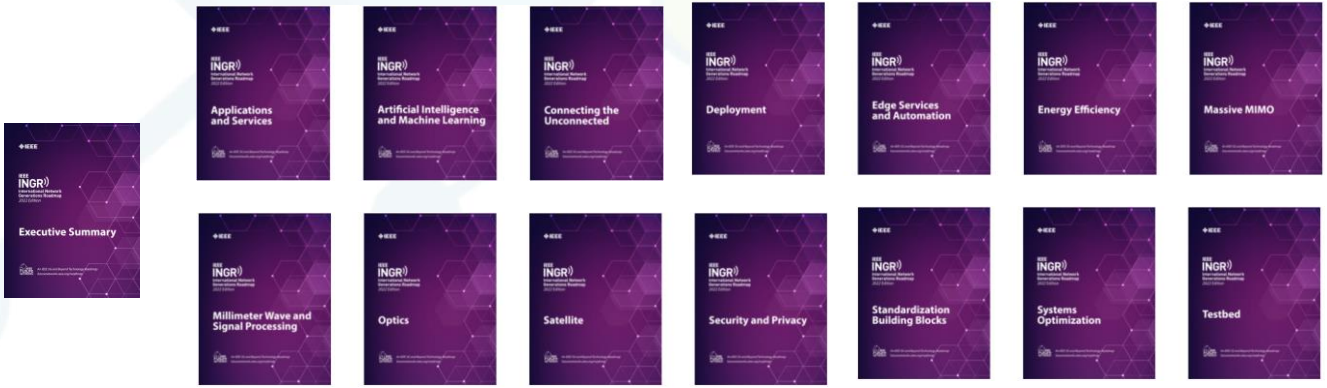
IEEE Future Networks Organization Structure



IEEE INGR Structure and Working Groups

CATEGORY	DESCRIPTION	INGR WORKING GROUP CHAPTERS
User Access	This group describes how the users reach the network	• Satellites • Deployment • Connecting the Unconnected (CTU)
Network Components and Performance	This group describes how the networks are interconnected	• Edge Automation Platform • Massive MIMO • System Optimization • Optics • mmWave
Systems and Standards	This group describes system standards and testability	• Standardization Building Blocks • Testbed • Energy Efficiency
Services and Enablers	This group represents all the elements that enable deployment, assure functionality and security and address impact on society and environment	• Security • Applications and Services • Artificial Intelligence and Machine Learning (AI/ML)

14 INGR Technical Working Groups



https://futurenetworks.ieee.org/roadmap

IEEE Future Networks™ WORLD FORUM • 2023

13–15 November 2023 // Baltimore, MD, USA

Call for Papers and Proposals

IMAGINING THE NETWORK OF THE FUTURE

Submission Deadline: 25 September (FINAL)

PATRONS

TII Technology Innovation Institute

Google

Johns Hopkins Whiting School of Engineering

Financial Co-Sponsors

IEEE Antennas and Propagation Society

CAS IEEE Circuits and Systems Society

IEEE ComSoc IEEE Communications Society

IEEE Electronics Packaging Society

ITSS IEEE Intelligent Transportation Systems Society

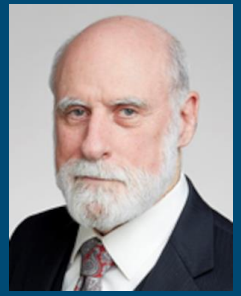
MTT-S IEEE Microwave Theory & Technology Society

IEEE Reliability Society

SSCS IEEE Solid-State Circuits Society IC Innovation

IEEE VTS Connecting the Mobile World

KEYNOTE SPEAKERS



VINT CERF
VICE PRESIDENT &
CHIEF INTERNET
EVANGELIST
GOOGLE

MÉROUANE
DEBBAH
TECHNOLOGY
INNOVATION
INSTITUTE, UAE

NADA GOLMIE
NATIONAL
INSTITUTE OF
STANDARDS AND
TECHNOLOGY
(NIST), USA

THYAGA
NANDAGOPAL
NATIONAL
SCIENCE
FOUNDATION
(NSF), USA

SAIFUR
RAHMAN
2023 IEEE
PRESIDENT &
CEO

KHALED B. LETAIEF,
NEW BRIGHT
PROFESSOR OF
ENGINEERING AND
CHAIR
PROFESSOR, HKUST
, HONG KONG

REGISTRATION

https://fnwf2023.ieee.org/registration

Prof Mischa Dohler

Mischa Dohler is VP Emerging Technologies at Ericsson Inc. in Silicon Valley, working on cutting-edge topics of 6G, Metaverse, XR, Quantum and Blockchain. He serves on the Technical Advisory Committee of the FCC and on the Spectrum Advisory Board of Ofcom.

He is a Fellow of the IEEE, the Royal Academy of Engineering, the Royal Society of Arts (RSA), the Institution of Engineering and Technology (IET); and a Distinguished Member of Harvard Square Leaders Excellence. He is a serial entrepreneur with 5 companies; composer & pianist with 5 albums on Spotify/iTunes; and fluent in several languages. He has had ample coverage by national and international press and media and is featured on Amazon Prime.

Supercharge 6G with AAA

Prof Mischa Dohler

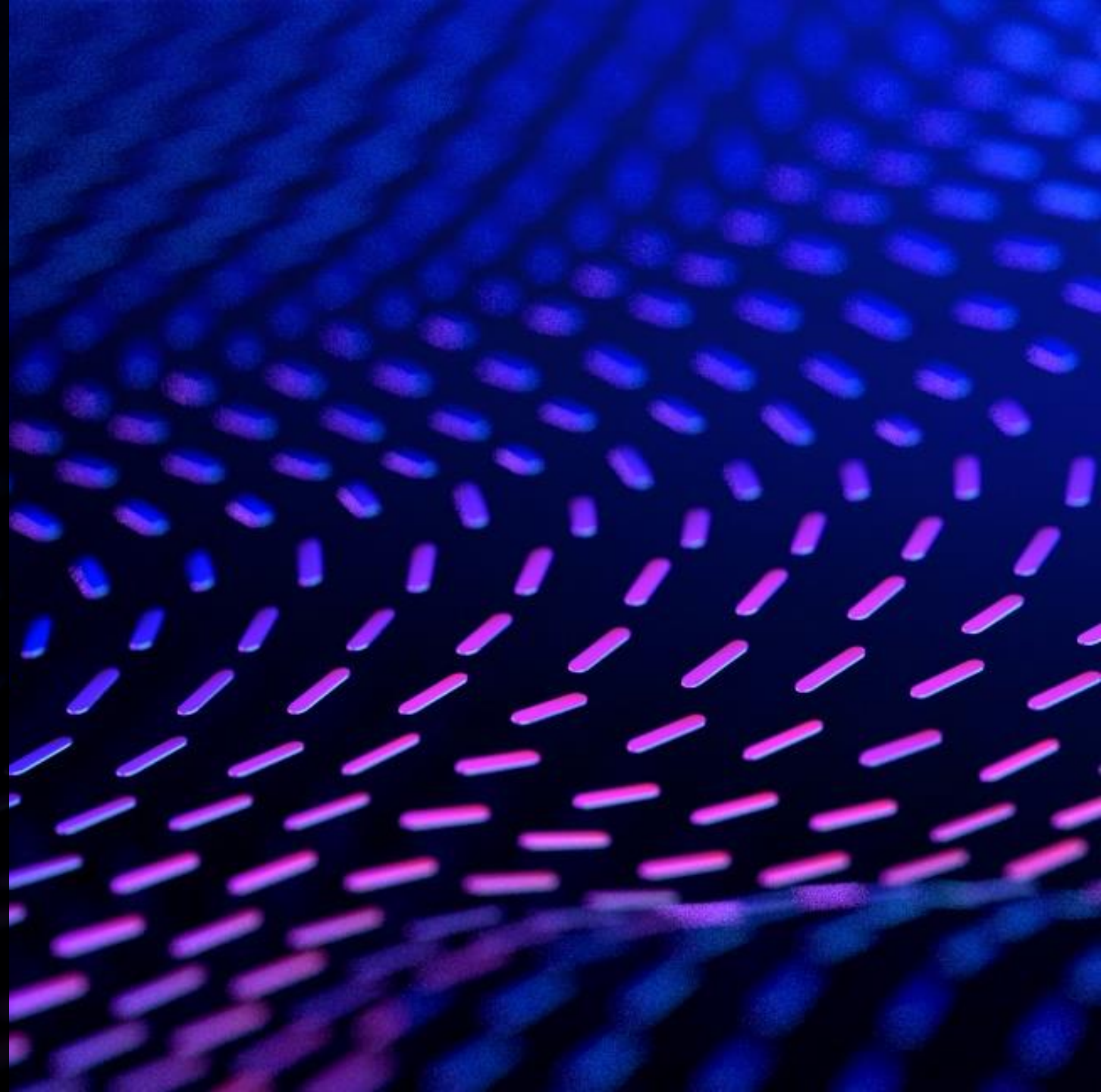
Fellow IEEE, Fellow Royal Academy of Engineering, Fellow Royal Society of the Arts

VP Emerging Tech, Ericsson Inc, Silicon Valley

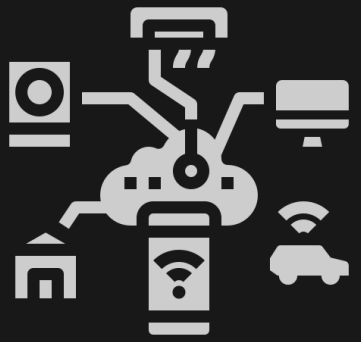
Advisory Board, FCC (TAC) & Ofcom (Spectrum)

Visiting Professor, King's College London

Sept 2023



Let's Get The Roadmap Right!



Human-Centric Internet
"Internet of Skills"

Immersive Internet
"Metaverse"

Things Internet
"Internet of Things"

Mobile Internet

Fixed Internet

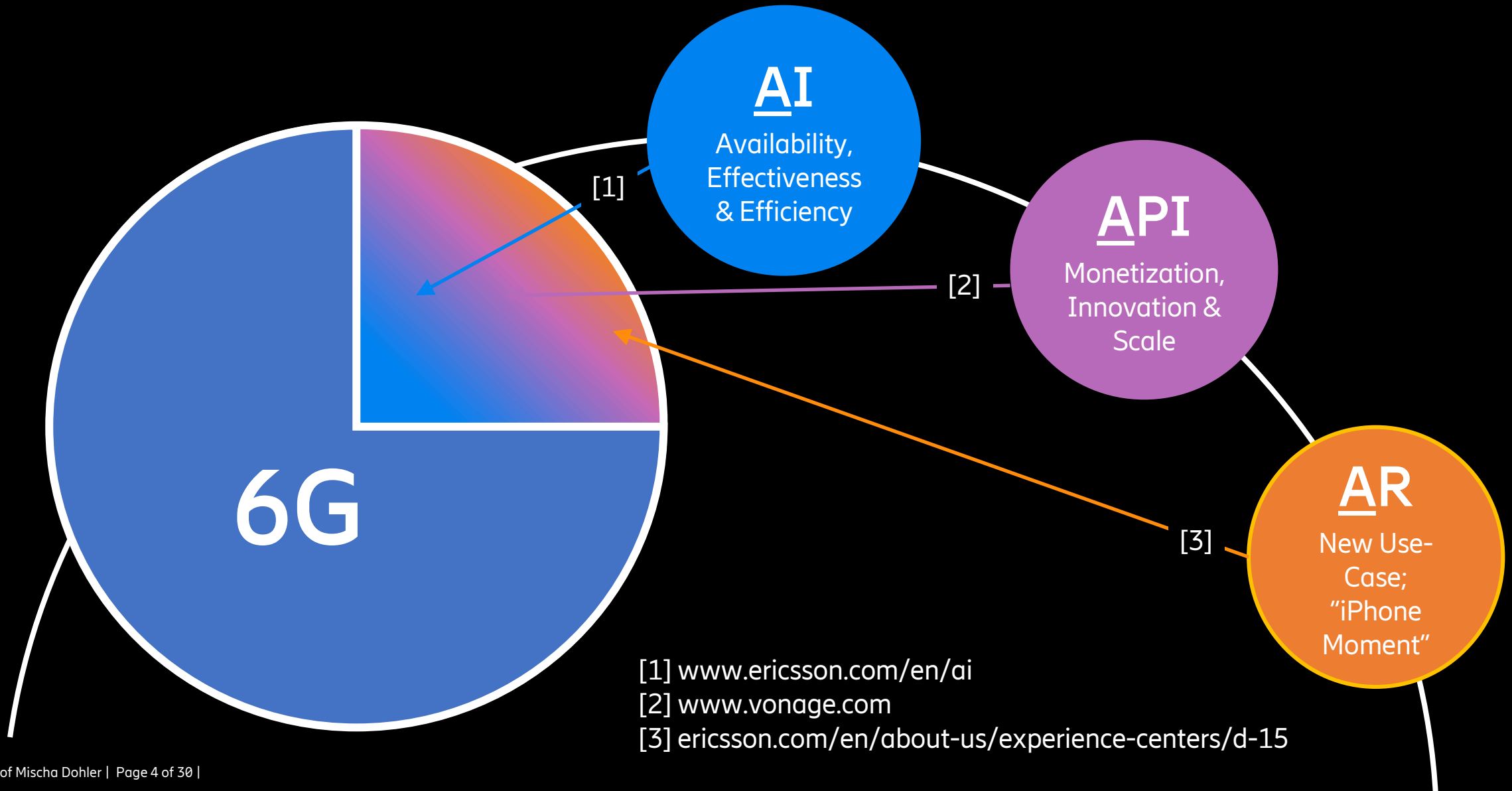
Machine-Centric Internet
"Singularity"

Where Do We Want To Be In 2030?

Possible 6G Use-Cases:

- **"Holographic Society"** and Merged Realities
- **Massive Digital Twinning** and JCAS
- **Situational Awareness** and Reprogramming of Cyber-Physical Worlds
- Efficient and Pervasive **Mobile Broadband**
- **Sustainability** and e-Health

Supercharge 6G With «AAA»



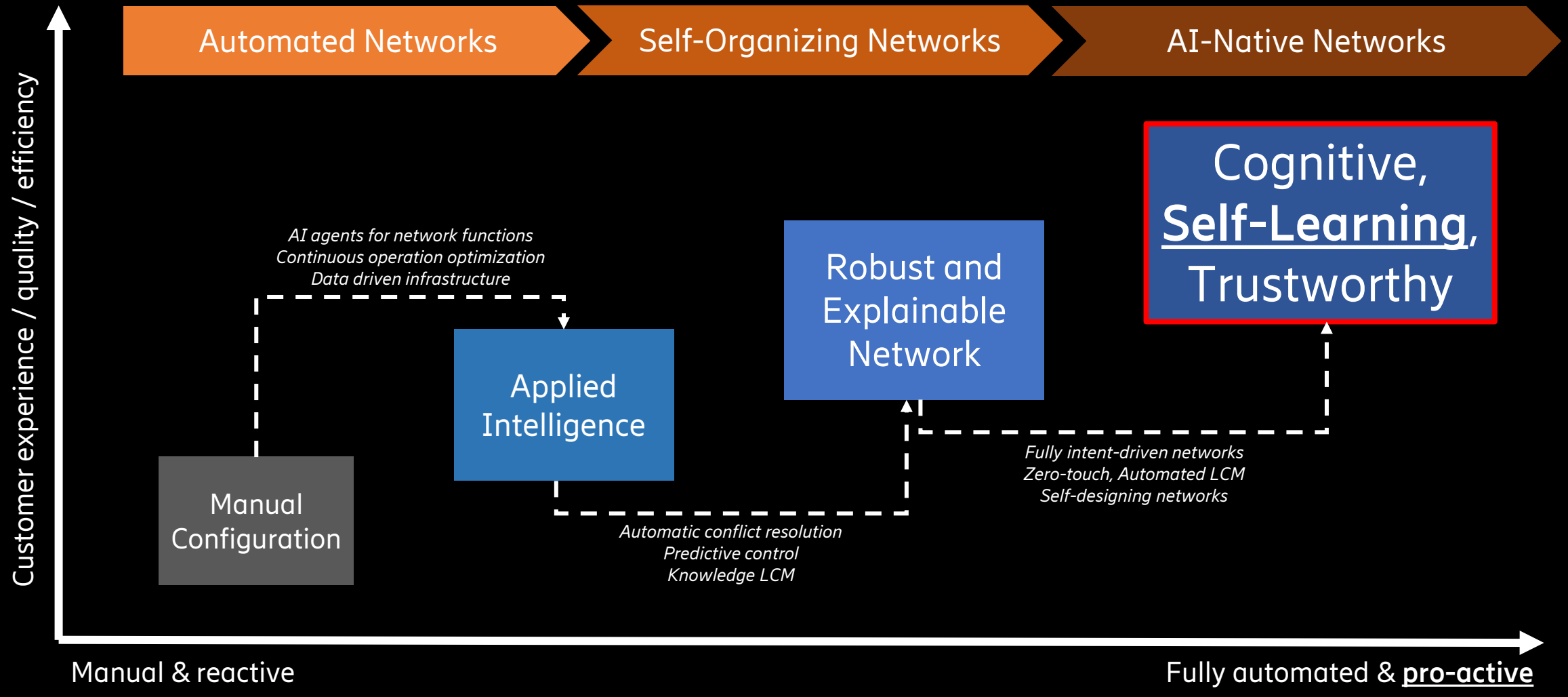
[1] www.ericsson.com/en/ai
[2] www.vonage.com
[3] ericsson.com/en/about-us/experience-centers/d-15

01
AI in 6G Networks

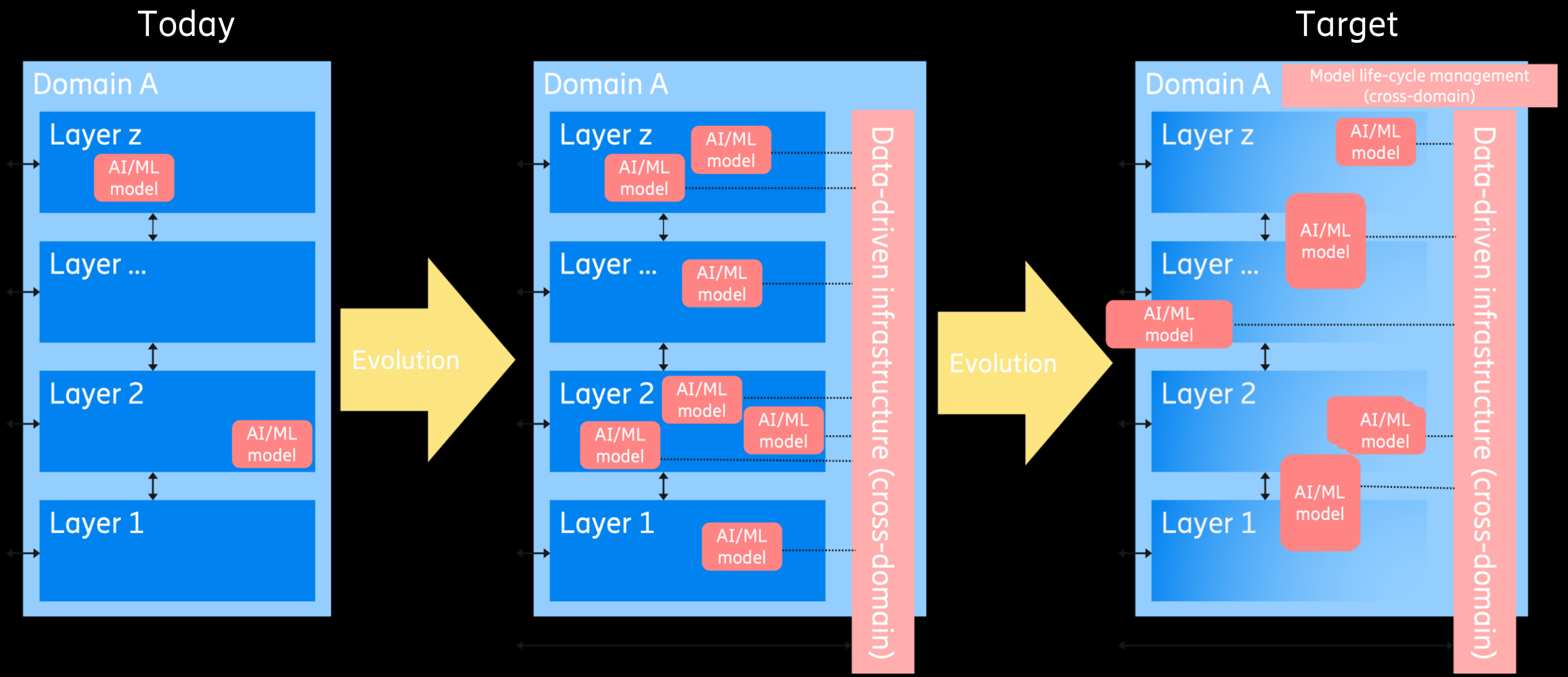
An overview of Artificial Intelligence in 6G Networks, across OSI Layers and operations.

Roadmap Towards Native-AI 6G Networks

"AI moves fast, which means incumbents don't have a big advantage over new-joiners," Jason W., 2023.

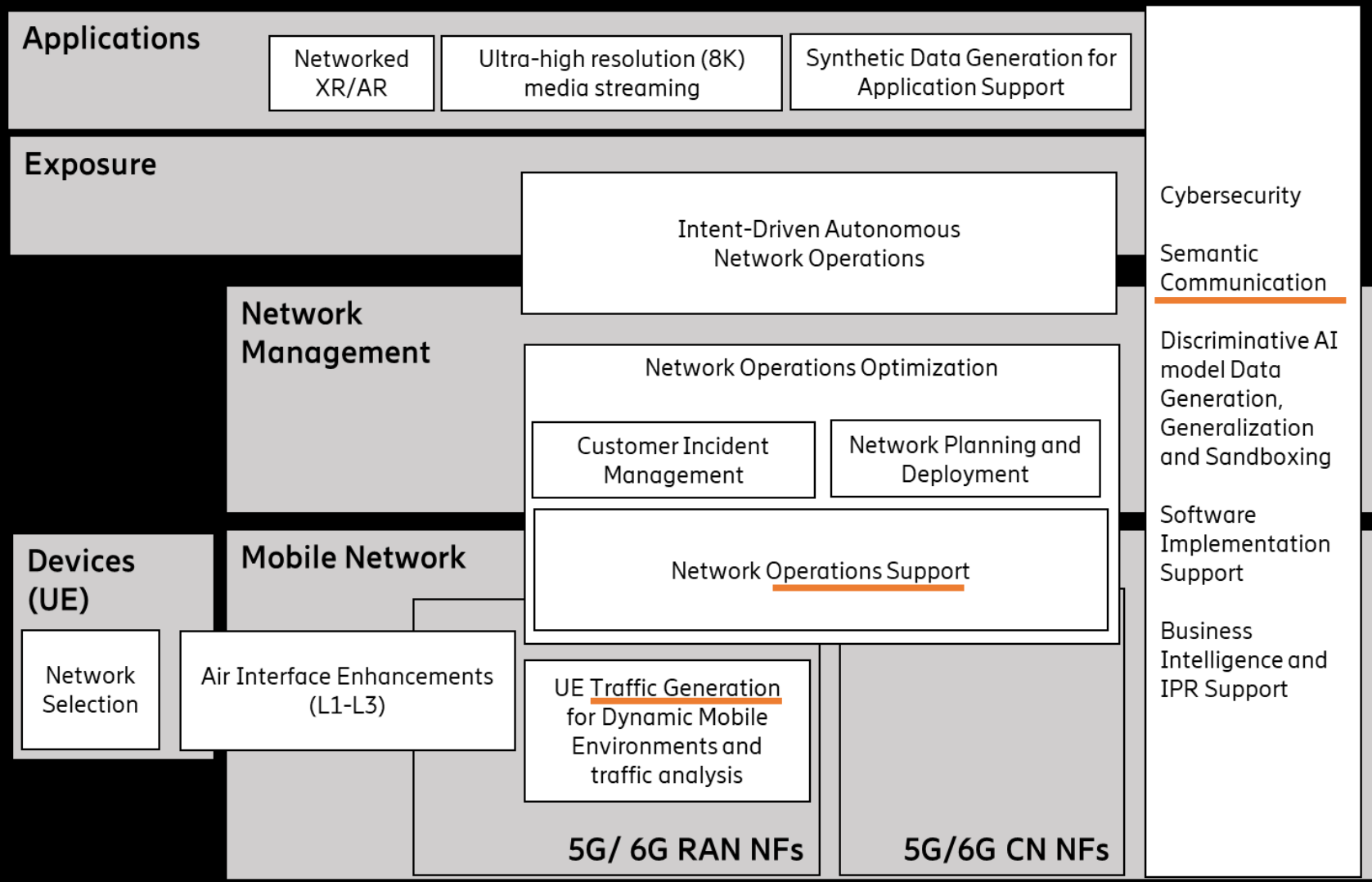


Towards Native-AI 6G Protocol Stack



Generative AI In 6G Systems

A. Karapantelakis, et al. "Generative AI in mobile networks: a survey," Annals of Telecoms, July 2023

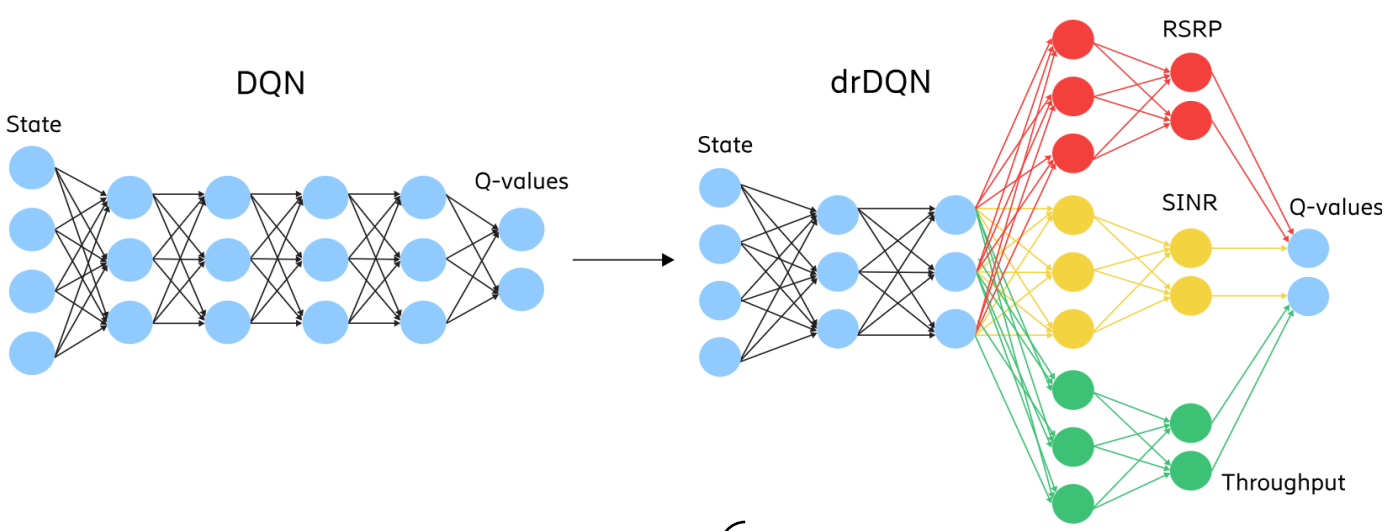


Generative AI Taxonomy:

- Explicit Density Function (RNN)
- Implicit Density Function (GAN)
- No Density Fct / Attention (LLM)

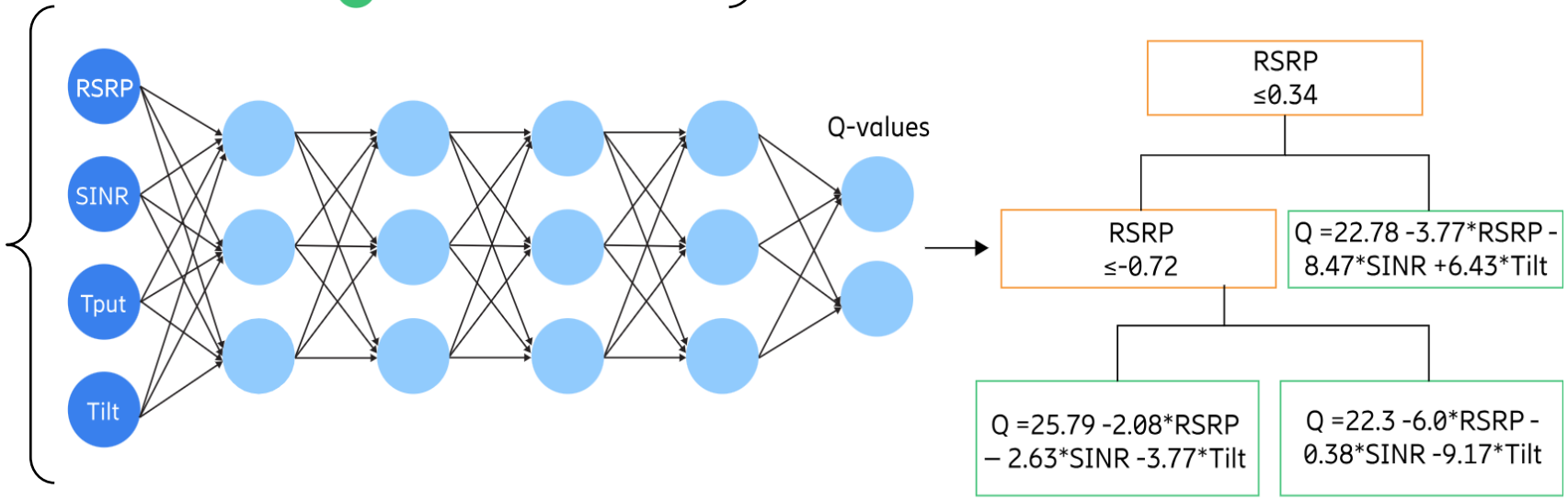
Trustworthy AI In 6G Systems

https://www.ericsson.com/en/reports-and-papers/white-papers/trustworthy-ai



- Reinforcement Learning (RL) -> Q-Learning -> Deep Q-Networks (DQN) -> decomposed reward DQN (drDQN)
- No performance loss, transparent, user-interpretable and thus trustworthy

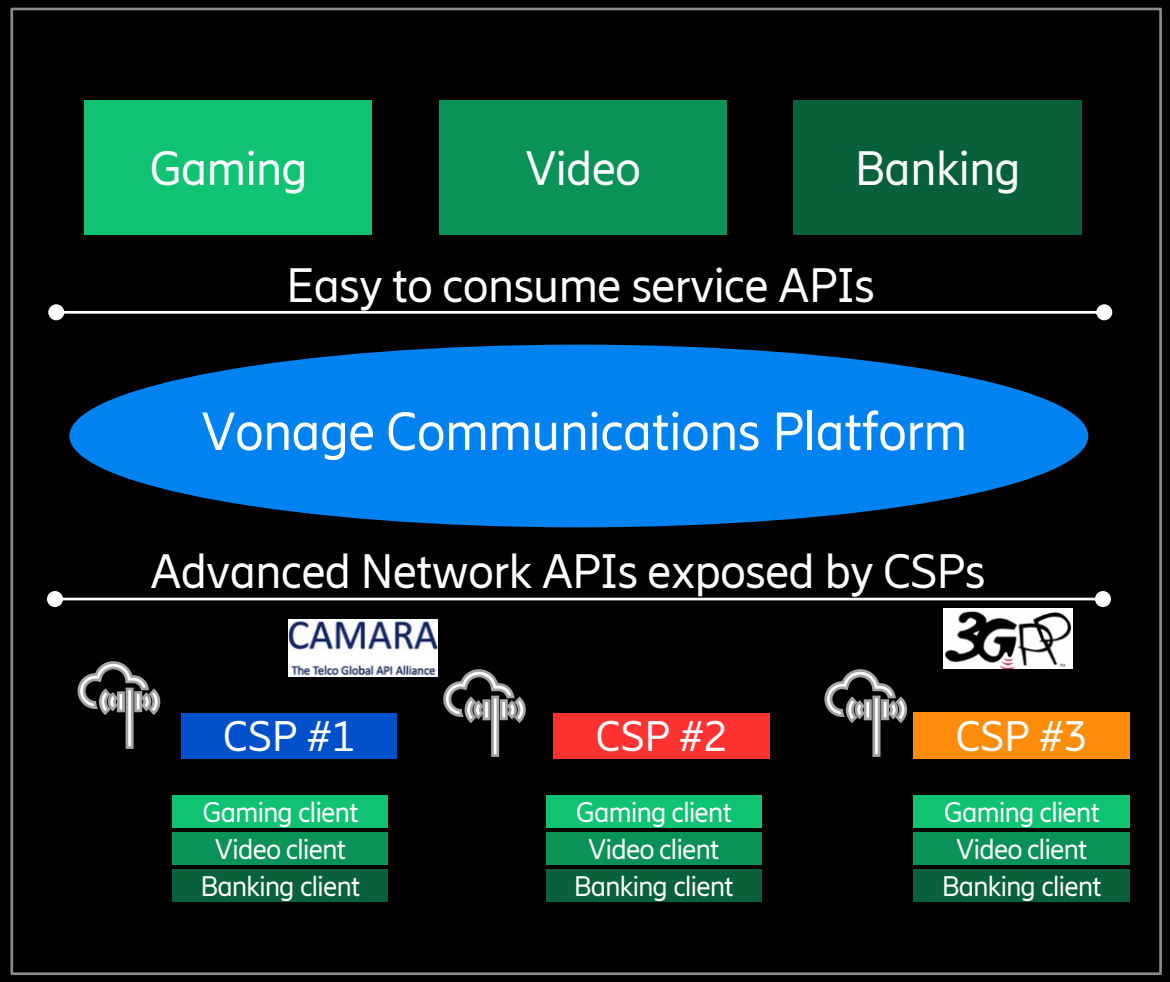
- Linear Model U-Tree (LMUT) distils a decision model from a trained agent by transferring the neural network (NN) to a linear decision tree
- No performance loss, transparent but less than drQDN



02
API in Future Networks

An overview of APIs in 5G SA & Beyond Networks
and their value towards monetization in telecoms.

Opening Up Telco Networks To App Devs



- Making it easy for developers to use and bundle API services in 5G SA & Beyond
- Exposing communication services and new advanced network functionality through easy-to-use APIs
- Enable native monetization in telco networks

Communication & Network APIs

Communications APIs

Voice · SMS · Video · Auth · IP Chat

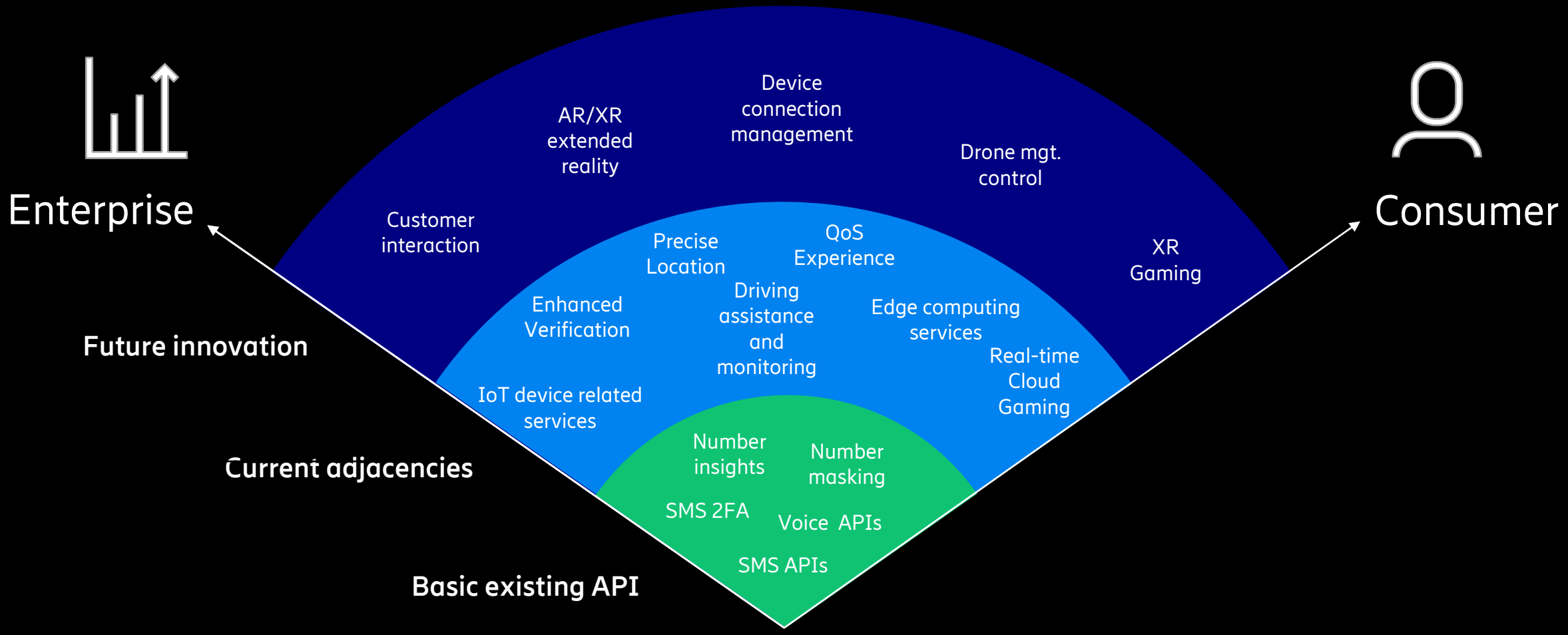
Network APIs

QoS · Silent Auth · Location · Device Data · More to come ...

High speed & Low latency · Reliability · Wireless edge solutions · Security · Network slicing

Worldwide 5G and future 6G networks

Enabling Native Monetization In Telecoms



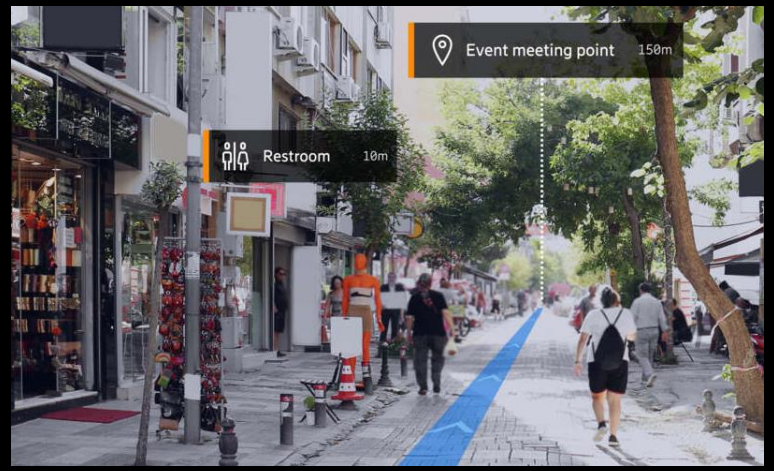
03
AR in Future Networks

An overview of AR in 5G SA & Beyond Networks
and their value as a unique 6G use-case.

Our AR Predictions In The 5G & 6G Era

VR to AR
2023 - 2025

Blended information



AR takes lead
2025 - 2027

Spatial anchoring

All day XR
2027 - 2030

Fully immersive

Likely scenario development:

- VR/MR, simple AR
- Static, on device, tethered
- Starts with local deployments

- 5G-native AR takes lead
- Local → wide area networks
- >1m users per AR app

- Global adoption with >1bn users
- Stand-alone, cloud, multi-user
- Privacy will be key

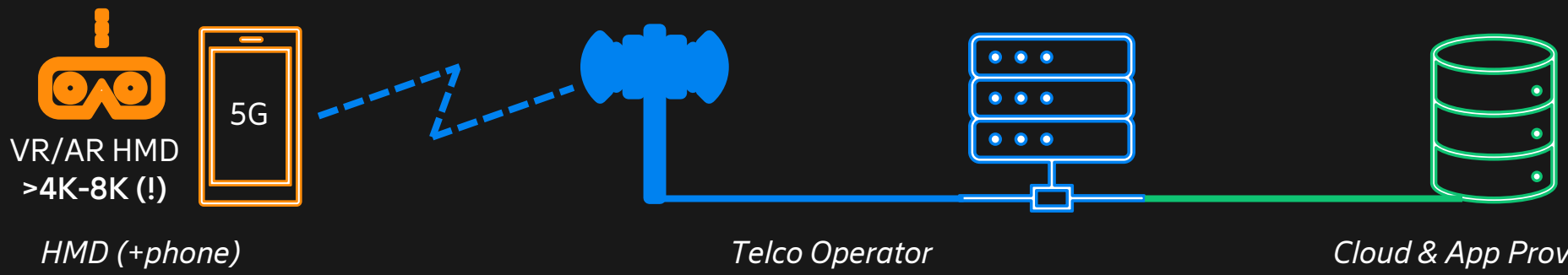
Ericsson's 5G "Holotaring" AR Prototype

© Ant Reality @ AWE2023

© Vuzix @ MWC2023

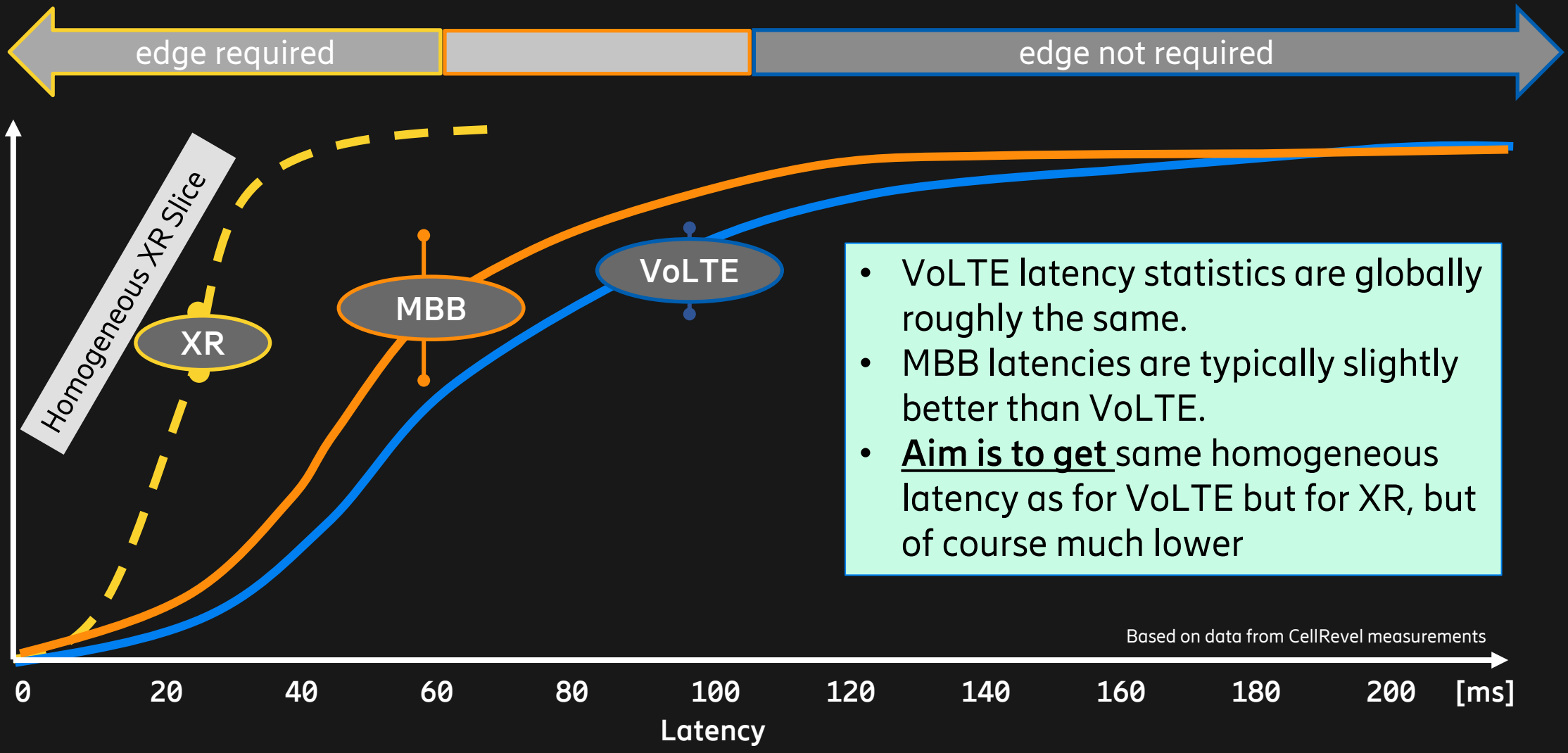
Imagine Live Kick Off 2022 – Ericsson, MWC 2022 & 2023

Tech Innovation: Edge-Cloud Rendered AR



	Device-Rendered Content	MEC-Rendered Content
GPU	<1 W processing power	350 W
Memory	Limited	Unlimited
Battery	Significant Drain	2x-7x Saving
Connectivity	MBB 10kbps-1MBps	TCC 0.1-10s Mbps & 10-40ms RTT & 3ms jitter

Native "E2E System Low Latency" In 6G



- VoLTE latency statistics are globally roughly the same.
- MBB latencies are typically slightly better than VoLTE.
- **Aim is to get** same homogeneous latency as for VoLTE but for XR, but of course much lower

04
6G Technologies

An overview of underpinning 6G technologies and architecture approach.

Ericsson's 6G Technology Focus

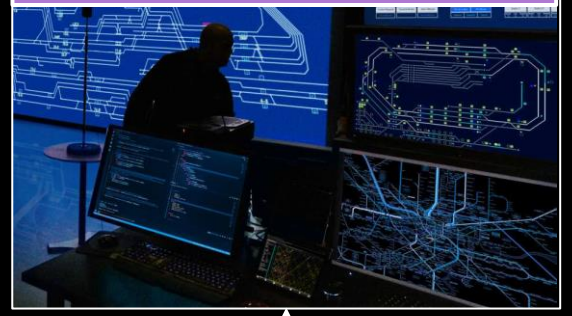
Nov 2022 Blog: Why it's a great time to start talking 6G – Ericsson
Feb 2023 Blog: Nine takeaways from early 6G research - Ericsson

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

Limitless connectivity

Make dev & app centric for strong business case.

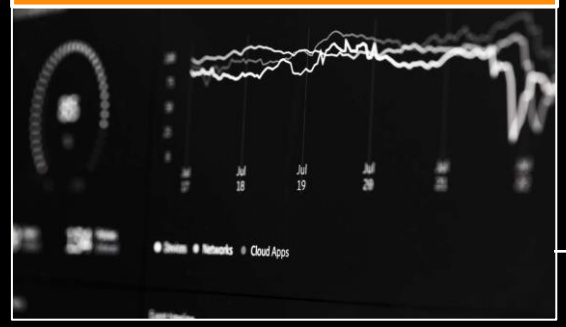
Cognitive network



Ensure that system & AI "behave properly".

Ensure that 6G use-cases can be supported!

Network compute fabric



Ensure that 6G system can be scaled.

Trustworthy Systems

Multi-Layer Spectrum In 6G

Sub-Terahertz (90..300 GHz): Complimentary spectrum for extreme performance in very local areas

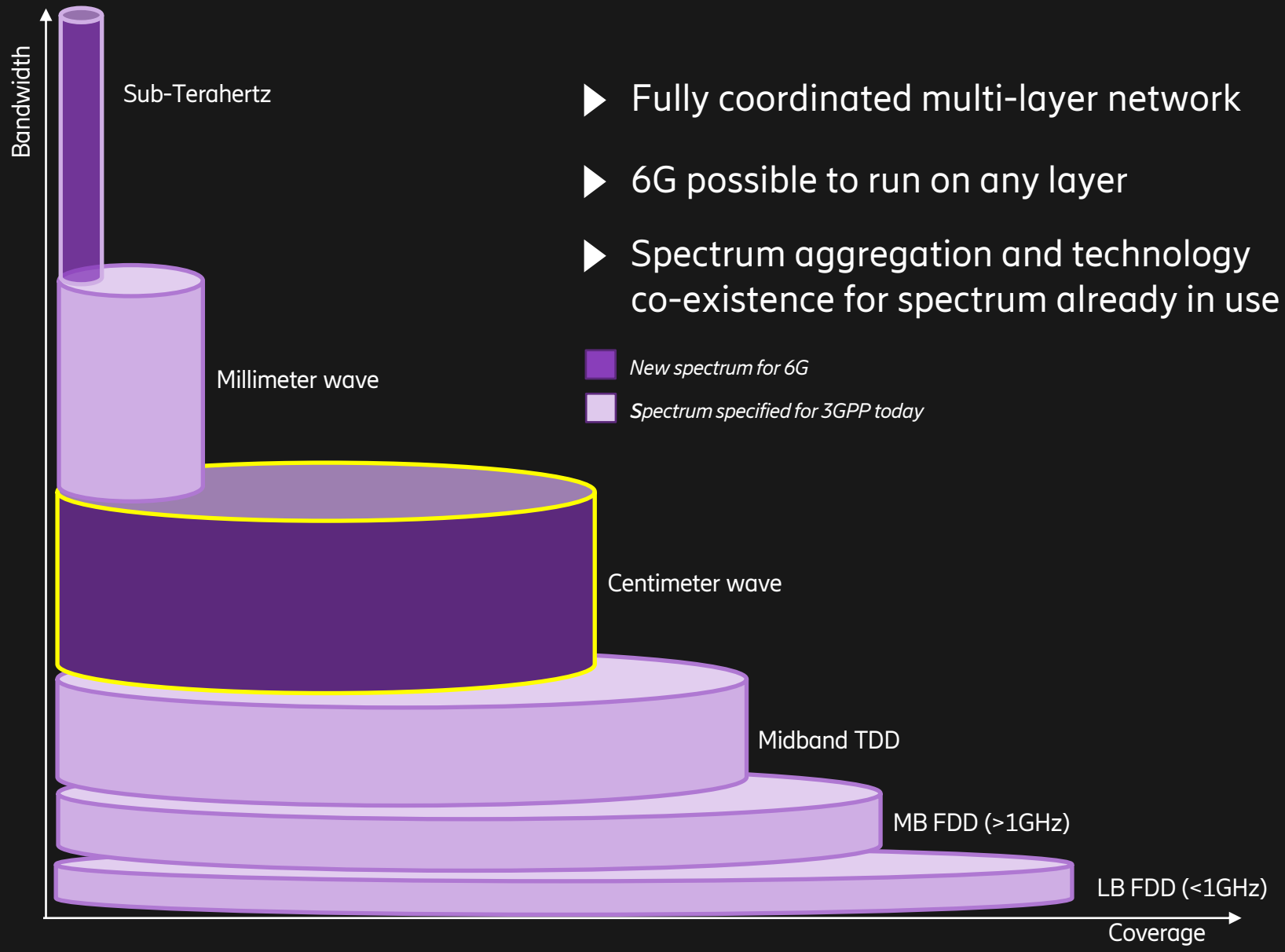
mmWave (24...47 GHz): High-speed, very low latency in local areas

Centimeter (7...15GHz): Essential spectrum **for 6G,** good coverage and capacity (the lower , the better)

Midband TDD (2.3...7 GHz): The "Sweetspot" – Wide area coverage and good capacity

FDD (1.. 2.7 GHz): Nationwide coverage and indoor penetration

FDD (<1 GHz): Nationwide coverage and deep indoor penetration



- Fully coordinated multi-layer network
- 6G possible to run on any layer
- Spectrum aggregation and technology co-existence for spectrum already in use

New spectrum for 6G

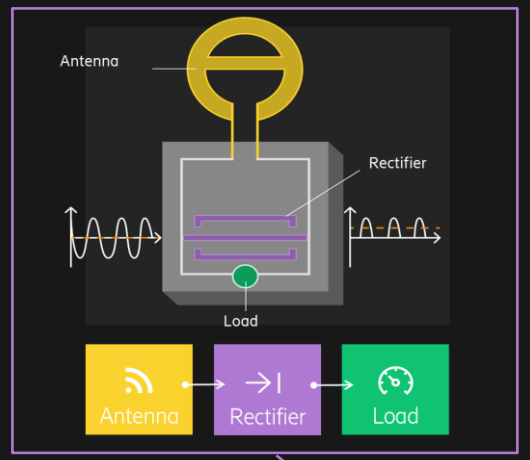
Spectrum specified for 3GPP today

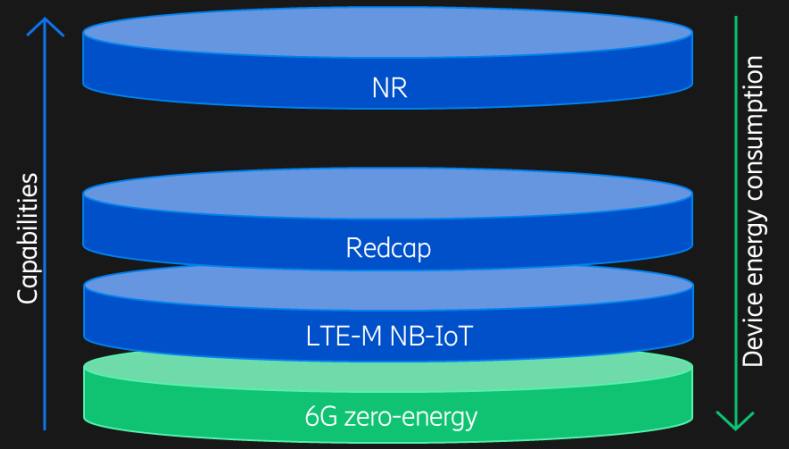
6G Coverage & Capacity Comparison

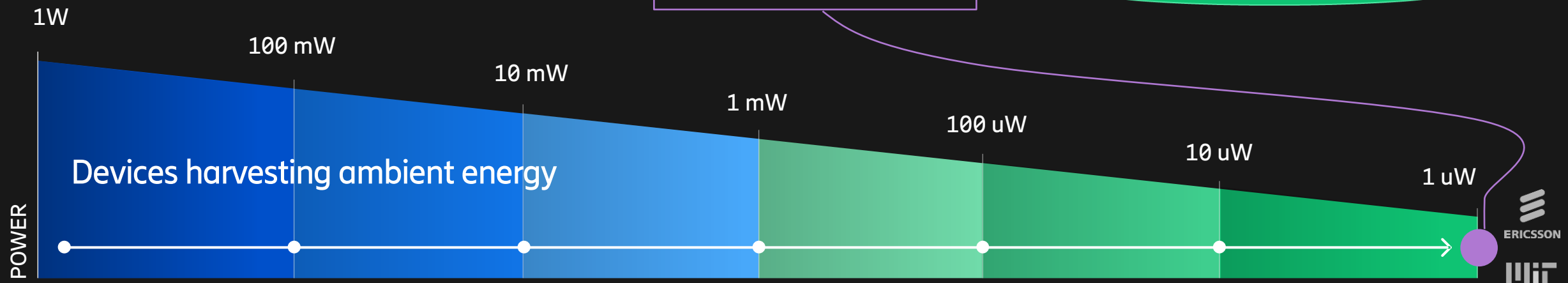
Essential centimeter wave

Complementary sub-THz

6G Zero-Energy Devices







Solar panel

Vibration (trains, heavy machinery)

Small turbines

Small thermoelectric generator

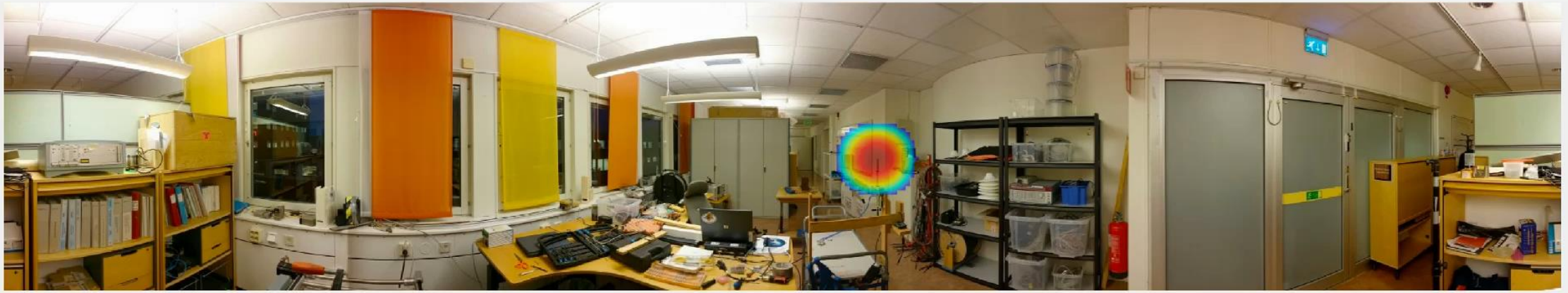
Indoor light

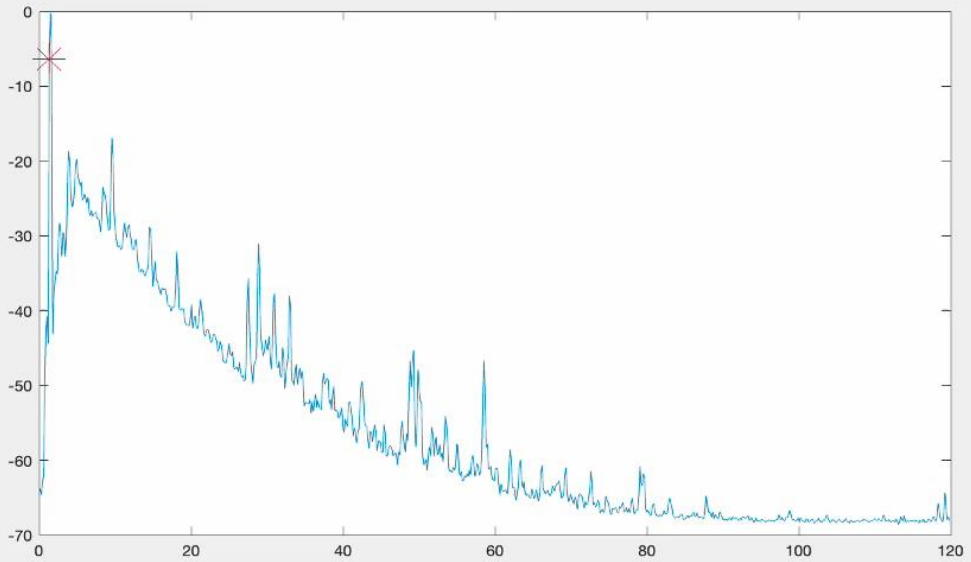
Wireless charger (a few meters)

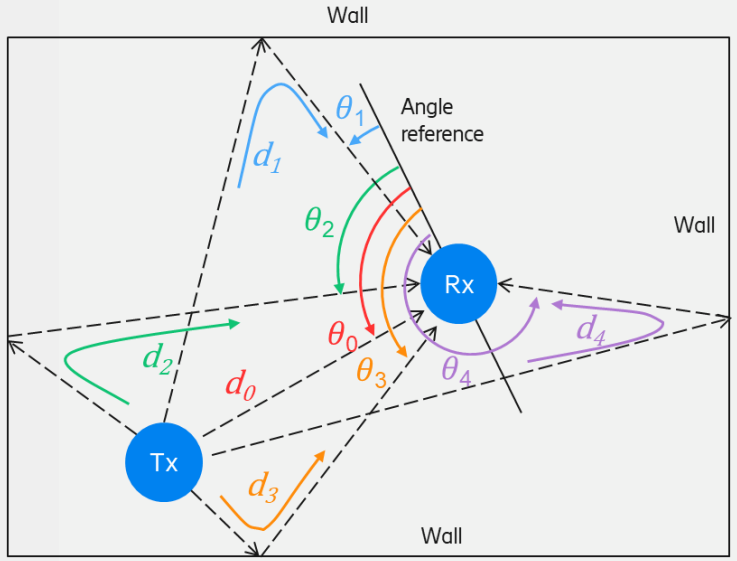
Acoustic noise

Radio energy

6G Joint Communications & Sensing (JCAS)



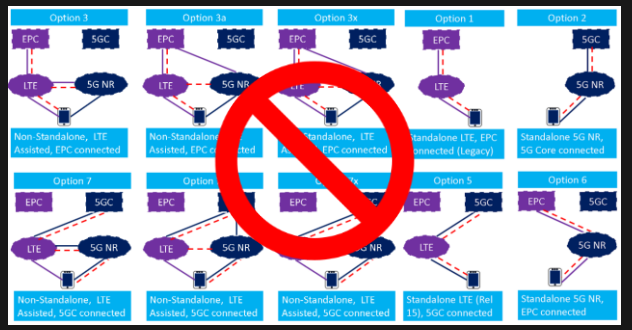




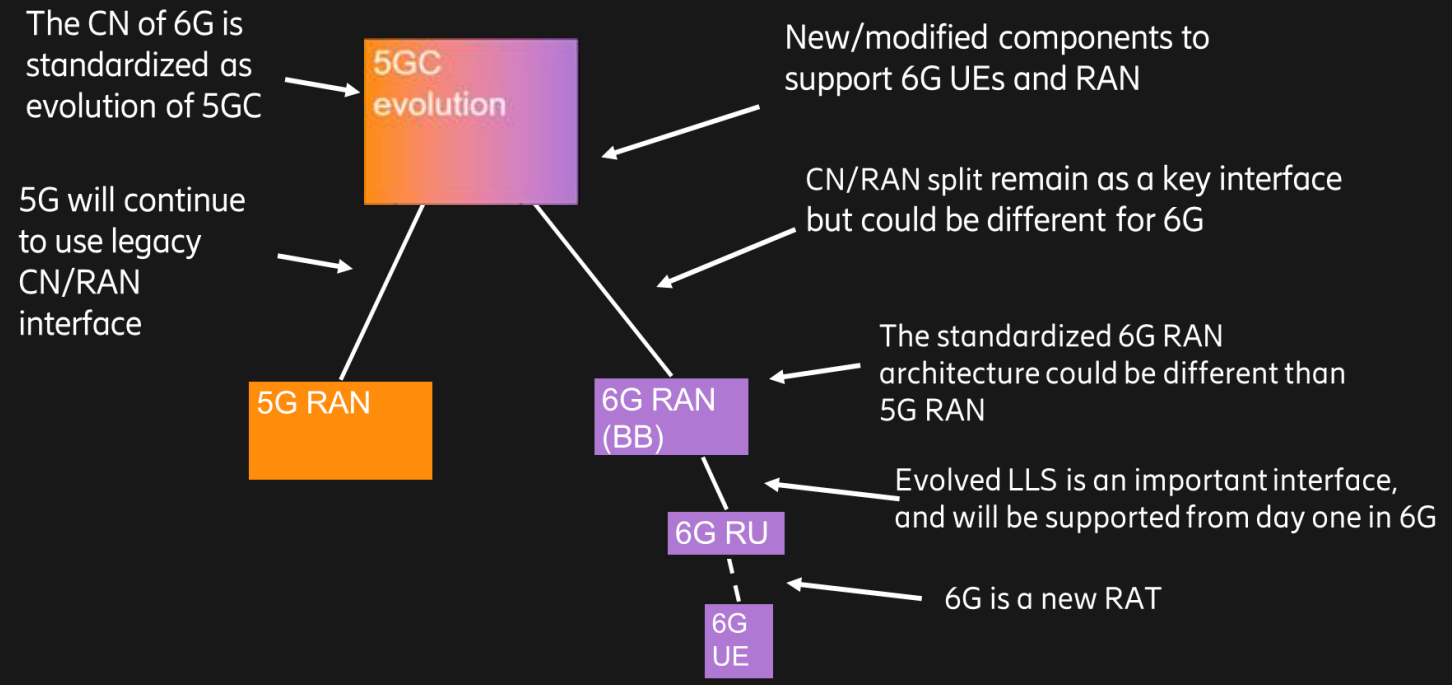
- Every peak channel impulse response = f{distance & angle}
- Frequency: 60 GHz
- Bandwidth: 2 GHz
- Number of antennas 25x25 = 625
- Antenna spacing: 0.4 λ
- Distance between Tx and Rx: 1.5m

Overall 6G Architecture Approach

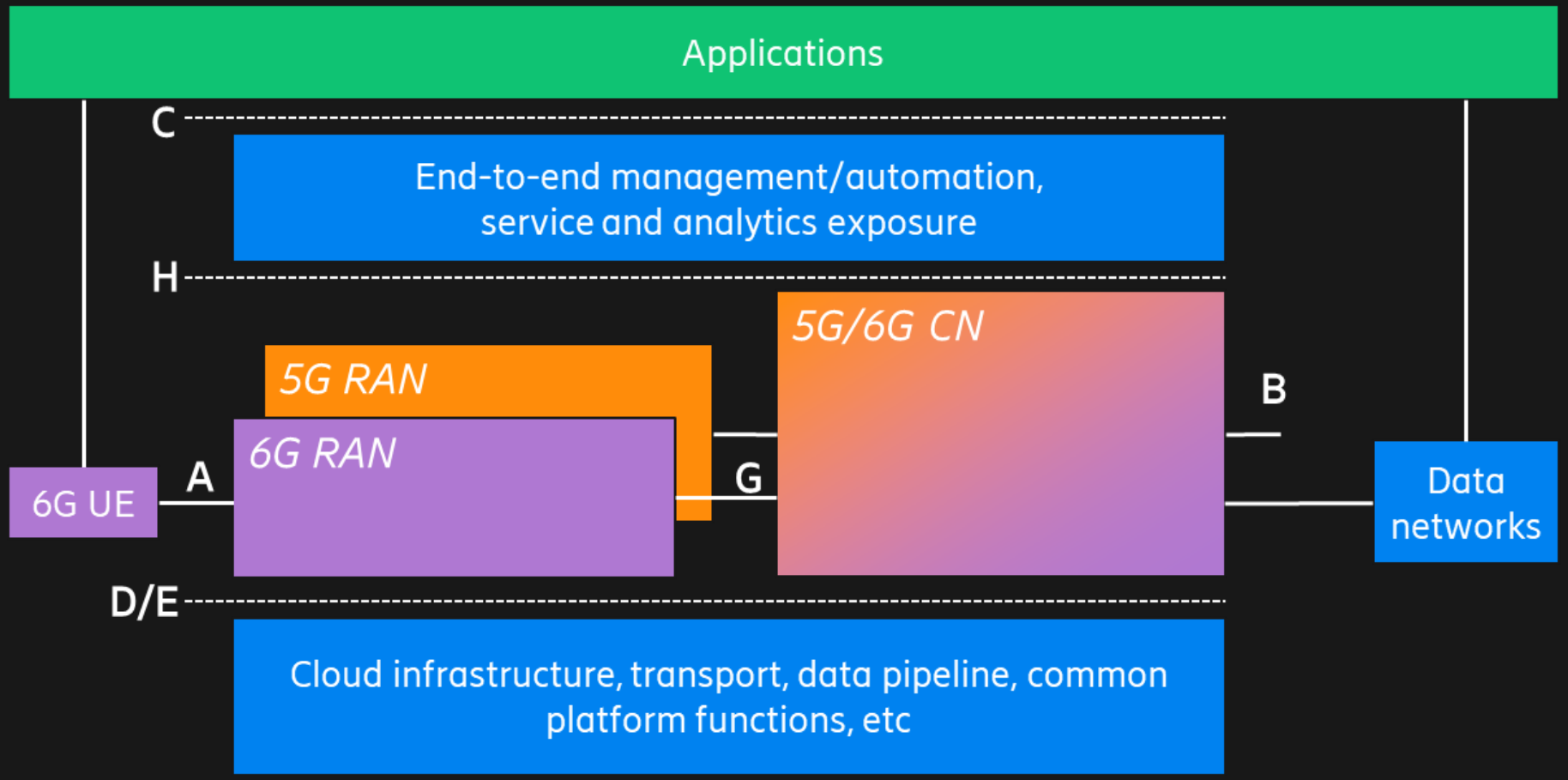
- Alignment within industry on key migration path prior to start of standardization
- Enable fast deployment of SA 6G by avoiding unnecessary deployment options



- Aim to simplify the 6G architecture, by aligning industry on key interfaces for standardization
- Reuse investment in 5GC, allowing smoother 6G introduction, and alignment of migration paths



Network Horizontalization Central To 6G



- Native separation of NFs from underlying platform, and overlaying management and exposure
- Beneficial to the continuous evolution of underlying platform technologies (from IT eco-system)

6G Testbed Proof-Points

Sub-THz 6G Communications


6G Digital Twin


Zero-Energy Joint Sensing-Comms


Centimetric 6G Communications

05
Concluding Remarks

A non-exhaustive summary of key findings towards a successful implementation of 6G.

Summary of (Some) Gaps Towards 6G

6G Architecture & Overall Approach:

* Embrace new capabilities yet simplify 6G architecture & deployment options
* Supercharge 6G with AAA, i.e. AI, API and AR

AI – Artificial Intelligence:

* Develop methodologies & standards towards interoperable AI
* Significantly expand R&D and standards on Trustworthy AI

API – Application Protocol Interface:

* Expand Beyond-5G architecture work to natively include horizontal architecture
* Natively embed monetization capabilities into 6G via APIs

AR – Augmented Reality:

* Make a big bet on a next "iPhone moment"; ensure e2e design on all what this use-case needs
* Ensure consistent QoE, through consistent RAN, CN and E2E MECs

ericsson.com/future-technologies

UPCOMING EVENTS

20 September

21-22 September

IEEE Future Networks

Be connected to IEEE Future Networks to shape future network requirements

Get monthly updates on technical workshops, summits, webinars, podcasts, and call for proposals, papers, and volunteer opportunities

Thousands are already members

Join today: bit.ly/fntc-join