

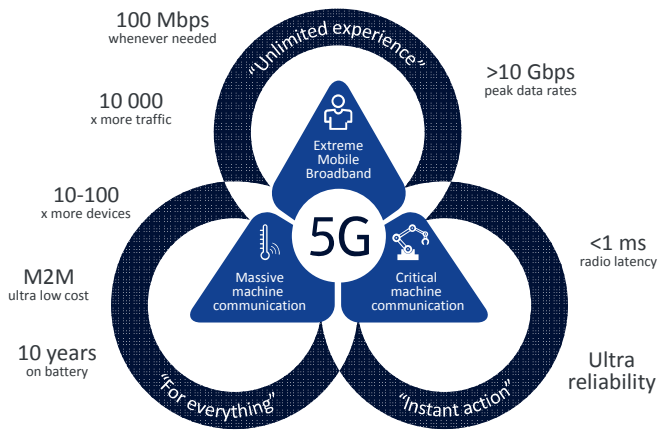
NOKIA

5G – Evolution and Revolution

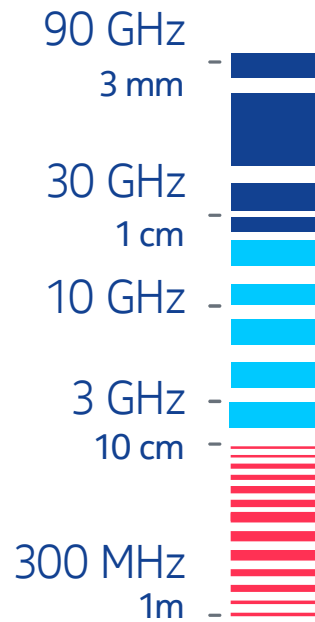
Sigurd Schuster, Josef Urban
Nokia



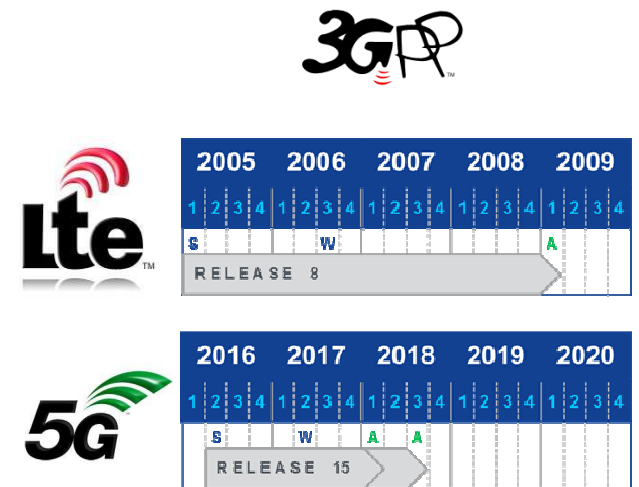
5G Magic?



Does everything!



Works Everywhere!

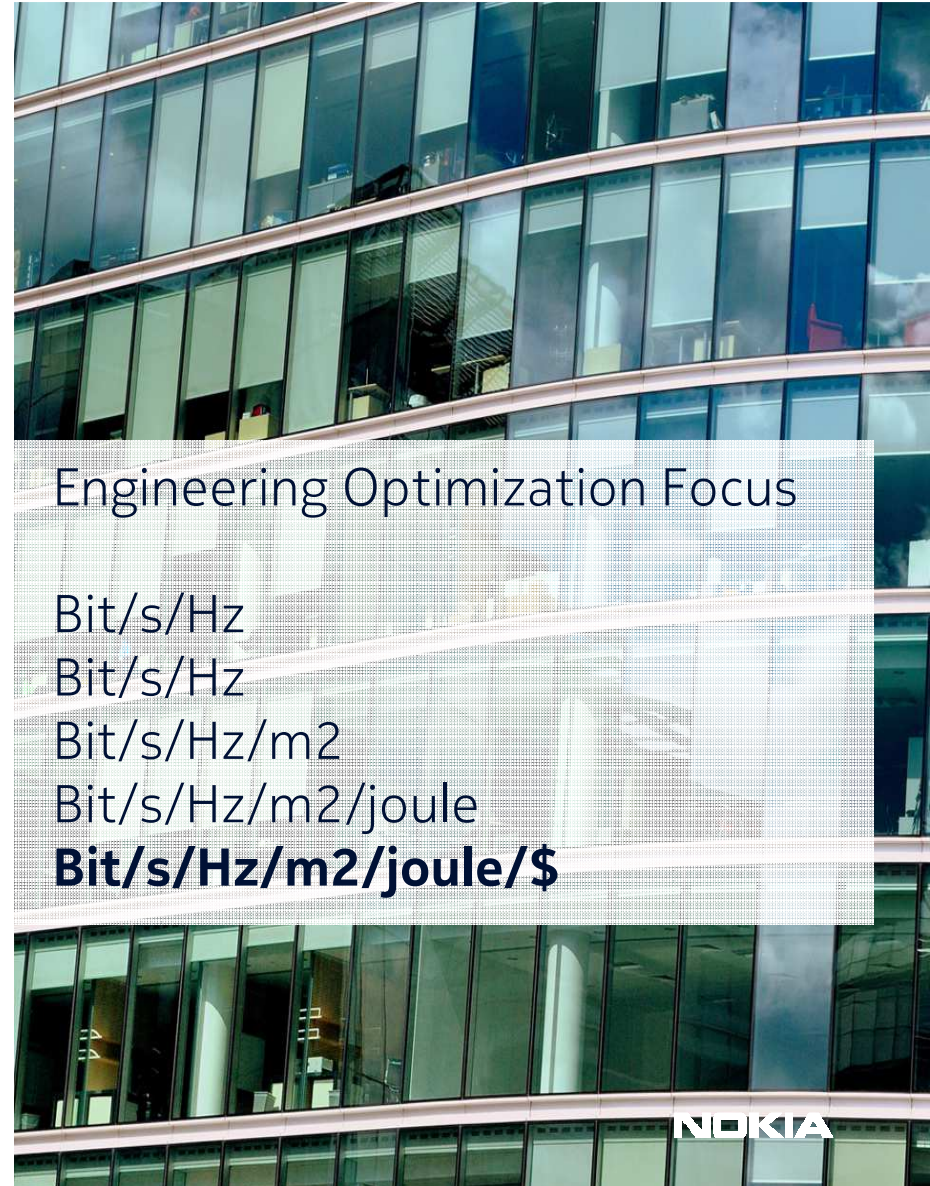
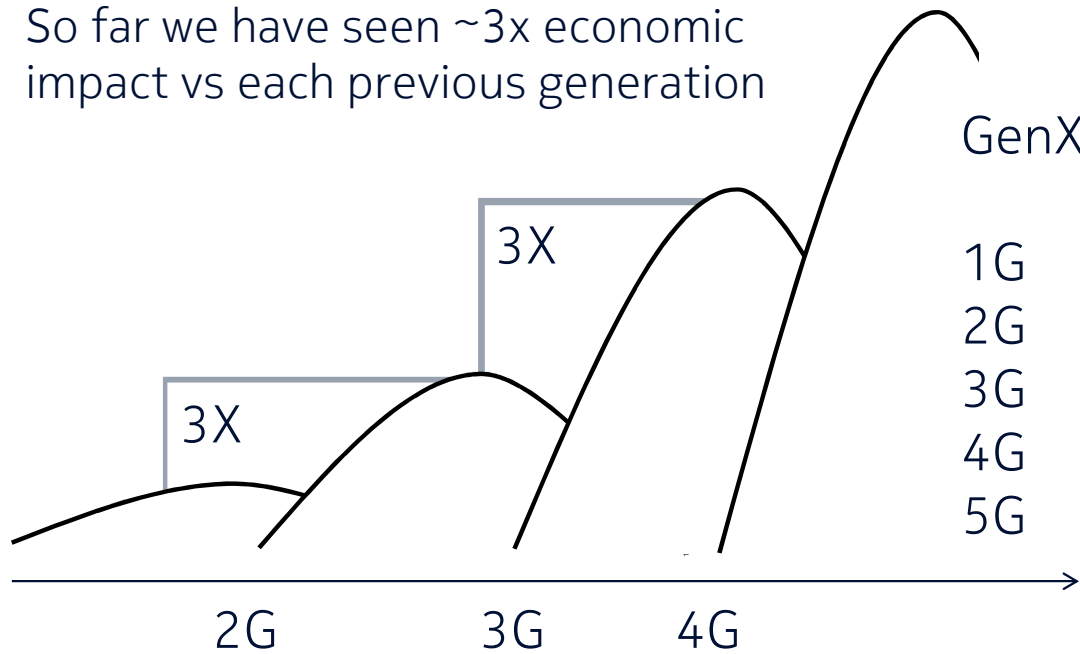


Is ready in no time!

5G designed to solve three problems

Problem #1: Economics

So far we have seen ~3x economic impact vs each previous generation



Engineering Optimization Focus

1G
Bit/s/Hz

2G
Bit/s/Hz

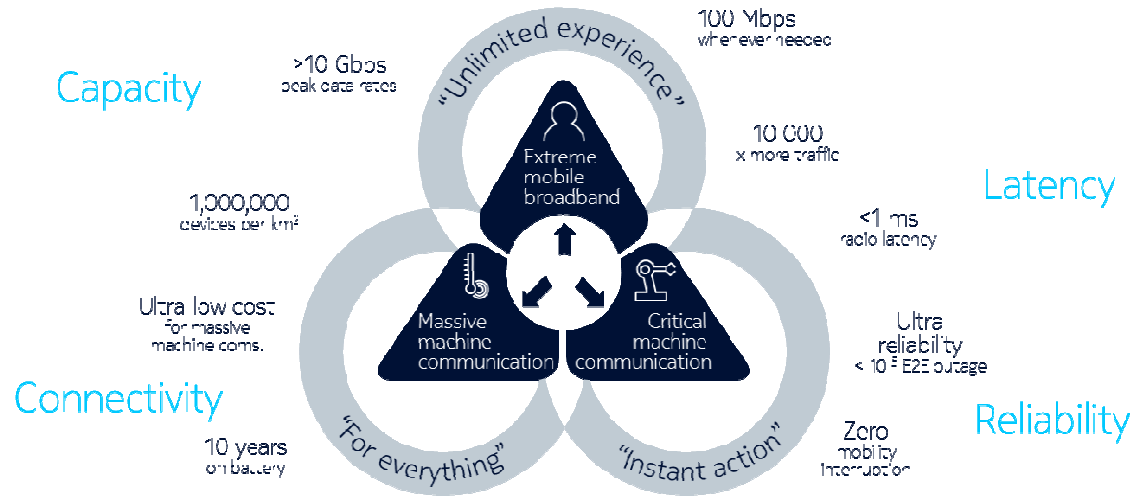
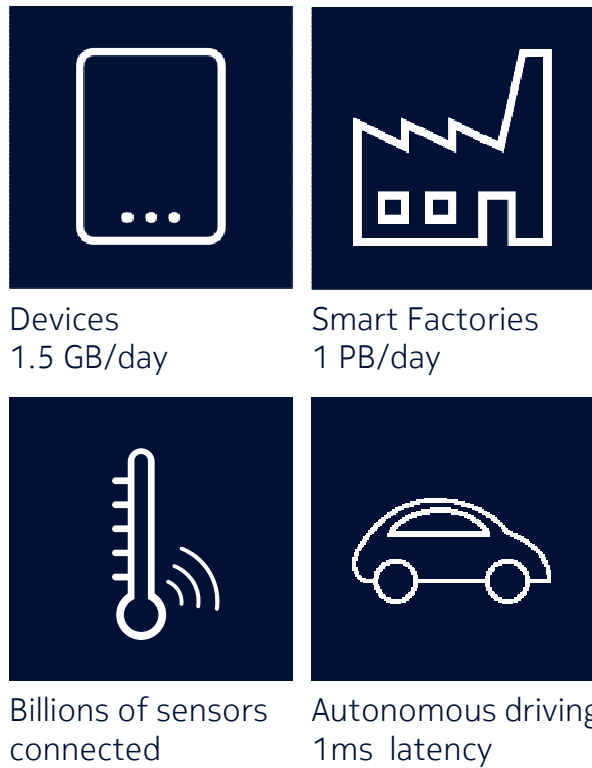
3G
Bit/s/Hz/m²

4G
Bit/s/Hz/m²/joule

5G
Bit/s/Hz/m²/joule/\$

5G designed to solve three problems

Problem 2#: New user demands with extremely diverse requirements



→ Design and architecture principles:
flexible | scalable | automated | cloud native
software centric | dynamic network slicing

5G designed to solve three problems

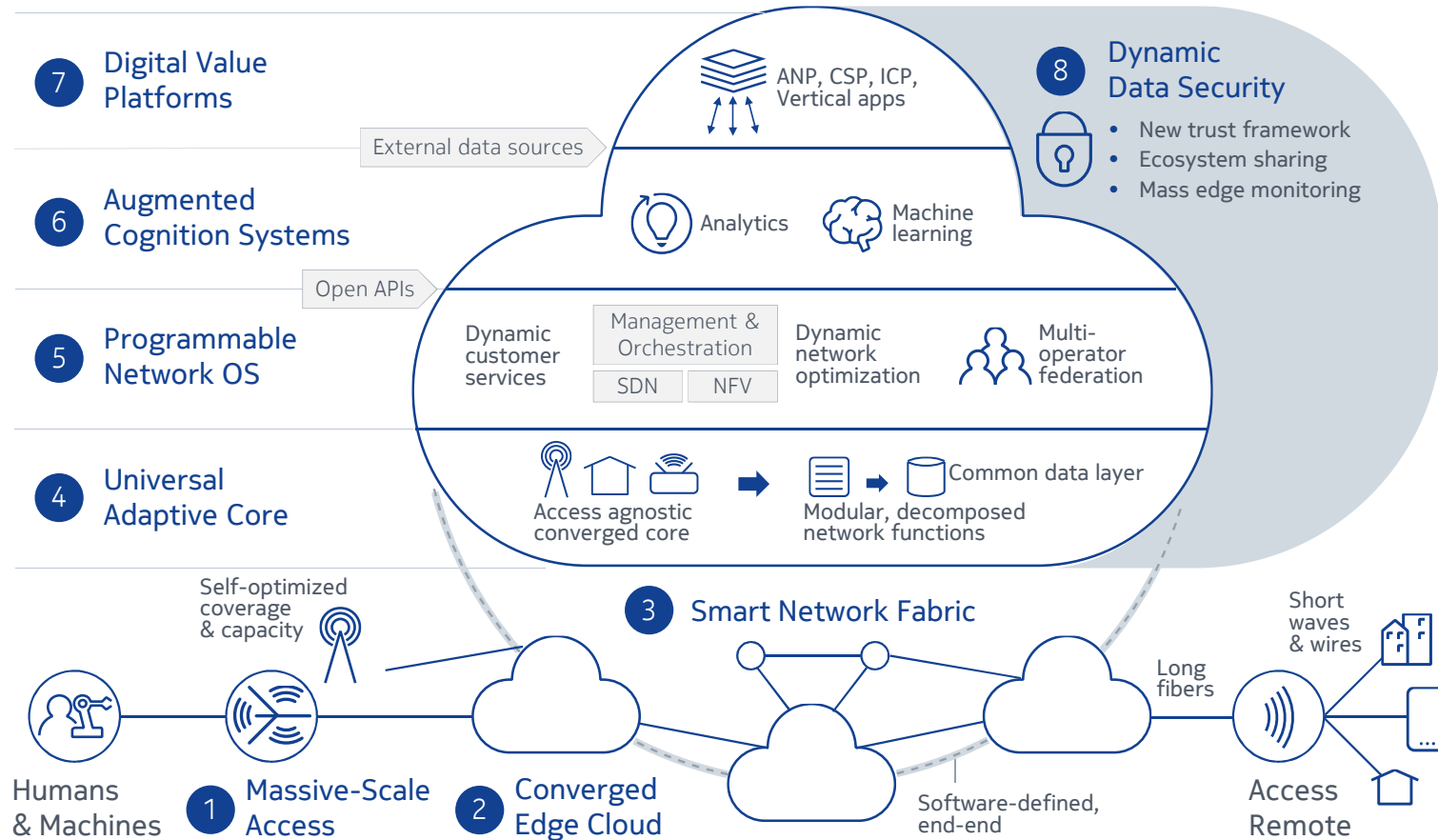
Problem #3: Physical limitations

$$c = 3 \times 10^8 \text{ m/s}$$

$$C = B \log_2 (1 + S/N)$$

Speed of light
& Shannon's law
(latency & capacity
limitations driving
network evolution)

Nokia's vision for the 5G era – driven by “Future-X” architecture



What is 5G? Radio Design (NR)

A new set of technologies for a generation leap in capabilities

	3G	4G	5G
Downlink waveform	CDMA	OFDM	OFDM, SCFDMA
Uplink waveform	CDMA	SCFDMA	OFDMA, SCFDMA
Channel coding	Turbo	Turbo	LDPC (data) / Polar (L1 contr.)
Beamforming	No	Only data	Full support
Spectrum	0.8 – 2.1 GHz	0.4 – 6 GHz	0.4 – 90 GHz
Bandwidth	5 MHz	1.4 – 20 MHz	Up to 100 MHz (400MHz for >6GHz)
Network slicing	No	No	Yes
QoS	Bearer based	Bearer based	Flow based
Small packet support	No	No	Connectionless
In-built cloud support	No	No	Yes

What is 5G? Core Network Design

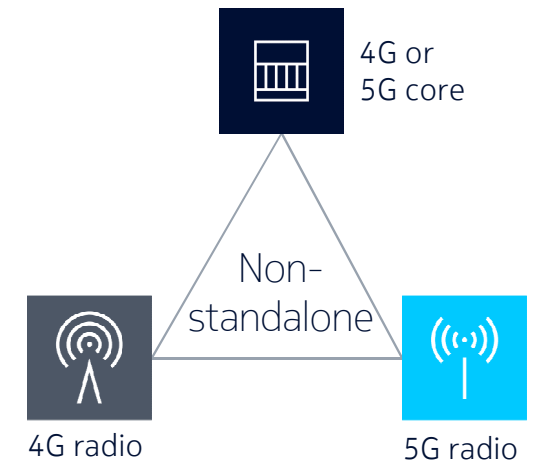
Designed for the Cloud, support of verticals and novel business models

	EPC (4G)	5G Core
RAN – core interface	One per device	Multiple
Network slicing	Single slice	Multiple slices
Quality of Service model	Bearer based	Flow based
Short packet support	Connection oriented	Connectionless
Cloud native	Transparent to implementation	Cloud optimized Design
Authentication and session management	Access dependent	Unified procedures

3GPP Architecture Options in Rel 15 Stand-Alone (SA) and Non-Standalone (NSA)

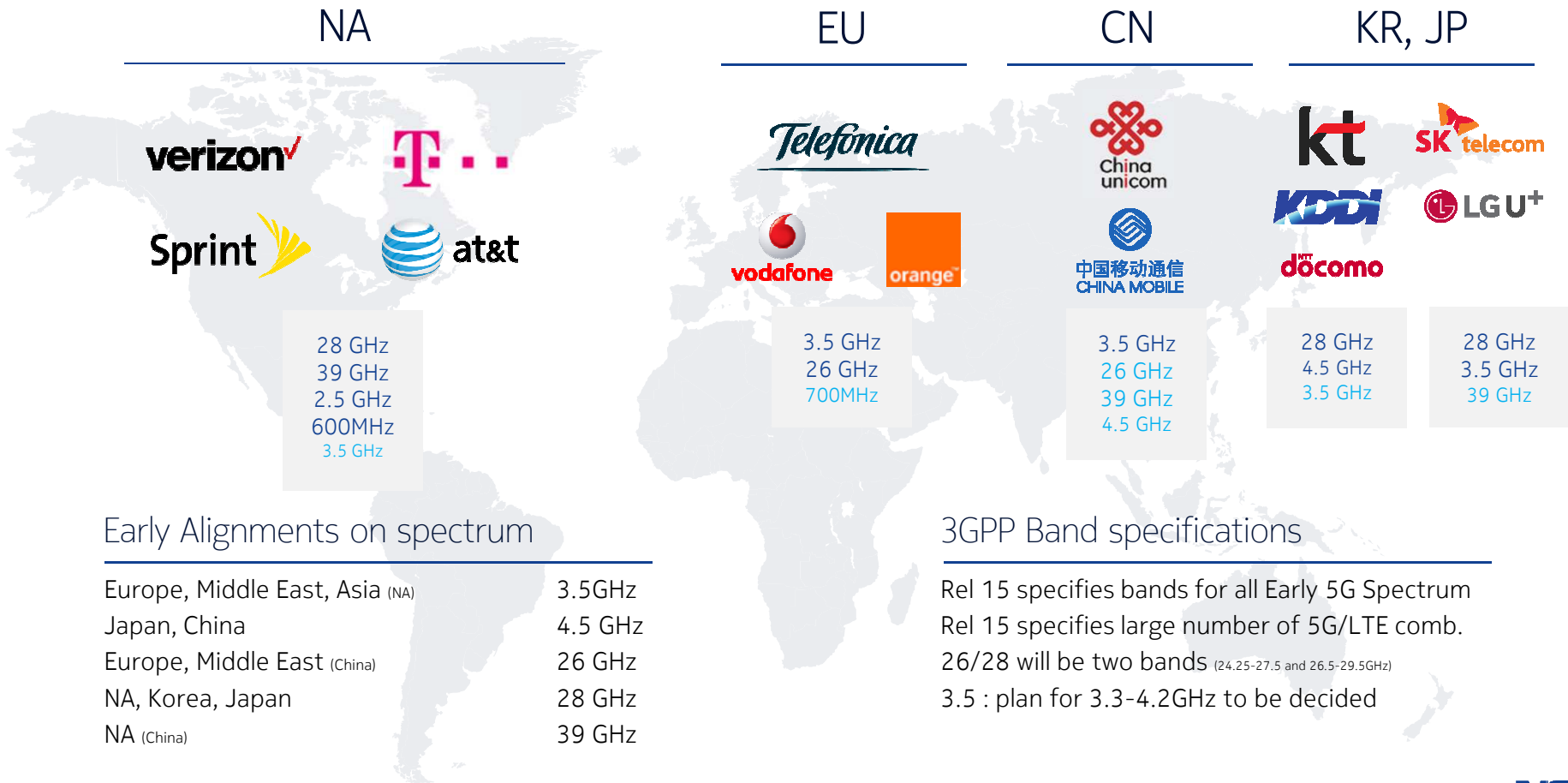
Variety of deployment options drives complexity

	Standalone (SA)	Non-standalone (NSA)
5G radio cells	Directly used by 5G device	Only available as a secondary carrier, under the control of an LTE base station
Core Network	5G next-gen core	4G core (EPC) or 5G next-gen core
Organisation perspective	Simple, high performance overlay	Leverages existing 4G deployments
3GPP Architecture Option	Option 2	Option 3 (EPC) or Option 7 (5G Core)
Completion Date*	June 2018	Dec 17 (Opt 3) / June 18 (Opt 7)



Early 5G Spectrum Globally

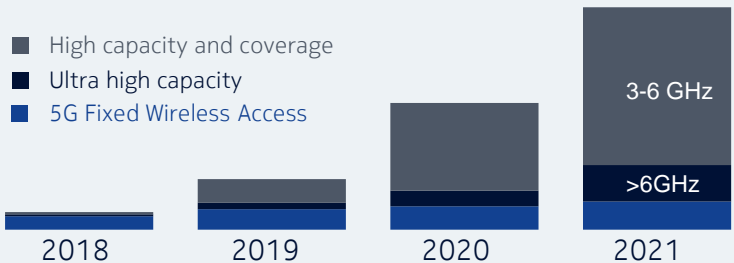
Firm
Next in Line



Market outlook

5G market will start with extreme mobile broadband

Extreme mobile broadband market starts



E2E solutions for all three markets

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

5G Fixed Wireless Access

- Extension of fiber access
- cm/mmWave
- Line of Sight (LOS)

Machine markets will start to develop 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

