Ever-present intelligent communication - Taking 5G to 6G

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- The Internet of Senses
- Connected intelligent machines
- Digitalized & programmable physical world
- Sustainable world
- Limitless connectivity
- Trustworthy systems
- Cognitive network
- Network compute fabric
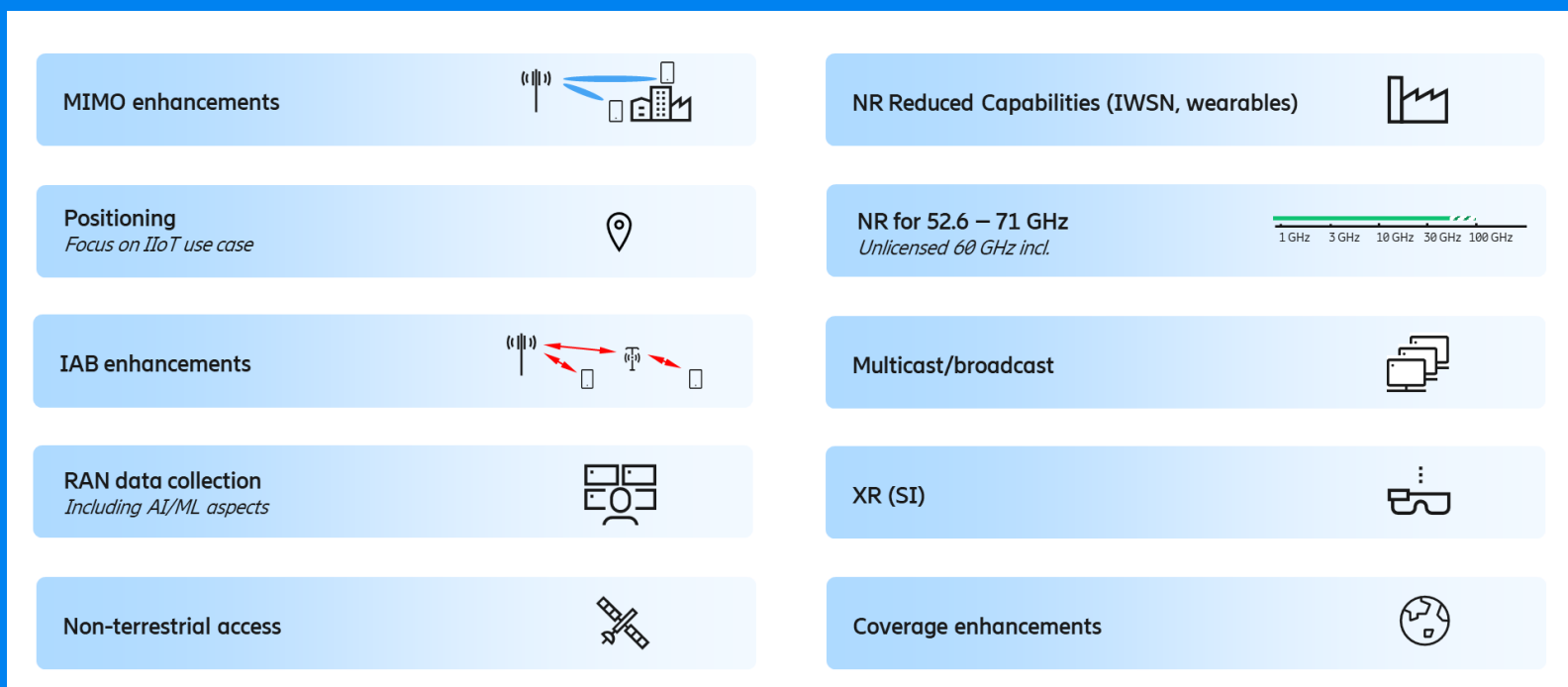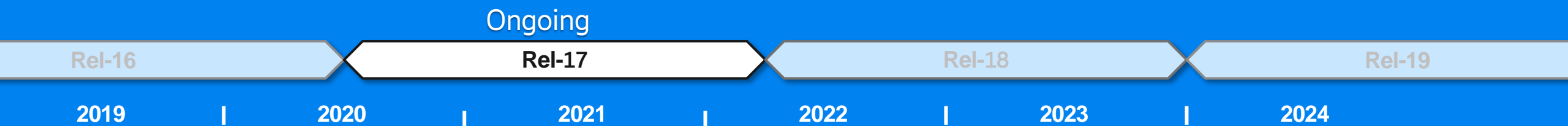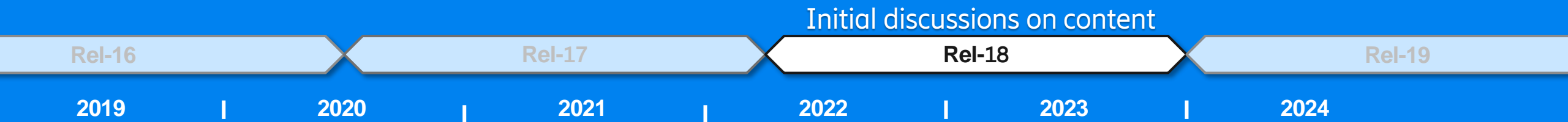
Agenda

- 5G Evolution – short overview

- Positioning 6G
  - Drivers and trends

- 6G use case scenarios

- The 6G network platform
  - Needed capabilities
  - Technology scenarios

- 6G worldwide
  - Tentative timeline
  - 6G initiatives around the world

- Summary

5G Evolution – short overview

5G

Rel-16	Rel-17	Rel-18	Rel-19

2019 — 2020 — 2021 — 2022 — 2023 — 2024

MIMO enhancements	NR Reduced Capabilities (IWSN, wearables)
Positioning *Focus on IIoT use case*	NR for 52.6 − 71 GHz *Unlicensed 60 GHz incl.*
	1 GHz 3 GHz 10 GHz 30 GHz 100 GHz
IAB enhancements	Multicast/broadcast
RAN data collection *Including AI/ML aspects*	XR (SI)
Non-terrestrial access	Coverage enhancements

Not complete scope

Rel-18: 5G Advanced

Initial discussions on content

Rel-16	Rel-17	**Rel-18**	Rel-19

| 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |

- *Content in Ericsson roadshow*

- massive MTC
  - Reduced Capabilty devices (RedCap)
  - RedCap Positioning
- time-critical communication
  - XR (AR/VR/cloud gaming)
  - URLLC/IIOT

- enhanced MBB
  - MIMO
  - Dynamic Spectrum Sharing
  - Network energy efficiency
- Public Safety
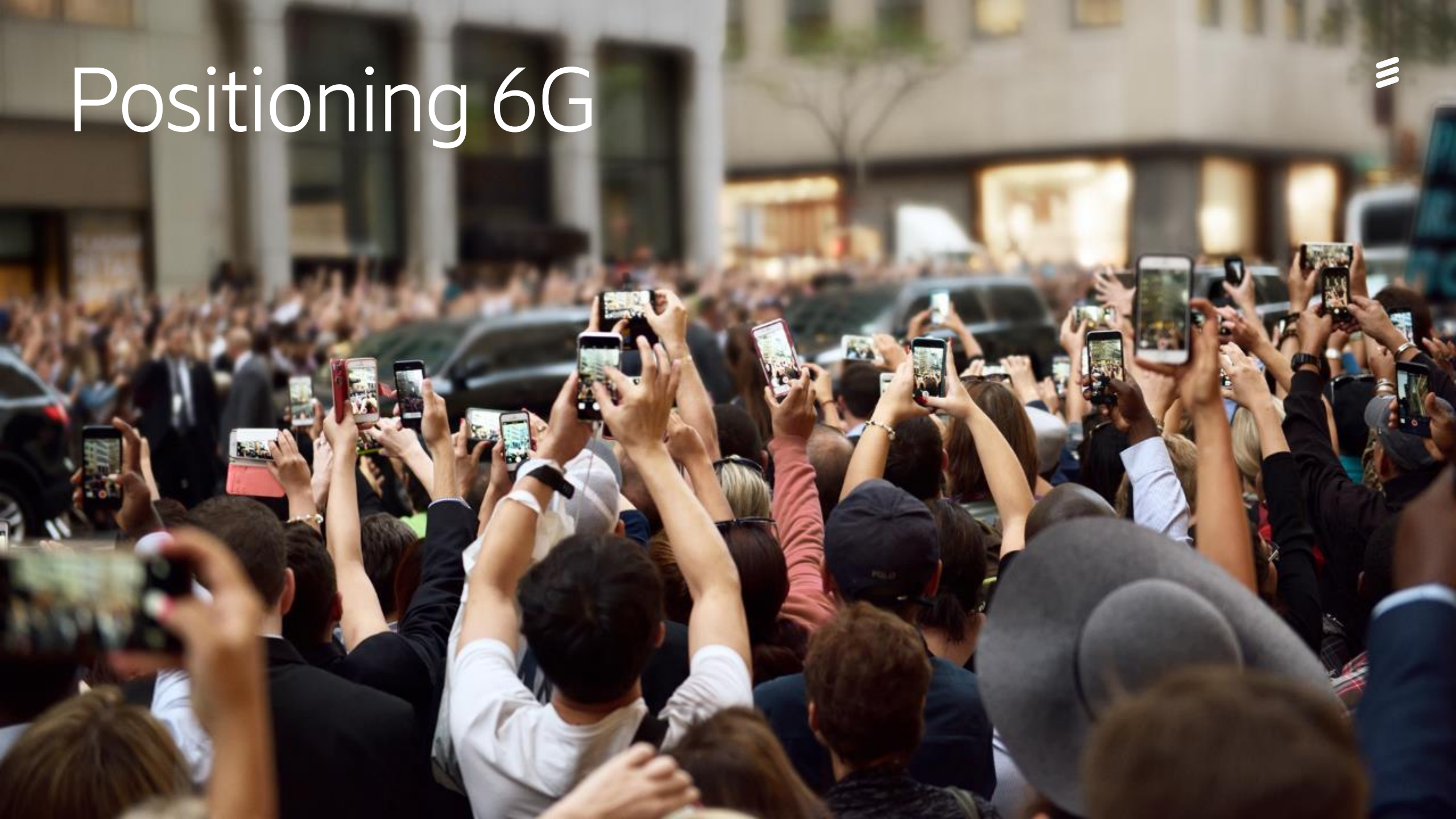 - Drones/UAV
  - Multicast/Broadcast
- cross-domain
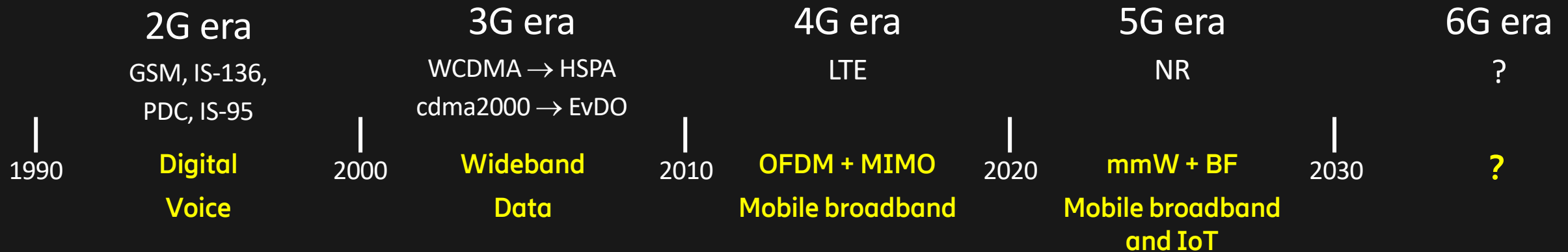 - Trustworthiness
  - AI/ML RAN enhancements

AI/ML for PHY is gaining momentum

Positioning 6G

What is 6G *wireless access*?

2G era		3G era		4G era		5G era		6G era
GSM, IS-136, PDC, IS-95		WCDMA → HSPA cdma2000 → EvDO		LTE		NR		?

1990		2000		2010		2020		2030	
Digital		**Wideband**		**OFDM + MIMO**		**mmW + BF**		**?**
Voice		**Data**		**Mobile broadband**		**Mobile broadband and IoT**		

Each generation typically associated with specific new radio-access technology but

- cdma2000 was an evolution of IS-95, NR at least to some extent based on LTE
- sometimes the important technology step has taken place within a generation (e.g. WCDMA → HSPA)

So... what is next?

Some drivers for future technology evolution
Outside in perspective

Application demands

extended and new services requiring extreme connectivity performance

Trustworthiness

trusted communication and computing for industry and society relying on critical information

Sustainable world

communication and networking as part of and enabler for sustainable development

Simplified life
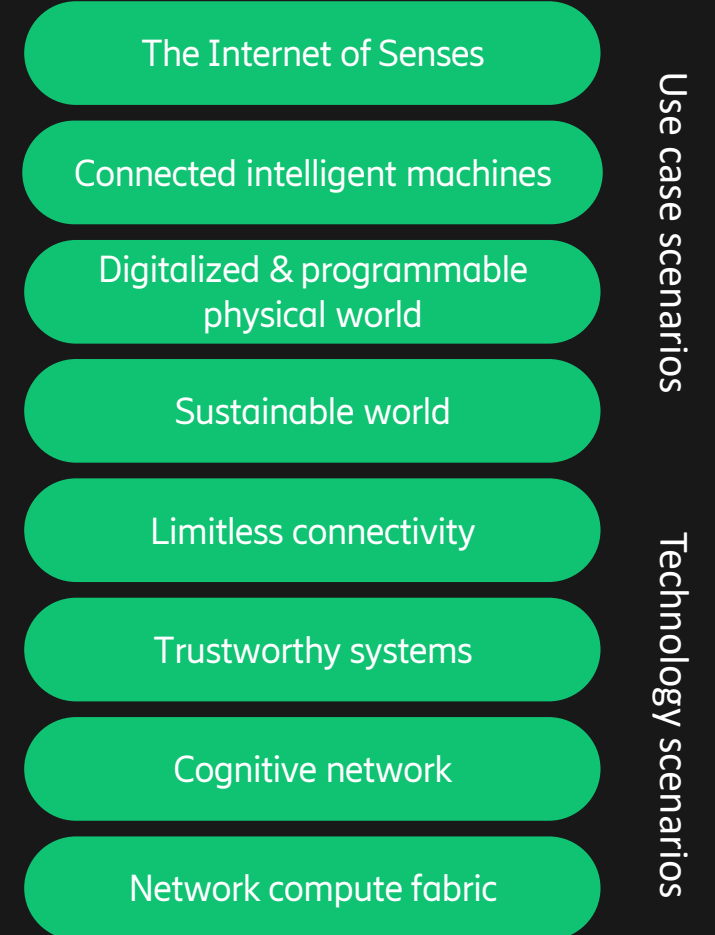
communication and massive use of AI across systems for optimal assistance and efficiency

Some technology trends

Emerging technology landscape

Robotization

Cloud & Edge

Trustworthiness technologies

Alternative energy technology

Smart materials

AI

Ubiquitous connectivity

New ways of interaction

New computing paradigms

Technology journeys

The Internet of Senses

Connected intelligent machines

Digitalized & programmable physical world

Sustainable world

Limitless connectivity

Trustworthy systems

Cognitive network

Network compute fabric

Use case scenarios

Technology scenarios

6G use case scenarios

6G: moving in a cyber-physical continuum

Programmable digital representation of the physical world

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

Cyber-physical continuum

Connected intelligent machines

Internet of senses

Digital world

Physical world

Digitalized & programmable physical world

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

The network platform provides intelligence, ever-present connectivity, and full synchronization in a cyber-physical continuum

Connected sustainable world

The physical world of sensing, action, and experience

Use-case scenarios

Use-case scenarios enabled by the network platform

The Internet of Senses

Connected Intelligent Machines

Digitalized & programmable physical world

Connected sustainable world

Use-case examples

The Internet of Senses	Connected Intelligent Machines	Digitalized & programmable physical world	Connected sustainable world
Telepresence	AI partners	Interactive 4D map	E-health for all
Merged reality game/work	Interacting robots	Precision healthcare	Earth monitor
Immersive sports	Flexible manufacturing	Sensor infrastructure web	Autonomous supply chains

Also part of Hexa-X use cases deliverable 1.1

Internet of senses

Telepresence

- Experience cyber-physical objects with all senses, blurring the line between physical and digital world

Immersive physical experience of the world away from you through interaction in the digital world

- Teletravel
- Televisits (culture/commerce)
- Immersive communication
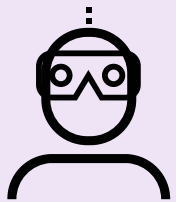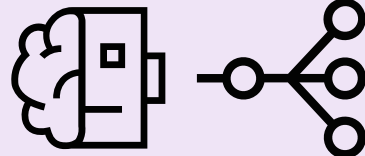
- Person
- In/On-body devices
- Intelligent network
- Sensors
- Sensed world

Connected intelligent machines

AI partners

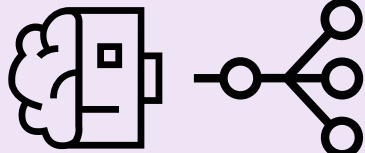- Autonomous systems and robots assist and collaborate with human colleagues to solve simple or complicated tasks
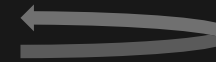
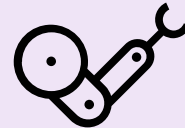Separate parts of the digital world are merged through the physical network
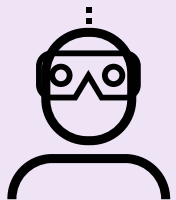
- Person
- Sensors
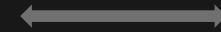- Intelligent network
- Sensors
- Cobot

- Autonomous cobots
- Intent interpretation
- Remote factories

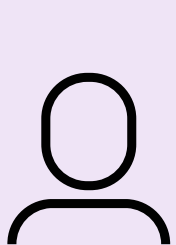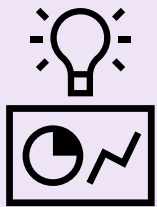# Digitalized & programmable physical world

Interactive 4D map

- Optimized design and management of cities and utilities using real-time digital twin

The physical and the digital worlds are synchronized with sensor/actuator data
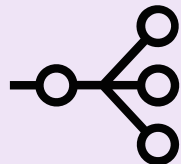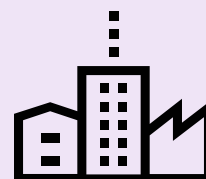
- Person
- Data representation and optimization
- Intelligent network
- Sensors/Actuators
- Connected city

- Minimization of resource use
- 4D planning of activity
- Fault prediction and mending

Connected sustainable world

E-health for all

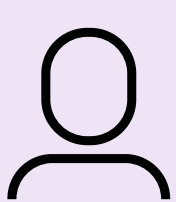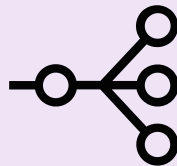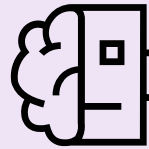- Provide cost-effective video/XR doctor's consultations remotely to everyone (rural/impoverished/etc.)
- Population level health monitoring and disease prevention using ubiquitous sensors

Using networks to enable a sustainable transformation

- Predictive/preventive health
- Automated health
- Ubiquitous health

- Person
- In/On-body devices
- Connectivity
- Intelligent network
- E-health service

The 6G network platform

Needed capabilities

- "Classical" capabilities still important
  - Stretching 5G

- New capabilities for emerging use cases
  - Adding new dimensions to the network

- Total cost of ownership at the core

Security and privacy

Service availability

Data rates

Extreme devices

Latency

Network energy efficiency

Service versatility

Total cost of ownership

Positioning

Coverage

Traffic capacity

Sensing

Hosting distributed applications

Deployment flexibility
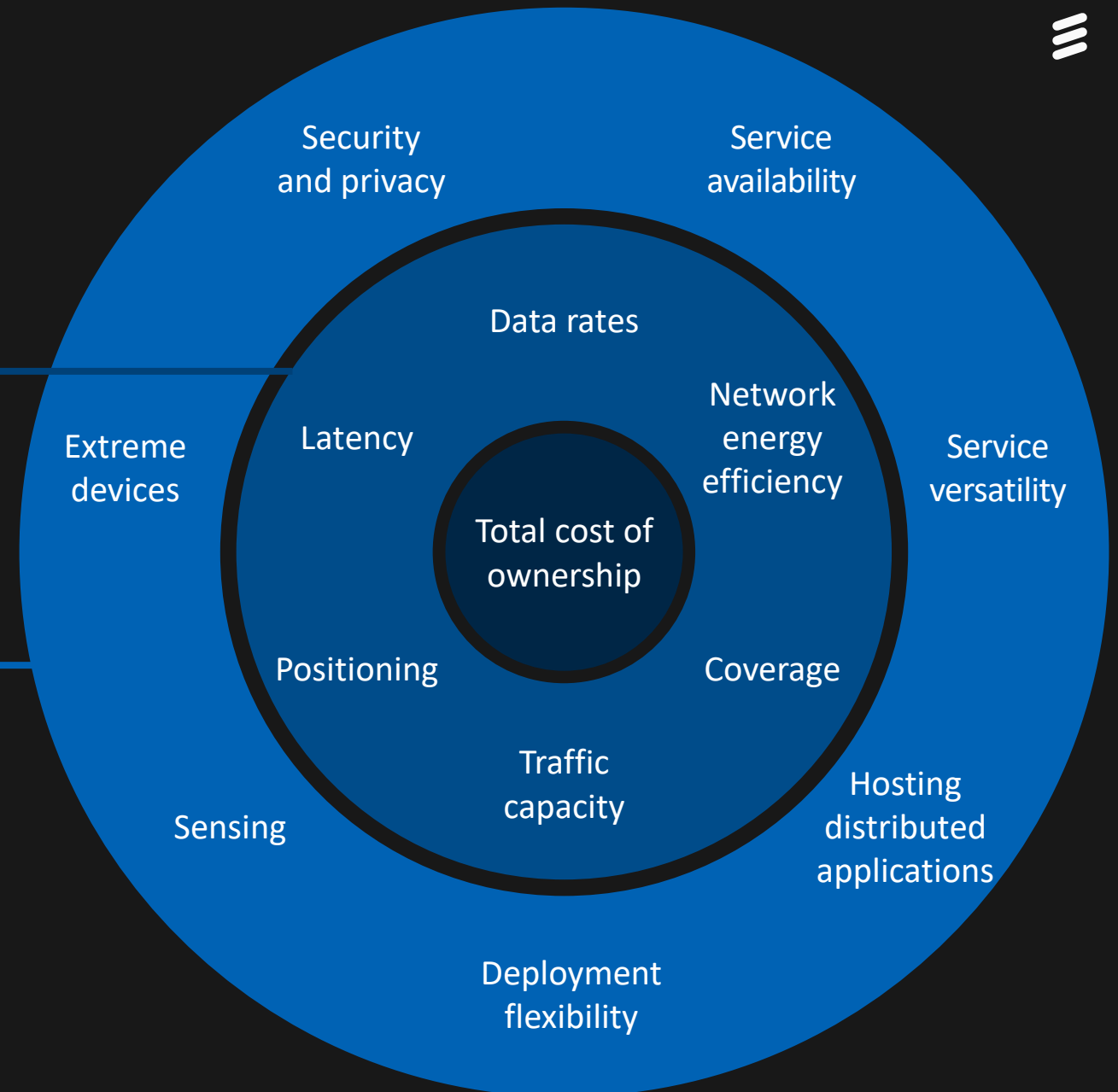
Technology scenarios

Technology scenarios evolving the network platform

| Limitless connectivity | Trustworthy Systems | Cognitive network | Network compute fabric |

Technology journeys: technology focused

Technology scenarios evolving the network platform

Limitless connectivity

Limitless connectivity

- Network adaptability
- End-to-end functions
- Extreme performance
- Embedded devices everywhere

Trustworthy Systems

Trustworthy systems

- Security assurance
- Service availability
- Solutions built on conf. computing
- Secure identities & protocols

Cognitive network

Cognitive network

- Data-driven operations
- Distributed intelligence
- Continuous learning
- Intent-based management
- Explainable & trustworthy AI
- Cognitive system

Network compute fabric

Network compute fabric

- Unified telco-IT ecosystem
- Unified execution environment
- Unified data infrastructure
- Unified application management

Some technology building blocks - summary

Integration of new nodes of multiple types, versatile programmable transport

Flexible and dynamic networks

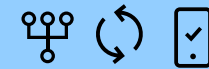**Separate application, infrastructure, management**

Cloud-optimized architecture

Dynamic deployment of services and features

Programmable networks

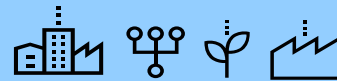**Mutual understanding of needs and conditions**

Explicit network-app collaboration

Energy harvesting, embeddable, efficient devices

Zero-energy devices

Context handling, random access, efficient signaling

Trillion device support

Wide range of shared, local, co-existing spectrum

Spectrum flexibility

Multi-site, distributed MIMO

Multi-connectivity

Stable performance across system
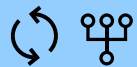
Predictable E2E performance

Radio sensing for mapping, localization, and access performance

Sensing/Localization

Networks of capillary networks

Extreme-short range

Fluid, integrated, ubiquitous computing

Unified execution environment

Autonomous system operation and management

Cognitive system

Trusted execution environments

Confidential computing

Root-of-trust and privacy mechanisms

Secure identities and protocols

Seamless data access across locations

Unified data infrastructure

6G worldwide

6G industry timeline

17	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	203

Regional initatives

CN initiatives
(MOST and MIIT)

EU Hexa-X   KR

ATIS NGA   JP

6G technical standardization

6G evolution

Basic research

ITU process

Applied research

Basic technology trials

System test beds and trials

Commercialization

17	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	203

Regional/national initiatives regarding 6G

Europe
- ICT-52 call
  - Hexa-X (Nokia, Ericsson et al)*
  - REINDEER*
- Horizon Europe (coming)
  - Smart network & Services
- 6G Genesis and other
- One6G association?
- 6G SIG in NetworldEurope?*

India
- TDSDI 6G track?

China
- IMT-2030 promotion group (driven by MIIT)*
- MOST
  - National key project – 6G part*
  - 6G promotion group
- Future forum

USA
- ATIS Next G Alliance*
- NSF RINGS*

Japan
- 6G promotion strategy (MIC)
- Innovative Optical & wireless network forum (IOWN) *

General
- NGMN*
- GSA*
- ITU-R*

Korea
- 6G R&D strategy (Ministry of Science and ICT)
- 5G Forum

Initiatives still in a research phase

* Ericsson is involved

Summary

Summary

"6G" is broader than the radio-access technology

- A trusted platform delivering **ever-present intelligent communication** including connectivity, data and compute

"6G" is the overall solution available around 2030

Forming and defining 6G is still in the research phase

- We are actively driving and encouraging inclusive research cooperation across industry and academia

Driving forces

↕

Use cases

↕

Capabilities

↕

Technology

Ericsson 6G white paper

Released November 6 ([link](#))

Presents Ericsson's 6G vision for 2030 - a broad view covering our ongoing explorative research

Ericsson whitepaper
GFTL ER
November 2020

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Ever-present intelligent communication –
A research outlook towards 6G