Qualcomm

5G/6G NR-NTN
A Hardware perspective

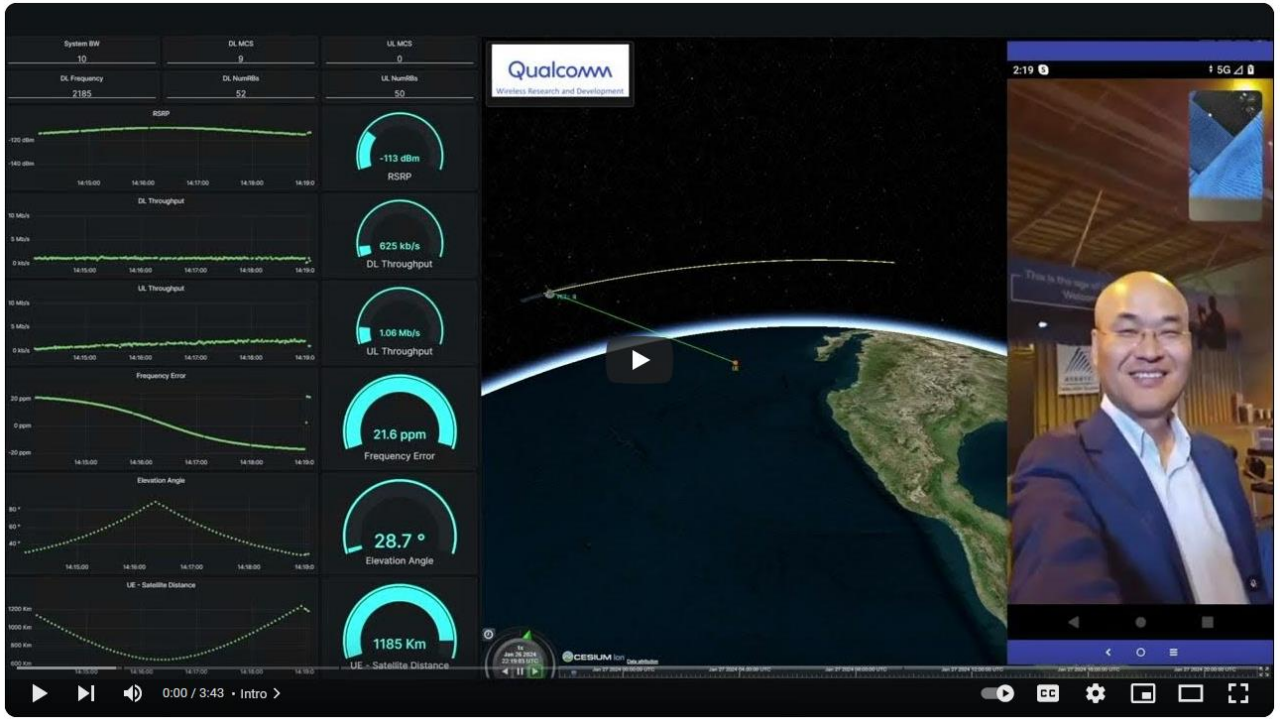
Alexander Dorosenco

Engineer, Principal/Manager, Qualcomm Technologies Inc.

adorosen@qti.qualcomm.com

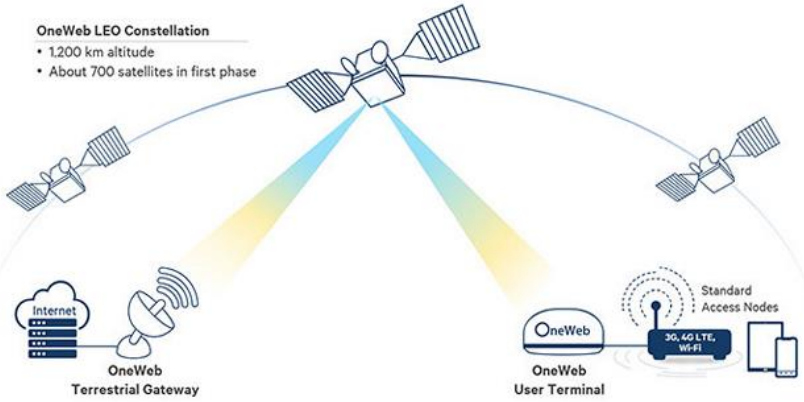
5G NR-NTN activities

- Qualcomm Technologies has been developing 5G NR-NTN hardware since 2022.
- A recorded demo has been presented at MWC 2024 in Barcelona, Spain.

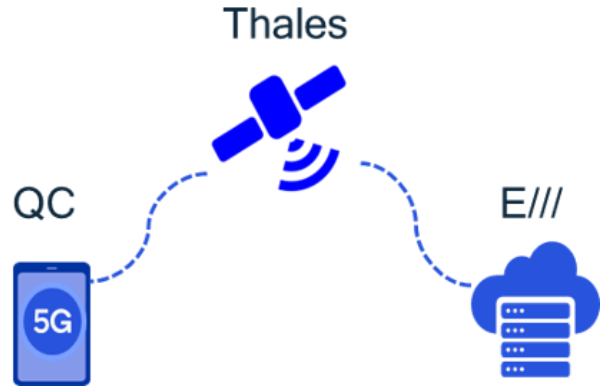


Qualcomm has a long history in satellite communications

[Qualcomm Awarded $275 Million Contract as Globalstar Gateway Manufacturer](#) (1997)



[Connecting the unconnected—Qualcomm and OneWeb developing a global network to extend the reach of the Internet](#) (2015)



[Ericsson, Qualcomm and Thales to take 5G into space](#) (2022)

5G NR-NTN challenges

- New frequency bands are being introduced (TS 38.101-5):

REL	WI	NR band	Uplink (UL) operating band Satellite Access Node receive / UE transmit $F_{UL,low}$ – $F_{UL,high}$	Downlink (DL) operating band Satellite Access Node transmit / UE receive $F_{DL,low}$ – $F_{DL,high}$	Remarks
REL-17	NR_NTN_solutions	n256	1980 – 2010 MHz	2170 – 2200 MHz	FR1, FDD, S-band
REL-17	NR_NTN_solutions	n255	1626.5 – 1660.5MHz	1525 – 1559 MHz	FR1, FDD L-band
REL-18	NR_NTN_LSband	n254	1610 – 1626.5MHz	2483.5 – 2500MHz	FR1, FDD, LS-band
REL-18	NR_NTN_enh	n512*, n511*, n510*	27.5 – 30.0GHz 28.35 – 30.0GHz 27.5 – 28.35GHz	17.3 -20.2GHz 17.3 -20.2GHz 17.3 -20.2GHz	FR2, FDD, Ka-band

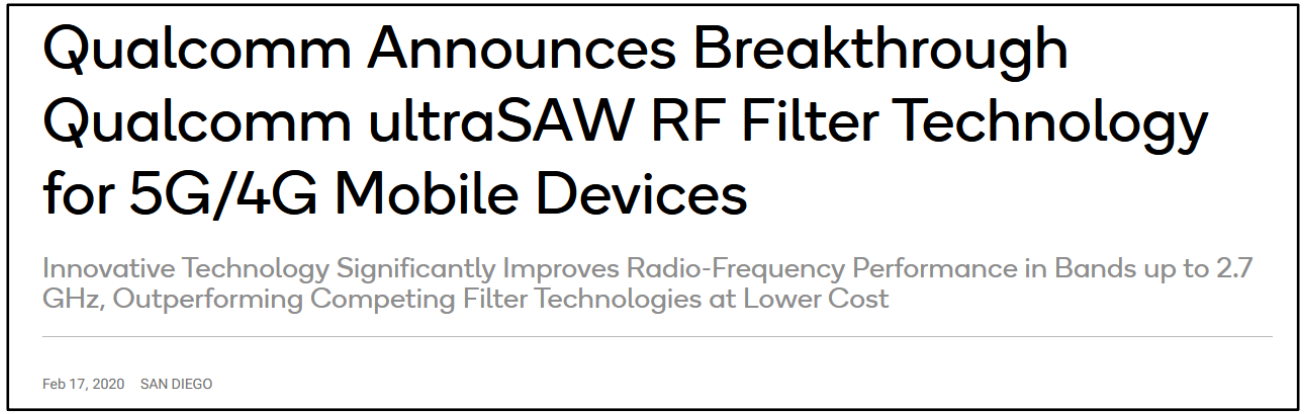
* Under discussion.

- Each band comes with its own challenges…
- Only FDD operations are being considered, which add the difficulty of receiver immunity.

5G NR-NTN challenges

- S-Band :

  - The n256 band is adjacent to the n1 band (upper side) with no separation
  - Very stable and very low insertion loss filters are needed to support TN / NTN co-existence.
  - Qualcomm Technologies has developed Rx, Tx and duplex filters to support n256.



Qualcomm Announces Breakthrough Qualcomm ultraSAW RF Filter Technology for 5G/4G Mobile Devices

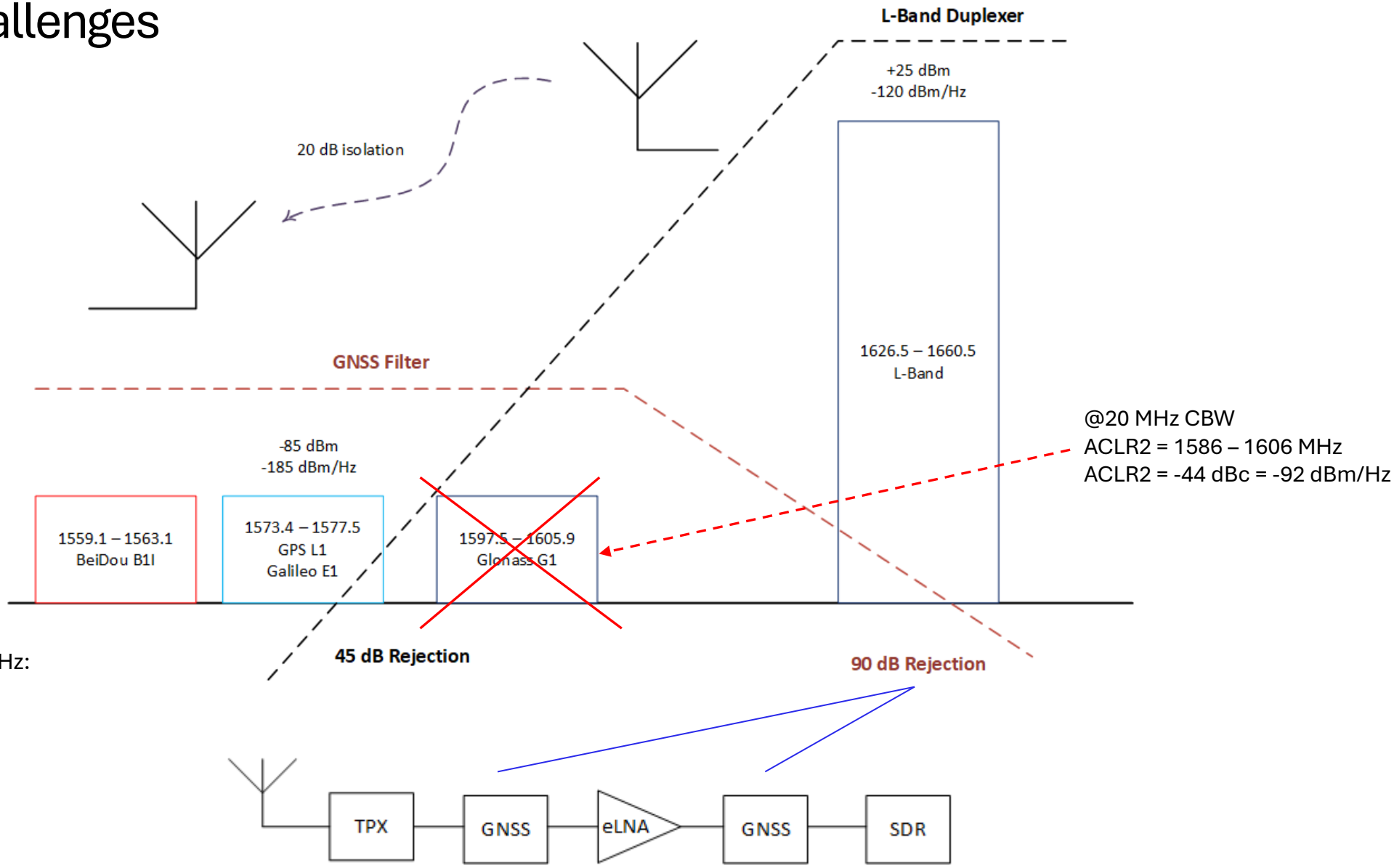
Innovative Technology Significantly Improves Radio-Frequency Performance in Bands up to 2.7 GHz, Outperforming Competing Filter Technologies at Lower Cost

Feb 17, 2020 SAN DIEGO

  - Qualcomm® ultraSAW™ technology has a temperature coefficient better than -9 ppm/K and Q > 5000, up to 2.7 GHz.

5G NR-NTN challenges

- L-Band



Duplexer Tx Rejection @1606 MHz:
- W/ Tx SAW: > 45 dB
- W/o Tx SAW: > 48 dB

Tx Pre PA SAW Specs:
- IL: < 1.5 dB
- @1606 Rejection: > 10 dB

5G NR-NTN challenges

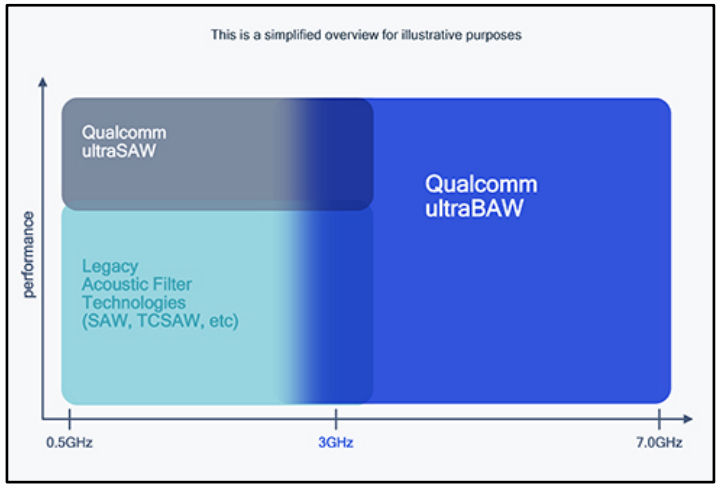
- Ka-Band :
  - The Ka-band is dedicated to VSAT applications. Mobility is still under discussion.
  - The biggest difference between FR2 and NR-NTN is full duplex vs half duplex terminals.
  - Lack of physical separation between Tx and Rx antennas can be compensated with Rx filters.

PRESS NOTE

Qualcomm Announces New RF Filter Technology to Enable Next Generation 5G and Wi-Fi Solutions

– Cutting Edge Qualcomm ultraBAW Filter Technology Extends Radio-Frequency Portfolio for 5G and Wi-Fi Segments up to 7 GHz –

Oct 19, 2021 SAN DIEGO



- Qualcomm® ultraBAW™ technology is a good candidate. However, 17-20 GHz BAW filters are still years away…

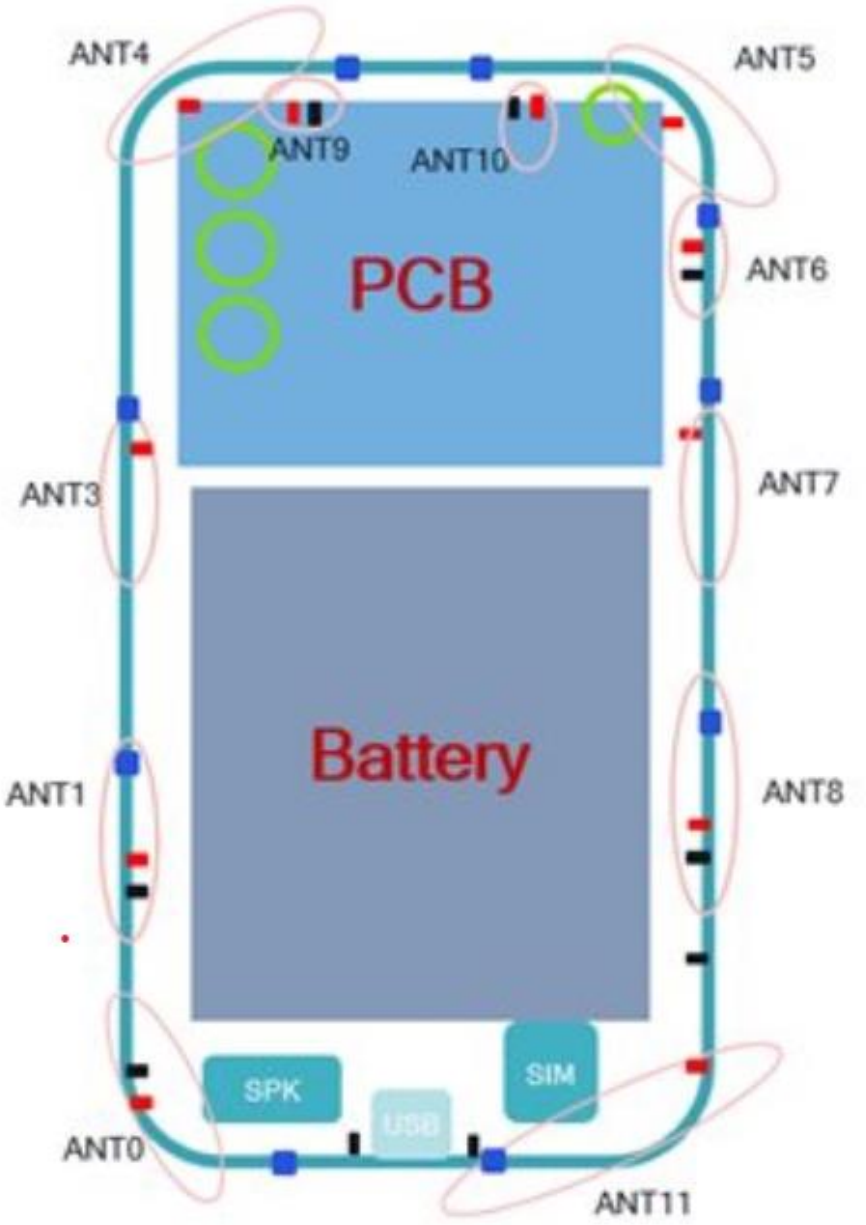
5G NR-NTN challenges

- Sub6 Antenna design :

  - Typical handsets have 2 antennas on top, 2 antennas on bottom and 2-3 antennas on the sides.
  - Antenna diversity provides a noticeable performance gain.
  - Also, PC2 (+26 dBm) can be achieved with dual antennas.

  - The main design goal is to pair the antennas and match radiation patterns.
  - Due to the need for position location before transmitting, GNSS to NTN antenna separation/isolation is required.

  - Transmitter beamforming would be a valuable feature.
  - However, coherence between two separate signal paths and two separate antennas is challenging.



5G NR-NTN challenges

- Ku- and Ka- Band Antenna design :
  - SpaceX™ is adding mobility to their SatCom offering.
  - Small antenna physical aperture: 10.2” x 11.75”
  - Maximum antenna aperture gain: +32.7 dBi ≈ 586 elements (λ/2)
  - Estimated EIRP: +10 dBm + 10 · log(586) + 32.7 dBi ≈ +70 dBm
  - USB-C power supply: 12V, <40W
  - Users are reporting high sustained throughputs: 100-200 Mbps

  - The main challenge for the Ka-band design will be the full duplex implementation in a small form factor.
  - +10 dBm linear power per channel for Ku and Ka band RFICs.
  - Low PAPR waveforms are needed, PA efficiency is hardly >10%

  - Tx-Rx isolation can be accomplished in various ways:
    - Physical Tx to Rx antennas separation
    - Cross polarization between Tx and Rx antennas
    - Use of Rx filters (cavity, waveguide, BAW??, etc…)
    - Use of high-Q LNA matching networks.

Thank you

Follow us on:

For more information, visit us at qualcomm.com & qualcomm.com/blog