Making 5G a commercial reality

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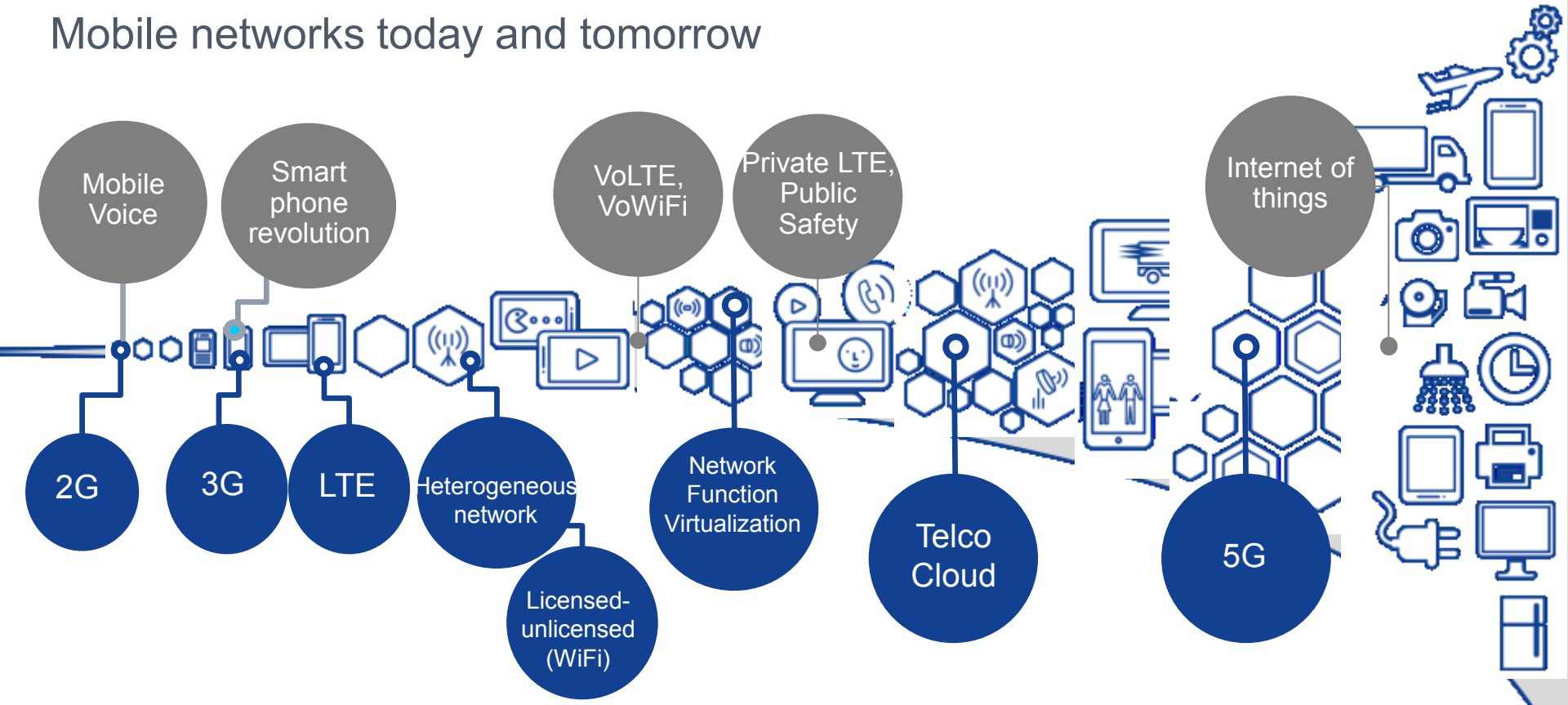
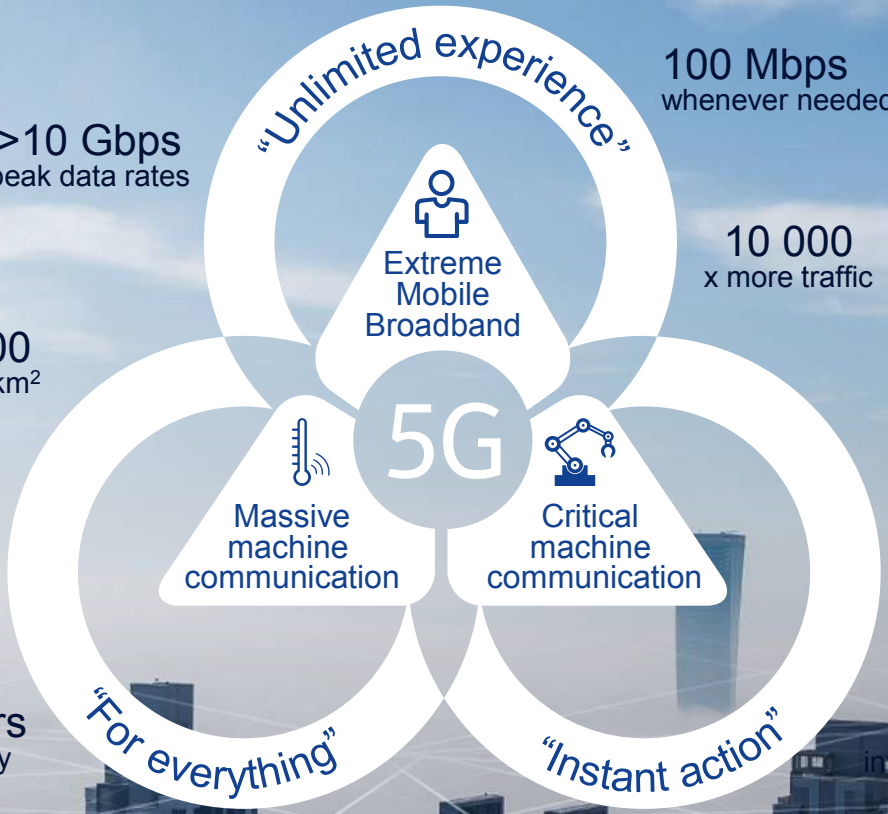
The journey for human technology

Mobile networks today and tomorrow



The promise of 5G



eMBB
Enhanced Mobile Broadband

>10 Gbps
peak data rates

100 Mbps
whenever needed

URLLC
Ultra-reliable and Low Latency Communications

10 000
x more traffic

1,000,000
devices per km^2

mMTC
Massive Machine Type Communications

<1 ms
radio latency

Ultra low cost
for massive machine coms.

Ultra reliability
< 10^{-5} E2E outage

10 years
on battery

Zero
mobility interruption

Consumer 5G survey key findings

Need or would like faster connectivity on next smartphone

>86%

Likely to purchase a phone that supports 5G next

~50%

Top use case — use cellular connectivity everywhere

Willing to pay extra for 5G

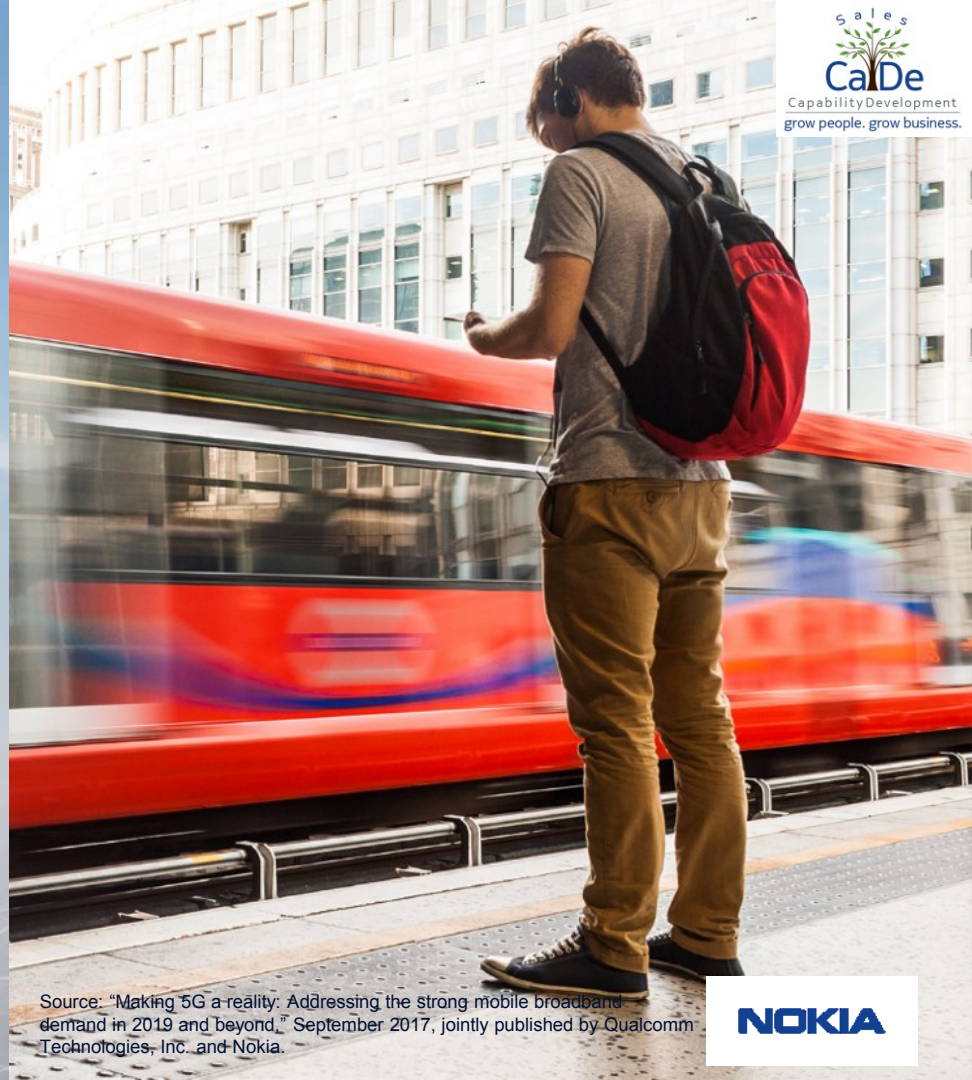
€€

Top 3 reasons for 5G:

10x faster speeds

10x quicker response time

More **cost-effective** data plans



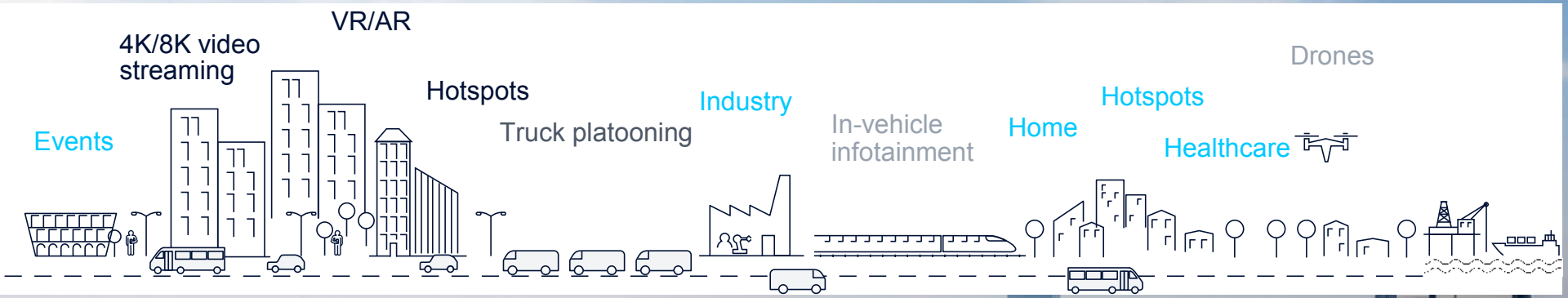
Source: "Making 5G a reality: Addressing the strong mobile broadband demand in 2019 and beyond," September 2017, jointly published by Qualcomm Technologies, Inc. and Nokia.

5G early market use cases

Nokia unveils high value 5G business models

Dense city area use cases	Highway use cases	Public transport use cases	Dedicated use cases

Structural 5G deployment area



Powerful Efficient Intelligent Flexible

Unleashing the potential of 5G – driven by architecture

Nokia Bell Labs
innovation in action

Digital Value Platforms
Augmented Cognition Systems
Programmable Network OS
Universal Adaptive Core

5G Future X

Autonomously
optimized coverage
& capacity

Software-
defined

Long
fibers

Short
waves
& wires

Emerging Devices
& Sensors

Massive Scale
Access

Converged
Edge Cloud

Smart Network
Fabric

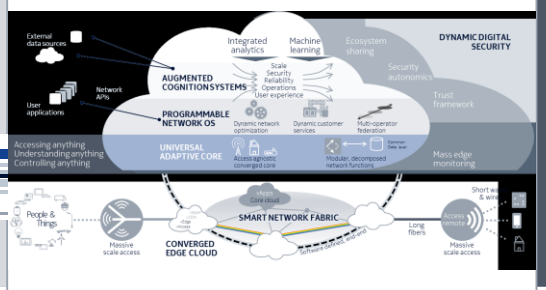
Converged
Node

New possibilities– from 4G to 5G

5G

Multiple connections simultaneously

Individual network ‘slices’ for different needs



Fully cloudified networks and applications

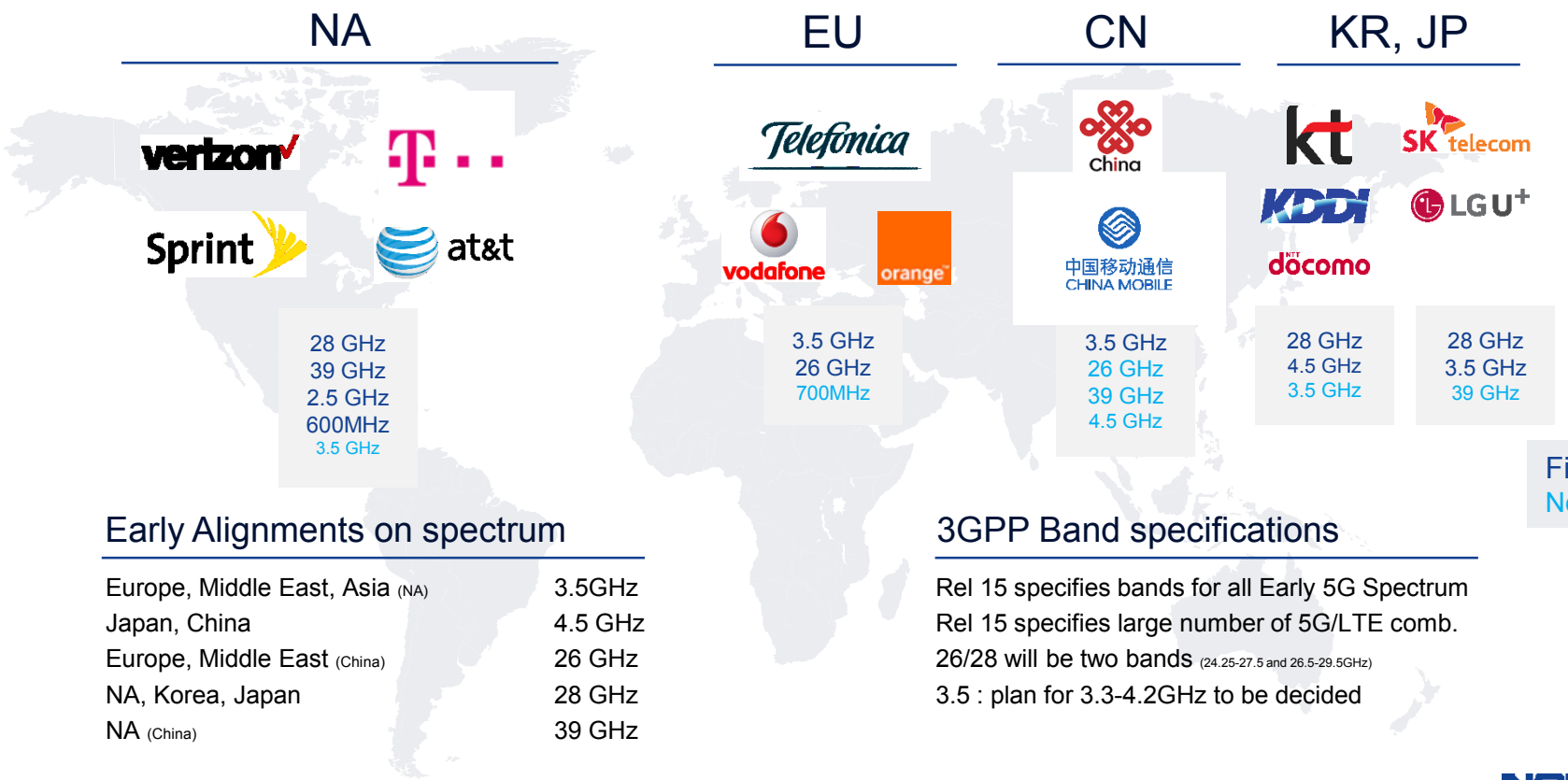
4G

One radio connection at a time

Single network for broadband video and machine type traffic

First steps into the cloud

Early spectrum for 5G globally



Early Alignments on spectrum

Europe, Middle East, Asia (NA)	3.5GHz
Japan, China	4.5 GHz
Europe, Middle East (China)	26 GHz
NA, Korea, Japan	28 GHz
NA (China)	39 GHz

3GPP Band specifications

Rel 15 specifies bands for all Early 5G Spectrum

Rel 15 specifies large number of 5G/LTE comb.

26/28 will be two bands (24.25-27.5 and 26.5-29.5GHz)

3.5 : plan for 3.3-4.2GHz to be decided

Early spectrum for 5G in EMEA

26 GHz

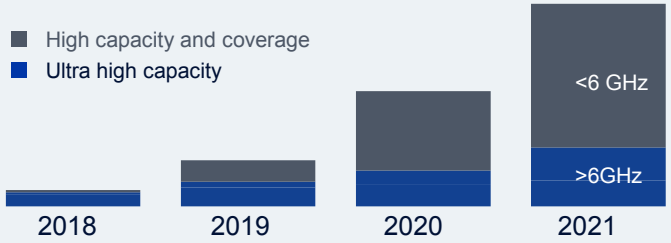
3.5 GHz

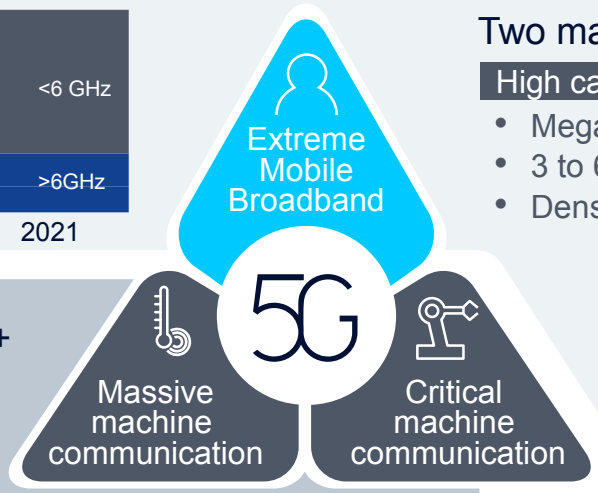
700MHz

5G market will start with enhanced mobile broadband

Nokia market view and derived engagement

Enhanced mobile broadband market starts





Two market segments

High capacity and coverage

- Megacity capacity densification
- 3 to 6GHz ~100MHz BW
- Dense urban grid

Ultra high capacity

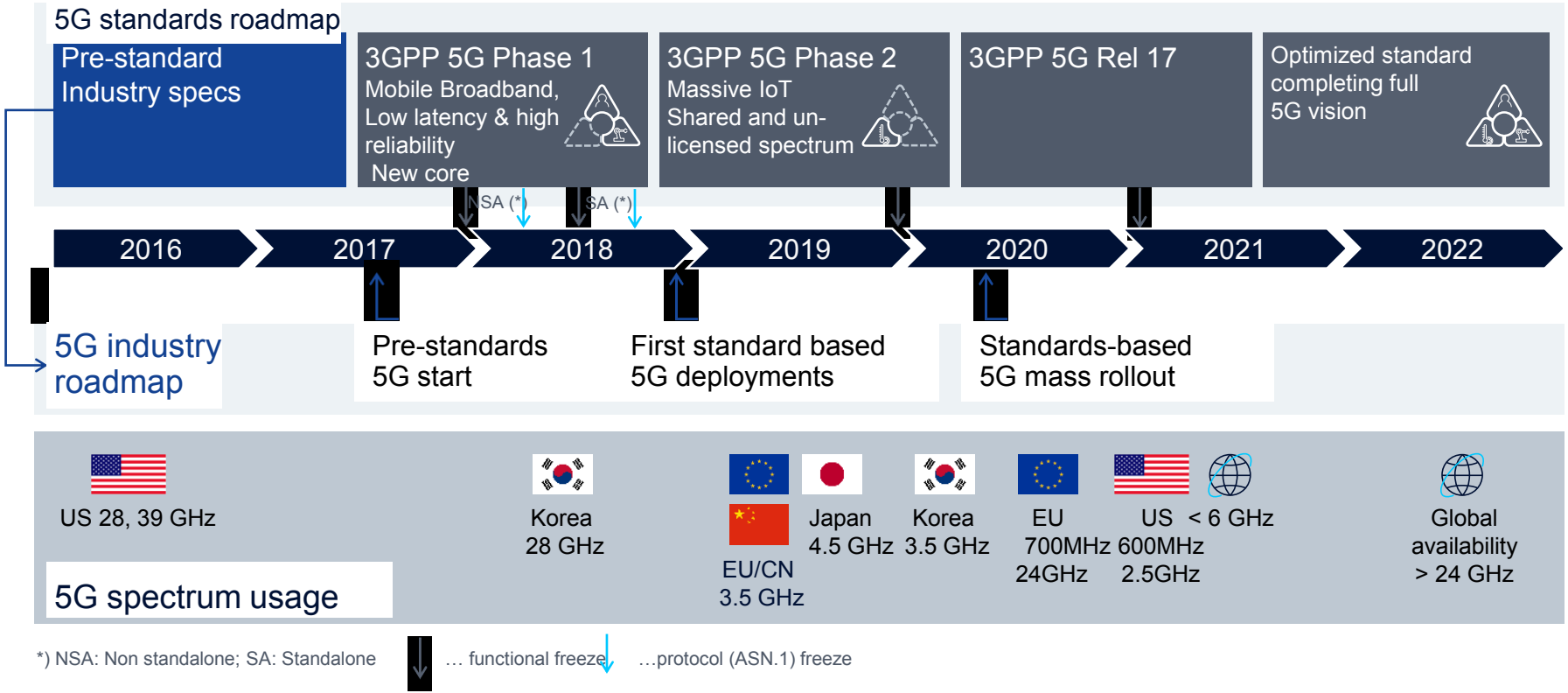
- Ultra dense use cases
- cm/mmWave
- Short range, LOS preferable

Machine markets will start 2022+

- Need for coverage layer and low cost devices
- Verticals not expected to be early adopters for 5G (low expertise)
- Earlier trials to test technology and define business models

Active in 3GPP standardization and supporting early adapters

5G spectrum – Nokia engaged in all 5G frequency bands



*) NSA: Non standalone; SA: Standalone … functional freeze …protocol (ASN.1) freeze

Operators around the world already trialing 5G use cases with Nokia

40+ engagements with global early adopters

AT&T – Multi-phase field trials with E2E 5G lab tests - 28, 39 and 73 GHz

Berlin stadium event - 5G powered entertainment in collaboration with DT

KT-Korea – pre-Olympic Games 5G mobile trial at 28GHz in 2018

Verizon –Commercial pre-standard 5G FWA.
First to complete 5G radio specifications 5GTF
Field coverage tests at 28GHz in several cities.

Docomo - 8K video over 5G radio, testing all frequency bands, from <6 GHz to mmWave

SKT-Korea – pre-standard 5G mobile trial planned at 28GHz in 2018

MIIT - Extensive testing on massive MIMO, new waveform, network slicing and MEC

Recent exciting developments

Nokia and Qualcomm complete key foundation tests of 5G New Radio network and devices

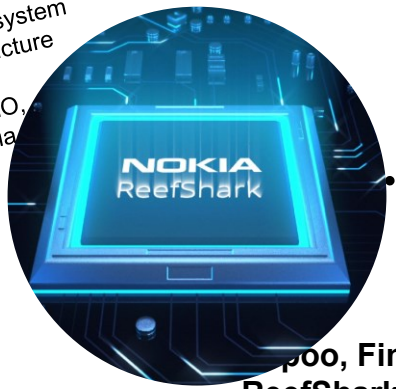
- Successful interoperability and over-the-air testing compliant with the 5G New Radio (NR) specification between network infrastructure and devices
- 5G NR testing has been performed on a commercially-available Nokia AirScale base station and Qualcomm Technologies' 5G NR UE prototypes
- Heralds operator trials as Nokia and Qualcomm Technologies drive ecosystem for widescale 5G deployments in 2019 with standards-compliant infrastructure and devices
- Operators* BT/EE, Deutsche Telekom, Elisa, KT, LGU+, NTT DOCOMO, Optus, SKT, Telia and Vodafone Group committed to working with Nokia Qualcomm Technologies in verifying and trialling 5G NR

Nokia implements Future X network architecture for 5G to deliver breakthrough network performance and reduce costs

- Future X combines high-capacity 5G New Radio, core and SDN controlled 'Anyhaul' transport to provide a complete set of network capabilities for commercial 5G
- Network architecture and ReefShark chipsets provide superior scalability and performance, tripling throughput of Nokia's existing market-leading RAN technology
- Automation using Nokia's open machine learning technology delivering Total Cost of Ownership (TCO) savings of up to 30%

Nokia, Deutsche Telekom and Hamburg Port Authority collaborate in 5G research in industrial environment

- 8,000-hectare site to carry out key tests of 5G applications
- 5G MoNArch project's main goal to gain knowledge and experience from 5G network slicing in 'real-world' environment
- Industrial use cases include traffic lights management, data processing from mobile sensors and virtual reality applications



Nokia and China Mobile show power of 5G to transform emergency patient care

- Companies use telehealth application to demonstrate how 5G will drive improvements to key services
- Demonstration uses Nokia 5G FIRST solution building on commercially available AirScale and AirFrame platforms

Espoo, Finland - Nokia has unveiled its new ReefShark chipsets, which leverage in-house silicon expertise to dramatically reduce the size, cost and power consumption of operators' networks and meet the massive compute and radio requirements of 5G.

Incorporating Nokia Bell Labs artificial intelligence (AI) innovations as well as Nokia's extensive capabilities in antenna development for mobile devices and base stations, ReefShark chipsets leverage silicon developed by Nokia in Oulu, Espoo and Tampere, Finland as well as Sunnyvale, California.

Driving the global 5G end-to-end ecosystem

Business partners

BOSCH

hp

IEEE Advancing Technology for Humanity

Intel

QUALCOMM

Verticals

Cities

Automotive

Utilities

Health

Safety

Leading contributor to standardization and research

Eura 5G

5G NORMA

3GPP

ngmn

METIS II

FANTASTIC 5

mmMAGIC

ITU

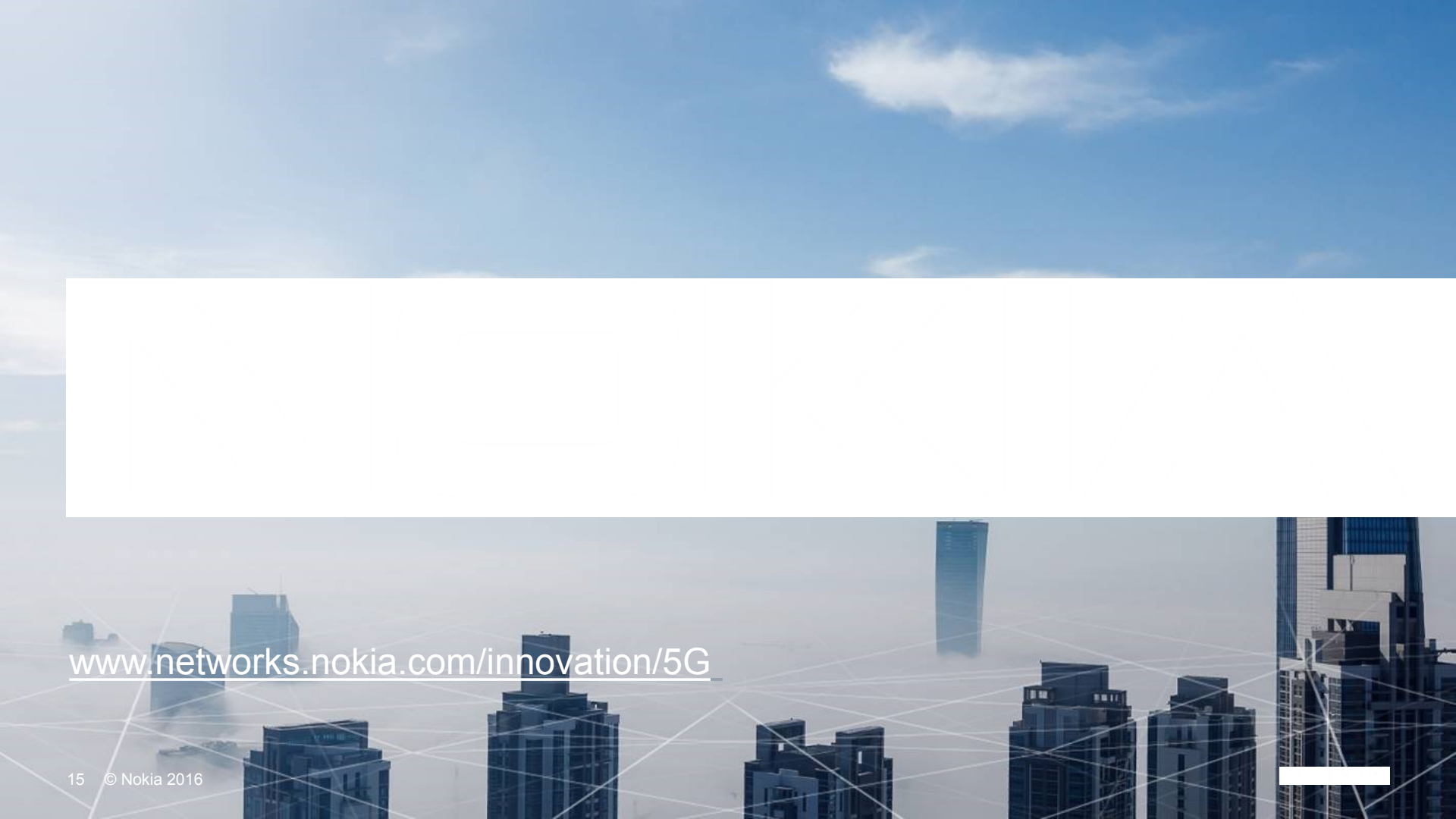
Lte

TECHNISCHE UNIVERSITÄT DRESDEN

NYU

5G Forum

NOKIA



www.networks.nokia.com/innovation/5G

