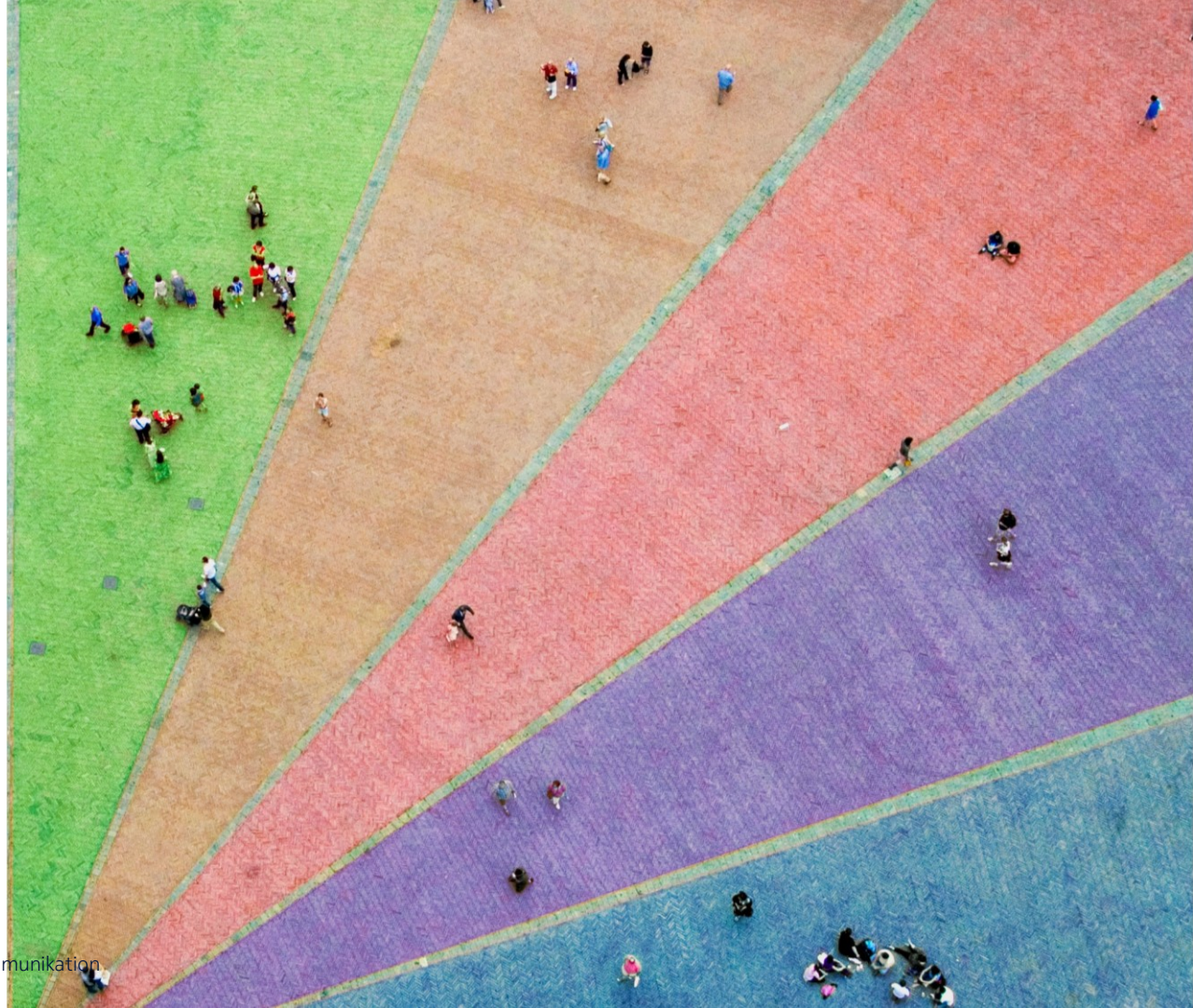# The 6G future: delivering new levels of customization, resilience, and privacy

Gerald Kunzmann, NOKIA

@27. VDE/ITG Fachtagung Mobilkommunikation
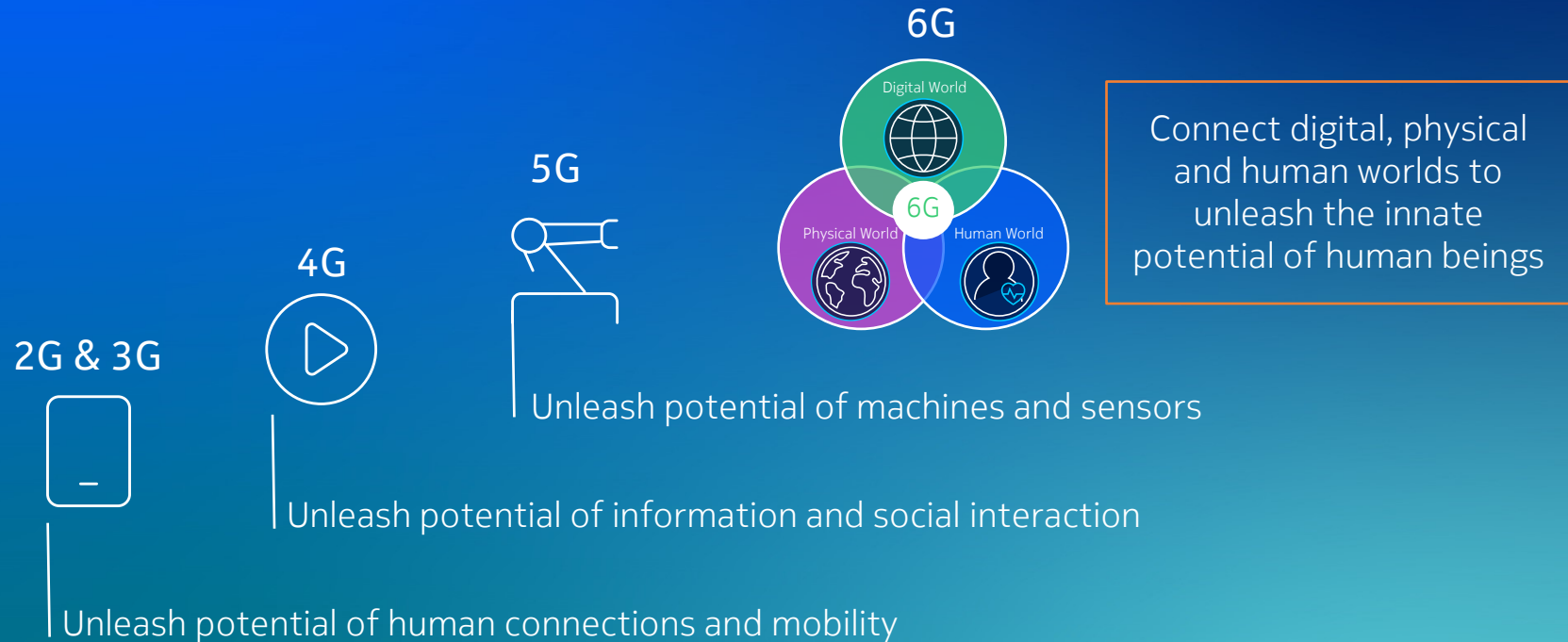
Agenda

- 6G Vision
- 6G System architecture
- 6G innovations under investigation
  - 6G sub-networks
  - Service-based architecture
  - 6G security
- 6G timeline

 | 27. VDE/ITG Fachtagung Mobilkommunikation

The digital, physical and human worlds will become closely integrated in the 6G era

6G

Digital World

Physical World   6G   Human World

Connect digital, physical and human worlds to unleash the innate potential of human beings

5G

4G

2G & 3G

Unleash potential of machines and sensors

Unleash potential of information and social interaction

Unleash potential of human connections and mobility

NOKIA

Technologies to be explored for 6G architecture innovations

Adaptive QoS/QoE for real time services offering in large scale.

Metaverse support in wide area

Cloud-optimized evolution of UE-RAN-Core Architecture and RAN-Core functional split.

RAN-Core SBI, RAN disaggregation

Address new technology trends

Unified data, analytics and AI, deterministic networking for IP, communication and sensing, application trends for 2030 era

Simplified Architecture for highly densified deployments, small cells, seamless mobility to macro.

Optimized Privacy, Security, Trust and Resiliency enabling new security paradigms .

Including quantum safety, AI/ML security, cloud security

Sustainability, energy efficiency, operational simplicity as integral part of the overall 6G Architecture design.

6G

| 27. VDE/ITG Fachtagung Mobilkommunikation

NOKIA

Single Standalone System Architecture for 6G

Key design principles:
- ➢ Native AI/ML
- ➢ Sustainability
- ➢ Cloud Native
- ➢ Trustworthiness

Core

6G CA or 6G DC

5G-6G MRSS **6G gNB**
Dynamically Re-farmed band

6G gNB

UE-1

UE-2
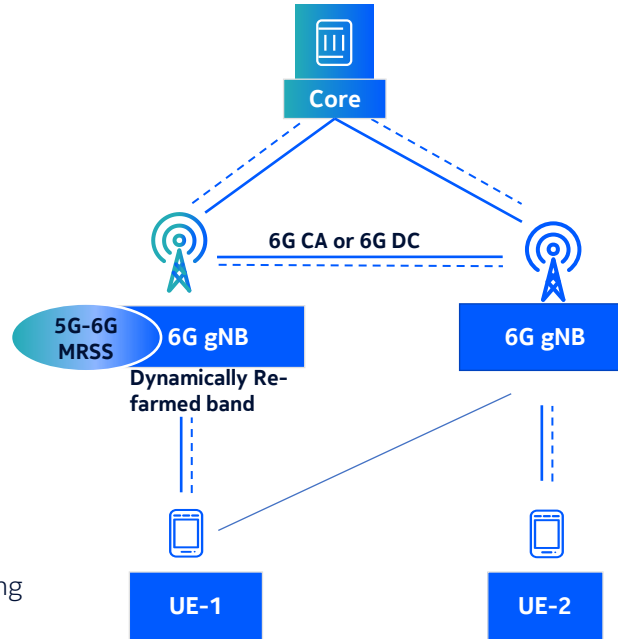
CA: Carrier Aggregation
DC: Dual Connectivity
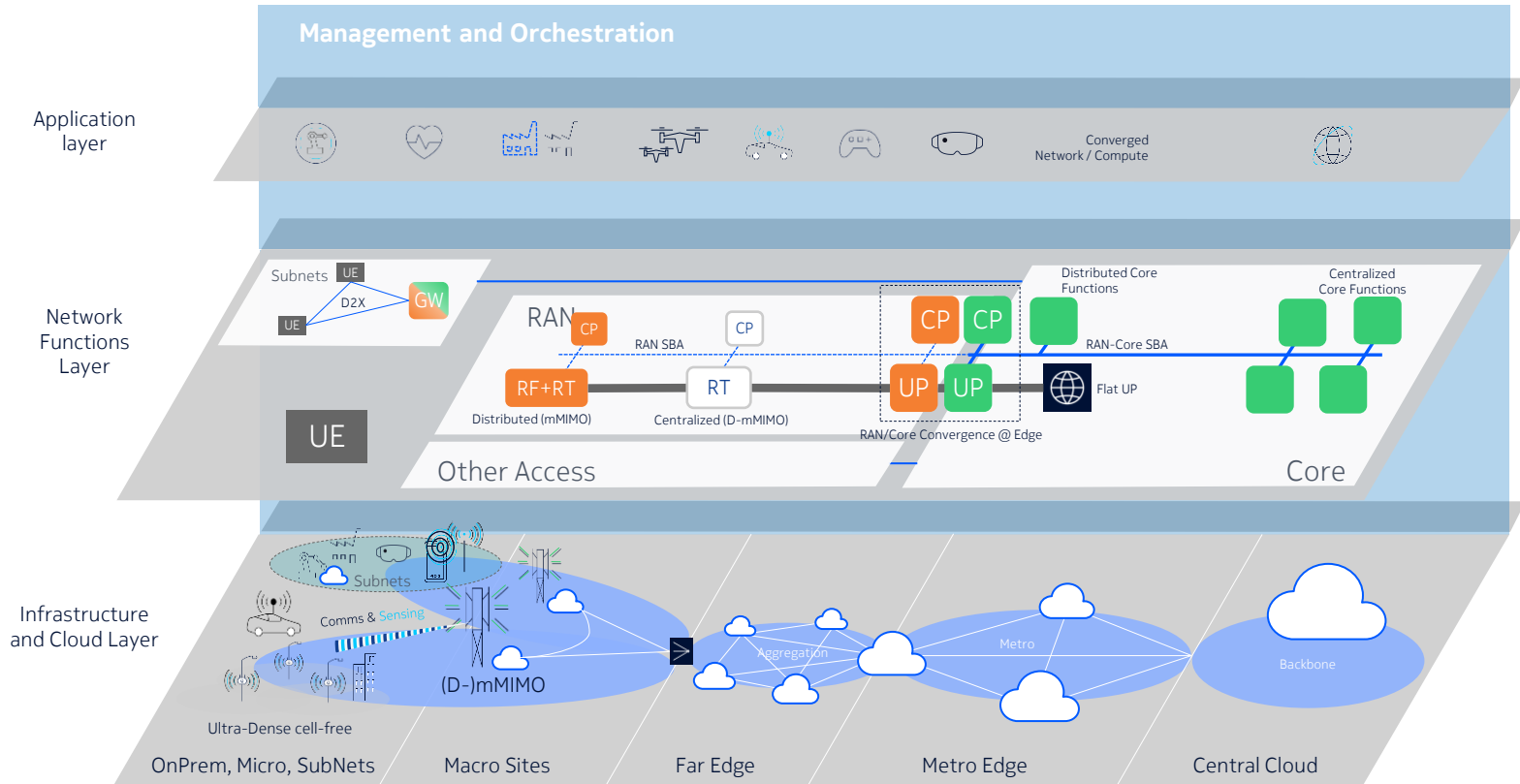MRSS: Multi-RAT Spectrum Sharing

—— User plane
---- Control plane

- ✓ MRSS transparent to the UE, providing ~95% efficiency (DSS <50%)
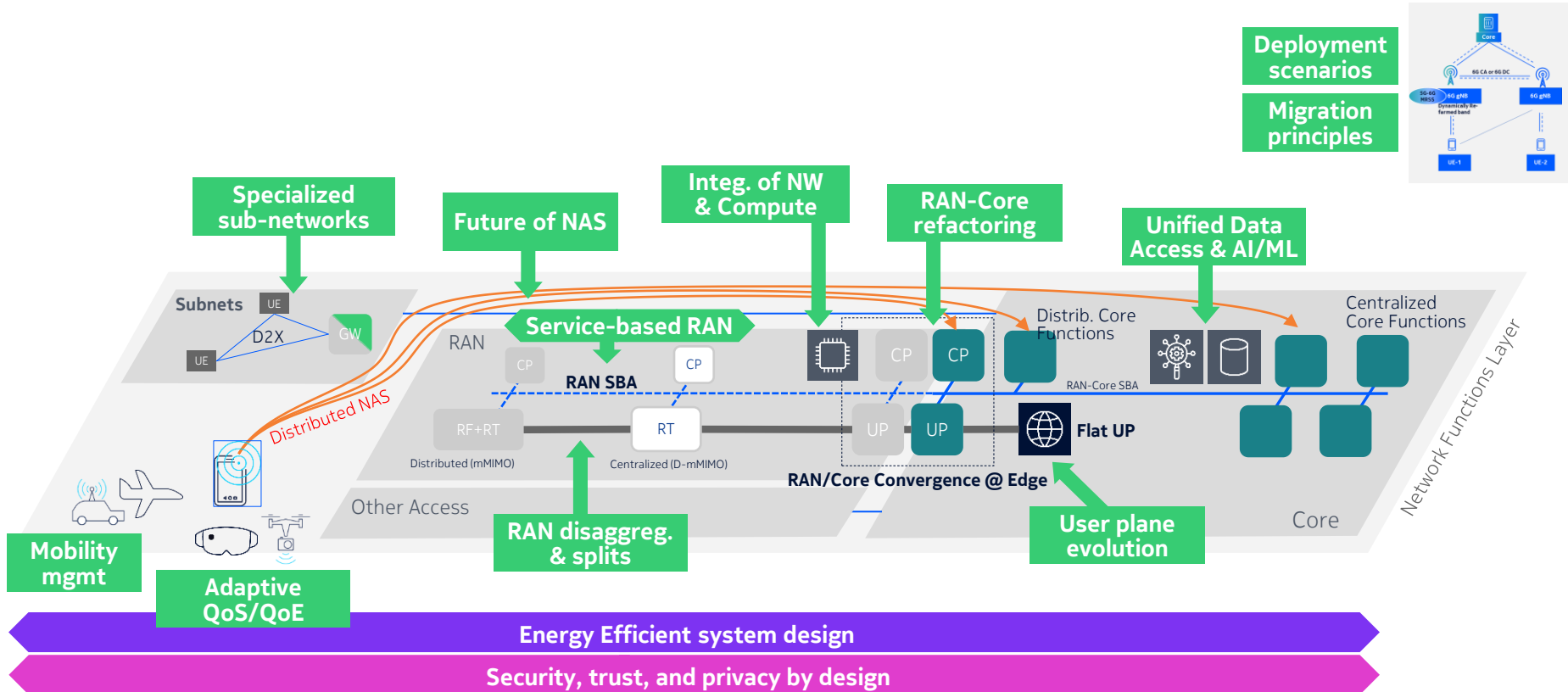- ✓ Intra-RAT aggregation only (CA or DC). No inter-RAT aggregation.
- ✓ 6G radio features can be fully utilized with 6G SA.
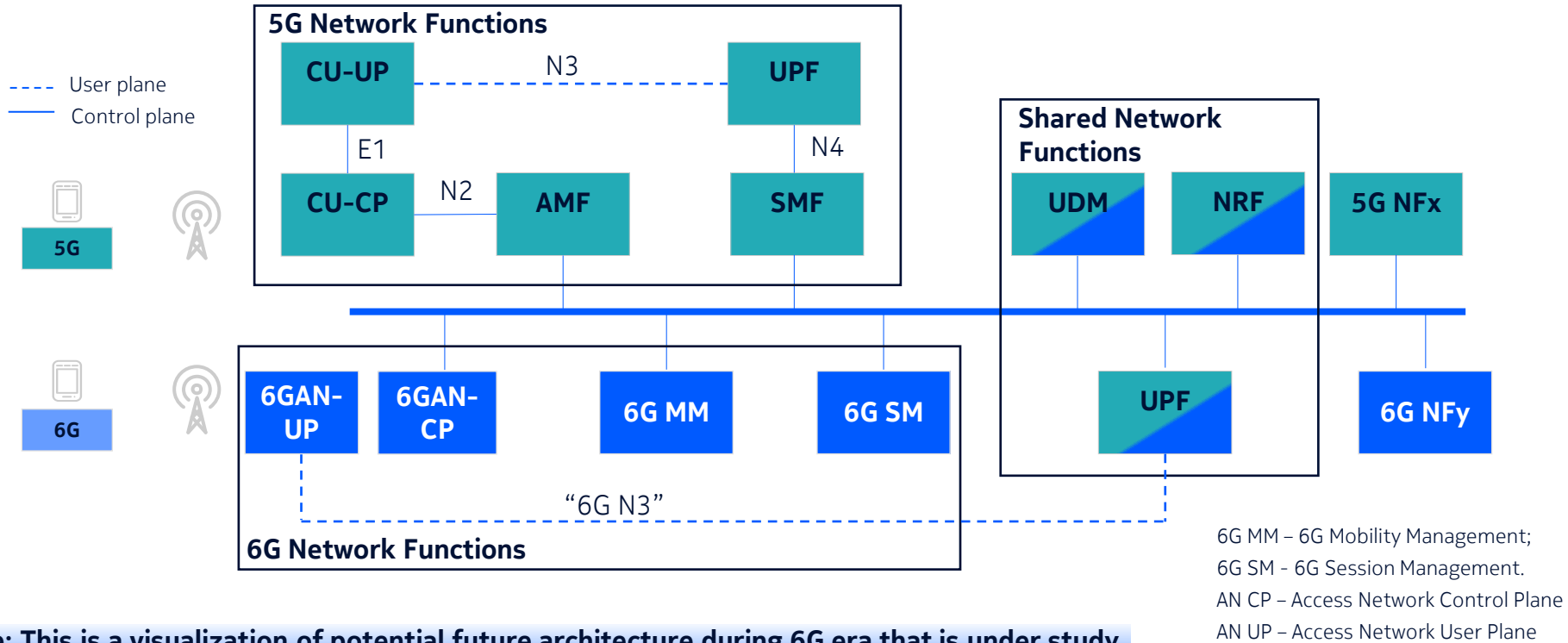- ✓ 5G SBI as the baseline for the 6G Core, leveraging full flexibility of SBI.

NOKIA

6G System Architecture

NOKIA

6G Architecture innovations under investigation

Deployment scenarios

Migration principles

Specialized sub-networks

Future of NAS

Integ. of NW & Compute

RAN-Core refactoring

Unified Data Access & AI/ML

Subnets

UE

D2X

GW

UE

RAN

Service-based RAN

Distrib. Core Functions

Centralized Core Functions

Distributed NAS

RAN SBA

CP

CP

CP

CP

CP

RAN-Core SBA

RF+RT

RT

UP

UP

Flat UP

Distributed (mMIMO)

Centralized (D-mMIMO)

RAN/Core Convergence @ Edge

Other Access

Core

Network Functions Layer

Mobility mgmt

Adaptive QoS/QoE

RAN disaggreg. & splits

User plane evolution

Energy Efficient system design

Security, trust, and privacy by design

NOKIA

6G System Architecture built upon common 5GS SBA framework

5G Network Functions

CU-UP — N3 — UPF

E1 | N4

CU-CP — N2 — AMF | SMF

- - - - User plane
——— Control plane

5G

Shared Network Functions

UDM | NRF | 5G NFx

6G Network Functions

6GAN-UP | 6GAN-CP | 6G MM | 6G SM

UPF | 6G NFy

"6G N3"

6G

6G MM – 6G Mobility Management;
6G SM - 6G Session Management.
AN CP – Access Network Control Plane
AN UP – Access Network User Plane

Note: This is a visualization of potential future architecture during 6G era that is under study

NOKIA

SBA extension into RAN?

Would it be beneficial to have SBA into/inside the RAN and how far should we go?

TODAY

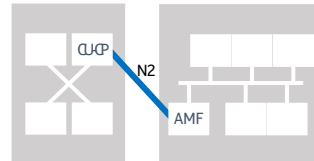5G Core is using SBA, enabling re-usability and modularity
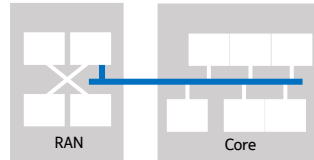
NG RAN relies on PtP interfaces

THREATS

Additional latency is challenge for RAN sensitive procedures e.g. handover
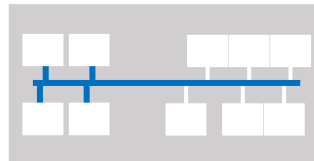
Interoperability issues

(a) Current 5G Architecture

CUCP N2 AMF

(b) Service based RAN-Core interface

RAN   Core

(c) Service-based RAN and Core

ADD-VALUE

Extend benefits of cloud-native design into RAN

Modularity enables easy introduction of new functionalities in RAN

Harmonization between RAN and CN

Unified security principles in CN and RAN

Figure taken from: https://www.bell-labs.com/institute/white-papers/technology-innovations-for-6g-system-architecture

NOKIA

6G Sub-networks

## as specialized networks at the edge of a 6G (public) operator network

TODAY

Local networks independent of operator network.
Best effort IP connectivity only.

TRENDS

More devices and sensors in private and industrial areas.

More dimensions of specialization (e.g., coverage, energy, sensing, …)

More flexible manufacturing processes and customized production.

AP

In-robot

Pacemaker

AP

Haptic sensors/actuators

In/on-body

In-house
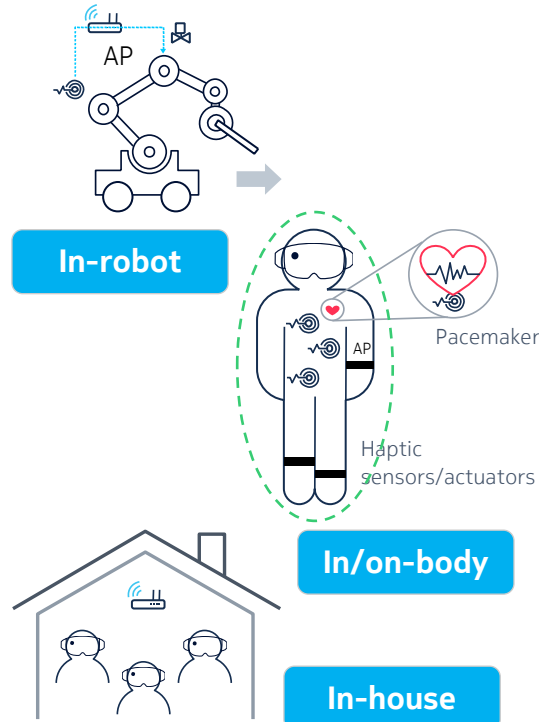
ADD-VALUE

Support communication with extreme performance requirements

Can have different ownership than the 6G operator network

Can operate in partial autonomous mode, e.g., when no (good) coverage

Allow mobility within sub-network, between sub-networks, towards operator network, and mobility of sub-network as a whole.

NOKIA

Re-architecting the System for Security, Trust & Privacy
to deal with AI/ML, Post Quantum & Cloud Native

THREATS

Cloud-native design principles adopted across full e2e architecture

AI applied to management, control, and user plane

Exposure of network data and capabilities in multi-party ecosystem

Prepare for Post-Quantum Cryptography (PQC)

Security, trust and privacy
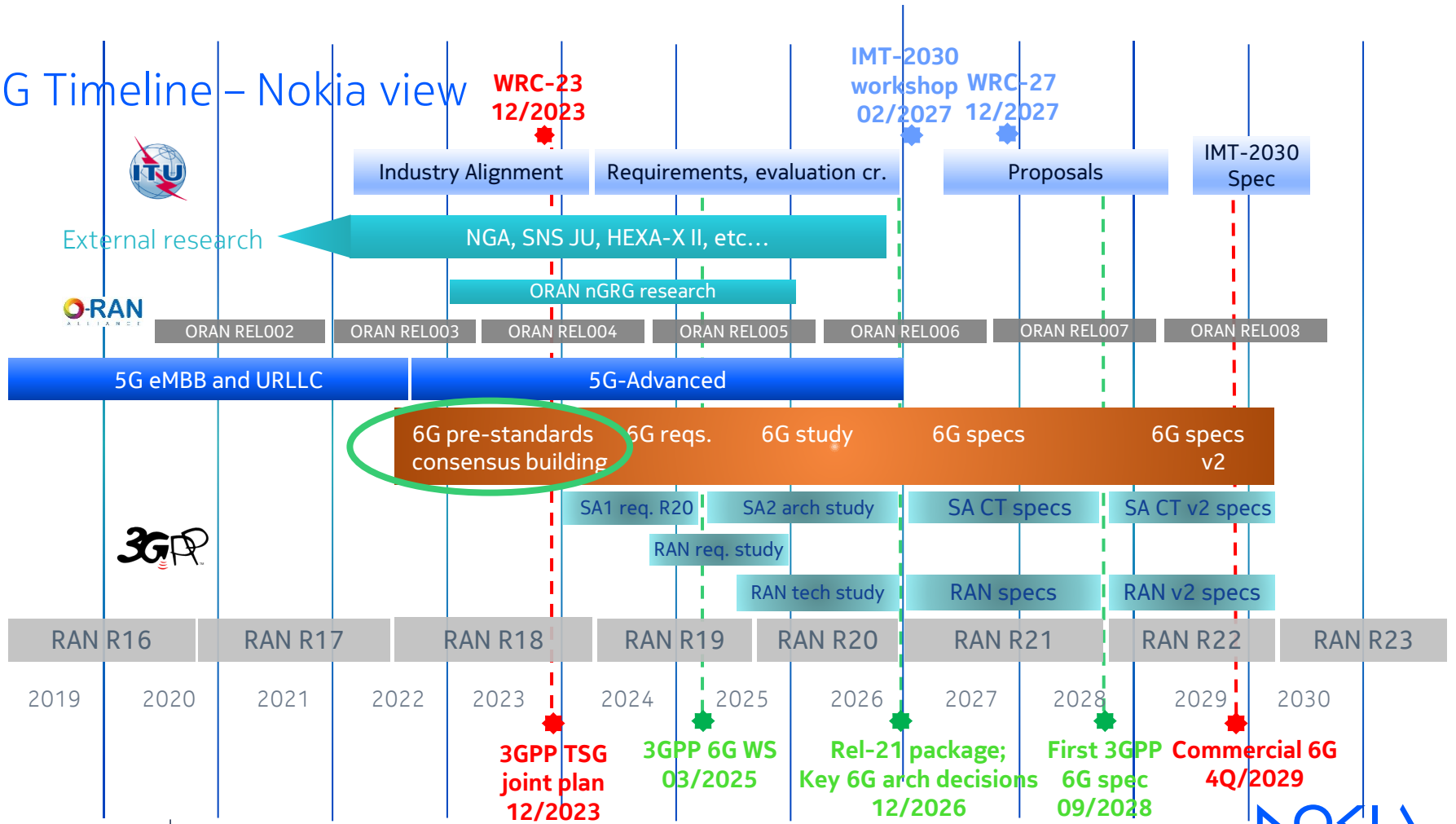
ADD-VALUE

Secure and automated SW supply chain

Resilient against (AI-based) attack

Privacy preserving technology

Fresh look into the overall security framework

NOKIA

6G Timeline – Nokia view

WRC-23 12/2023

IMT-2030 workshop 02/2027

WRC-27 12/2027

ITU
| Industry Alignment | Requirements, evaluation cr. | Proposals | IMT-2030 Spec |

External research — NGA, SNS JU, HEXA-X II, etc…

ORAN nGRG research

O-RAN ALLIANCE
| ORAN REL002 | ORAN REL003 | ORAN REL004 | ORAN REL005 | ORAN REL006 | ORAN REL007 | ORAN REL008 |

| 5G eMBB and URLLC | 5G-Advanced |

6G pre-standards consensus building | 6G reqs. | 6G study | 6G specs | 6G specs v2

3GPP
SA1 req. R20	SA2 arch study	SA CT specs	SA CT v2 specs
RAN req. study			
	RAN tech study	RAN specs	RAN v2 specs

| RAN R16 | RAN R17 | RAN R18 | RAN R19 | RAN R20 | RAN R21 | RAN R22 | RAN R23 |

| 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |

3GPP TSG joint plan 12/2023

3GPP 6G WS 03/2025

Rel-21 package; Key 6G arch decisions 12/2026

First 3GPP 6G spec 09/2028

Commercial 6G 4Q/2029

NOKIA

Key take aways

1 **Single architecture for 6G**

Smooth migration from 5G enabling coverage and capacity

2 **6G as evolution of 5G System**

From backward compatible updates to a new 6G System

3 **Technical innovations**

Identify the innovations that are key to have in the first 6G release

NOKIA

References

- [6G webpage](#) on bell-labs.com

- [6G teaser video](#)

- [Network evolution towards the 6G era](#), blog by Nishant Batra

- NOKIA Whitepaper "[Envisioning a 6G future](#)", June 2022

- NOKIA whitepaper "[Energy efficiency in next-generation mobile networks](#)", Nov 2022

- 6G explained: https://www.nokia.com/about-us/newsroom/articles/6g-explained/

- Metaverse Blog "[The metaverse will never move beyond our living rooms without a powerful network](#)"

- Nokia's vision for the 6G era:
  https://www.nokia.com/about-us/newsroom/articles/nokias-vision-for-the-6g-era/

NOKIA