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Spectrum sharing for 4G & 5G

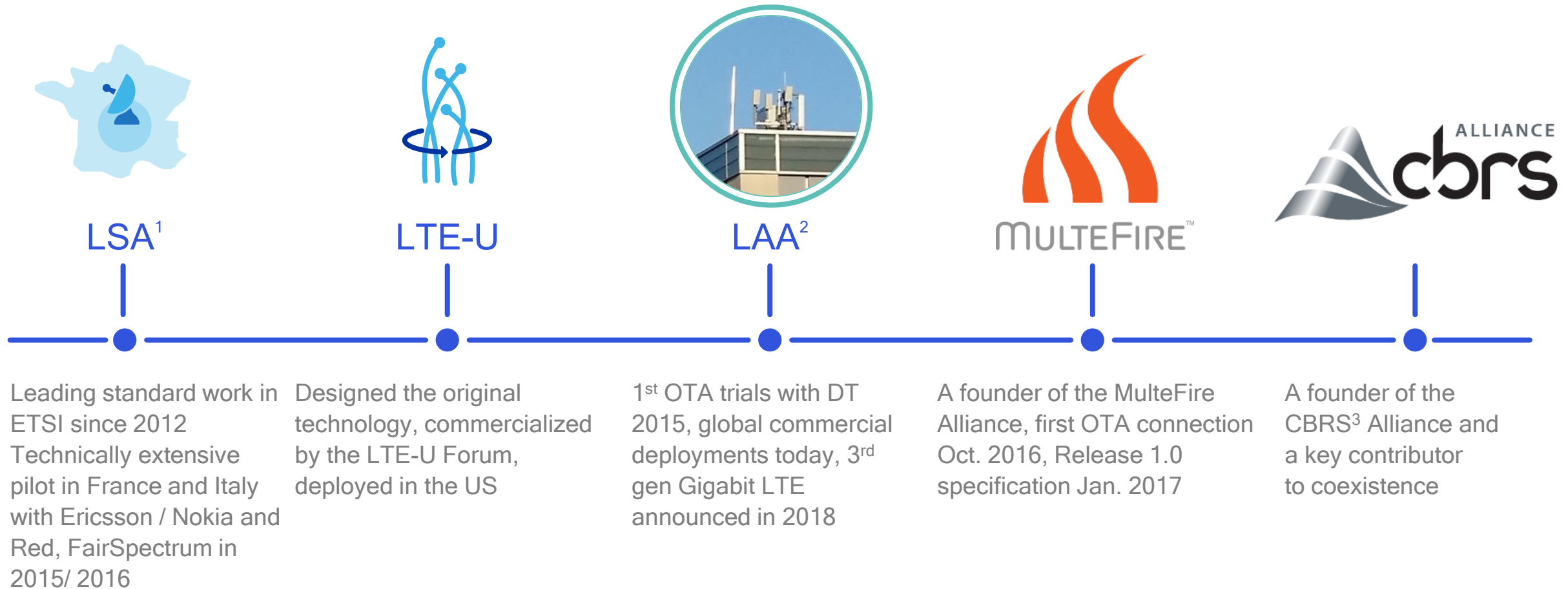
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Qualcomm Europe, Inc.



Pioneering shared spectrum technologies in LTE



1) Licensed Shared Access (LSA); 2) Licensed-Assisted Access (LAA), enhanced LAA (eLAA), Deutsche Telekom (DT), SK Telecom (SKT); 3) Citizen Broadband Radio Service (CBRS)

LTE-U and LAA are now a commercial reality

Powering Gigabit LTE devices globally since 2017



Specifications finalized and published

LTE-U Forum published the LTE-U specs in Q1 2014, 3GPP published Rel. 13 standard with LAA in Q1 2016



FCC authorized devices for US deployments

FCC has granted equipment authorization for both LTE-U¹ and LAA²



LAA for global deployments

Listen-before-talk (LBT) is used by both LAA and Wi-Fi globally in the 5 GHz unlicensed band



Supported by Qualcomm[®] Snapdragon[™] LTE modems

LTE-U starting with X12 LTE modem; LAA starting with X16 LTE modem in Snapdragon 835 mobile platform

Spectrum is critical for 5G success

Using all spectrum types and bands



5G

Licensed spectrum

Exclusive use

Over 40 bands globally for LTE, remains the industry's top priority

Shared spectrum

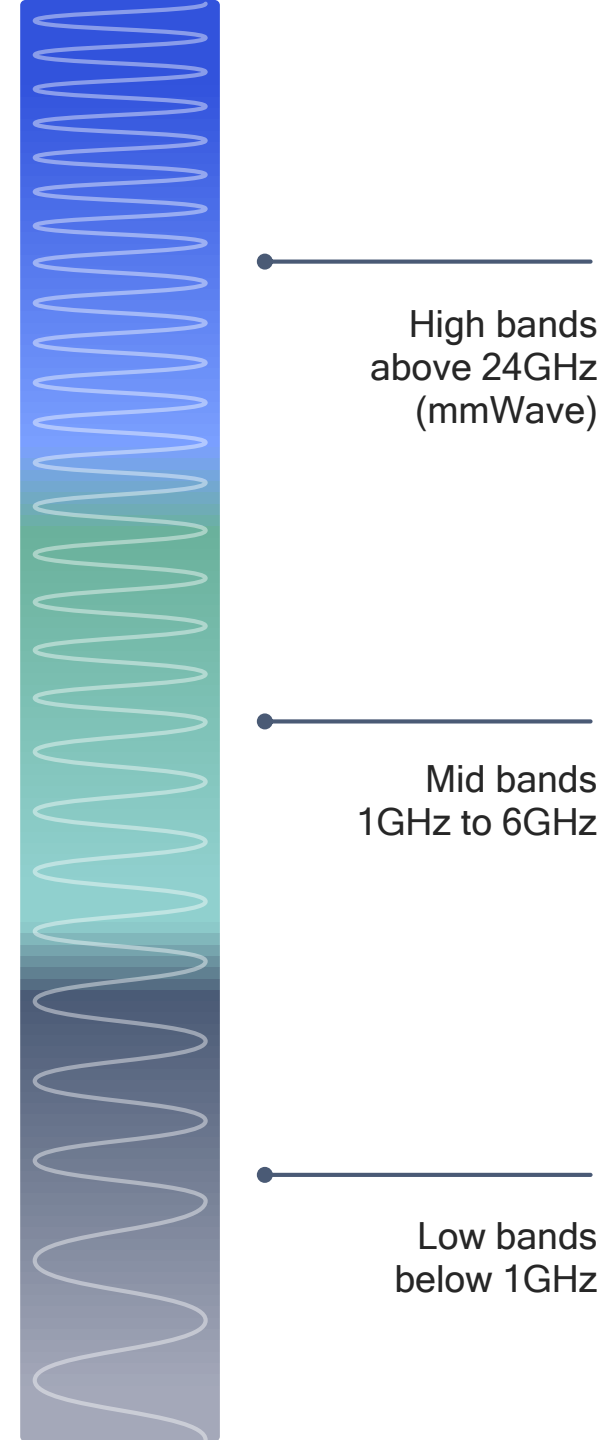
New shared spectrum paradigms

Ex: 2.3 GHz Europe / 3.5 GHz USA

Unlicensed spectrum

Shared use

Ex: 2.4 GHz / 5.9-7.1 GHz / 57-71 GHz global



High bands
above 24GHz
(mmWave)

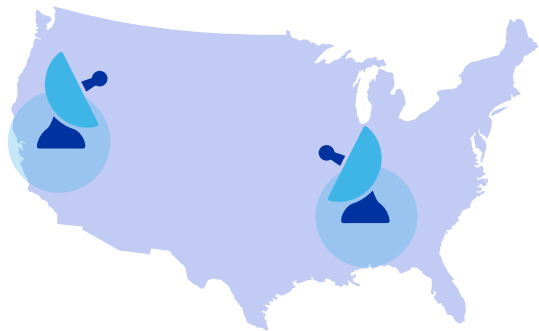
Mid bands
1GHz to 6GHz

Low bands
below 1GHz

New opportunities with shared/unlicensed spectrum

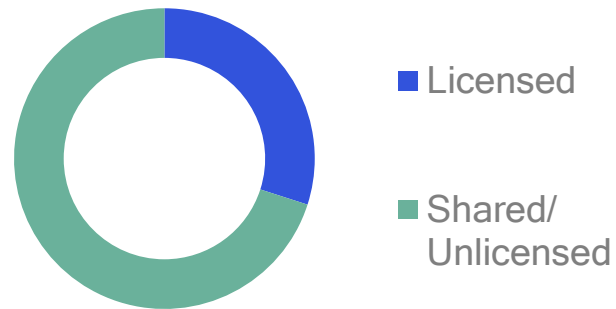
New spectrum sharing innovations can unlock more spectrum

Some spectrum is lightly used by incumbents, so spectrum sharing can increase utilization



Large amount of spectrum for 5G will be shared/unlicensed

E.g. FCC's first mmWave decision in 2016 included 7.6 GHz of unlicensed/shared spectrum¹



Higher spectrum bands are particularly well suited for sharing

Shorter signal propagation at higher bands, e.g., 6 GHz & mmWave, makes them suitable for sharing



¹ FCC ruling FCC 16-89 on 7/14/2016 allocated 3.25 GHz of licensed spectrum and 7.6 GHz of shared/unlicensed spectrum.

5G NR-U valuable for wide range of deployments

3GPP study on 5G NR in unlicensed spectrum, fair coexistence with LAA, Wi-Fi

Licensed assisted NR-U

Boosting existing deployments

Better user experience with higher speeds



Stand-alone NR-U

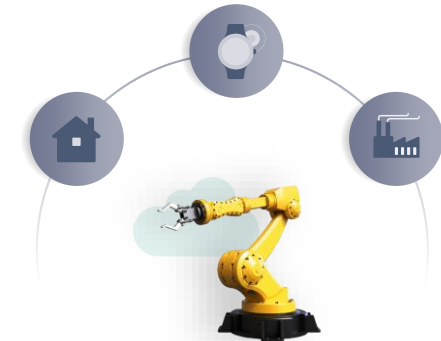
Open mobile broadband

Neutral host, neighborhood network



Private networks¹

Industrial IoT, enterprise broadband



Aggregating licensed and unlicensed spectrum

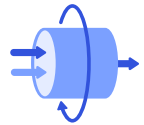
Expanding 5G market with new types of deployments

1) A private network can also support generic traffic as a neutral host, for example at an hospital it can provide dedicated services for employees/equipment and also operate as a neutral host for visitors.

Opportunity to introduce new sharing paradigms in 5G NR

Evolutionary path

NR unlicensed (NR-U)—existing coexistence rules



LAA NR-U



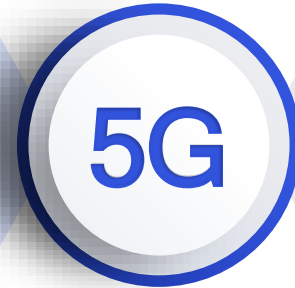
Stand-alone NR-U



Synchronized NR-U



Fair co-existence:
Wi-Fi, LTE-LAA...



5G

Revolutionary path

NR spectrum sharing (NR-SS)—potential for new rules



Predictable resources



5G CoMP



Spatial sharing



Flexible sharing



Time synchronization
provides great potential to share
spectrum more efficiently

What is possible when not constrained by existing rules?

5G

Revolutionary path

NR spectrum sharing (NR-SS)—potential for new spectrum sharing rules

For green-field bands such as global 6GHz and regional bands such as 37-37.6 GHz

Time synchronization



Predictable resources

- Prioritized resources for each operator → predictable service
- Opportunistic sharing of unused resources



5G CoMP

- Exploiting the spatial domain with 5G CoMP
- Significantly increased capacity and reliability



Spatial sharing

- Spatial sharing between multiple operators
- Allows for simultaneous use of same spectrum in same location



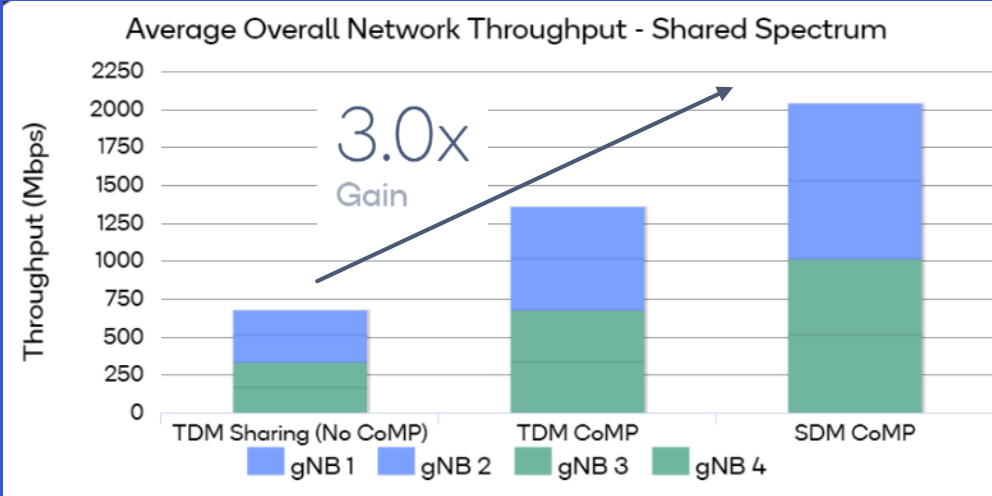
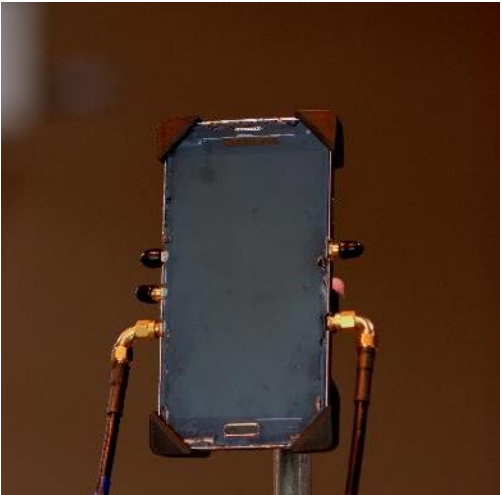
Flexible sharing

- Native support for sharing with different priority levels
- Flexible framework to support various regional sharing needs

Demonstrating the potential new 5G NR spectrum sharing paradigms

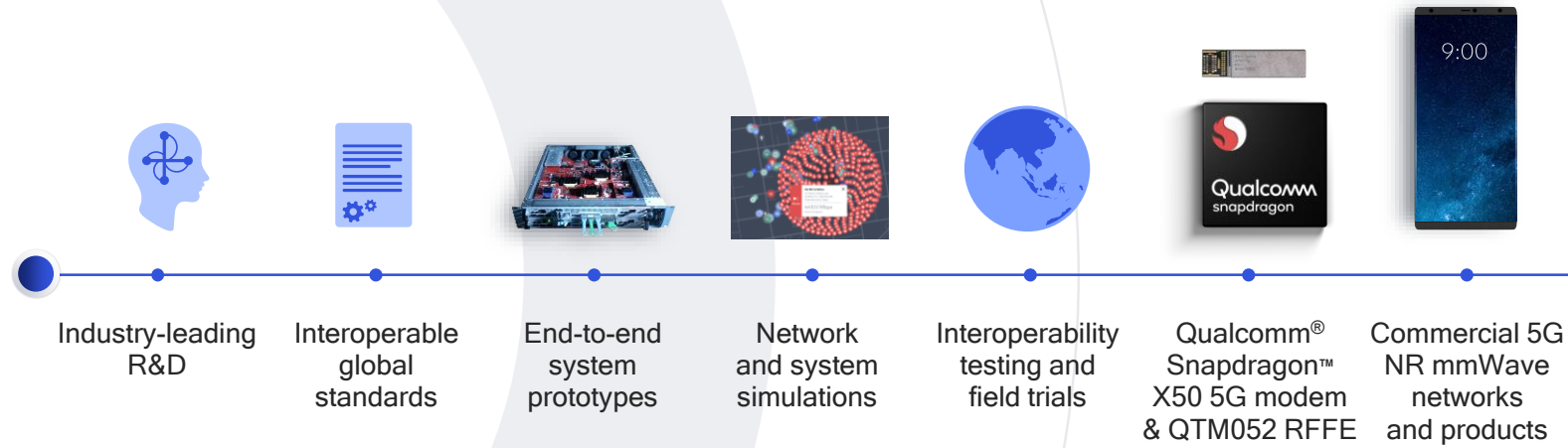
Utilizes 5G NR spectrum sharing prototype – designed to also support testing of 5G NR in unlicensed spectrum

Significant performance gains utilizing advanced intra-operator CoMP and inter-operator SDM techniques



COMP = Coordinated Multi-Point
SDM = Spatial Domain Multiplexing

Making 5G NR mmWave a commercial reality in 2019



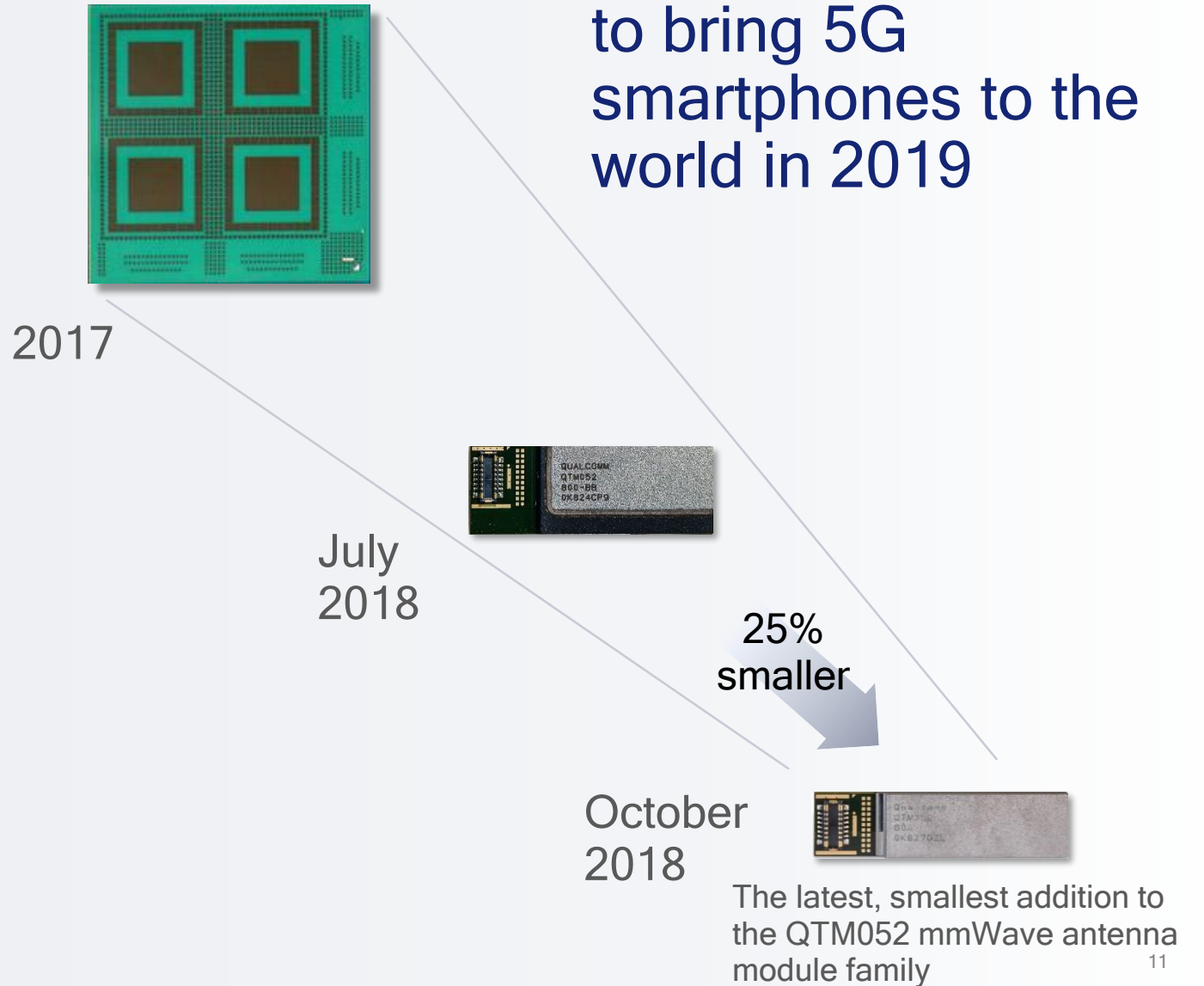


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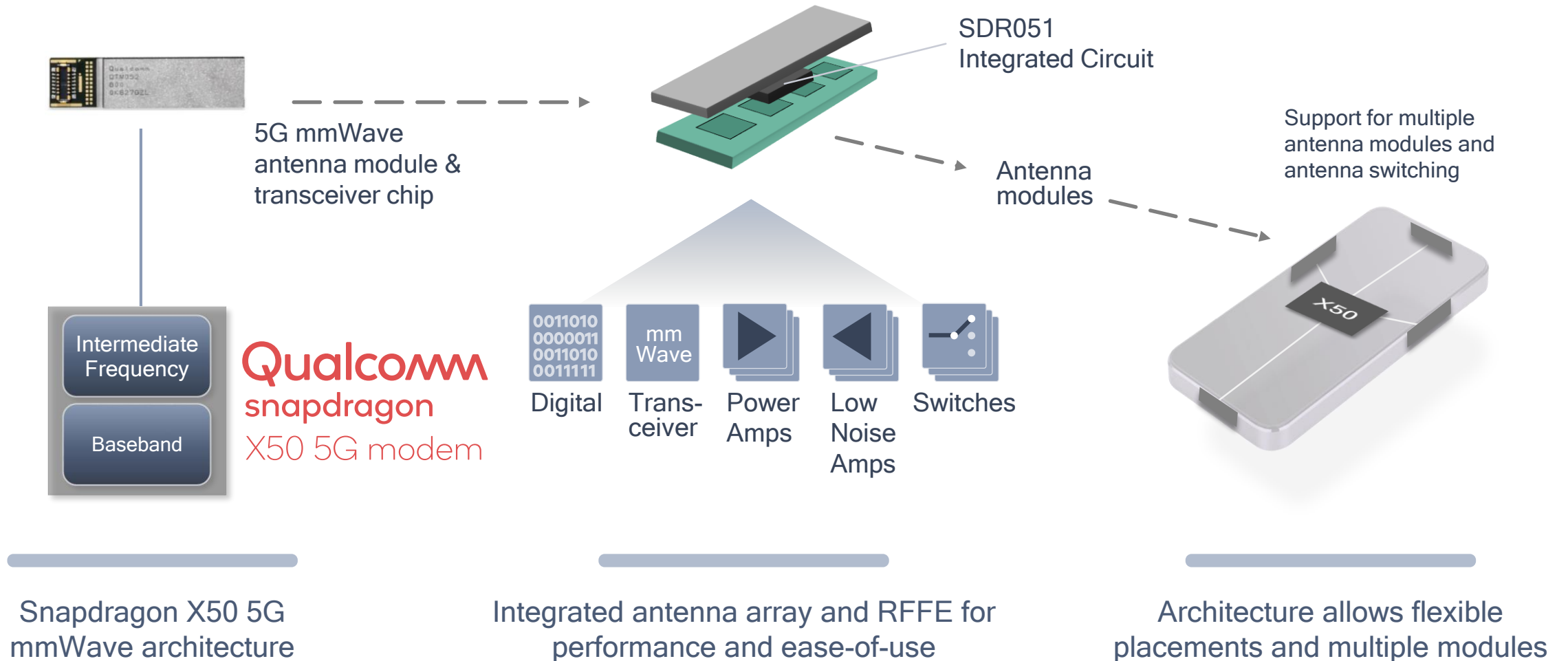
QTM052 mmWave
antenna module family

Qualcomm Technologies continues to
push the envelope on 5G mmWave
smartphone design

Rapid miniaturization
of mmWave modules
to bring 5G
smartphones to the
world in 2019





Modem-to-antenna 5G mmWave solution





Thank you!

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