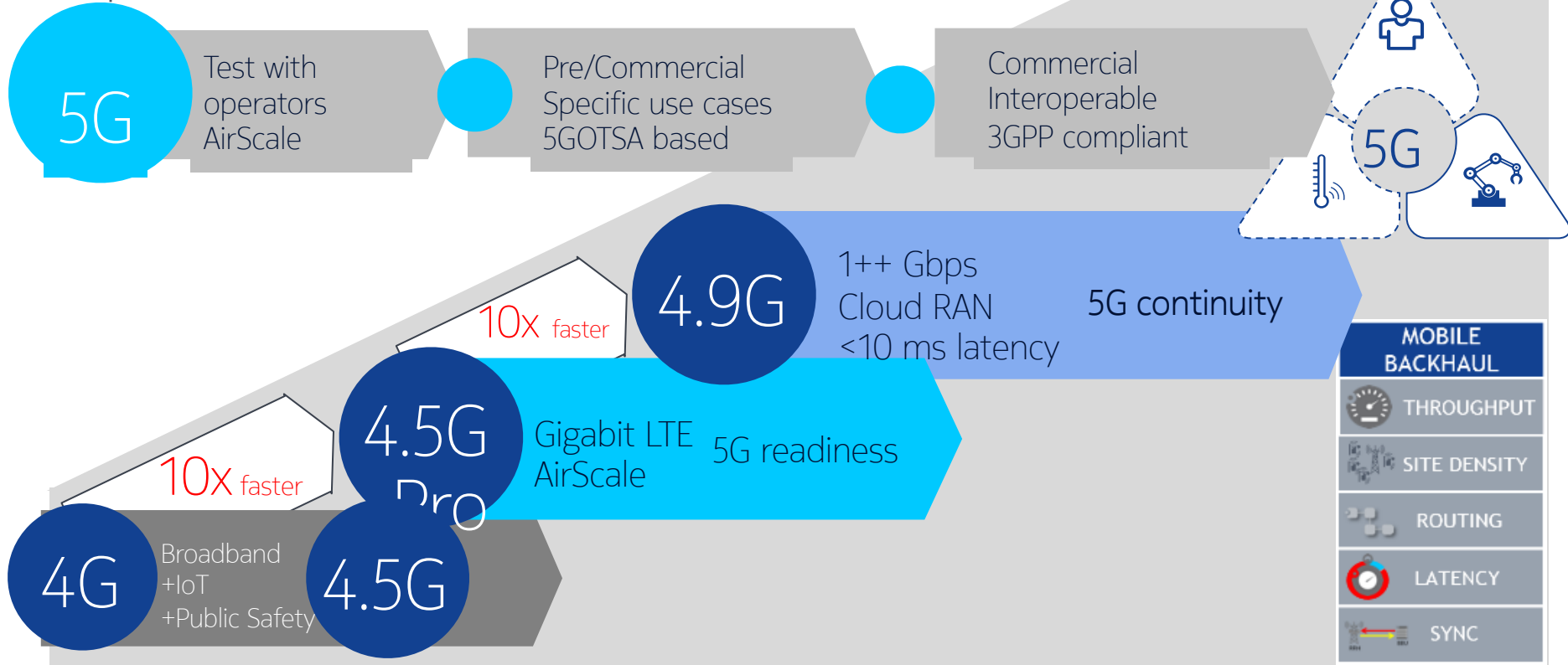


LTE. Path from 4G to 5G. How to use unlicensed spectrum

4.5G evolution makes the path to 5G

Stepwise evolution in LTE and 5G

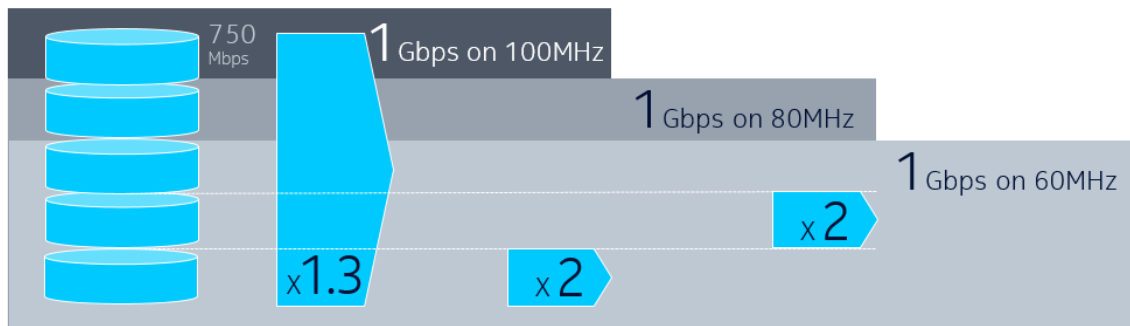


4.5G Pro

1 Gbps LTE

AirScale / 5G readiness

The flexible toolbox for Gigabit LTE on given spectrum



Carrier Aggregation

+ 256QAM

+ 4x4MIMO

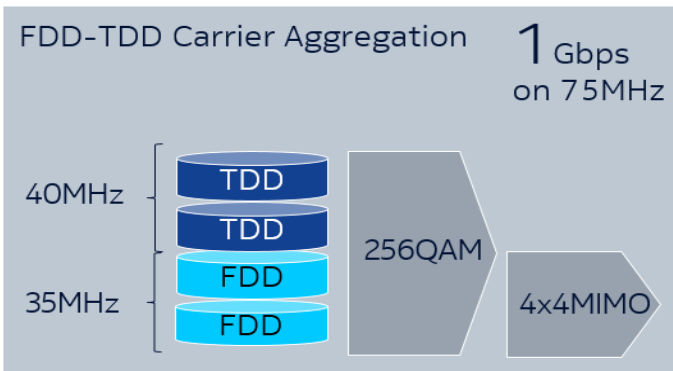
- Up to 100MHz

- Up to 5 component carriers

- on 1 carrier

- on 2 carriers

Note: example with 20MHz FDD carriers (150Mbps with 2x2MIMO)



MIMO Evolution | 200% capacity gain with mMIMO

From 2 to 64 antenna paths per cell

4.9G

1++Gbps
LTE

(massive MIMO)

4.5G
Pro

1Gbps
LTE

combined with
256QAM and
Carrier Aggregation

4x2MIMO, 4x4MIMO
8x2MIMO, 8x4MIMO

mMIMO

Semi static
beams

2x2 MIMO



3GPP Rel.8-based
commercial LTE

- Commercial mainstream (FDD, 2015)

3GPP Rel.10- based LTE-A (field
measurements, FDD)

- 2x faster peak data rates with 4x4MIMO
- 50% higher cell capacity

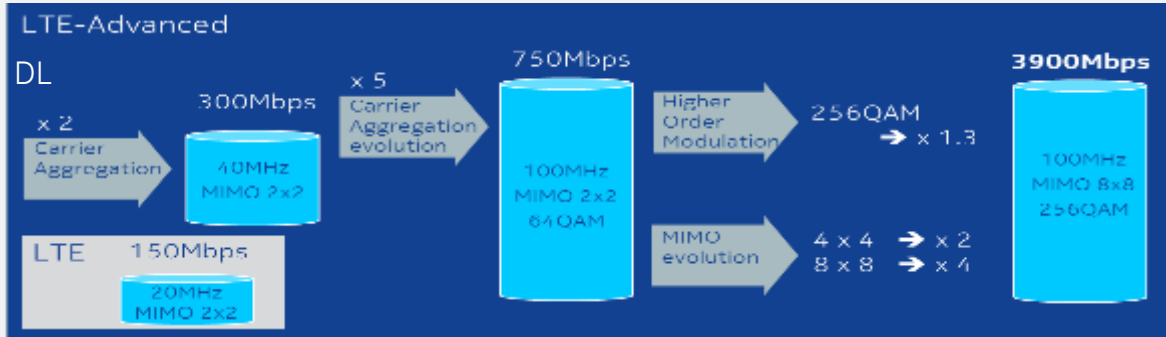
Potential of LTE-A Pro, 5G

- 16 (Rel. 13) and 64 (Rel. 14) antenna paths
- 200% spectral efficiency increase with 64 antenna paths (FDD)

Available (limited by UEs)

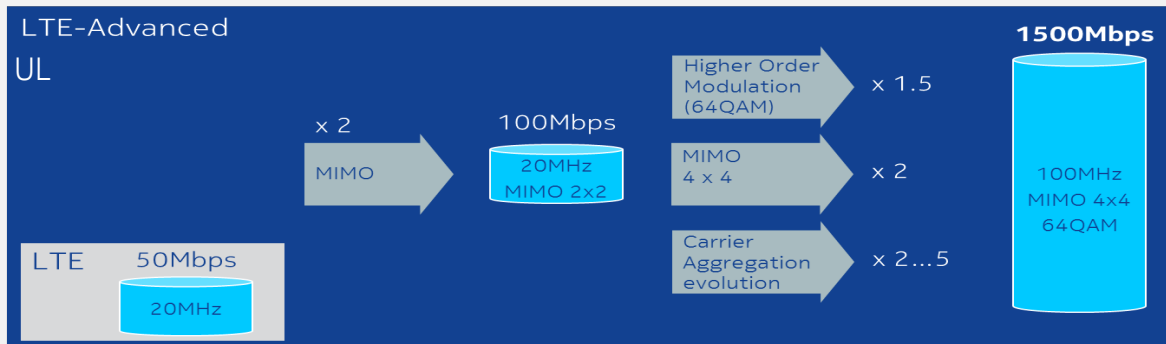
Planned (2017/18)

LTE-Advanced Pro



Carrier Aggregation with up to 32 component carriers

25Gbps



Carrier Aggregation with up to 32 component carriers

9.6Gbps





Small Cell Multi-band portfolio with unlicensed spectrum

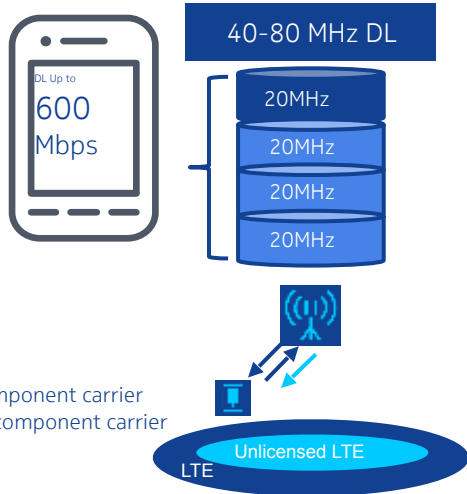
	LTE-U	LAA	eLAA	LWA	LWIP	MulteFire
Features	DL CA CSAT / <u>eCSAT</u> 5GHz Licensed as anchor Collocated	DL CA LBT 5GHz Licensed as anchor Collocated	DL CA + UL CA LAA Dual Connectivity 5GHz Licensed as anchor Non-collocated	DL CA 2,4GHz and 5GHz Xw interface (New!) Licensed as anchor Non-collocated	DL + UL (no CA) 2,4GHz and 5GHz <u>IPSec Tunnel</u> Licensed as anchor Non-collocated	Standalone LTE 5GHz
Specs	LTE-U Forum	3GPP Rel13	3GPP Rel14	3GPP Rel13	3GPP Rel13	MulteFire Alliance
CA BW	30 (10L+20U) available 60 (20L+40U) planned 80 (20L+60U) future ...	80 (20L+60U) planned	80 (20L+60U) planned	100 (20L+80U) planned	N/A	N/A

LTE-U – LTE Unlicensed, LAA – Licensed Assisted Access, eLAA – Enhanced Licensed Assisted Access, LWA – LTE WLAN Aggregation, LWIP – LTE WLAN Aggregation with IPSec Tunneling
 CSAT - Carrier sensing adaptive transmission, eCSAT – Enhanced Carrier sensing adaptive transmission, LBT - Listen before talk
 SDL – Supplemental Downlink

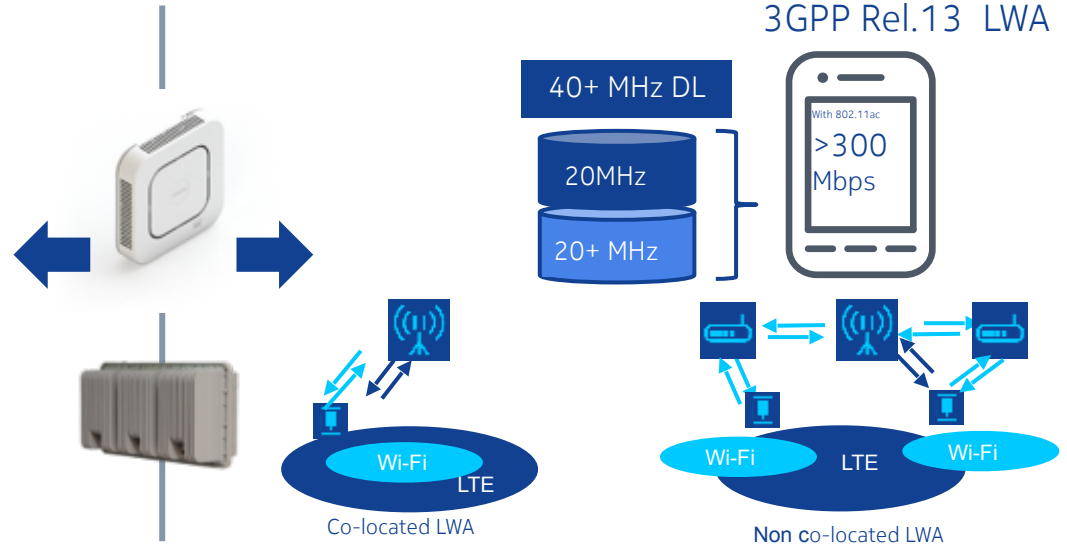
Extending the Small Cell Multi-band portfolio with unlicensed spectrum

LTE-U/LAA and LWIP with common hardware platforms

LTE-U (Pre 3GPP R13) / 3GPP Rel.13 LAA



3GPP Rel.13 LWA



PCC – primary component carrier
SCC – secondary component carrier

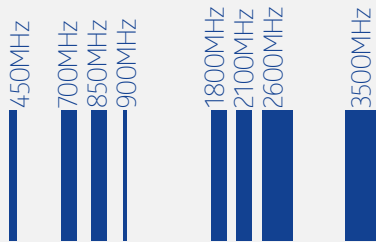
- Licensed LTE + unlicensed LTE to maximize coverage and throughput
- Peak DL Data Rate via licensed LTE and unlicensed LTE Carrier Aggregation
- Unlicensed LTE and Wi-Fi Fairness – eCSAT and R13 LBT

- Integrated LTE + Wi-Fi
- Peak Data Rate via licensed LTE and WiFi Carrier
- Supports Downlink and Uplink Aggregation
- RF bandwidths: 20 DL + 20 UL Licensed + 802.11ac

LTE Unlicensed | LAA for band 3 + 46D (1800MHz + 5GHz)

Licensed Bands

(450-3800MHz)



Unlicensed Bands (used for WLAN)

2,4GHz
(BW = 83,5MHz)

5GHz
(BW = 610MHz)



Spectrum usage

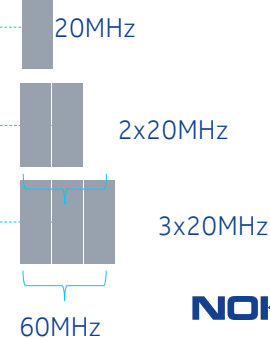
CA Examples



10MHz
20MHz
20MHz

CA 10+20MHz (⇒ 225Mbps)
CA 20+40MHz (⇒ 450Mbps)
CA 20+60MHz (⇒ 600Mbps)

DL



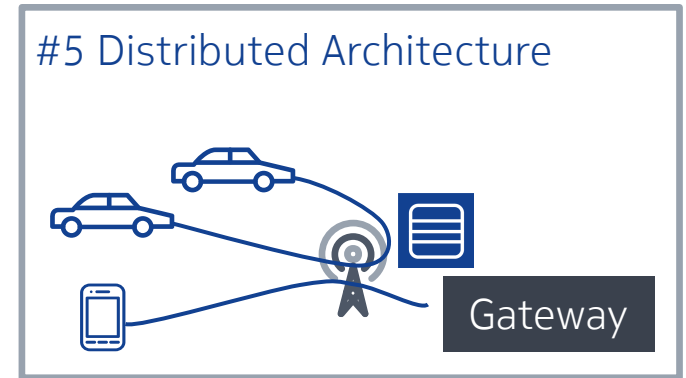
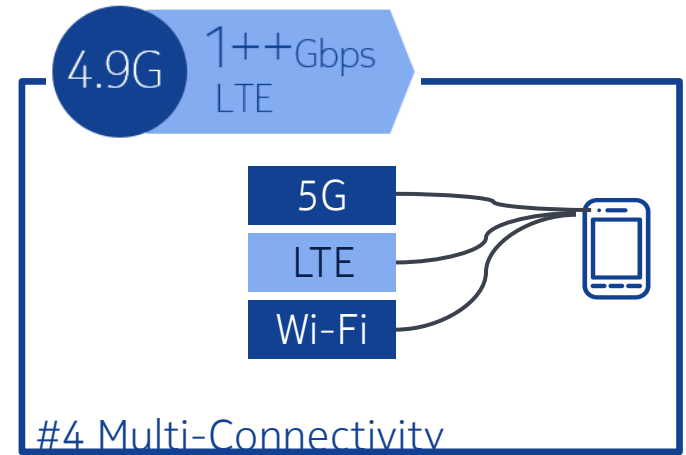
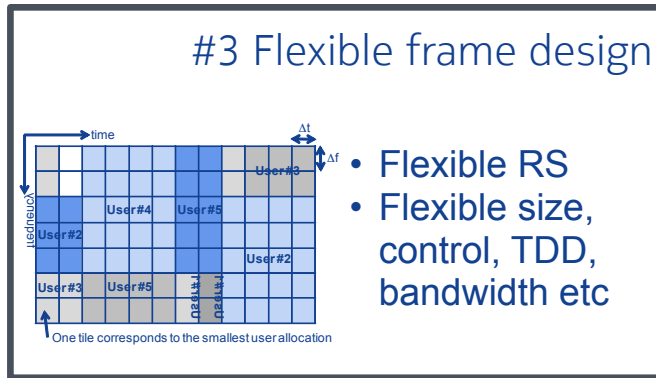
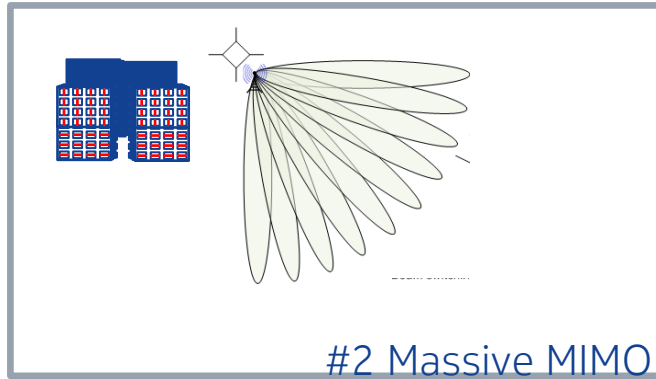
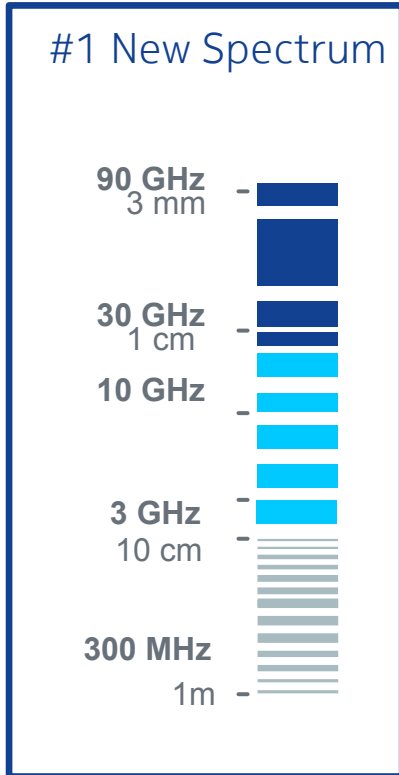
20MHz
2x20MHz
3x20MHz
60MHz

Suitable spectrum for LTE-U/LAA

NOKIA

5G and 4.9G | Evolution of LTE-Advanced to 5G service continuity

Five Key Technology Components of 5G



NOKIA