Making 5G a commercial reality

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The journey for human technology
Mobile networks today and tomorrow

- Mobile Voice
- Smart phone revolution
- 2G
- 3G
- LTE
- Heterogeneous network
- VoLTE, VoWiFi
- Licensed-unlicensed (WiFi)
- Private LTE, Public Safety
- Network Function Virtualization
- Telco Cloud
- Internet of things
- 5G
- 3G
- Smart phone revolution
- LTE
- Voice revolution
- Private LTE, Public Safety
- Internet of things
- 5G
The promise of 5G

- eMBB: Enhanced Mobile Broadband
- URLLC: Ultra-reliable and Low Latency Communications
- mMTC: Massive Machine Type Communications

- "Unlimited experience": >10 Gbps peak data rates
- "For everything": 1,000,000 devices per km²
- "Instant action": Ultra low cost for massive machine communications

- "Extreme Mobile Broadband": 100 Mbps whenever needed
- "Massive machine communication": 10,000 x more traffic
- "Critical machine communication": <1 ms radio latency
- "Ultra reliability": <10⁻⁵ E2E outage

- "Zero mobility interruption": 1,000,000 devices per km²

Enhanced Mobile Broadband
Massive Machine Type Communications
Ultra-reliable and Low Latency Communications
Ultra low cost for massive machine communications
"For everything"
"Instant action"
"Unlimited experience"
### Consumer 5G survey key findings

<table>
<thead>
<tr>
<th>Need or would like faster connectivity on next smartphone</th>
<th>Likely to purchase a phone that supports 5G next</th>
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<tbody>
<tr>
<td>&gt;86%</td>
<td>~50%</td>
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<table>
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<tr>
<th>Top use case — use cellular connectivity everywhere</th>
<th>Willing to pay extra for 5G</th>
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<td>€€</td>
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**Top 3 reasons for 5G:**
- 10x faster speeds
- 10x quicker response time
- More cost-effective data plans

5G early market use cases
Nokia unveils high value 5G business models

- Dense city area use cases
  - 4K/8K video streaming
  - VR/AR
  - Events

- Highway use cases
  - Hotspots
  - Truck platooning

- Public transport use cases
  - Industry
  - In-vehicle infotainment

- Dedicated use cases
  - Home
  - Healthcare
  - Drones

Key features:
- Powerful
- Efficient
- Intelligent
- Flexible
Unleashing the potential of 5G – driven by architecture

Powerful

Efficient

Intelligent

Flexible

Nokia Bell Labs innovation in action

Digital Value Platforms

Augmented Cognition Systems

Programmable Network OS

Universal Adaptive Core

Emerging Devices & Sensors

Massive Scale Access

Converged Edge Cloud

Converged Node

Short waves & wires

Long fibers

Converged

Smart Network Fabric

Autonomously optimized coverage & capacity

Nokia 2016

Unleashing the potential of 5G – driven by architecture

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5G Future X – Unleashing the potential of 5G
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
- High capacity and coverage
- Ultra high capacity

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

**5G standards roadmap**

- **Pre-standard Industry specs**
- **3GPP 5G Phase 1** - Mobile Broadband, Low latency & high reliability
- **3GPP 5G Phase 2** - Massive IoT
- **3GPP 5G Rel 17**

**5G industry roadmap**

- **2016**: Pre-standards
- **2017**: 5G start
- **2018**: First standard based
- **2019**: 5G deployments
- **2020**: Standards-based
- **2021**: 5G mass rollout
- **2022**: Optimized standard completing full 5G vision

**5G spectrum usage**

- **US 28, 39 GHz**
- **Korea 28 GHz**
- **EU/CN 3.5 GHz**
- **Japan 4.5 GHz**
- **Korea 3.5 GHz**
- **EU 700MHz 24GHz**
- **US < 6 GHz 600MHz 2.5GHz**
- **Global availability > 24 GHz**

*) 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

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

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

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

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

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

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, and devices
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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

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

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.

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Driving the global 5G end-to-end ecosystem

Business partners

Leading contributor to standardization and research

Verticals

Shaping 5G with all major operators