Qualcomm

5G Positioning

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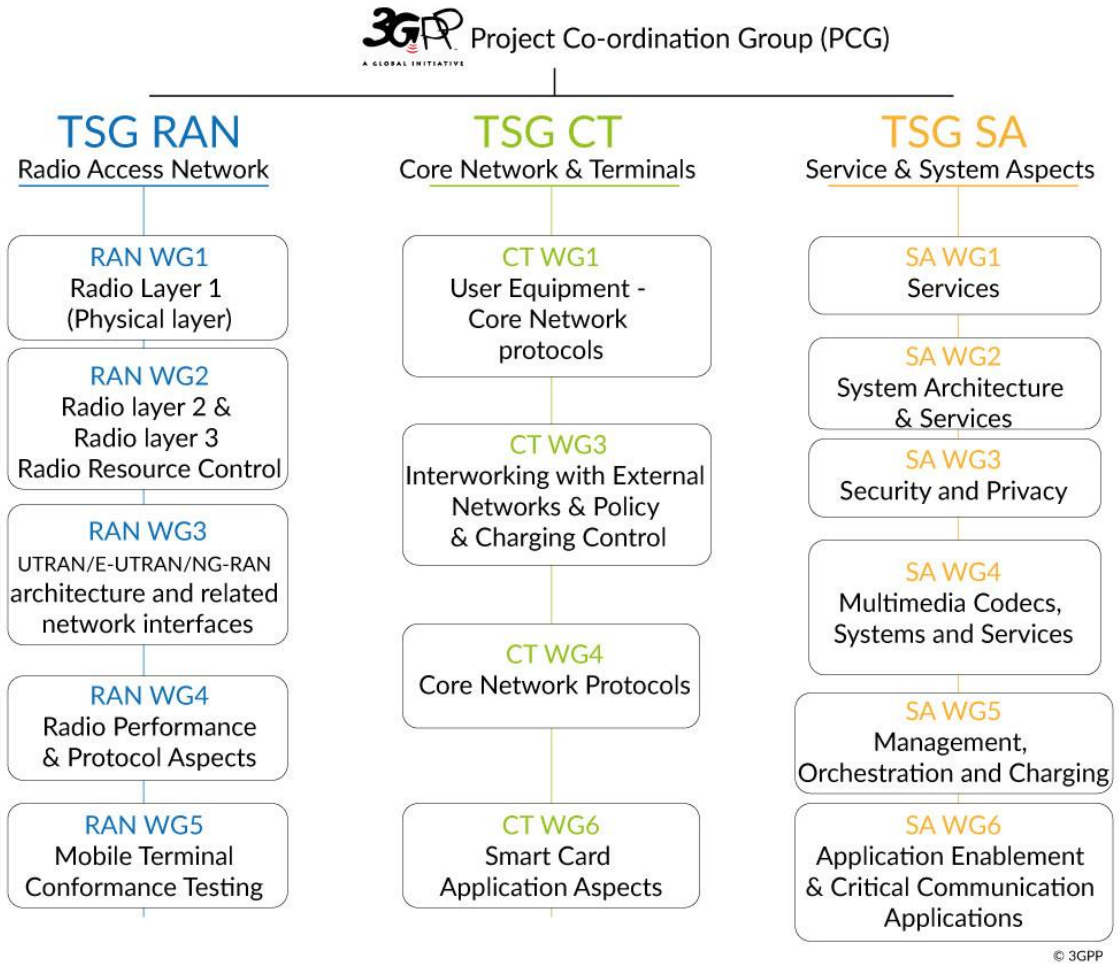
Overview

- Standardization in 3GPP
- Measurement Methods
- Frequency Ranges
- Signals
- Demo Video

3GPP

3rd Generation Partnership Project (3GPP)

- Industry-driven standardization organization for cellular communication and positioning
  - Umbrella organization for ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC
  - 3G: Universal Mobile Telephone Standard (UMTS)
    - First release: R99 in 1999
  - 4G: Long Term Evolution (LTE)
    - First communication release: Rel-8 in 2007
    - First positioning release: Rel-9 in 2009
  - 5G: New Radio (NR)
    - First communication release: Rel-15 in 2018
    - First positioning release: Rel-16 in 2020
    - Current working release: Rel-17 ETA 2022



https://www.3gpp.org/about-3gpp/about-3gpp

3GPP Process and Deliverables

- Meetings and schedules
  - Typically, 5-6 meetings per year
  - Standards revision cadence ~ 2 years
    - Study items
    - Work items
- Use cases and performance targets
- Simulation assumptions
  - Feasibility and validation of performance targets
- Signal definitions
  - 38.211
- Measurement methods
  - 37.355 LTE Positioning Protocol (LPP)
    - Extended for NR from 36.355 for LTE
  - 38.455 NR-Positioning Protocol A (NR-PPa)
- Protocols and call-flows
  - 37.355 LPP
  - 38.455 NR-PPa
- Conformance tests
  - Minimum performance
  - 37.571-1

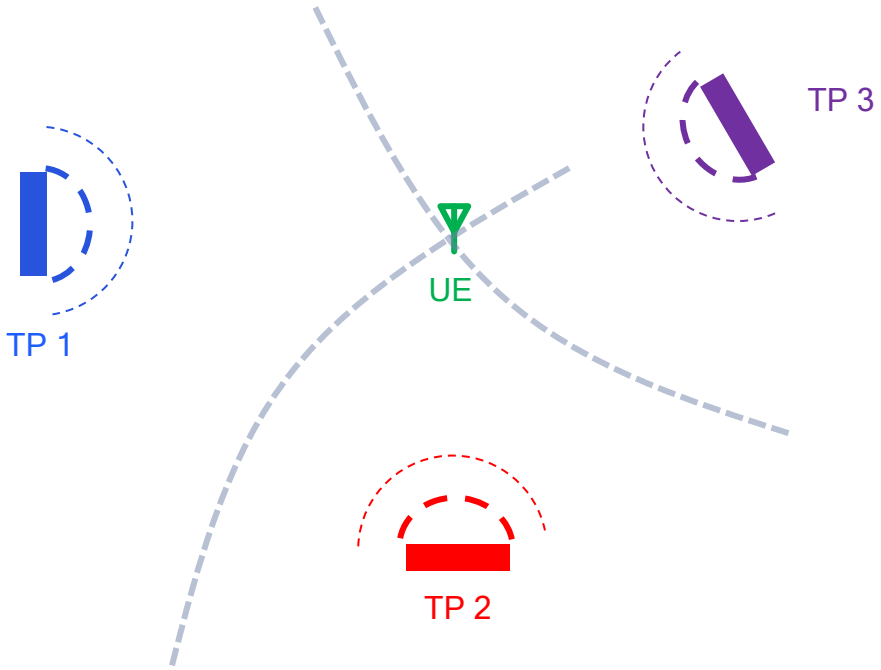
5G Positioning in 3GPP Rel-16

- Regulatory use cases (E-911)
  - 50m horizontal accuracy at 80th percentile
- Commercial positioning use cases
  - Outdoor
    - 10m horizontal accuracy at 80th percentile
  - Indoor
    - 3m horizontal accuracy at 80th percentile
- UE-B and UE-A
- Cellular network synchronization requirement for communication
  - Time Division Duplex (TDD): 1.5 - 3 µs
  - Frequency Division Duplex: N/A
  - Note: No requirements exist for positioning in 3GPP
- Measurement methods
  - Downlink-only
    - DL-Time Difference of Arrival (DL-TDOA)
      - **Needs accurate network sync** (< 3,10, 50 m)
    - DL-Angle of Departure (DL-AoD)
      - TDD-level accuracy recommended (3 µs)
  - Uplink-only
    - UL-Relative Time of Arrival (UL-RTOA)
      - **Needs accurate network sync** (< 3,10, 50 m)
    - UL-Angle of Arrival (UL-AoA)
      - TDD-level accuracy recommended (3 µs)
  - Uplink + Downlink
    - Multi-Cell Round-Trip-Time (MC-RTT)
      - TDD-level accuracy recommended (3 µs)
    - Enhanced Cell Identity (eCID)
      - TDD-level accuracy recommended (3 µs)

Measurement Methods

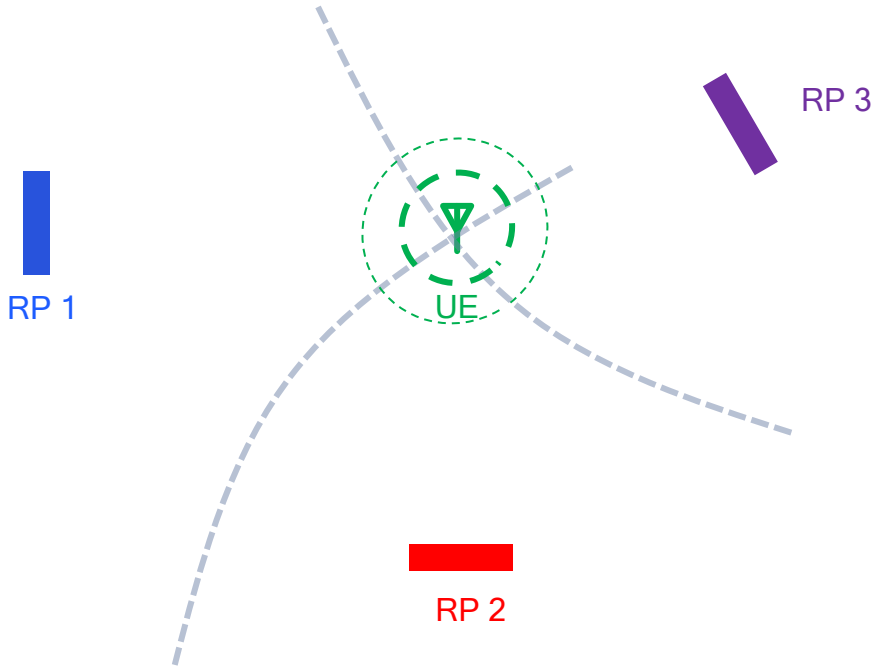
Pseudo-Range Based Methods

Time Difference of Arrival (DL-TDOA)



“GPS/ LORAN”

Relative Time of Arrival (UL-RTOA)

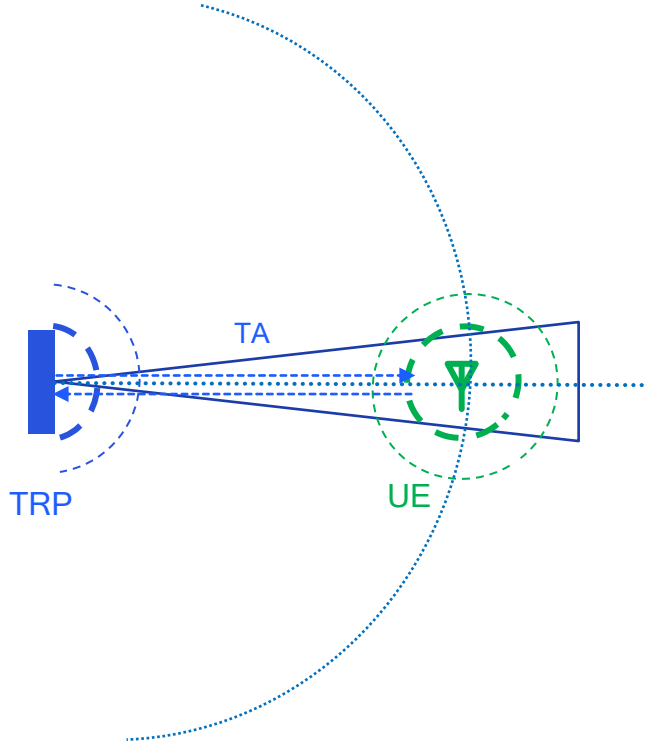


“GPS NDS”

UE: User Equipment (e.g. smartphone)
TP: Transmission Point
RP: Reception Point

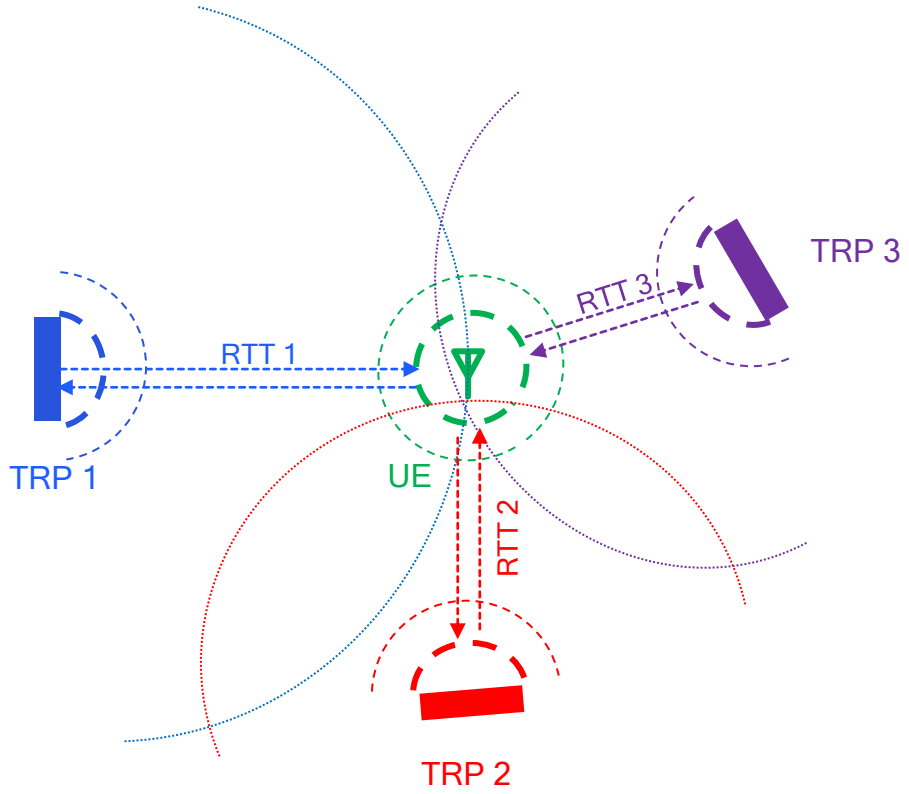
Uplink (UL) and Downlink (DL) Methods

eCID (Rel-15 signals)



“VOR + DME”

Multi-cell RTT (Rel-16 signals)

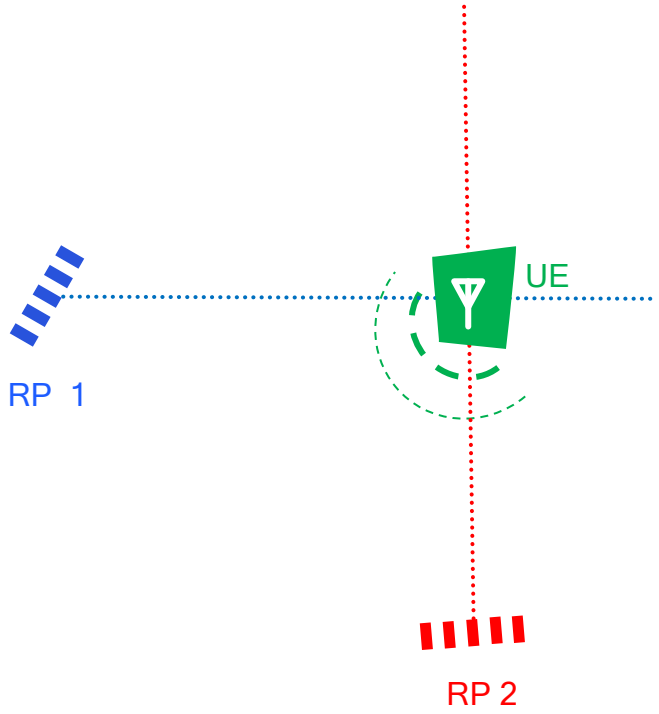


“DME + DME”

TA: Timing Advance
TRP: Transmission and Reception Point

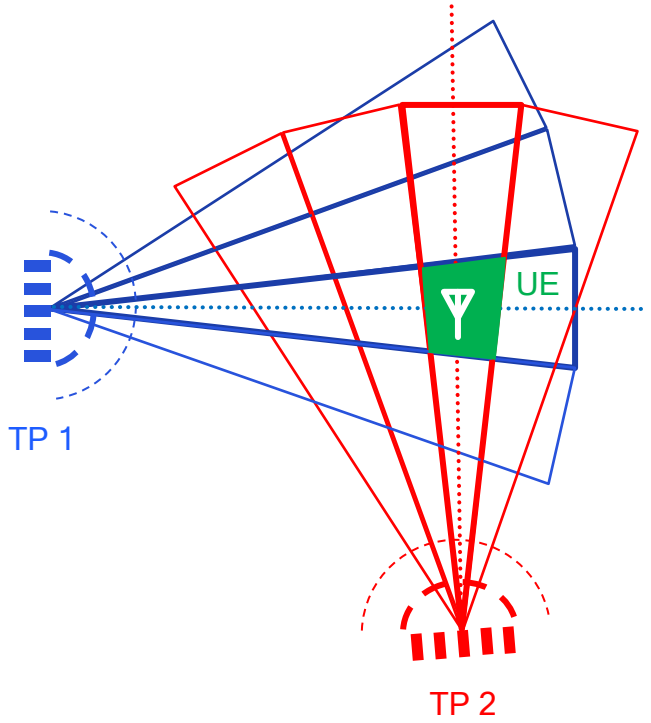
Angle-Based Methods

UL-Angle of Arrival (AoA)



“Direction finding/Triangulation”

DL-Angle of Departure (AoD)



“VOR + VOR”

TP: Transmission Point
RP: Reception Point

Frequency Ranges

Frequency Ranges

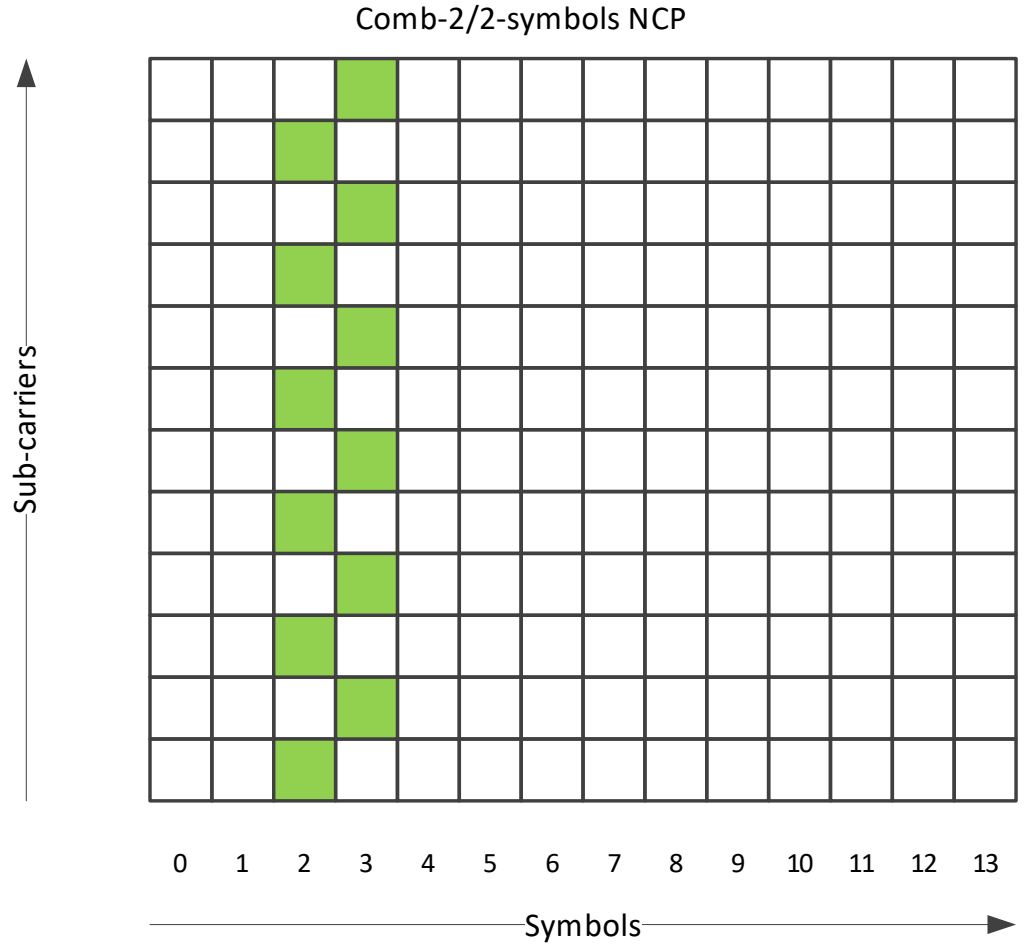
"L1, L2, L5"

- FR1: "sub-6" GHz
  - 410 MHz – 7,125 MHz
  - BW options from 5 MHz to 100 MHz
  - 56 Band-Classes (BCs)
    - 5 – 1200 MHz of contiguous BW
    - Support for up to 100 MHz BW channels
- FR2: "mmW"
  - 24,250 MHz – 52,600 MHz
  - BW options: {50, 100, 200, 400} MHz
  - 6 BCs
    - 0.85 – 4 GHz of contiguous BW
    - Support for up to 400 MHz BW channels

Signals

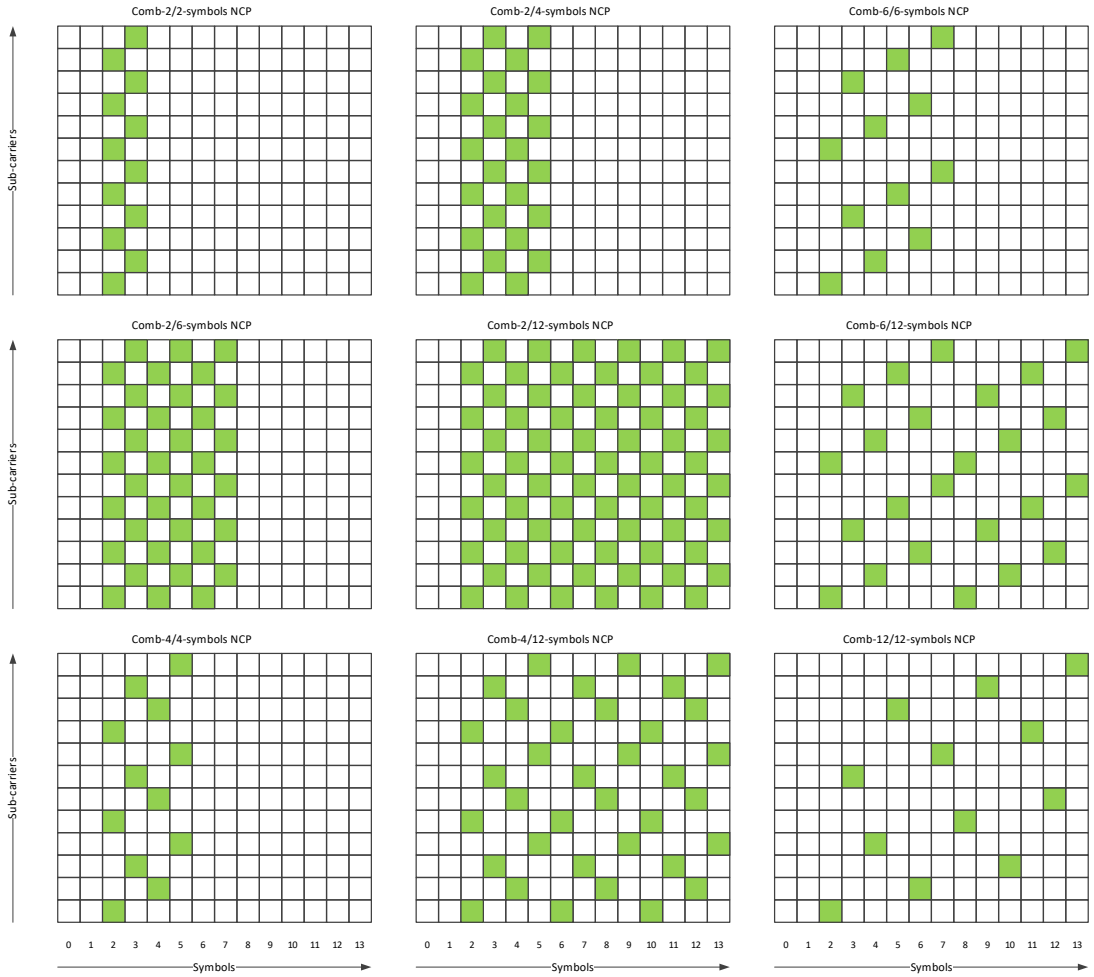
Orthogonal Frequency Division Multiplexing (OFDM)

- OFDM characteristics
  - Resource Element (RE): 1 sub-carrier for 1 symbol
  - Resource Block (RB): 12 sub-carriers for 12 or 14 symbols
    - Build BW as a function of #RBs
  - Slot: 12 (ECP) or 14 symbols (NCP)
  - Sub-carrier spacing
    - FR1: {15, 30, 60} kHz
    - FR2: {60, 120} kHz
  - Frame: 10 ms
- Inter-Symbol Interference (ISI)
  - Cyclic pre-fix
- Inter-Carrier Interference (ICI)
  - Frequency accuracy requirements
    - 50 ppb to 250 ppb

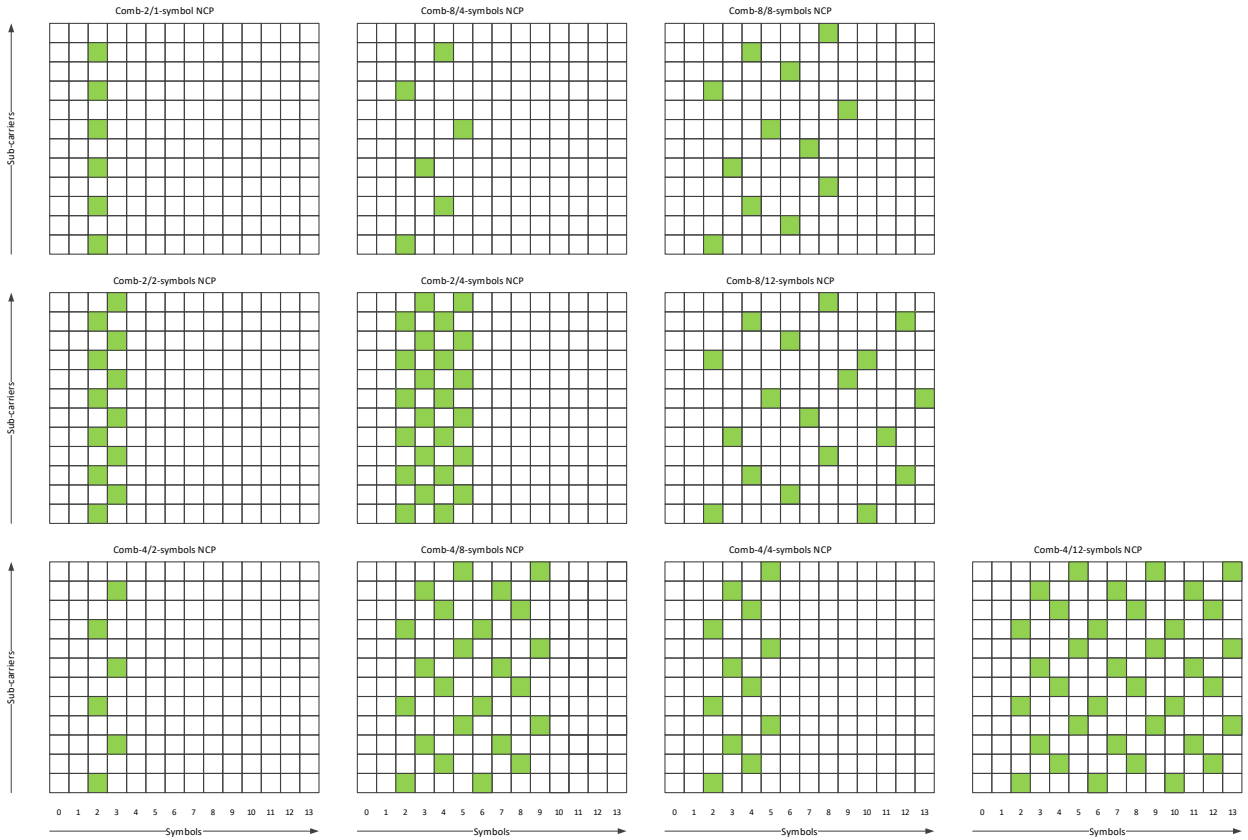


Signals defined in 3GPP Rel-16

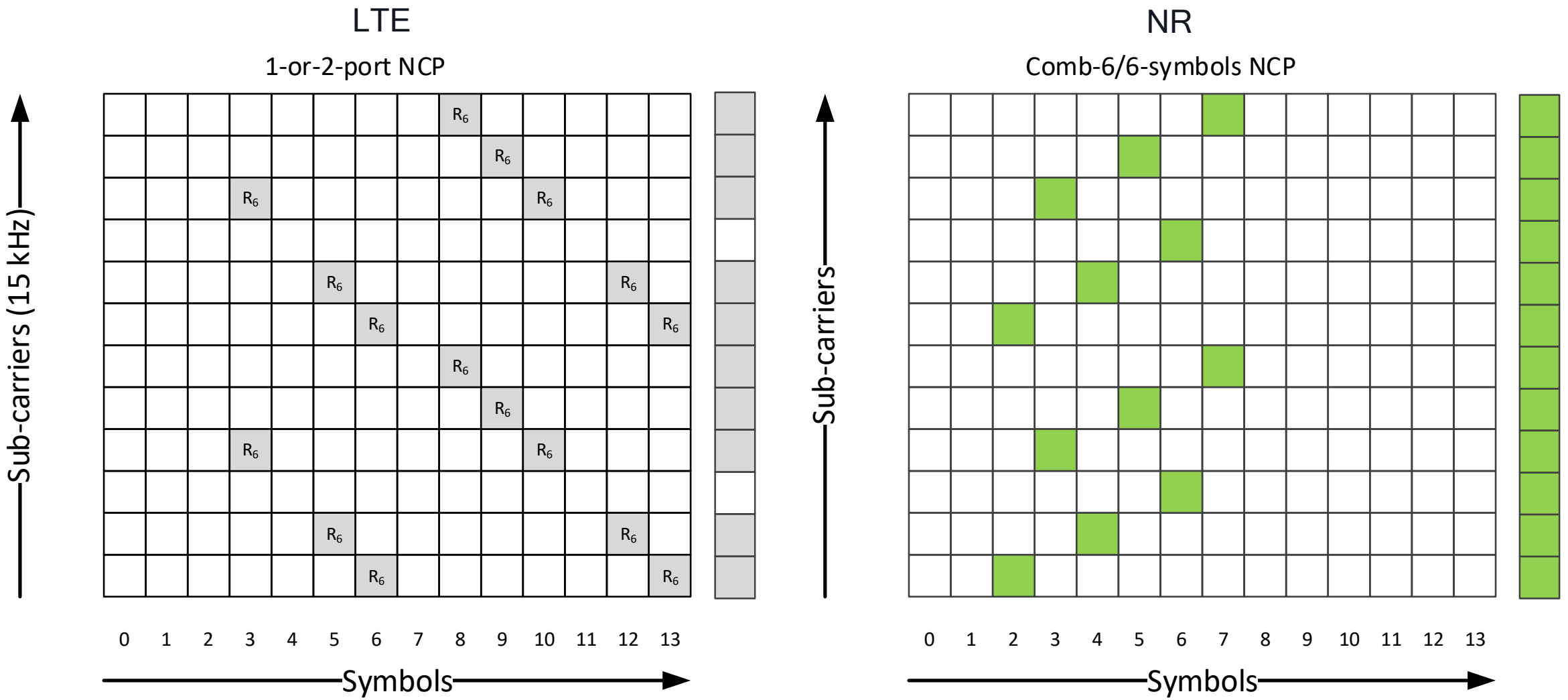
Downlink Positioning Reference Signal (DL-PRS)



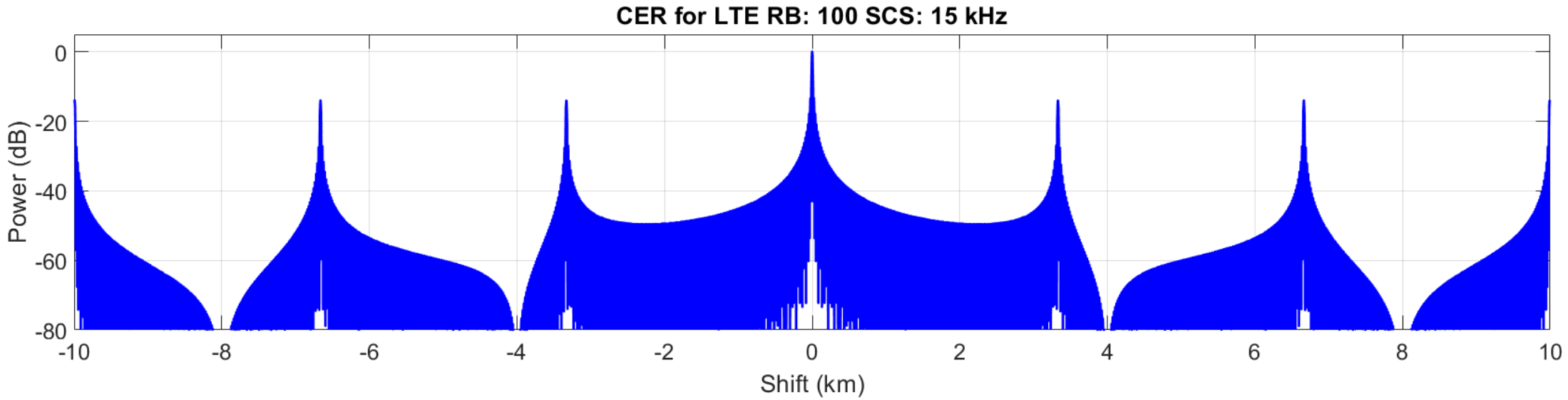
Uplink Sounding Reference Signal for positioning (UL-SRS)

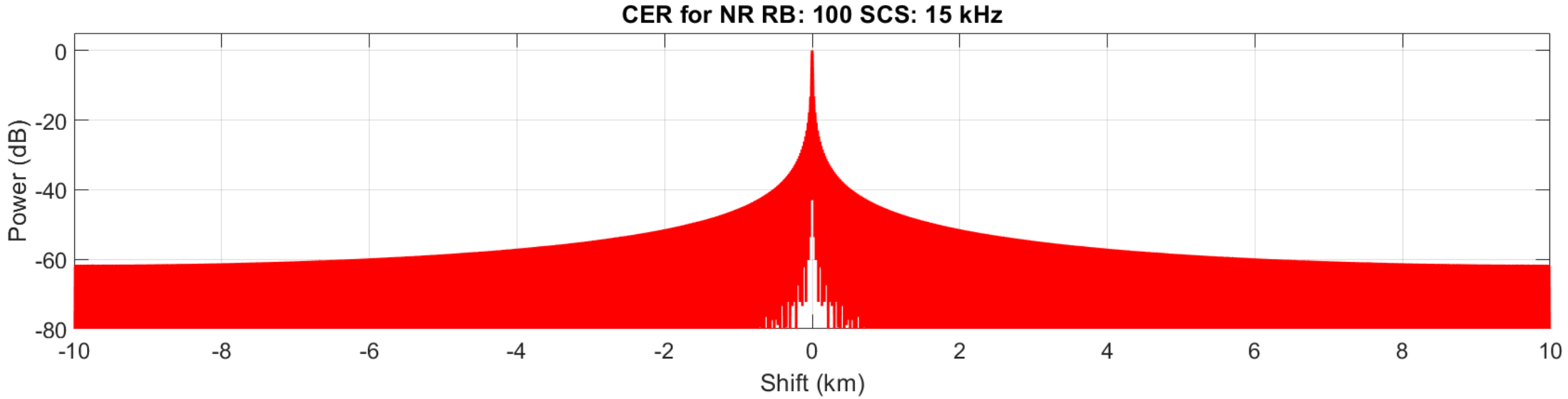


Comparison Between LTE and NR

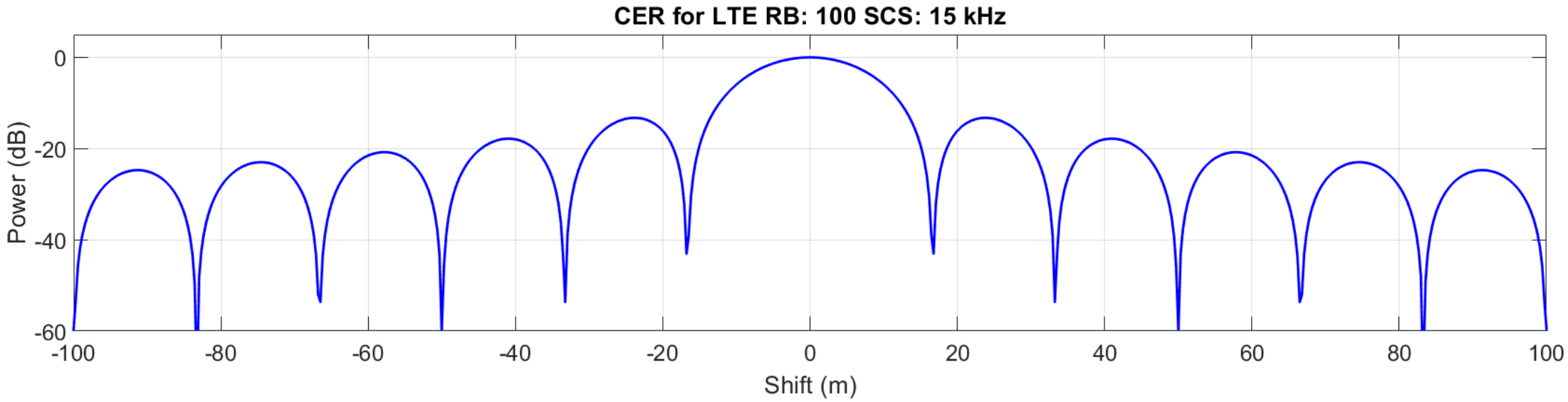


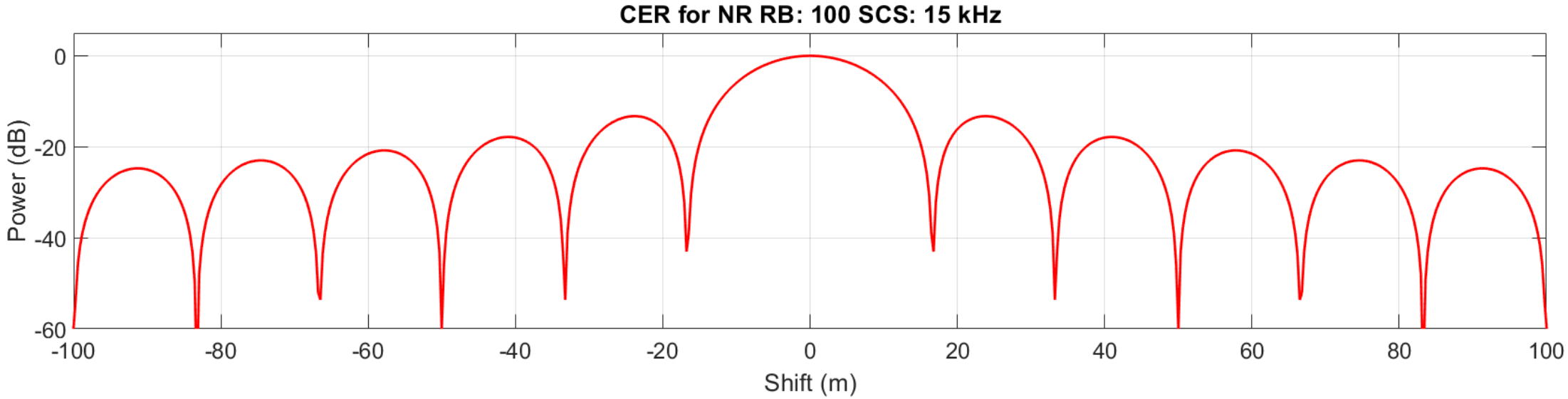
Comparison Between LTE and NR for 20 MHz BW





Comparison Between LTE and NR for 20 MHz BW (Zoom)





MC-RTT + UL AoA Demo

https://www.qualcomm.com/videos/5g-multi-cell-positioning-ota-demonstration

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