NOKIA

Enhanced positioning accuracy for Rel-18

RAN Rel-18 Workshop

28th June – 2nd July 2021

RWS-210117

Nokia, Nokia Shanghai Bell

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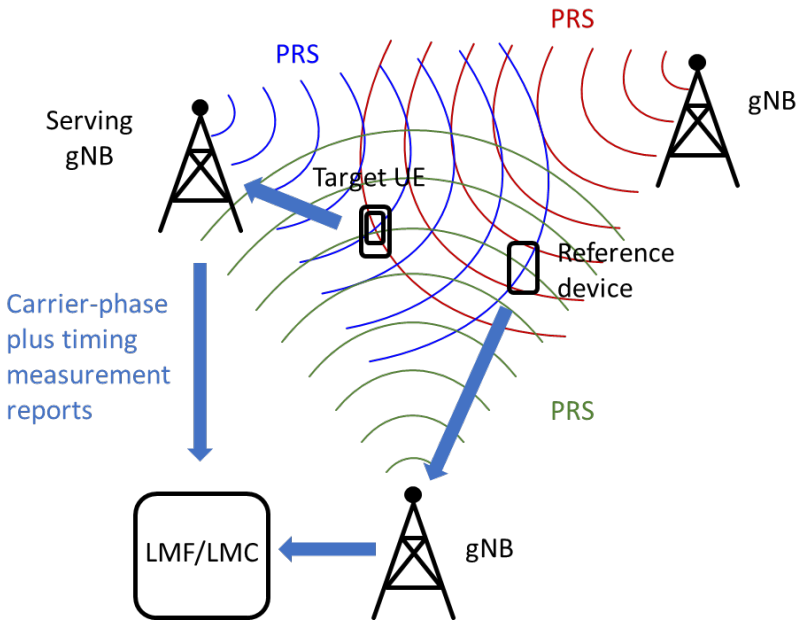
Enhanced positioning accuracy: Motivation

- Commercial interest in high-accuracy positioning is increasing
  - e.g. for industrial automation
- For outdoor scenarios, support for carrier-phase based GNSS has been available since Rel-15, delivering sub-10cm accuracy
- For consistency of service, similar accuracy should be achievable without reliance on GNSS:
  - Indoors (industrial automation/logistics)
  - Tunnels (automotive, public safety)
  - Resilience (interruption of GNSS)
- Rel-17 positioning enhancements bring incremental accuracy improvements, but not order of magnitude
- Some possible techniques have already been discussed in studies, of which we believe the most promising is **carrier phase positioning using the terrestrial NR signals**
  - Uses carrier-phase measurements on 5G NR signals on top of time measurements
    - Similar technique to RTK-GNSS, but using NR signals rather than GNSS
  - Factor of ~10 higher accuracy compared to purely time-based positioning methods
  - Can work both outdoors and indoors
    - outdoor alternative to GNSS-RTK, e.g. in case of GNSS non-availability
    - indoor complement to outdoor GNSS-RTK



Carrier phase based NR positioning has the potential to extend cm-level positioning to indoor scenarios

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Enhanced positioning accuracy: Objectives

- Specify terrestrial carrier-phase positioning for NR, with the aim of achieving sub-10cm accuracy consistently both indoors and outdoors. Downlink, uplink and round-trip based carrier-phase methods are included.
  - Specify positioning reference signal for carrier phase positioning method [RAN1/2]
    - Focus on reuse of existing PRS and/or SRS as first priority; other reference signals or new reference signal may be considered as second priority.
  - Study, and if needed, specify procedures, signaling, and reporting for integer ambiguity resolution and cycle slip detection [RAN1/2].
  - Specify signalling for configuration and reporting [RAN1/2/3]
    - Specify phase measurement request and resource configuration signals
  - Specify UE carrier phase measurements and requirements [RAN1/4]
    - Define carrier phase measurement accuracy and measurement period requirements, including study of impacts from phase discontinuity/distortion.
  - Specify gNB carrier phase measurements. [RAN1/4]
  - Study and specify the use of OTA measurements (e.g., using a reference device) for mitigation of Tx/Rx (time and) phase errors [RAN1/4]

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Background

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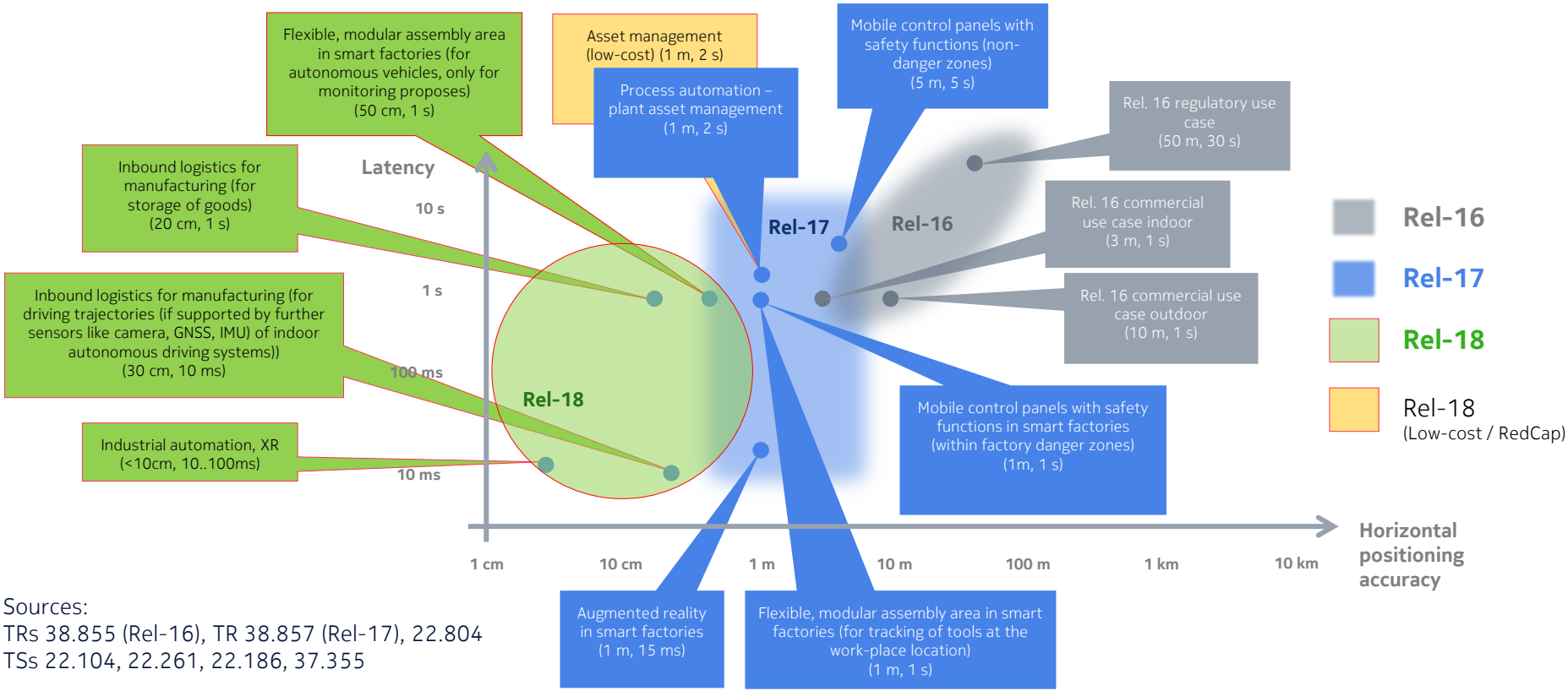
Positioning use cases and performance requirements for Rel-16, 17 & 18



Sources:
TRs 38.855 (Rel-16), TR 38.857 (Rel-17), 22.804
TSs 22.104, 22.261, 22.186, 37.355

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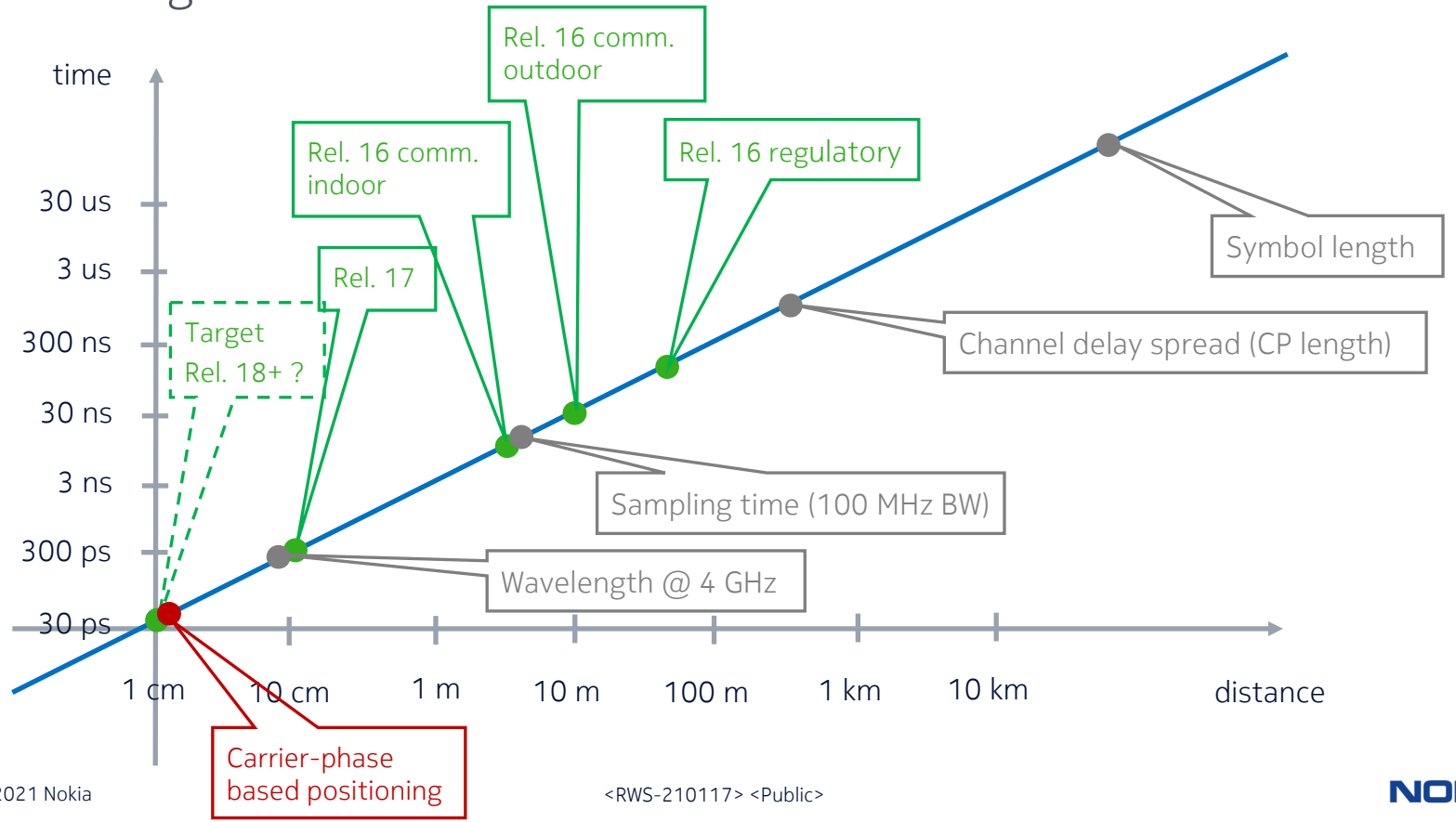
Carrier-Phase Based Positioning

Time and length scale



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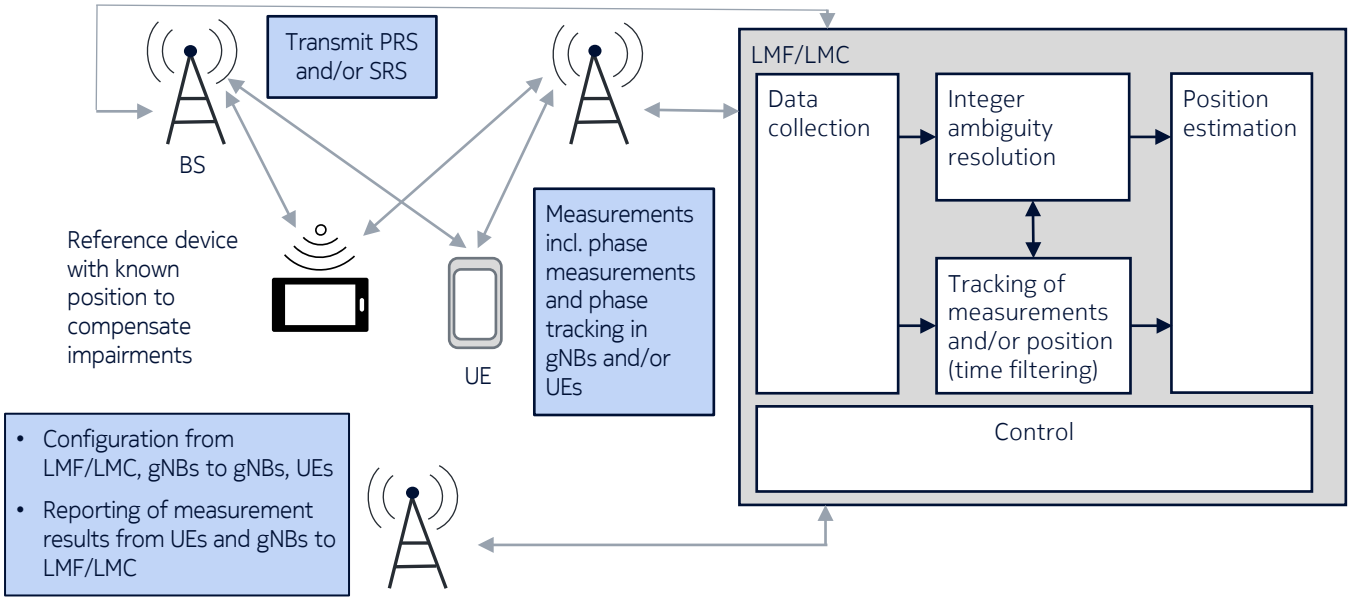
NR Carrier-Phase methods for downlink and/or uplink



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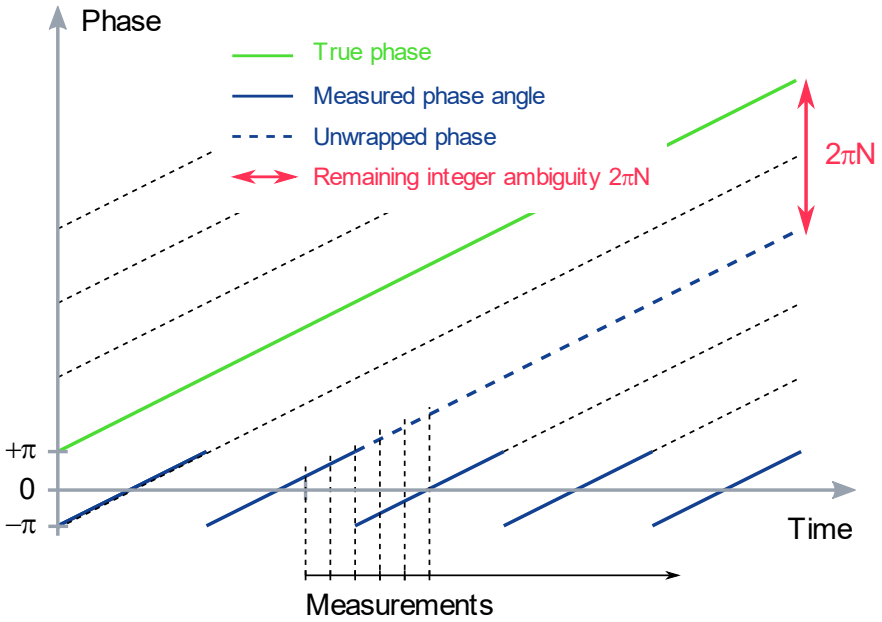
Principle of carrier-phase measurement and phase ambiguity

- Measure baseband amplitudes and calculate phase angle in $(0 \ldots 2\pi)$
- Unwrap phase by frequent measurements, detecting and removing cycle slips

$$\varphi = \begin{cases} \tan^{-1}\left(\frac{\mathrm{Im}(z)}{\mathrm{Re}(z)}\right) & \text{if } \mathrm{Re}(z) > 0 \\ \tan^{-1}\left(\frac{\mathrm{Im}(z)}{\mathrm{Re}(z)}\right) + \pi & \text{if } \mathrm{Re}(z) < 0 \text{ and } \mathrm{Im}(z) > 0 \\ \tan^{-1}\left(\frac{\mathrm{Im}(z)}{\mathrm{Re}(z)}\right) - \pi & \text{if } \mathrm{Re}(z) < 0 \text{ and } \mathrm{Im}(z) < 0 \end{cases}$$



- Phase measurements are ambiguous because we actually measure the amplitude of a periodic signal
- Phase unwrapping can remove a part of the phase ambiguity (avoid cycle slips)
- Remaining phase ambiguity must be resolved later

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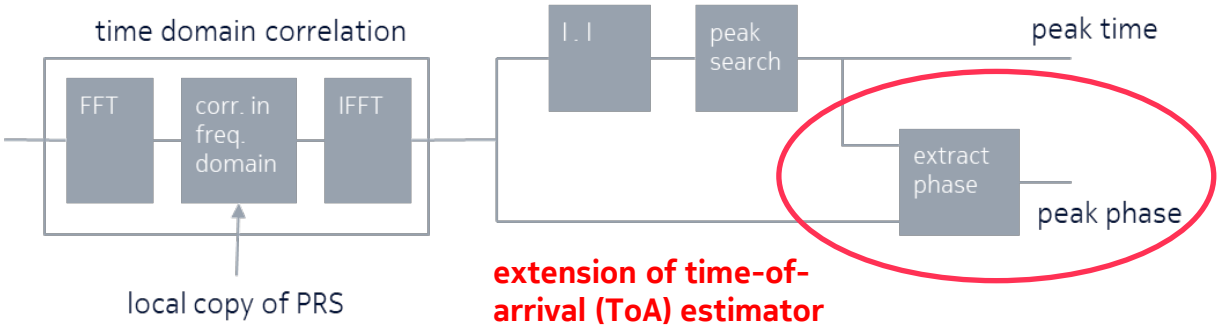
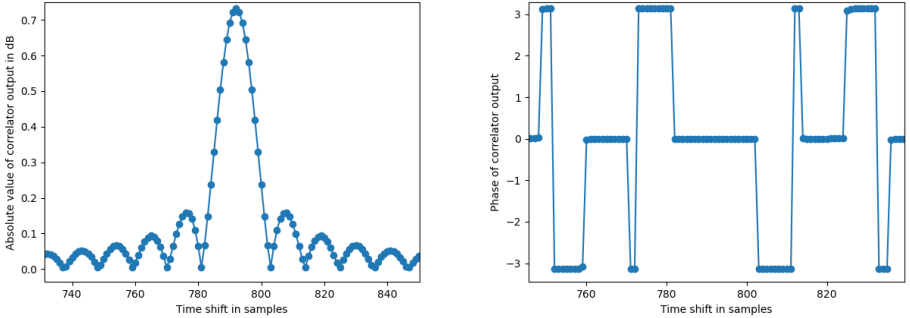
Carrier-phase measurement on wideband PRS



Baseline solution for carrier-phase estimation on wideband PRS

More advanced methods for multipath separation are, e.g., super-resolution algorithms like ESPRIT

- Measured phase on the LOS path is insensitive to timing errors (in absence of frequency offsets)
- Impact of NLOS paths needs to be mitigated (e.g., using ESPRIT algorithm)



Magnitude and phase of the correlator output on LOS path

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