5G for people and things

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Heterogeneous use cases – diverse requirements

- **“Unlimited experience”**
  - >10 Gbps peak data rates
  - 100 Mbps whenever needed
  - 10,000 x more traffic

- **“For everything”**
  - 10-100 x more devices
  - M2M ultra low cost
  - 10 years on battery

- **“Instant action”**
  - Critical machine communication
  - Extreme Mobile Broadband
  - M2M communication

- **Ultra reliability**
  - <1 ms radio latency

- **Massive machine communication**
Key to the programmable world
Key to the programmable world
5G for people and things
Expanding the human possibilities of cellular technology

- Give back 2hrs/day... never be in a rush
- Everyone is an innovator – easier and faster to innovate
- Towards zero road fatalities, > half a million lives saved
- Zero loss water distribution
- Healthy people with connected wearables, remote medics
- Less transport costs and fuel consumption
- Never lost – always find an address – always on time
- 50% higher industry productivity by connected cyber physical systems
- Safer in connected homes

Individual  
Society  
Economy
5G

Key to the programmable world

- Possibilities
- Versatile radio
- System of systems
- Practicalities
- Potentials
5G for people and things | Key to the programmable world

Versatile radio

- Unlocking spectrum assets
- Dynamic resource usage
- Configurability
- Massive MIMO
- Multi-connectivity
- Extreme Mobile Broadband
- Critical machine communication
- Massive machine communication
- Slim Radio
- 1ms Radio
Unlocking new spectrum assets | Foundation for 5G
Leveraging all bands, ranging from ~400MHz - 100GHz

Different characteristics, licensing, sharing and usage schemes

Carrier BW  n * 20MHz  n * 100 MHz  1-2GHz

Duplexing  FDD  TDD

Cell size  Macro  Small  Ultra small

Coverage  Capacity

Continuous coverage, high mobility and reliability

Higher capacity and massive throughput

Leading METIS I & II spectrum work package

Leading modeling know-how
Channel measurements from 3-73GHz

World’s 1st trials on shared spectrum access

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WRC-19 preparations – WRC-15 AI10
Nokia thinking on 5G spectrum

Current activities should be focused to find ranges/bands to be studied between WRC-15 and WRC-19 (and not to find and decide on the bands to allocate)

Keep the 5G spectrum ranges to be studied as wide as possible.
Keep as many ranges alive as possible, especially below 30GHz.
2-4 wide ranges in low (~6-20GHz), medium (~20-40GHz) and high (~40-90GHz) frequencies.

For example:
5.925 – 8.5 GHz
10.7 – 19.7 GHz
24.25 – 29.5 GHz
36 – 50.2 GHz
66 – 71 GHz
71 – 76 / 81 - 86 GHz

Rationale
Tentative 5G spectrum bandwidth estimate per operator:
~500MHz below 20GHz
~1GHz between 20-40GHz
~2 GHz above 40GHz.
Multi-Connectivity | Perception of infinite capacity
Multiple radio technologies collaborating as one system

10,000 x >10 Gbps 100 Mbps <1 ms 10-100x ultra low 10 years

Extreme mobility robustness and ultra reliability

>100 Mbps anywhere 3 x burst throughput*

4G/5G real-time radio resource management know how built on demonstrator

*in example area, 50% load
Further aspects we are looking into Versatile Radio

- 1ms Radio
- Waveforms
- Hybrid ARQ

- Full duplex
- Perception of always on
- Configurability
- Multi connectivity

- Massive MIMO
- D2D
- Advanced TX/RX
- Interference mitigation

- Self backhauling
- Unlocked Spectrum Access
- Efficient Coding

- Channel Measurements
- Unlocking Spectrum Access
- Synchronization
- Slim Radio

- Dynamic Resource Mgmt.
- Multi connectivity
- Efficient Coding
- Slim Radio
Key to the programmable world
5G for people and things | Key to the programmable world
System of systems
Network Slicing | Optimized service delivery for heterogeneous use cases
Multiple independent instances on one physical network

- Distributed Content & processing where its needed
- Programmable Software-defined functions
- E2e management & orchestration

- Security & Privacy
- Orchestration
- Applications
- Platforms
- Infrastructure

- Full automation and self-optimization
- All kinds of NaaS business models
- Leader of 5GPPP NORMA*
- 5G ready AirFrame data enter
- Programmable core and transport

*5G Novel Radio Multiservice adaptive network Architecture

- 10,000 x
- >10 Gbps
- 100 Mbps
- <1 ms
- 10-100 x
- ultra low
- 10 years

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Key to the programmable world
Active in shaping and aligning the global 5G end-to-end ecosystem

**COLLABORATION**
- Technical manager
- Chairing association
- Project lead
- 5G expert group lead

**RESEARCH**
Holistic systems research, prototyping & development

**REGULATORY & STANDARDS**
- ITU-R
- Lte
- 3GPP

**POLICY**
Supporting right technology related policies

**ALIGNMENT**
Bringing together industry, academia & regulators

**Focused customer collaborations**

**University collaborations**

**Conference, Journal & Workshops**

**Brooklyn 5G Summits**
5G Possibilities Versatile radio System of systems Practicalities Potentials

Key to the programmable world
Growth and enabler of societal innovation
What is needed to make 5G a true global success?

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<td>Cross region collaborative research and pre-consensus</td>
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<td>Drive global standardization</td>
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<td>More globally harmonized spectrum (for LTE and 5G)</td>
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| Market driven competition and consolidation |
| Data protection for information centric networks |
| Legislation on Net Neutrality |
| Fair rules for standard essential patents |