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Nokia Networks

5G Small Cell Technology

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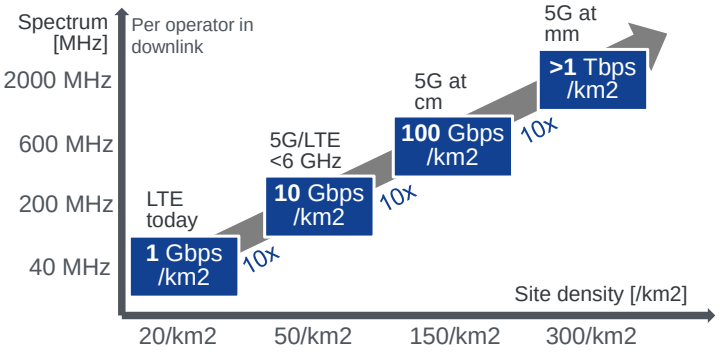
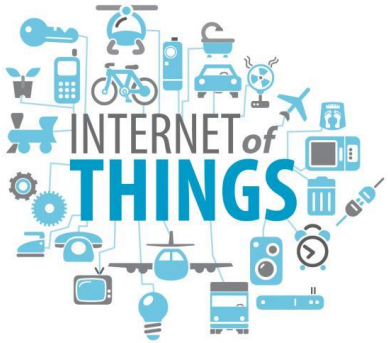
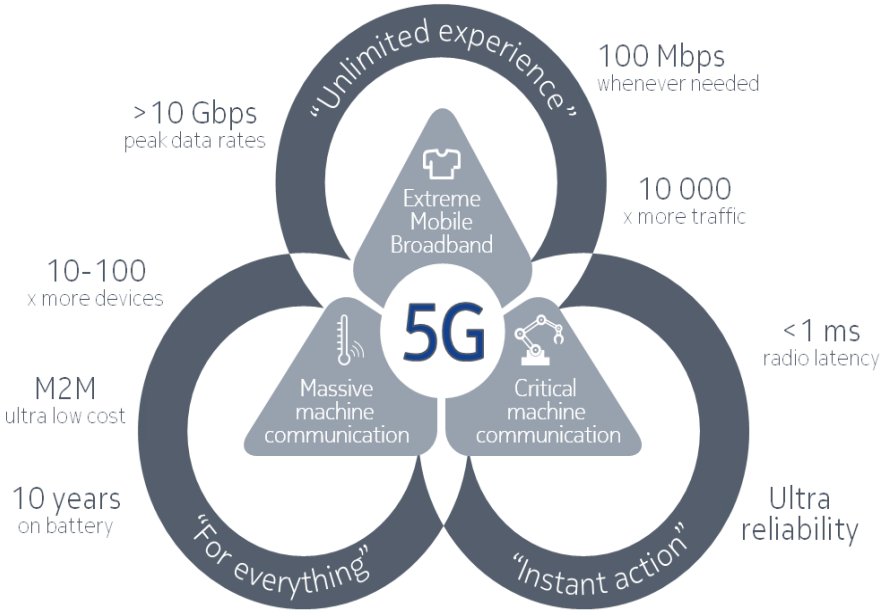
IoT value capture from 5G Evolution and Revolution towards 1 Tbs/km2 …

Three-pronged requirements for 5G networks







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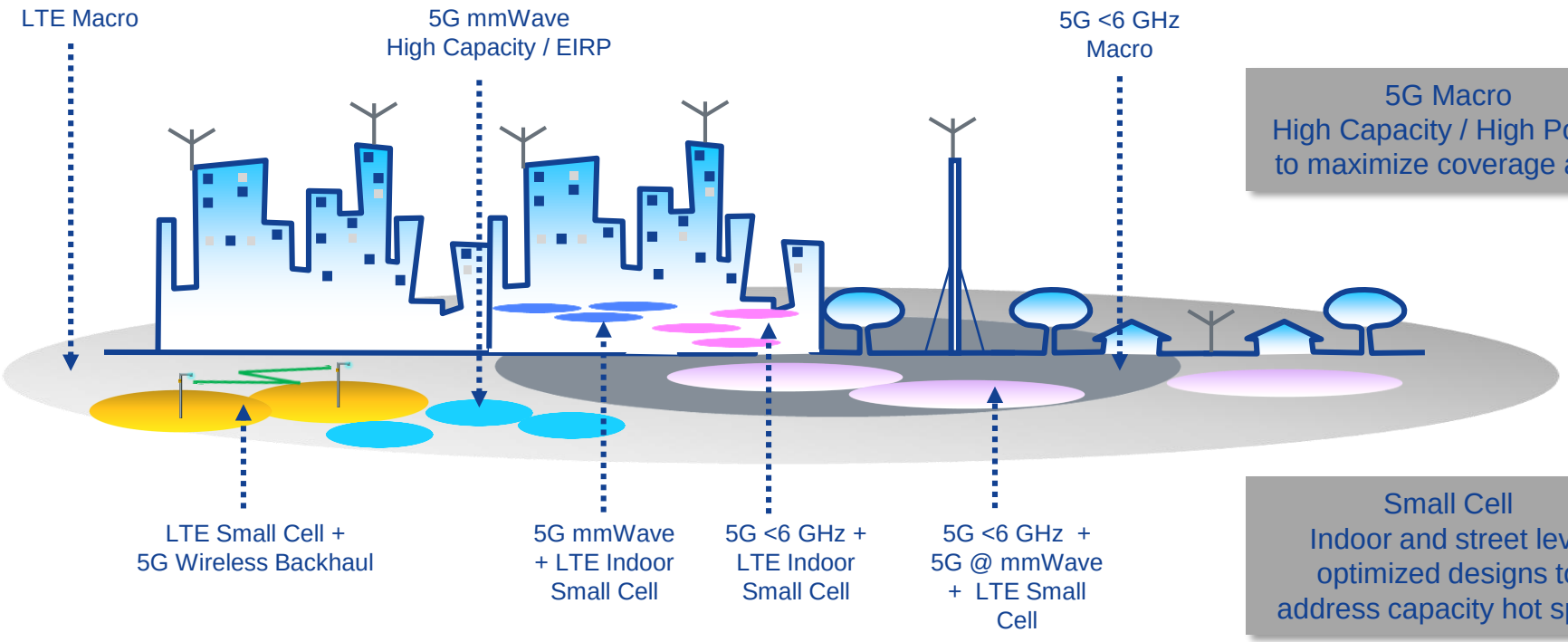
5G Small Cell Deployment Context



5G Macro
High Capacity / High Power
to maximize coverage area

Small Cell
Indoor and street level
optimized designs to
address capacity hot spots

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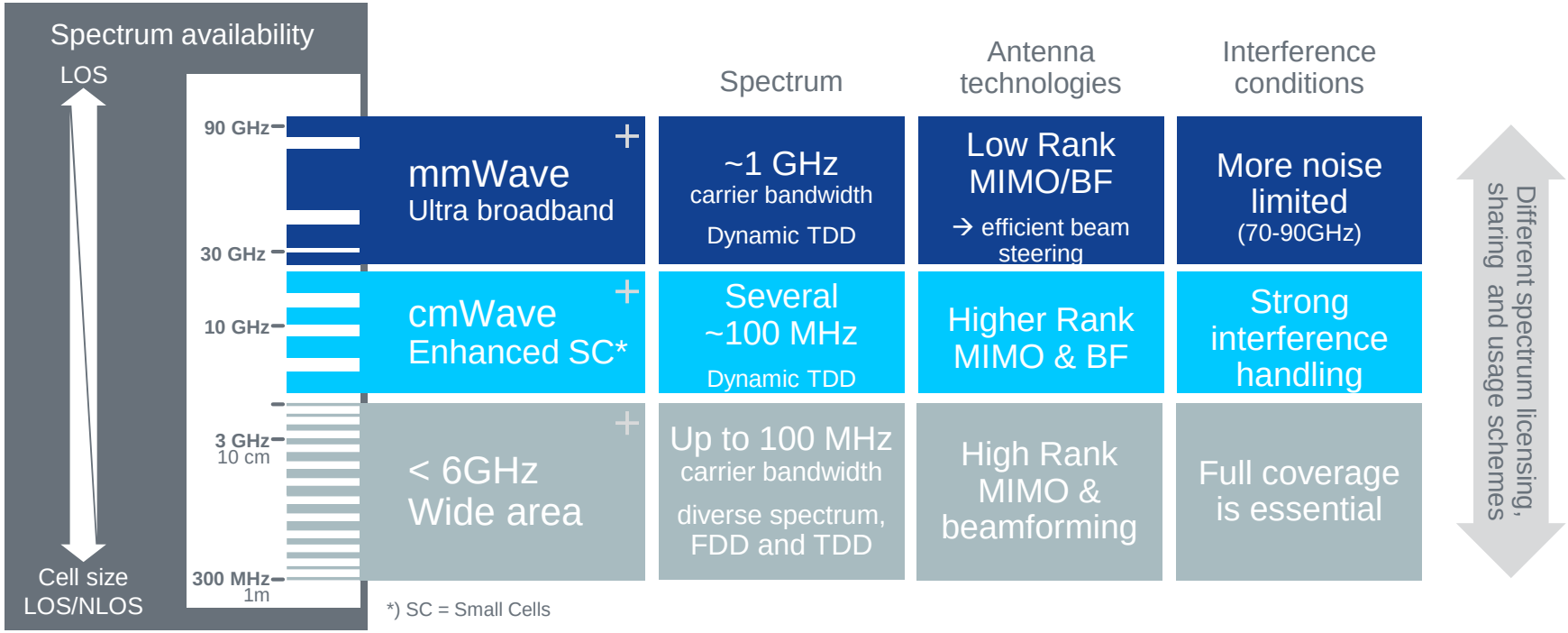
5G is to enable above 6 GHz access & optimize below 6 GHz access

Expanding the spectrum assets to deliver capacity and experience



*) SC = Small Cells

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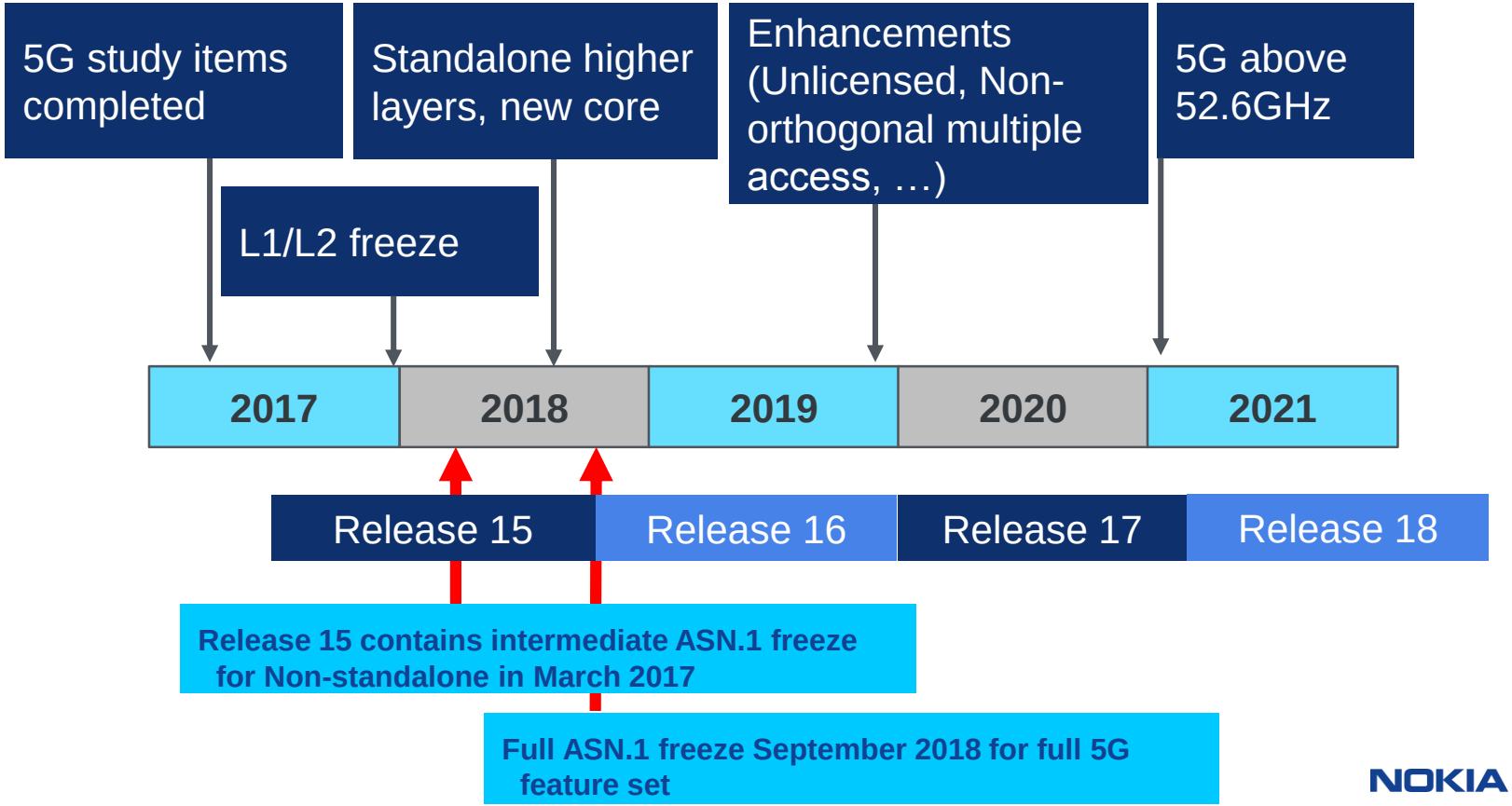
5G (New Radio) Schedule in 3GPP (Release 16/17 schedule TBC)



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Summary of 5G RAN prioritization

Phase 1 WI (Rel-15)
- Main assumption: general support for stand-alone NR below 40GHz (option 2 scenario) including DC
- 4G-5G interworking
- MIMO/Beamforming (fundamental features)
- Mini-slot (note: enabler for URLLC and ensures forward compatibility)
- Public warning/emergency alert (for regulatory needs)
- SON functionality for Dual Connectivity
- RRC inactive data

Phase 2 WI (Rel-16)
- Potential enhancements for eMBB support below 40GHz
- URLLC (below 40GHz)
- 4G-5G interworking – remaining options
- Shared spectrum and 5GHz unlicensed spectrum
- Location/positioning functionality (for regulatory needs)
- MIMO enhancements

Note: some Phase 1 SIs might belong to Phase 2 WI as well (not shown here explicitly)

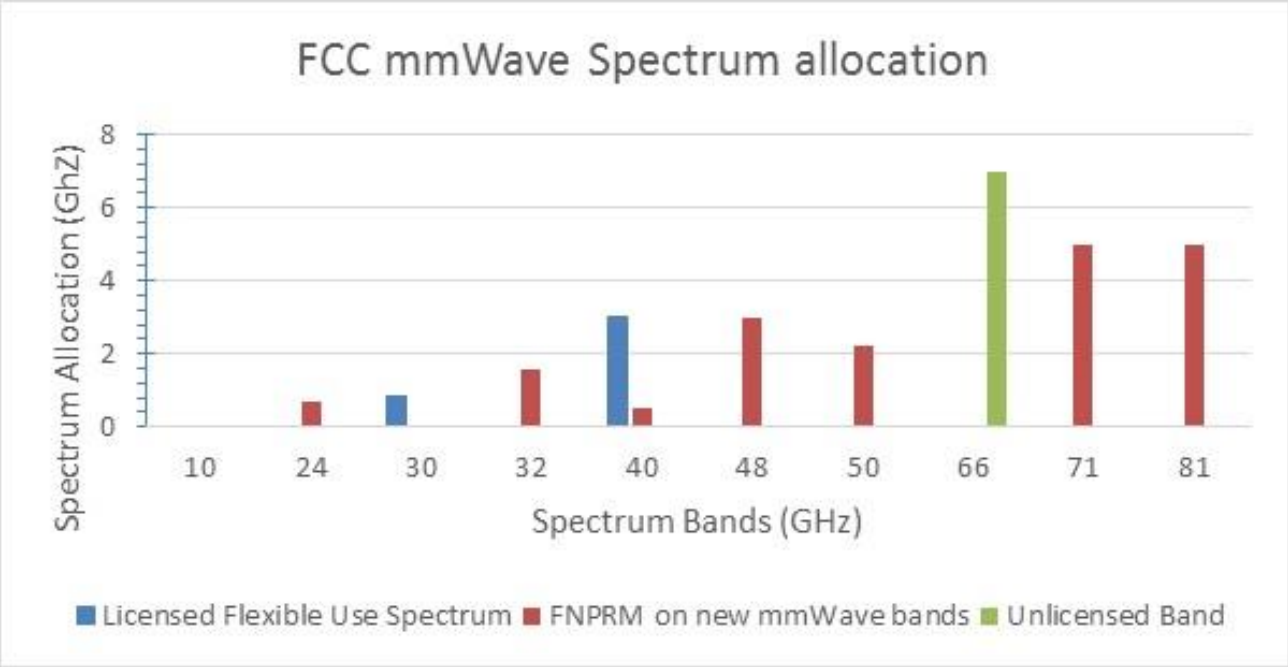
Phase 1 SI (Rel-15)
- **Unlicensed spectrum**
- **URLLC (below 40GHz)**
- **Non-orthogonal multiple access**
- Location/positioning functionality (for regulatory needs)
  - Indoor/Outdoor
- New SON functionality
- Sidelink (use cases out of reach of LTE evolution)
- NR-Wi-Fi interworking
- **Integrated Access Backhaul**
- **Non-terrestrial networks**
- **eV2V evaluation methodology**

Phase 2 SI (Rel-16)
- mMTC
- **Waveforms for >40GHz**
- **URLLC for >40GHz**
- **MIMO for >40GHz**
- Multi-connectivity (for >2 nodes)
- Uplink based mobility
- 2-step RACH
- TX interference coordination
- **V2V and V2X (use cases out of reach of LTE evolution)**
- **NAICS**
- Multimedia Broadcast/Multicast Service
- **Air-to-ground and light air craft communications**
- Extreme long distance coverage
- Satellite communication
- Other verticals
- **60GHz unlicensed spectrum**

NR frequency ranges/bands after RAN#75

Frequency range/LTE band	Operators whose request is included in the frequency range
3.3-4.2 GHz	DOCOMO, KDDI, SBM, CMCC, China Unicom, China Telecom, KT, SK Telecom, LG Uplus, Etisalat, Orange, Telecom Italia, British Telecom, Deutsche Telekom
4.4-4.99 GHz	DOCOMO, KDDI, SBM, CMCC, China Unicom, China Telecom,
24.25-29.5 GHz	DOCOMO, KDDI, SBM, CMCC, KT, SK Telecom, LG Uplus, Etisalat, Orange, Verizon, T-mobile, Telecom Italia, British Telecom, Deutsche Telekom
31.8-33.4GHz	Orange, Telecom Italia, British Telecom
37-40 GHz	AT&T, Verizon, T-mobile
1.427-1.518G	Etisalat
1710-1785MHz/1805-1880MHz (Band 3)	CMCC, China Telecom
2500-2570MHz/2620-2690MHz (Band 7)	CHTTL, British Telecom
880-915MHz/925-960MHz (Band 8)	CMCC
832–862MHz/791–821MHz (Band 20)	Orange
703-748MHz/758–803MHz (Band 28)	Orange, Swisscom, Telecom Italia, Telefonica, Vodafone
2496-2690MHz (Band 41)	Sprint, China Telecom, C-Spire, China Unicom
1710-1780MHz/2110-2200MHz (band 66)	T-mobile, Dish
1920-1980MHz/2110-2170MHz (Band 1)	China Unicom, China Telecom

FCC mmWave Spectrum Allocation



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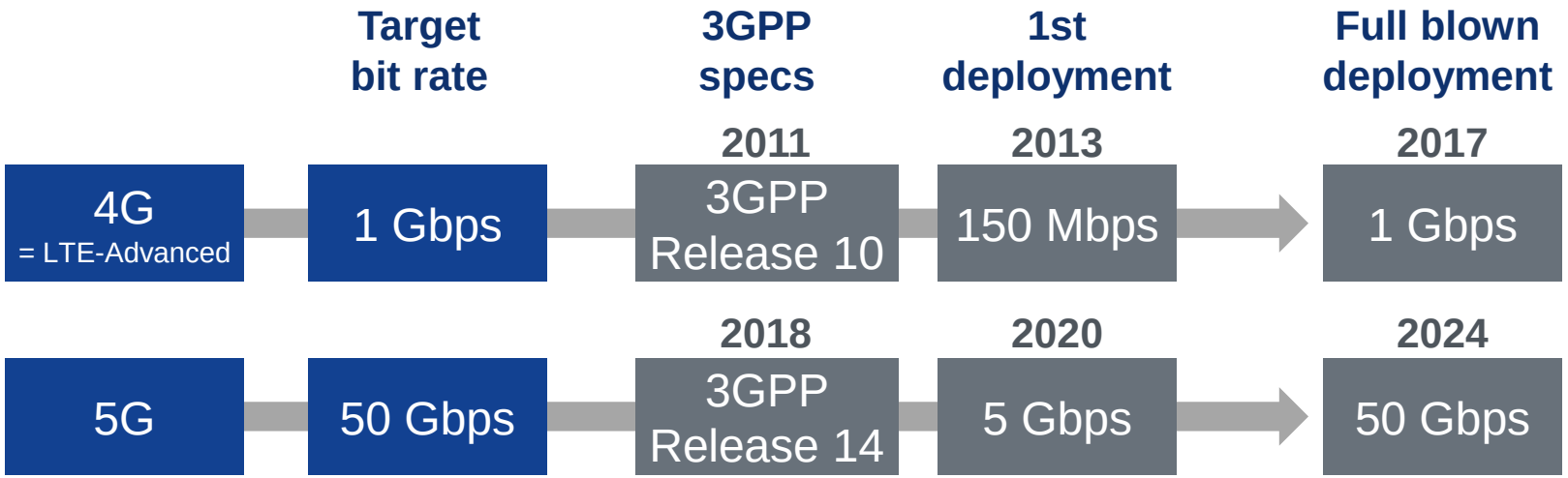
5G Peak Rates

- 4G achieved 10-15% of the target bit rate in the first deployment and the full target four years later.
- Extrapolating to 5G would give 5 Gbps by 2020 and 50 Gbps by 2024



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5G Technology Components for Enhancing S.E. Compared to LTE (sub 6Ghz)

Technology component	Gain
Enhanced beamforming	+0..60%
Lean carrier	+20%
Enhanced inter-cell cancellation	+20%
Improved spectral usage	+10%
Non-orthogonal transmission	?
Dynamic TDD in small cells	+30%

Total gain	+50..150%

Gain values preliminary

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What is “Massive MIMO”

ANTENNA ARRAYS
large number (>>8) of controllable antennas

ANTENNA SIGNALS
adaptable by the physical layer

Not limited
to a particular implementation

Benefits

Enhance Coverage
High gain adaptive beamforming

Enhance Capacity
High order spatial multiplexing

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MIMO in 3GPP

Release 8	Release 9	Release 10	Release 11
• 4x4MIMO • 4x2MIMO • 8RX uplink • Uplink CRAN	• 8TX TM8	• 8TX TM9	• Downlink CoMP (TM10)

Release 12	Release 13	Release 14	Release 15+
• Downlink eCoMP • New 4TX codebook	• Massive MIMO 16TX	• Massive MIMO 32TX	• 5G massive MIMO 64TX+

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5G vs. 4G Capacity per Cell (sub 6 GHz)

5x More Spectrum with 2 – 4x More Efficiency

LTE2600 with
2x2 MIMO

2.6 GHz	3.5 GHz
20 MHz	100 MHz
2 bps / Hz	4-8 bps / Hz
40 Mbps cell throughput	400-800 Mbps cell throughput

10-20 x

5G 3500 with
massive MIMO
beamforming

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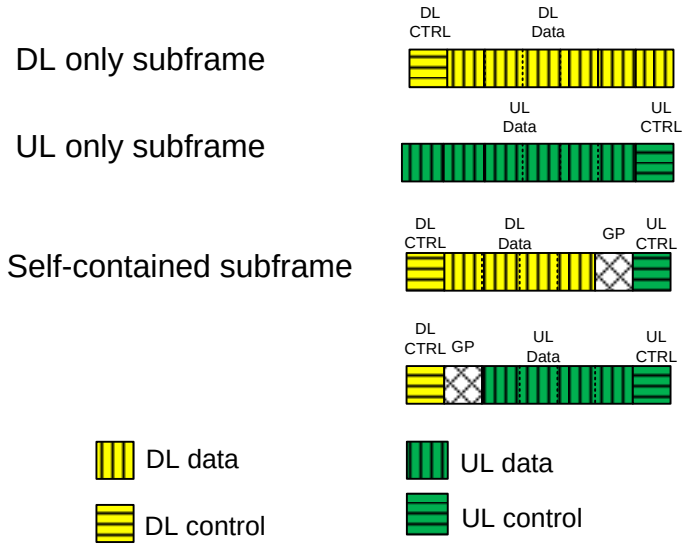
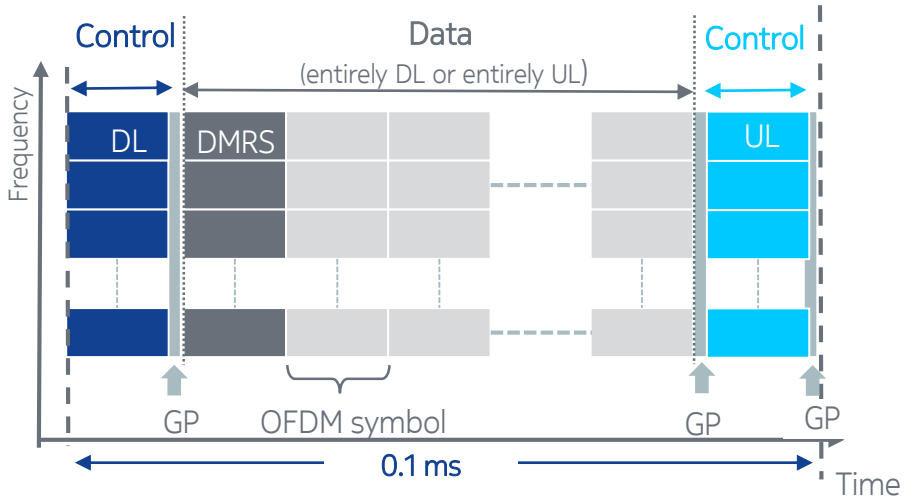
NR frame/subframe structure





0.125ms frame with cascaded UL/DL control signals

0.5 ms user plane latency

Same physical layer in UL and DL

Flexible UL/DL

Control channel just before data

Energy-effective processing

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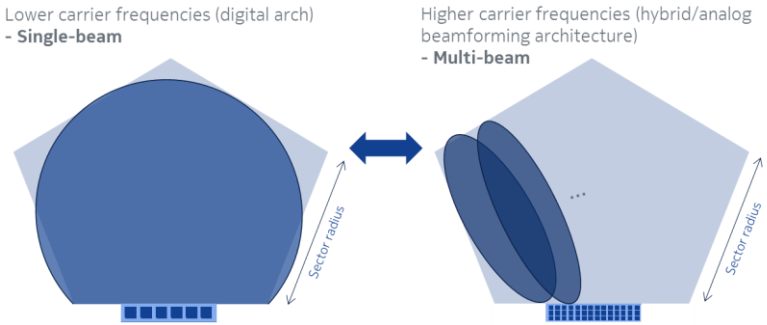
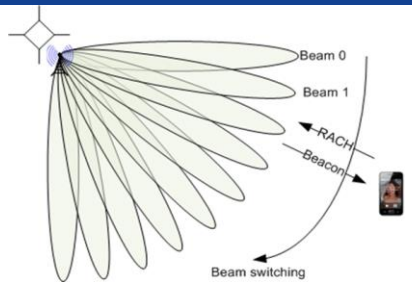
Massive MIMO in 3GPP New Radio – Beam Based Air Interface

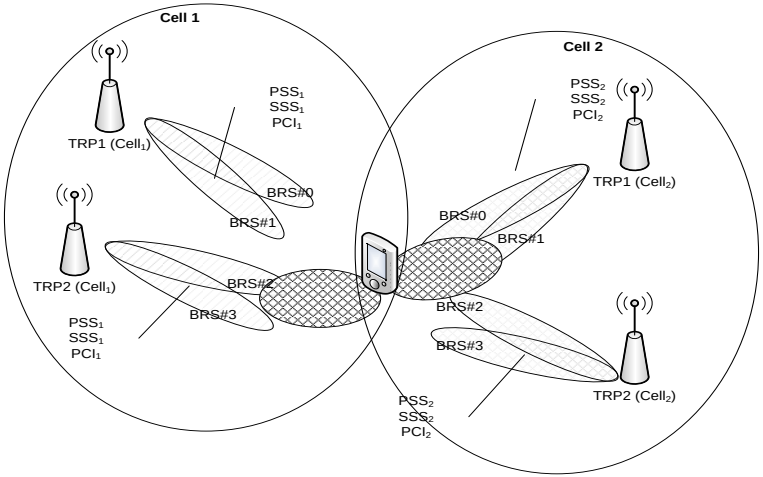
Beamformed Control Channels



Beam Scanning



Beam Management



- Acquisition and maintenance of a set of beams for TX and RX at base and UE
- CoMP is built in

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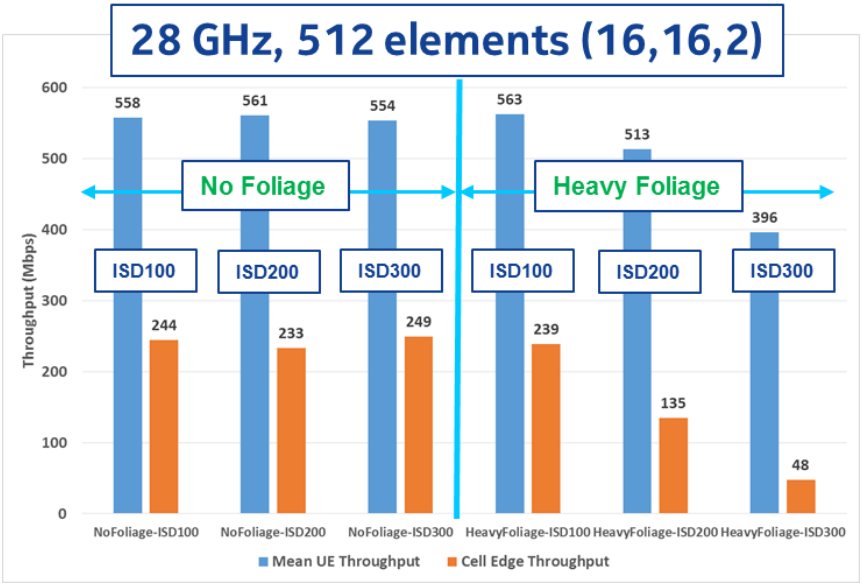
Early 5G use case: Extreme broadband to the home (mmWave)



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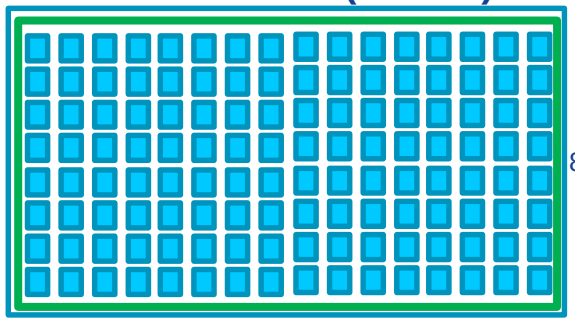
Antenna Array Comparisons - AP Antenna Aperture Constant vs. Frequency

5dBi ant element gain, 7dBm AP Pout per element, 1dBm UE Pout per element, shown to scale

AP

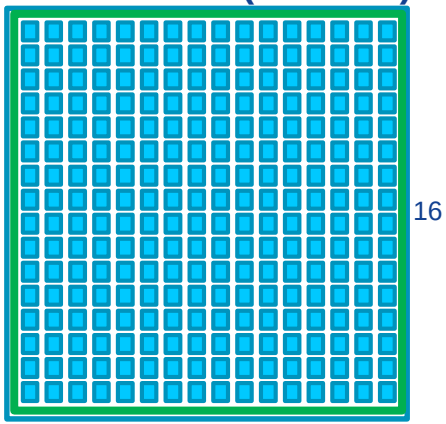
28 GHz
256 elements (8x16x2)



2 TXRUs

Max EIRP ≈ 60.2 dBm

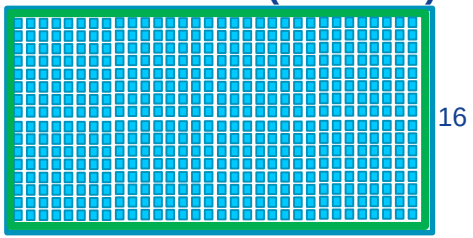
39 GHz
512 elements (16x16x2)



Max EIRP ≈ 66.2 dBm

103% area relative to 28GHz

73 GHz
1024 elements (16x32x2)



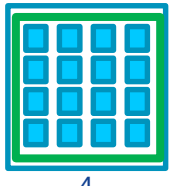
Max EIRP ≈ 72.2 dBm

59% area relative to 28GHz

Room to grow…normalized array size is ~4.5dBm more than above

UE

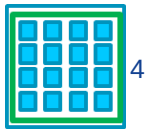
28 GHz, 32 elements, (4x4x2)



2 TXRUs

Max EIRP ≈ 36.1 dBm

39 GHz, 32 elements, (4x4x2)



Max EIRP ≈ 36.1 dBm

52% area relative to 28GHz

73 GHz, 32 elements, (4x4x2)

Max EIRP ≈ 36.1 dBm

15% area relative to 28GHz

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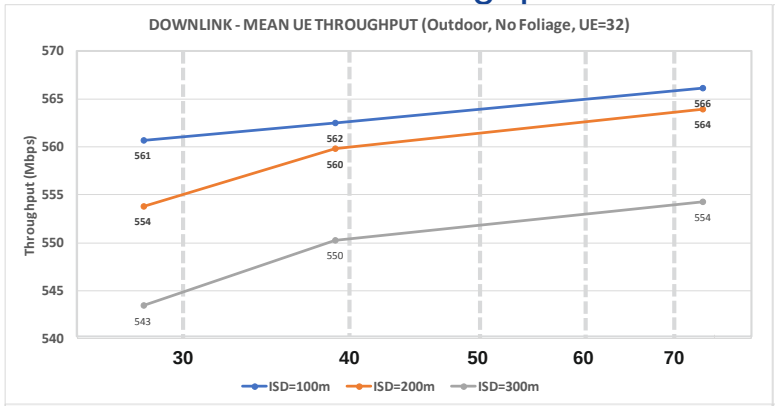
System Simulation Results for the Suburban Micro Environment

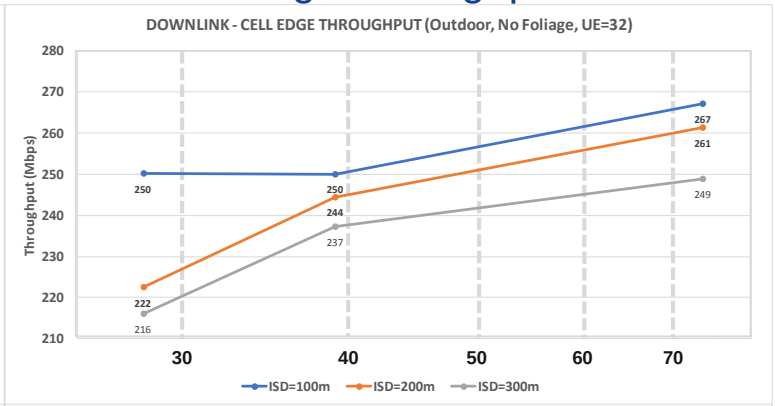
Constant Antenna Aperture for 28 GHz, 39 GHz and 73 GHz

Mean UE Throughput

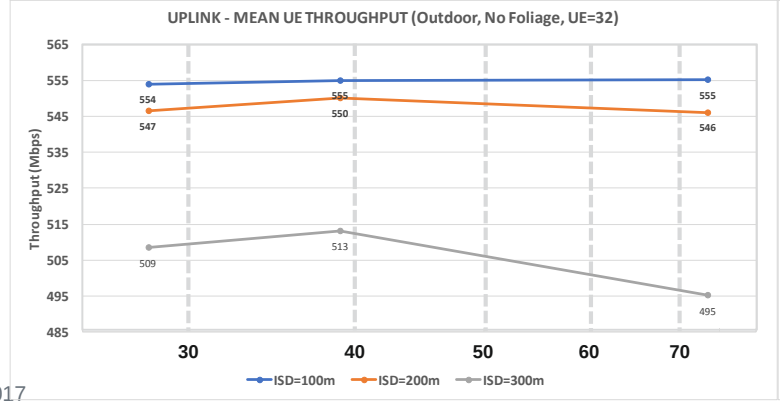
Cell Edge Throughput

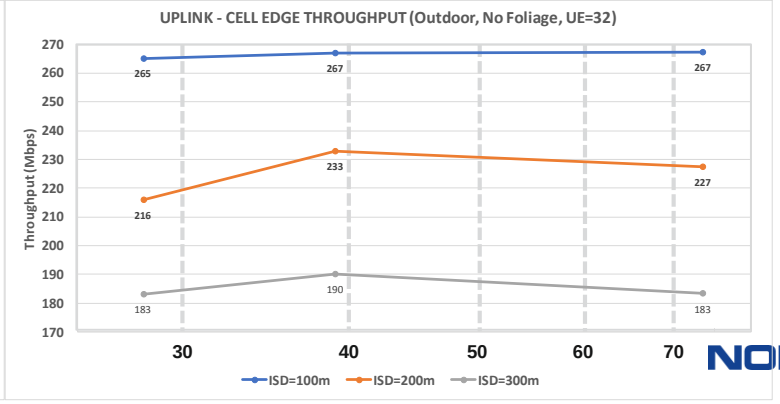
Downlink





Uplink





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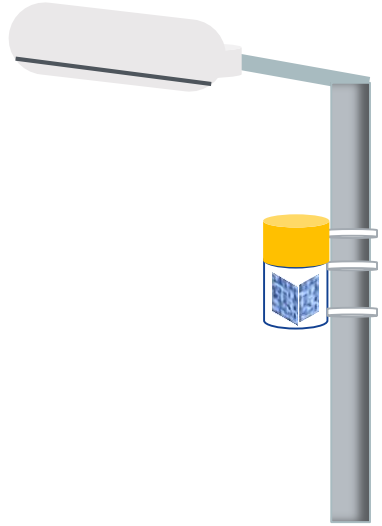
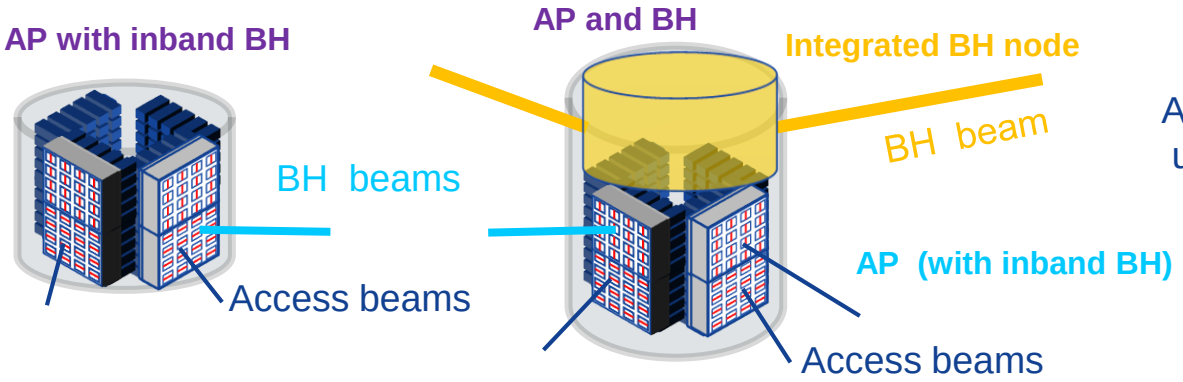
Basic Network Building blocks

- 5G mmW basestation and integrated wireless backhaul will be a small box which is easy to install to lamp posts, walls or small masts.
- The cost of the box is mainly in RF, antennas and BB-SoC, of course some cost goes for cover mechanics and power supply.
- Investigating how to arrange the creation and manufacturing of the RF and antenna components.
- Multi-sector sBH is the assumption





AP and Integrated BH
use quite similar technologies

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