NOKIA Bell Labs

Non-Terrestrial Networks for 5G New Radio

IEEE Workshop on 5G Technologies for Tactical and First Responder Networks

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NTN for Public Safety

- Extending coverage to places without terrestrial coverage
- Supporting mission critical services
- Providing 5G reliability and resilience

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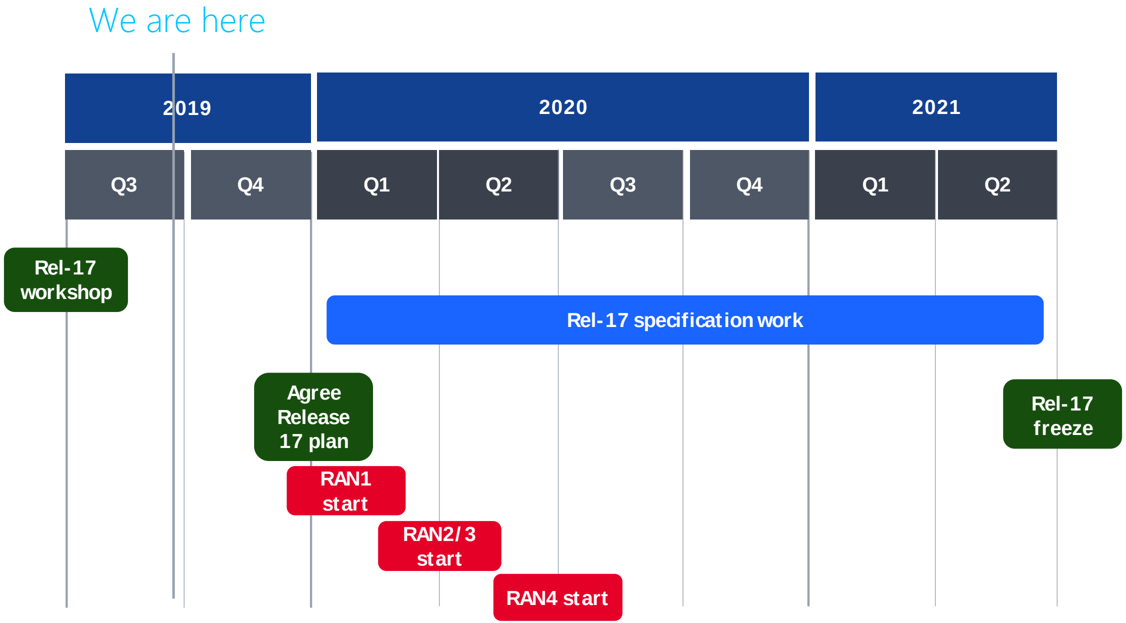
NTN for 5G New Radio

- Study item on NR to support Non-Terrestrial Networks completed in 38.811
- Potential solutions are being evaluated in Rel-16 - study item report in 38.821
- Specification work is expected to start in Rel-17



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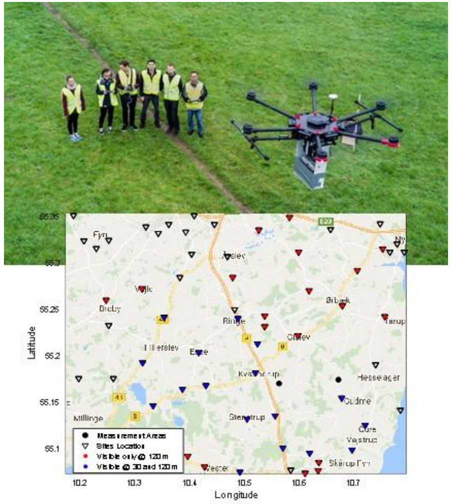
Nokia HAPS Related Experience

- Nokia actively involved in 3GPP and other NTN projects
- Nokia and High Altitude Platform Stations (HAPS) - GEO’s, MEO’s, LEO’s, Airplanes and Balloons
- HAPS Project using Balloons
  - Uses LTE to cover unserved areas
- Mission to the Moon (MttM)
  - E2E solution with Nokia’s small cell LTE eNB and UE (with partners)
  - Hardened to operate in harsh environment (vacuum, radiation) and survive launch, transit and landing mechanical stresses.
- Public Safety High-Altitude Deployments
  - Use Flexi Zone Micro Platform for providing coverage from stratosphere
- UAV
  - Aerial Radio Channel measurement using real live LTE commercial networks



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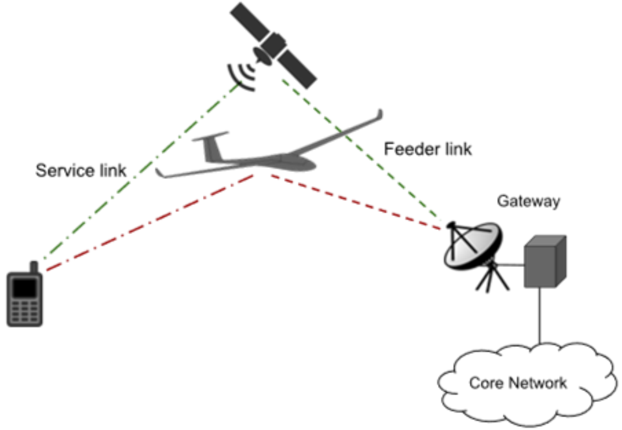
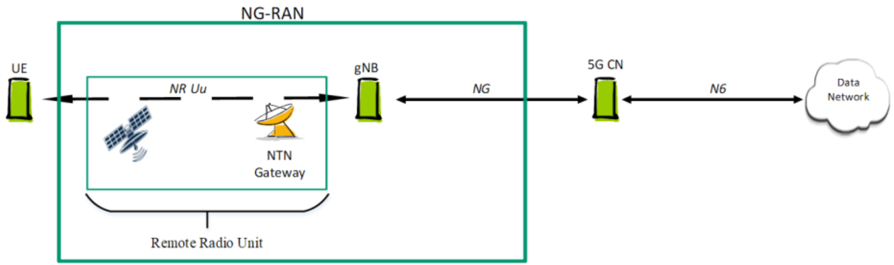
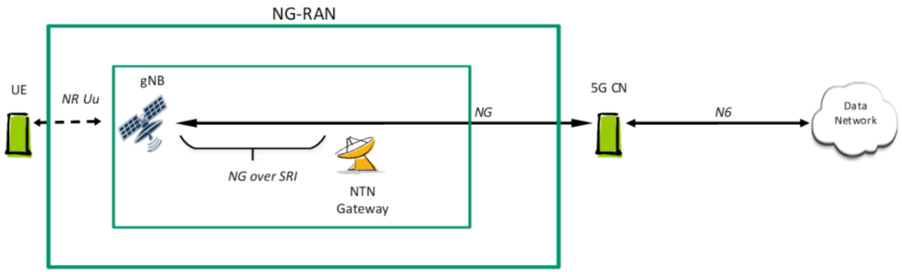
NTN Architecture

- NTN Architecture comprises of
  - Service Link
  - Feeder Link
  - Ground Gateway
- Airborne communication payload
  - Transparent: Change signal carrier frequency, filter, and amplify it between UE and GW. Digital processing is done at gNB at GW.
  - Regenerative: Perform digital processing function of gNB. The gNB functionality can be split between DU at satellite or HAPS and CU at GW.





Transparent Payload (38.821)



Regenerative Payload (38.821)

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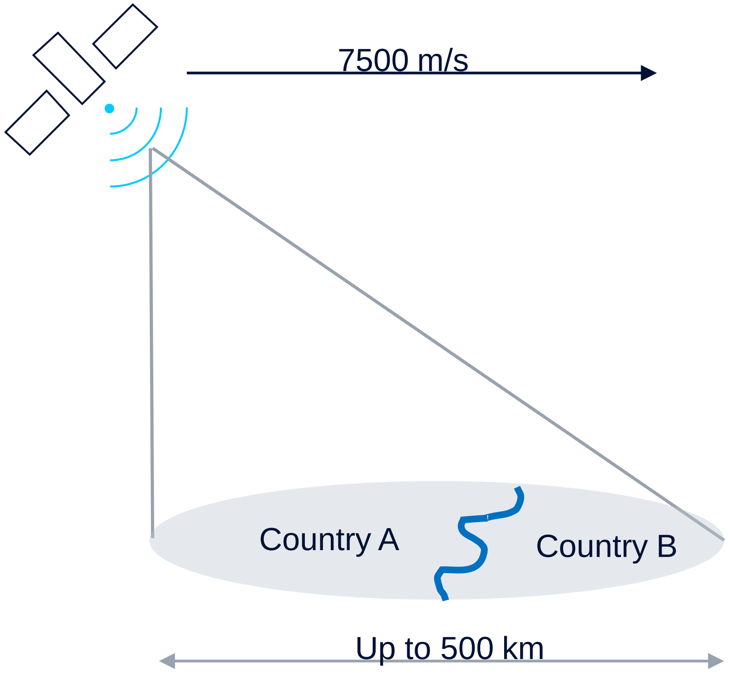
Overview of LEO Challenges

Recap of LEO at 600 km/ 1200 km

Large Distances:
- Up to 1932 / 3131 km
- Link Budget

Large Delays:
- Up to 12.9 / 20.9 ms
- CSI may be out-of-date
- Large HARQ buffer required



High Speed:
- Mobility
- Timing Advance
- Doppler

Cell Size:
- RACH/TA Range
- Country Identification

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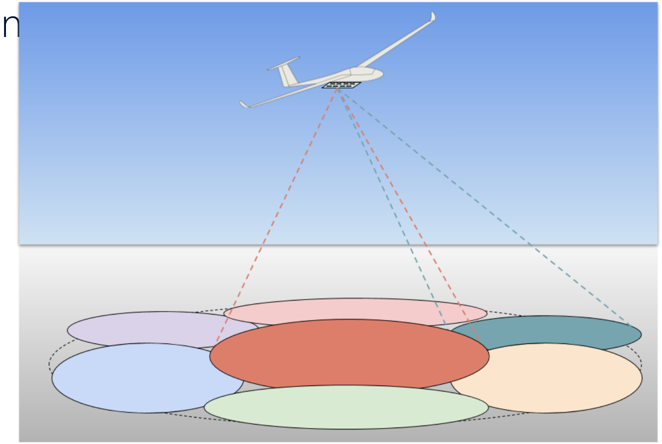
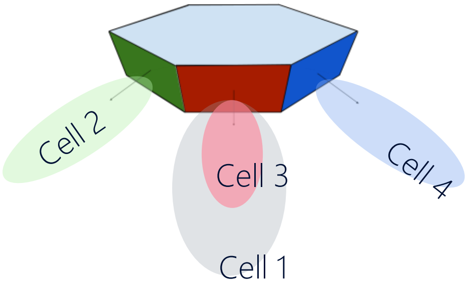
High Altitude Platform Stations

- HAPS can use a balloon or solar powered drone to operate in the stratosphere with typical altitude of 20 Km.
- Compared to LEO satellites, HAPS has the advantages:
  - Short propagation delay (<0.4 ms)
  - Low path loss
  - Negligible Doppler shift
- Spectrum: <6 GHz for service link, mmWave for feeder link
- Challenges
  - Equipment is subject to strict weight, size, and power budget
  - Equipment needs to operate in extremely cold temperature (≈-70ºC)
  - Large antenna arrays and high transmit power may not be possible
  - Feeder link using high frequency band may experience large rain fade (>25 dB)
- Phased array can be used to form steerable beams to serve fixed cells
- Preliminary study shows with light weight radio and antenna can achieve good throughput in a large coverage area.





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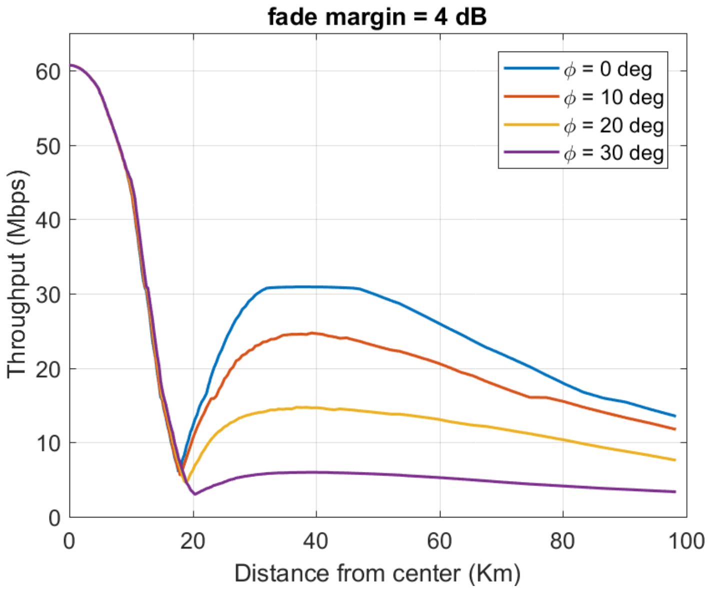
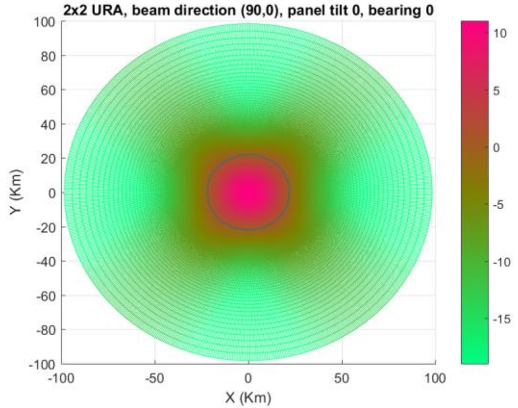
HAPS Service Link Capacity and Coverage

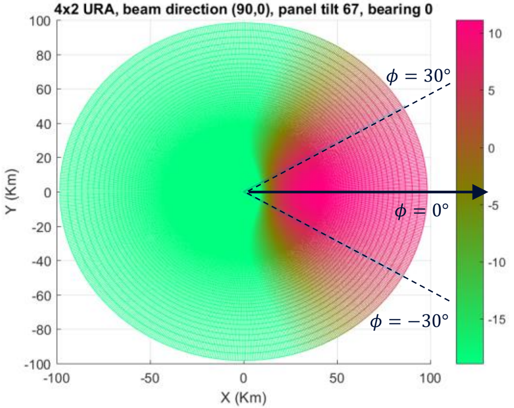
- Center cell has higher peak throughput.
- Outer cell throughput depends on the azimuth angle ϕ to its antenna panel boresight ($|\phi| \leq 30°$).



DL throughput using 20 MHz bandwidth. An outer is covered in azimuth angle $|\phi| \leq 30°$



Antenna gain of the center cell



Antenna gain of the outer cell

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Conclusion

- Feasibility of supporting non-terrestrial communication in 5G NR is being studied in 3GPP. LEO and HAPS are promising deployment scenarios due to their relatively shorter propagation delay.
- NR PHY layer needs to be extended to support the longer delay, large beam footprint of LEO.
- Mobility related impacts, e.g., cell reselection, handover, feeder link switch, also need to be studied for higher layer protocol.
- Compared to LEO, HAPS poses less impact to NR standard, but implementation is constrained by power, size, and weight of the HAPS platform.
- Preliminary study shows light weight radio equipment and antenna design can achieve good throughput and coverage for LOS users (15 Mbps with 20 MHz bandwidth at 100 Km distance).

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