Fraunhofer FOKUS
Institute for Open Communication Systems

Organic 6G Networks

Dr. Marius Corici
marius-iulian.corici@fokus.fraunhofer.de
www.6G-ready.org

6G READY

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Agenda

1 Fraunhofer FOKUS NGNI Mission

2 6G Technology Drivers

3 Design Aspects for 6G Core Networks

4 FOKUS 6G-ready Toolkit Roadmap

5 Summary & Outlook

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NGNI Mission & Research Market

- **Mission:**
  - **Researching & Prototyping of emerging global telco standards for Software-based Networks** (based on Network Virtualization) for addressing international markets & customers
  - Act as a top ten player (➔ stay the best in what you do – less is more!)
  - We are globally recognized as the 5G core network experts by the industry

- **Business Models:**
  - **Testbed as a Service:** 5G Playground – a 5G Reference testbed for prototyping 5G technologies and services
  - **Testbed2Go:** Open5GCore – ***THE*** reference software toolkit to build 5G testbeds anywhere

- **Key public research funding** originates from EU, ESA, BMVI, BMWI, BMBF
- **Key Industry Customers:** Operators (e. g. DTAG, BT, etc.), OT Companies (Bosch, Siemens, etc.), Vendors (GEC, Huawei, Airbus, etc.), Research Institutes (e. g. TNO, ETRI)

Our Business Model: Testbed as a Service & Testbed2Go (Toolkits)

3G 4G 5G 6G

2001 2005 2009 2015 2025

open ims core

OPEN BATON

open ims playground
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FUSECO playground

Leistungszentrum Digitale Vernetzung

5G Berlin

5G playground

6G-RIC
Research and Innovation Cluster

Open6G
Hub Germany

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Open5GCore Rel. 7

Software based core network – programs that can be deployed as containers, pods, VMs, …

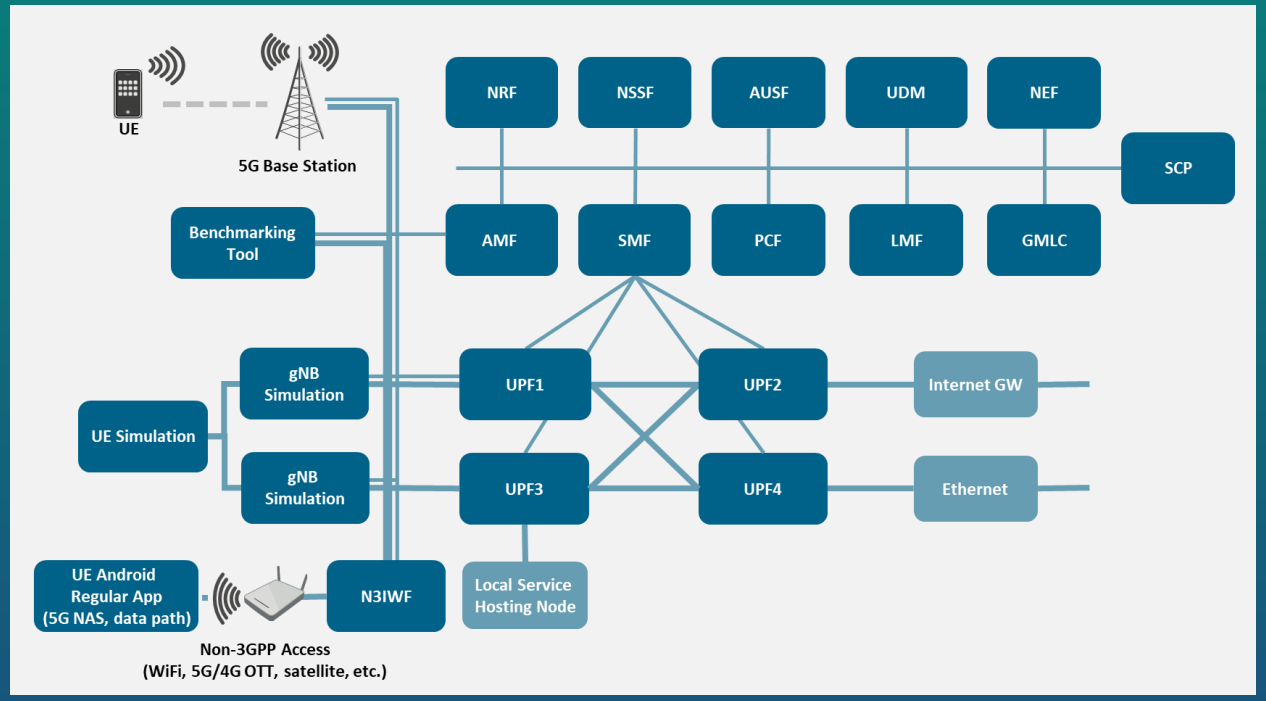
- Fundamental 5G core network functionality: AMF, SMF, UPF, PCF, UDM, AUSF, …
- Additional services: non-3GPP, location

Main features for 5G:

- Integrating with 5G NR SA, non-3GPP and satellite
- Data path diversity, local offload
- Advanced bearers, QoS and session management
- Network slice support
- Location service support
- Performance Benchmarking
- Own UE emulation of regular Android OS App

Highly configurable for:

- Edge-central split
- Dedicated, private and campus networks



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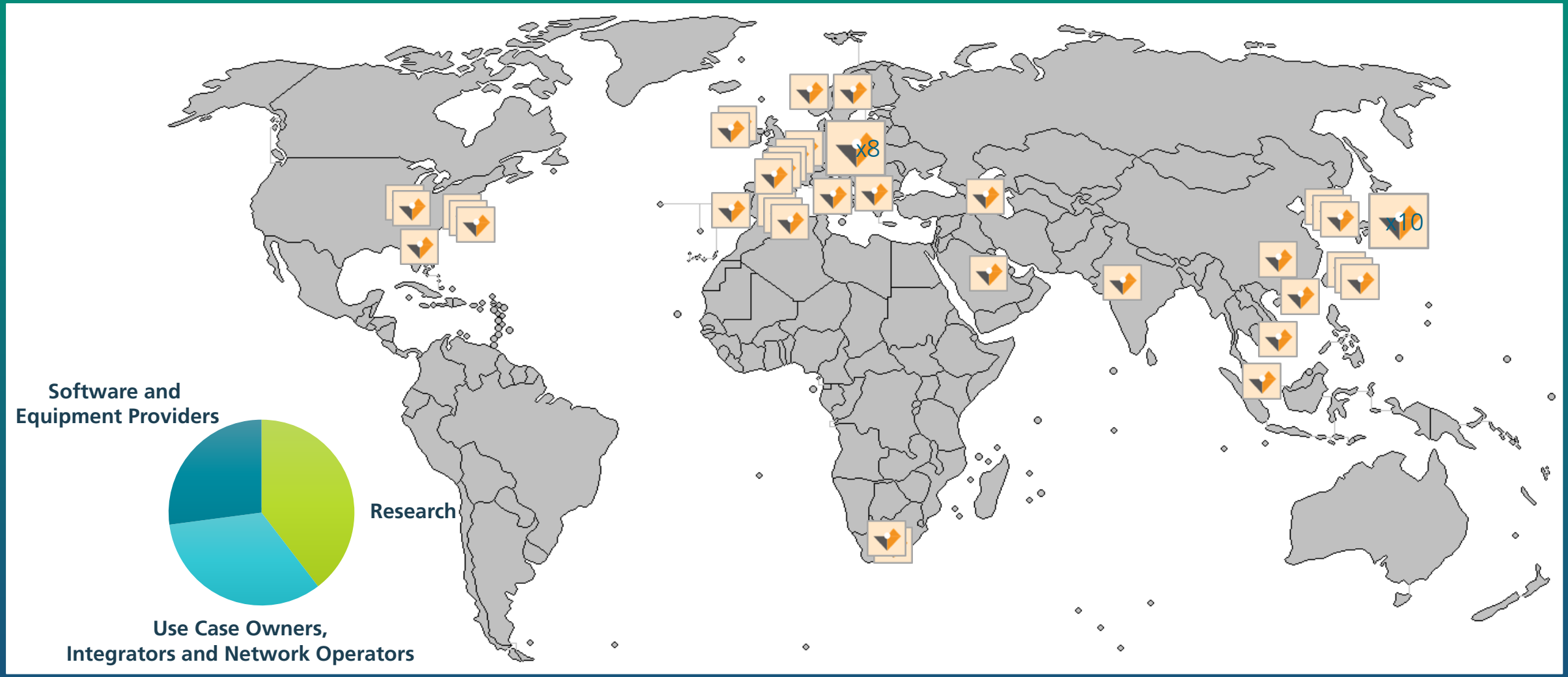
Deployments and Reference Customers (from 2014 on)



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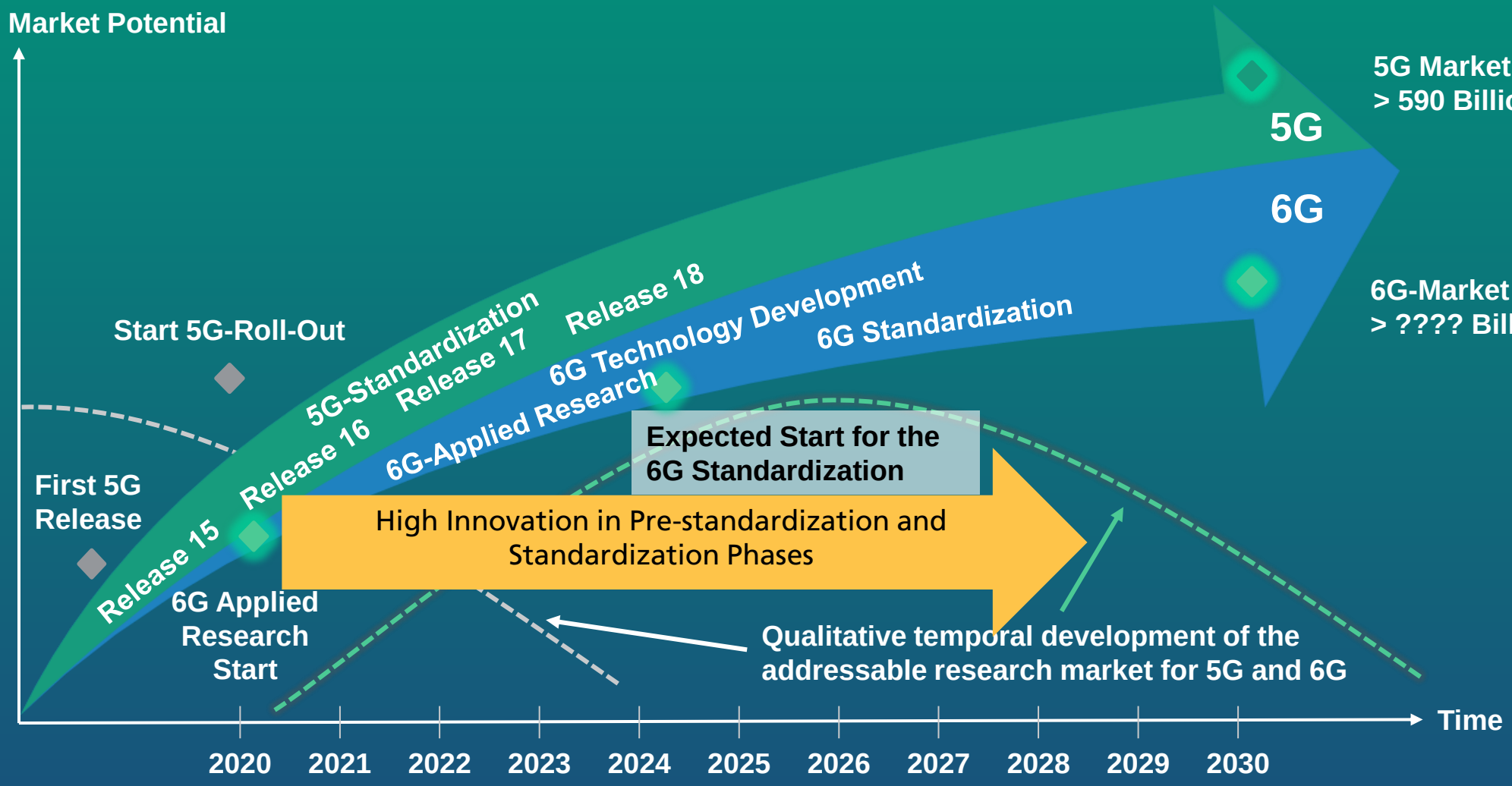
6G Research Market started in parallel to 5G Evolution Market



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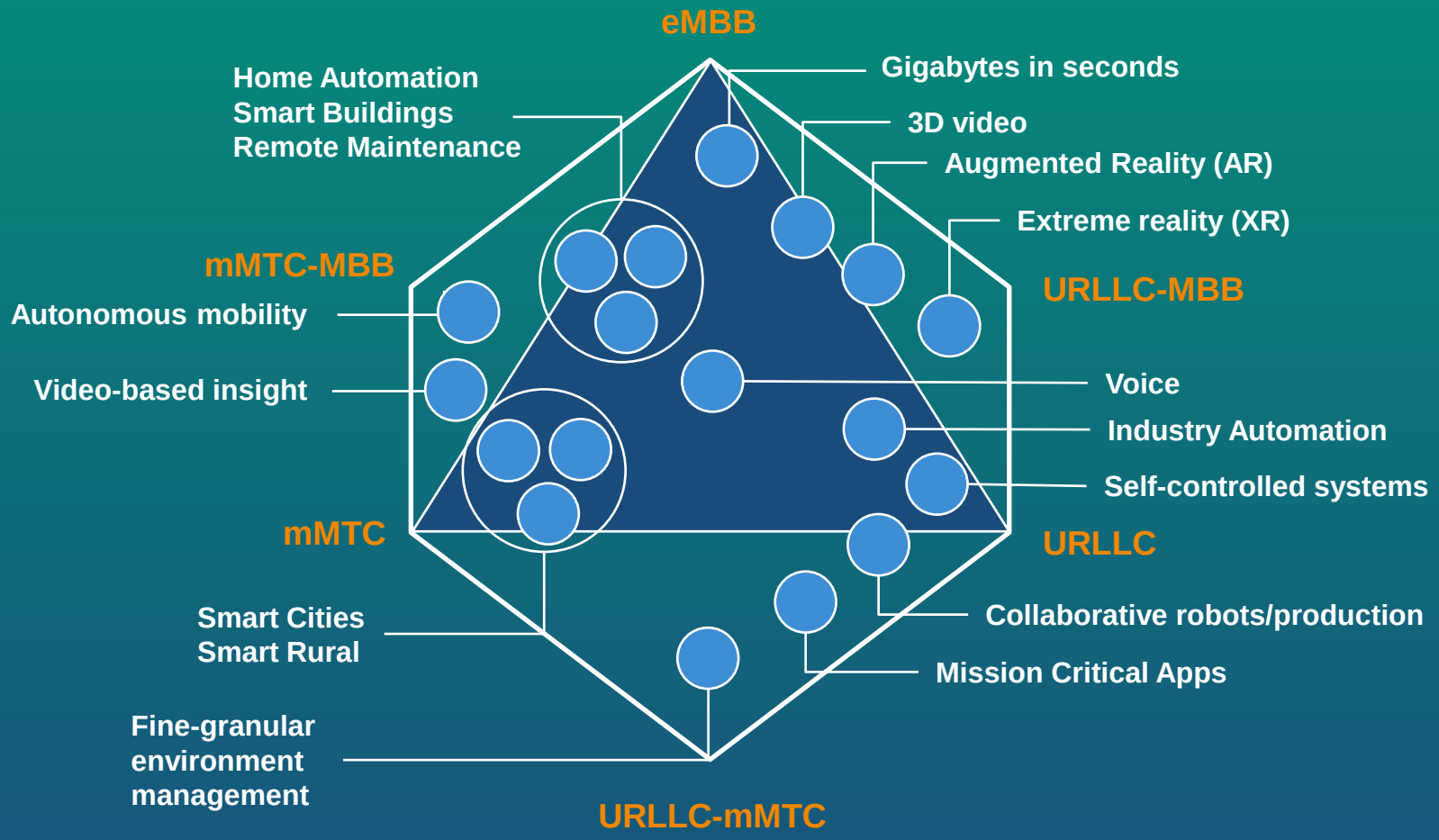
6G – More Use Case Dimensions compared to 5G



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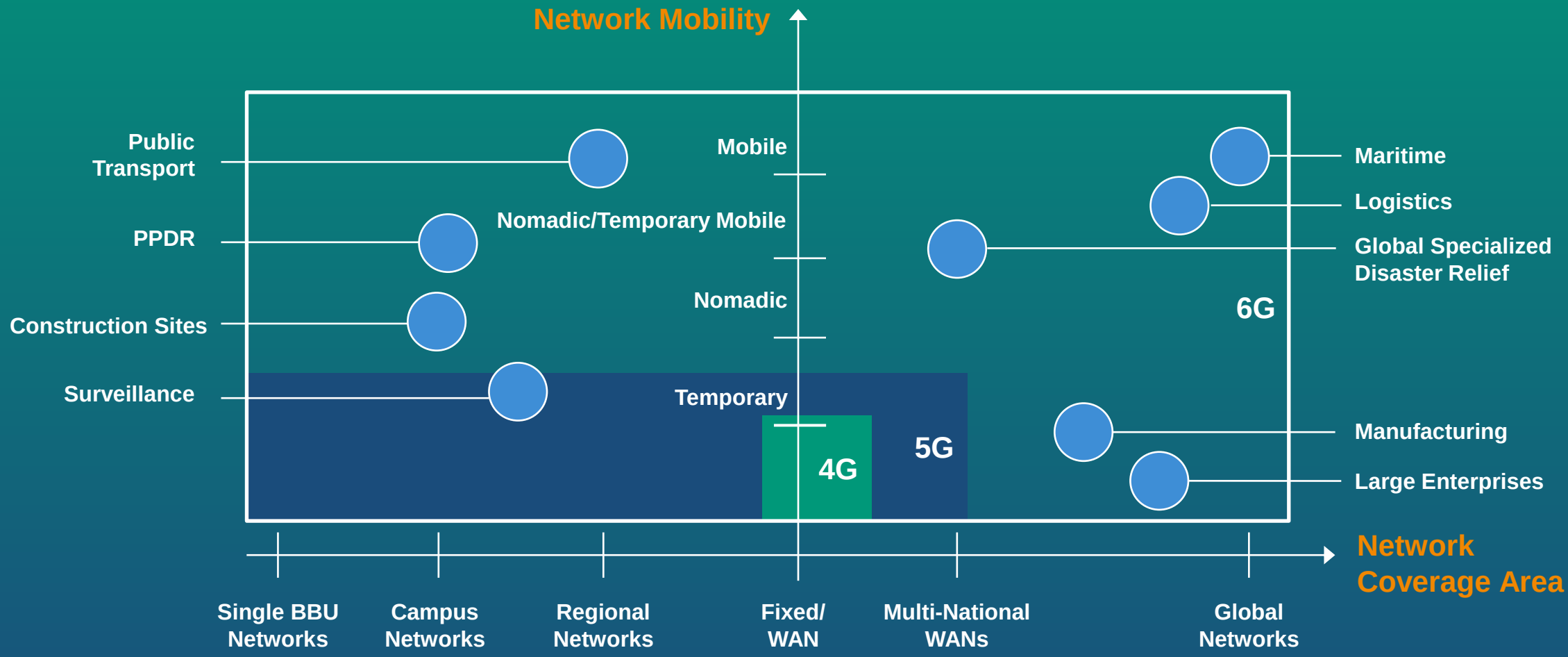
New 6G Use Cases: More Mobility and Coverage Area Variations



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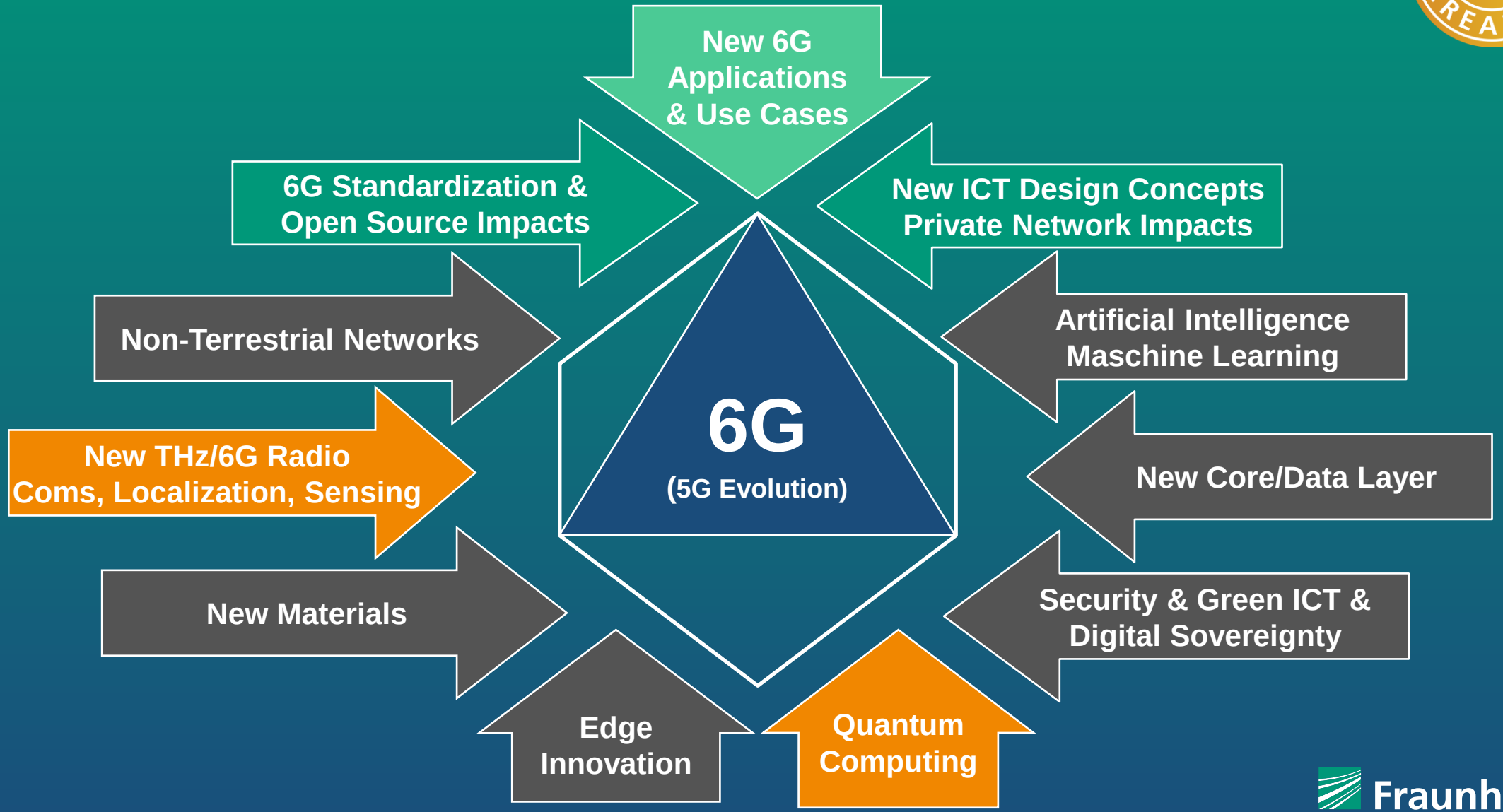
Technology Impacts for 5G Evolution towards 6G



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6G Research Directions

RAN-Core Integration
Mashup of the edge/central RAN functionality

Organic Core Networks
Adapting to deployment capabilities and use case requirements

Scheduled Networks
Optimizations through automated insight and resource sharing

Reliable & Secure
Specifically designed mechanisms for the new dynamic topologies

Data Centric
Ultra-flexible network adaptations based on data insight

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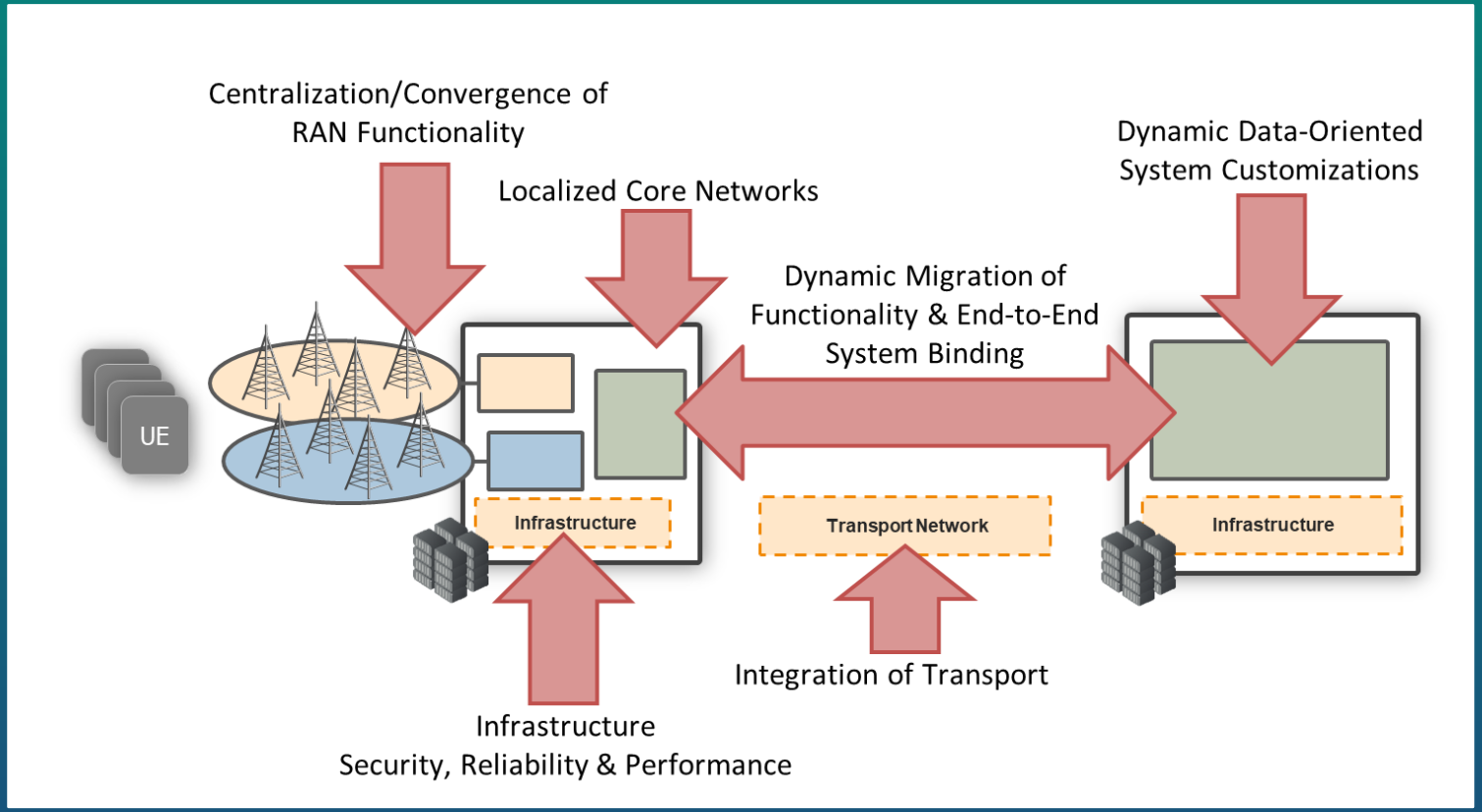
Evolution Trends for 6G

- Infrastructure-free RAN (centralized RAN)
- Pushing core networks to local infrastructure
- Dynamic binding of network pieces in end-to-end system
- Deep integration of transport
- Organic adaptations of networks
- Data oriented system optimizations (scheduling vs. protocol optimizations)



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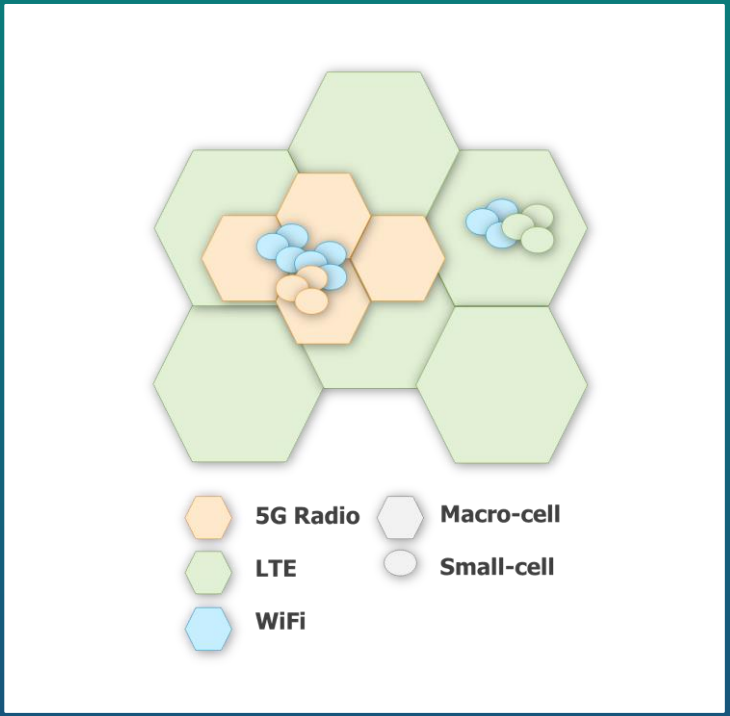
5G vs. 6G Deployments

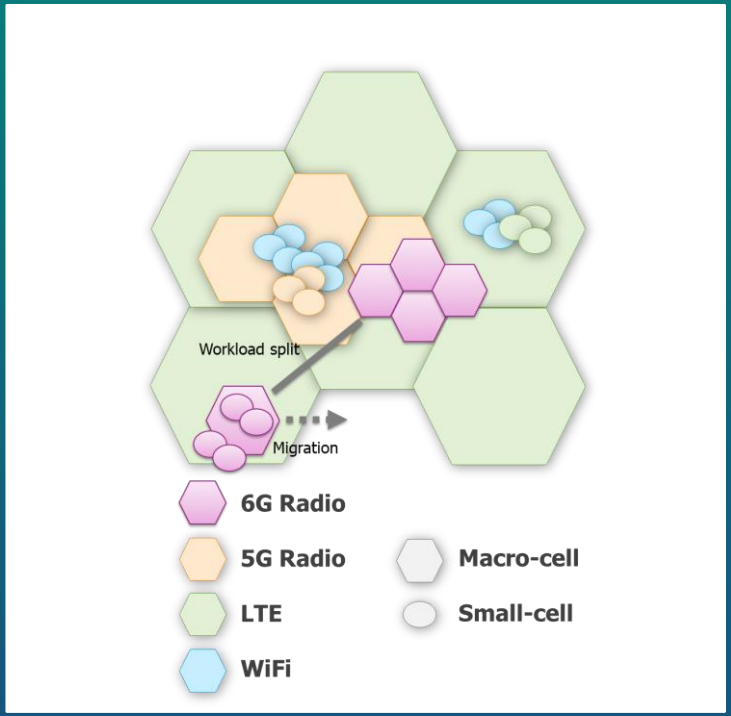
5G: Static Networks

- Macro-operator networks
- Dedicated slices in macro-operator networks
- Small(er) non-public networks



6G: Morphing Networks

- *Active* subscribers-based scaling
- Can migrate to new infrastructures
- Can split load between local and remote processing



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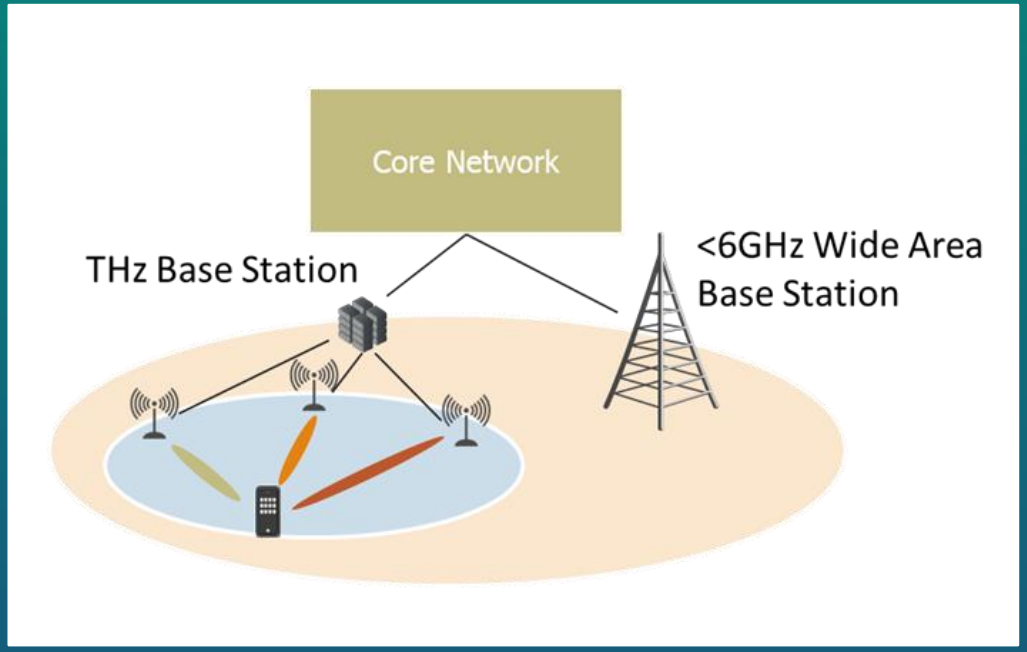
Core Support for THz RAN

- THz characteristics:
  - Highly directional beams ➔ needs advanced beam forming
  - Very low delay transmissions ➔ could be used to compute positioning
  - Very sensitive to interference ➔ massive MIMO is needed
  - Very high network capacity
  - Using currently unused spectrum



- Reduced coverage → needs fast handover support
- Only for low speeds ➔ handovers should be aware of the speed of UEs
- Signal could be very fast lost → Break-before-make handovers
- Usable as extra-carrier → needs support for carrier aggregation

➔There is a need for a comprehensive, highly dynamic UE profile (e.g. speed, location, state of communication, etc.)

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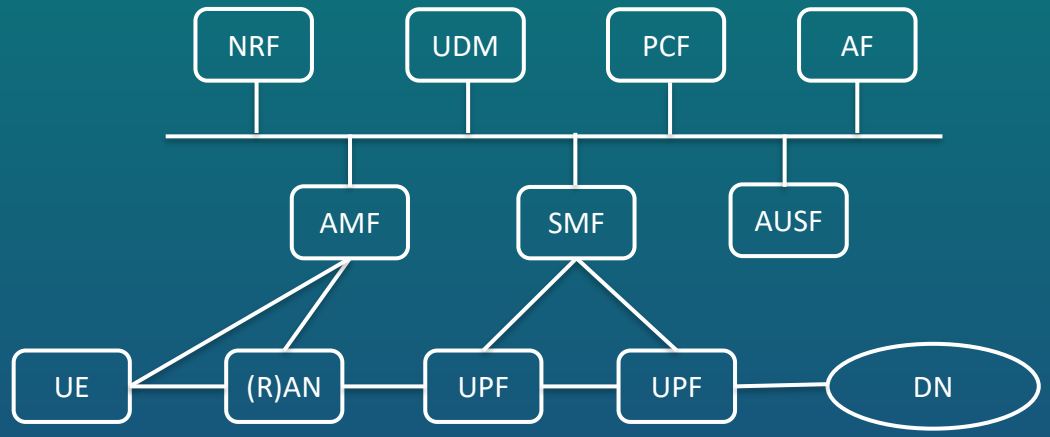
Background: 5G Architecture

- Based on Network Functions
- Each network function can be implemented as an independent micro-service
- Connected in a Service-Based Architecture
  - Using HTTP/2 as support communication protocol
  - Highly flexible in selecting the network functions



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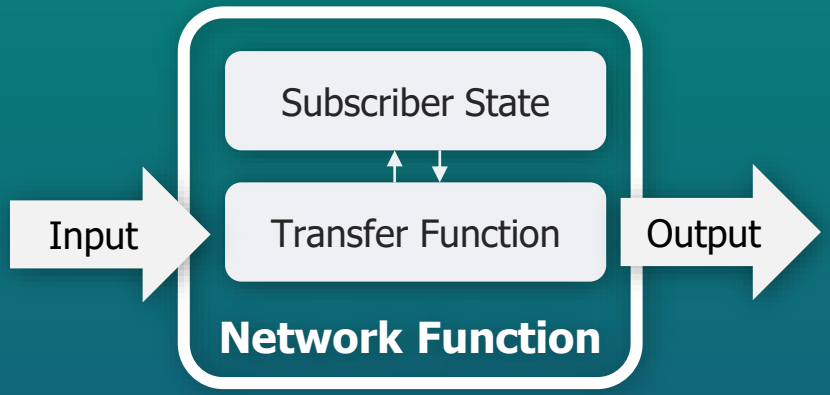
What is a Network Function?

- A Network Function (NF) is a basic element (a functional block) of a system, within a network infrastructure which has well-defined external interfaces and well-defined functional behaviour
  - Transfer Function and
  - Subscriber state



- Each interface exposed by the Network Function has to be standardized in order to allow interoperability without vendor lock-in.

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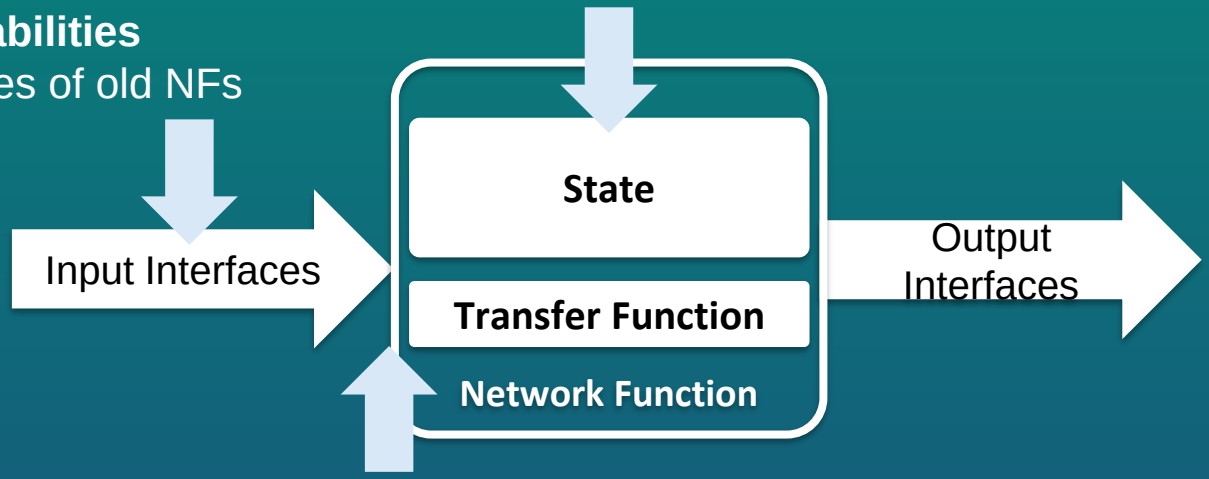
Limitations of Network Functions

Isolated state
Scaling is possible only within NF
Needs many operations to synchronize state with other NFs

Limited offered capabilities
New services need upgrades of old NFs



State and Transfer are bound together
Very complicated subscriber handovers to other NFs

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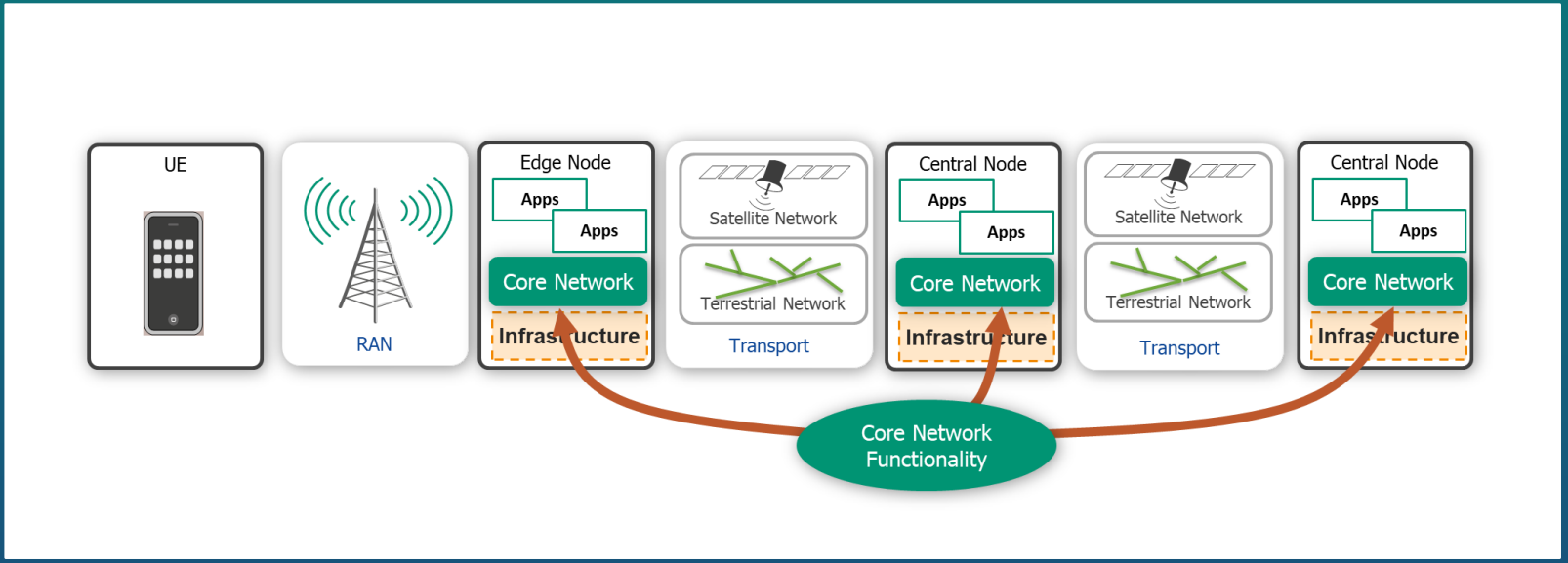
6G Requirements

Requirements	Challenges
Support the core network functionality	• Access control, authentication, and authorization • Connection management • Mobility management / Session management • Data path forwarding • Lawful interception and charging
Infrastructure free implementation	• Deployment on any hardware, transparent network bindings • Account for noticeable service characteristics
Complexity reduction	• Remove functionality replicas • Reduce the number of exchanged messages per procedure
Organic growth	• Regrouping of the functionality • Split processing and state elements
Simplify the addition of new functionality	• Reduce functional dependencies • Reduce the number of interfaces
Very fast scaling	• Native support for load balancing • Effective state sharing
High parallelization capacity	• Easy to split load across multiple worker entities • Able to parallelize across distributed infrastructures
Continuous Integration / Continuous Deployment	• Graceful deployment of functionality during the runtime of the system
Network management simplification	• Same type of components, uniform policies for scaling, uniform configurations, easy to adapt to automation

6G Core Network Split

Where to place the core network functionality to be able to:

- Provide the expected subscriber service
- Maintain the end-to-end service reliability
- Assure the service security – protection of authentication
- Assure the end-to-end service privacy



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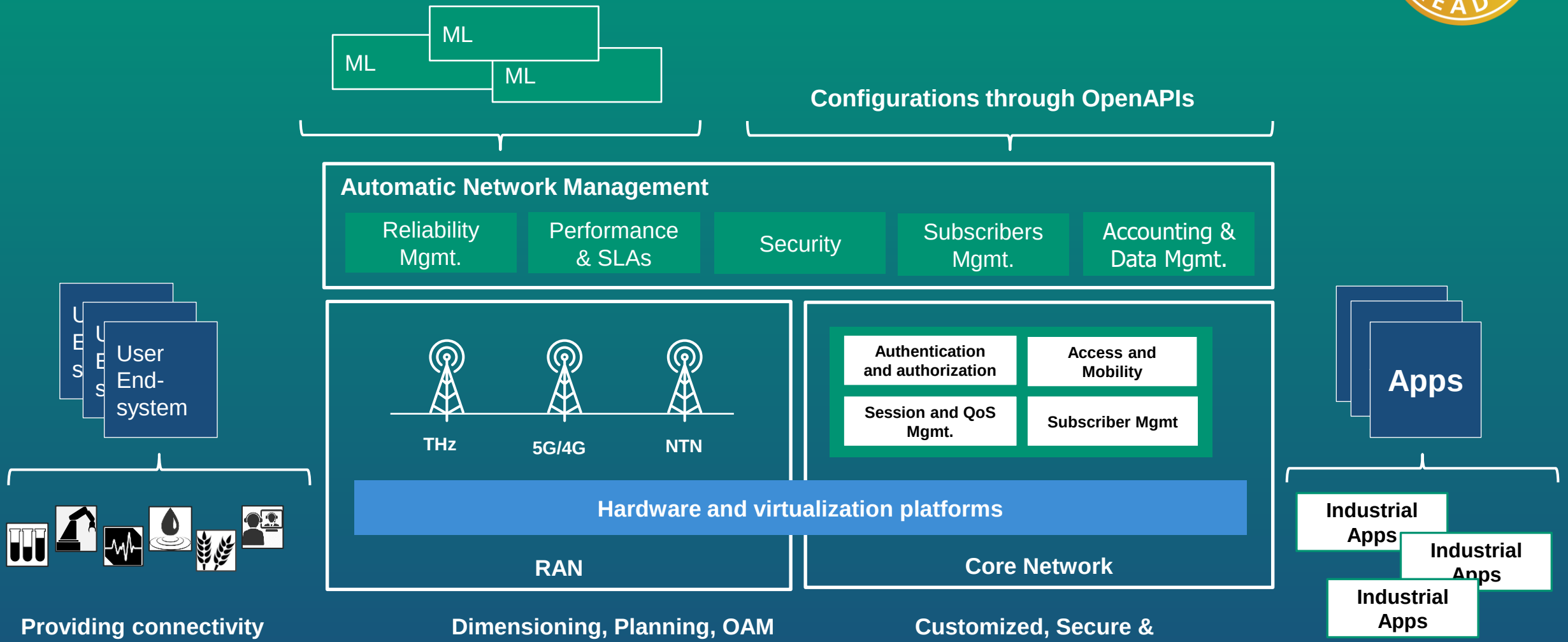
6G: End-to-end perspective



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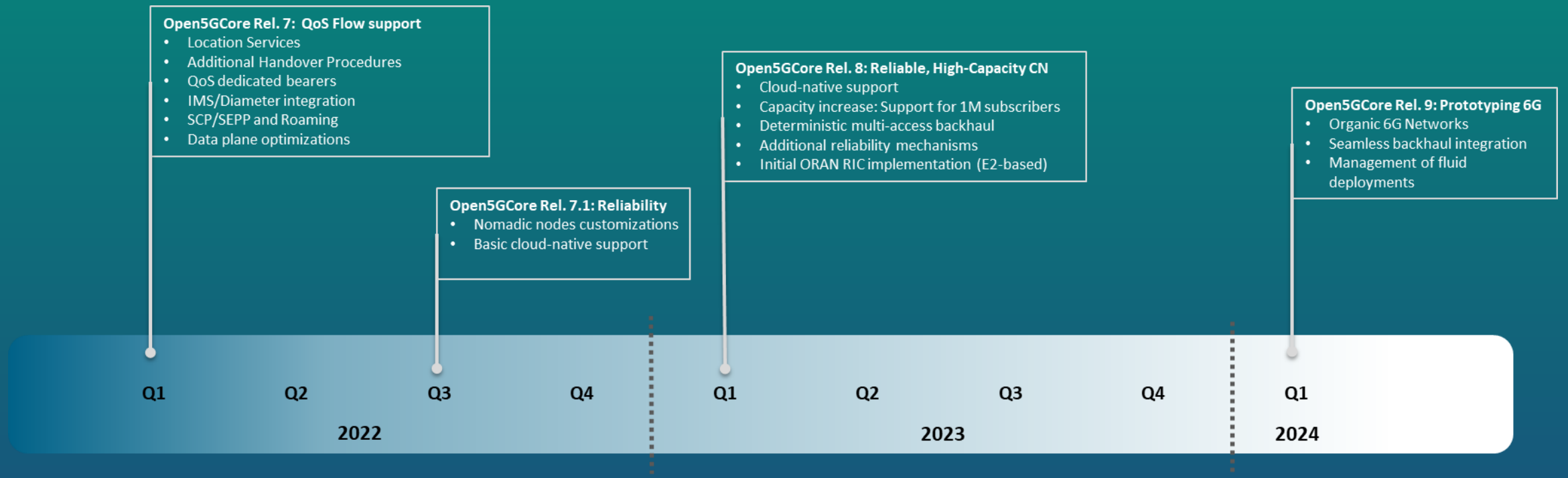
Roadmap for Open5GCore Rel. 8

Customization of testbeds towards use cases and specific deployments (user equipment, hardware, virtualization, integration with applications etc.), integration of base stations and end devices is available anytime on-demand.



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Preparing for 6G – from 6G-ready 5G Core towards Organic 6G Core

- NGNI is on track for 6G research: Focus is on Open & Nomadic 6G Campus Networks
- NGNI partners & customers ask regularly for upgrades
- Never change a winning team: Open5GCore is going to evolve towards 6G in three steps:
  - **OpenRAN-ready Open5GCore** (driven by BMWI CampusOS project)
  - **6G-ready Open5GCore** (driven by Fraunhofer 6G Sentinel project)
  - **Organic 6G Core** (new implementation from BMBF Hubs)

- Ca. 9 Mio. Euro funding secured for 6G research within the next 3 years:
- Fraunhofer 6G lighthouse project 6G Sentinel (2 Mio. Euro)
- BMBF 6G Hubs:
  - 6G-RIC Berlin (3 Mio. Euro)
  - Open 6G Hub Kaiserslautern (4 Mio. Euro)

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Open5GCore Evolution towards 6G

Demonstrations of limitations of 5G

5G-6G features
Features which could be immediately used in the 5G+ core

First 6G-ready 5G Core network
6G features in the 5G core

6G-ready End-to-end Demonstration
A complete 6G ready system

Infrastructure-free core network
6G Data Layer
Deep Integration of Transport
Pre-standardization research completed

First version of Open6GCore
New software toolkit addressing the specific 6G architecture

2020 2021 2022 2023 2024 2025 2026

OPEN RAN 5G+ READY

6G READY

ORGANIC 6G CORE

6G Standardization Start

6G-RIC Research and Innovation Cluster

Open6G Hub Germany

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6G Sentinel
Fraunhofer Lighthouse Project

- Fraunhofer flagship project Six G Enablers
- Flexible Networks, THz Technology and Integration, Non-Terrestrial Networks, SidElink, and Localization
- started in Q1 2021 with a duration of three years, budget: 8 Mio. Euros
- Bundles the competencies of five major Fraunhofer Institutes
- IZM, IAF, IIS, HHI, FOKUS
- to deliver systems know-how in 6G
- and funding for building FOKUS "6G-Ready" Open5GCore

- more information

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Upcoming BMBF 6G Research Hubs

Funding for the new FOKUS Organic 6G Core

- Germany is funding four 6G research Hubs with 250 Mio Euro
  - Berlin, Kaiserslautern, Aachen, Munich/Dresden
  - Start: August 2021 with a duration of four years

- FOKUS is contributing to two Open 6G Hub (Kaiserslautern) and 6G-RIC (Berlin) aiming to develop a new organic 6G core supporting RAN-CORE disaggregation

- 6G Hub Webnews

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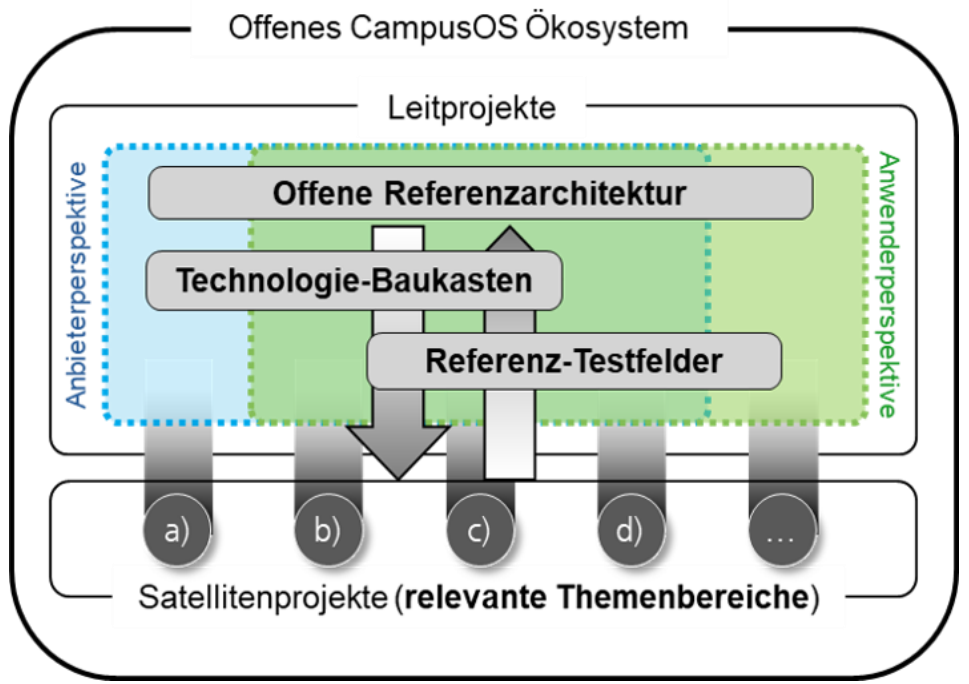
BMWK CampusOS (OpenRAN for Open Campus Networks)

CampusOS is:

- adapting Open RAN technology for building open 5G Campus networks
- aiming to develop an eco system for OpenRAN-based open campus networks targeting for German 5G digital sovereignty

- Budget: 40 Mio. Euro (20 Mio. Euro for 2 Leitprojekte + 20 Mio. Euro for 5-7 adjunct "Satellite" projects), **Start 01-2022, Duration 3 years**
- FOKUS (3,5 Mio. Euro) is co-leading with Franhofer HHI the two CampusOS main projects developing the reference architecture, developing key OpenRAN components, exploring different operation models, building reference testbeds, perfomimg trials with Industry partners (Bosch, Siemens, topcon, Still, etc.)

FOKUS will extend 5G playground and Open5GCore for "Open RAN-Readyness".



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Summary and Outlook

- FOKUS has a long tradition in building globally recognized telco software and testbeds
- We are driving the 6G Core network research in Germany
- We will extend Open5GCore to become 6G-ready to enable a potential smooth transition from 5G to 6G
- We will build a new Organic6GCore toolkit for the 2024 time frame to enable more disruptive 6G research
- You can licence Open5GCore today for YOUR rsearch
- We are open for joint international research projects
- For more look at www.6G-ready.org

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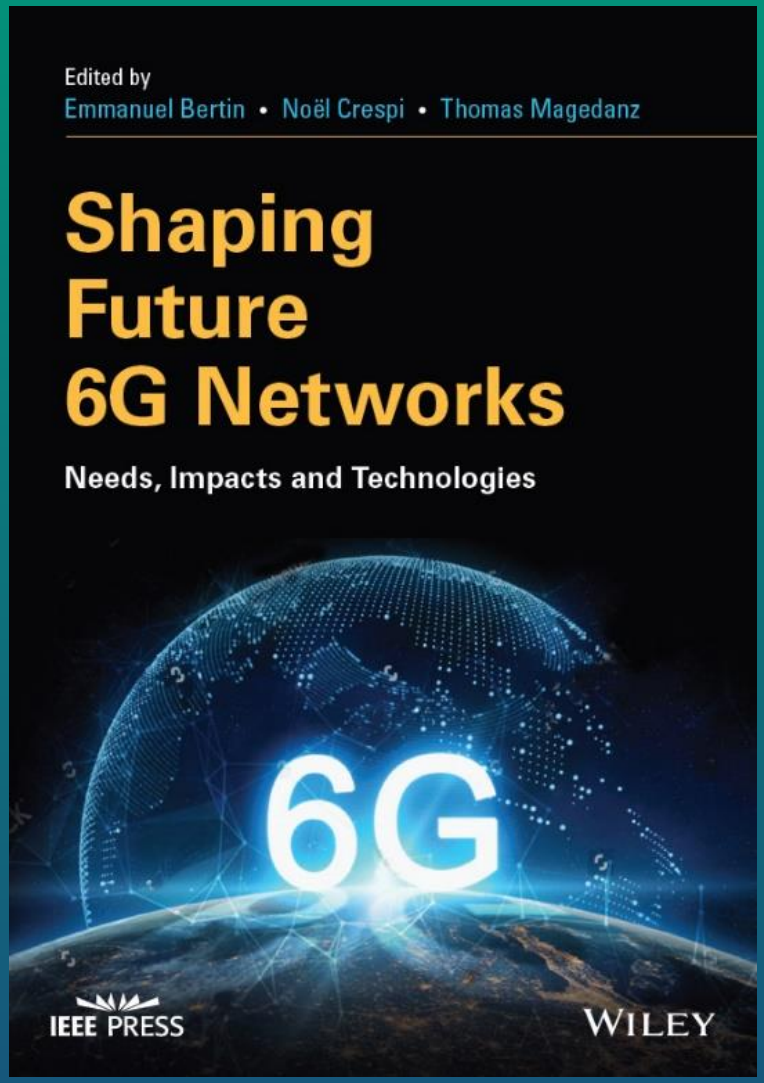
For further reading

E. Bertin, N. Crespi, T. Magedanz (Editors):
"Shaping Future 6G Networks
– Needs, Impacts and Technologies"
ISBN: 9781119765516 (Hardback), IEEE Press / Wiley
published in autumn 2021

Shaping Future 6G Networks: Needs, Impacts, and Technologies *is a holistic snapshot on the evolution of 5G technologies towards 6G. With contributions from international key players in industry and academia, the book presents the hype versus the realistic capabilities of 6G technologies and delivers cutting-edge business and technological insights into the future wireless telecommunications landscape.*



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Kontakt

Marius Corici
Dept. Head of the Software-based Division
Tel. +49 12 3463 7271
marius-iulian.corici@fokus.fraunhofer.de

Fraunhofer FOKUS Institute
Berlin, Germany
www.fokus.fraunhofer.de