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3GPP TSG RAN Rel-19 workshop RWS-230055

Taipei, June 15 - 16, 2023

Agenda Item: 5

Source: vivo

Title: Study Item on NR Sensing in Rel-19

Document for: Discussion

Priority on NR-based ISAC in Rel-19

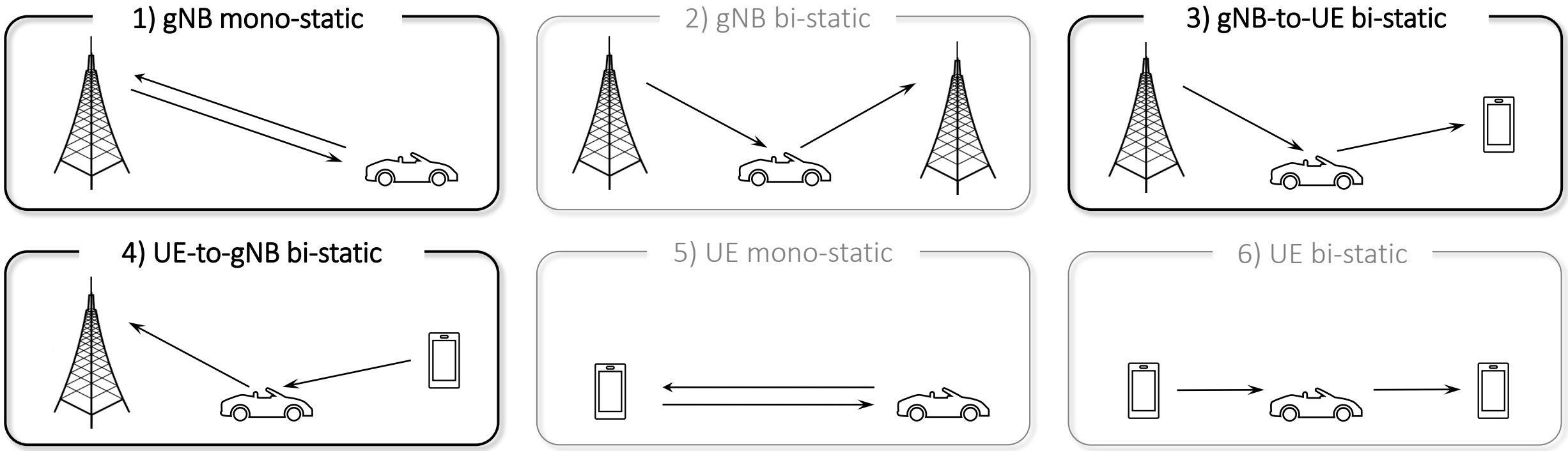
- Sensing modes
  - gNB mono-static sensing
  - gNB-to-UE bi-static sensing
  - UE-to-gNB bi-static sensing

- Use Cases and corresponding KPIs
  - SA1 use cases as a start point
    - E.g., Intruder detection
  - KPIs
    - Confidence level [%]
    - Accuracy of positioning in horizontal/vertical [m]
    - Missed detection [%] / False alarm [%]
    - Max sensing service latency [ms]
    - Refreshing rate [s], etc.

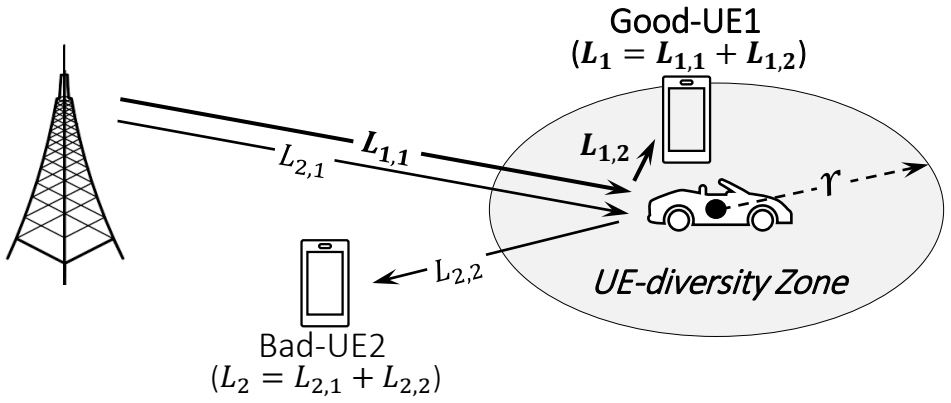
- Channel models: Coupling with sensing modes
  - gNB mono-static sensing
  - gNB-to-UE bi-static sensing
  - UE-to-gNB bi-static sensing

- Performance evaluation
  - E.g., range, AoA/AoD, and Doppler frequency
- Specification impacts
  - Sensing signal and measurements
  - L1 and higher layer procedures

Sensing Modes

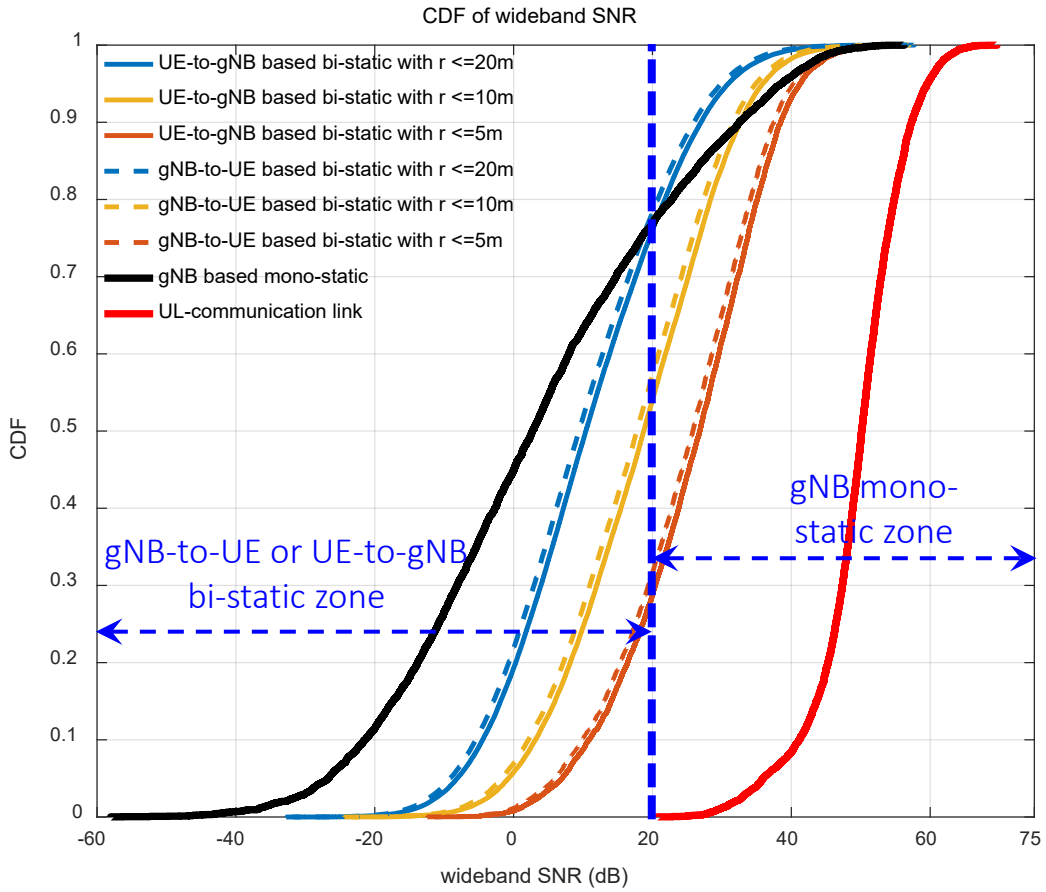


- Both UE mono-static and gNB mono-static modes require a full-duplex mechanism.
  - Mono-static sensing faces the worst path-loss.
- gNB-to-UE can provide the high SNR for sensing, thanks to the UE diversity ($L_1 \ll L_2$).



Sensing Modes: SNR Analysis

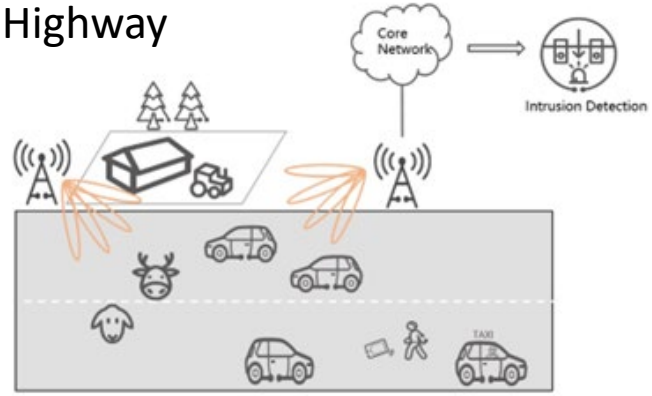
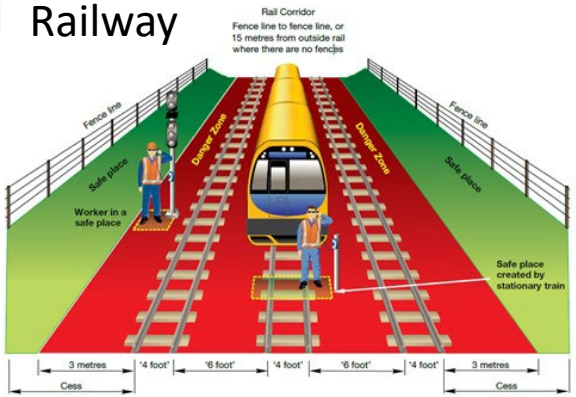
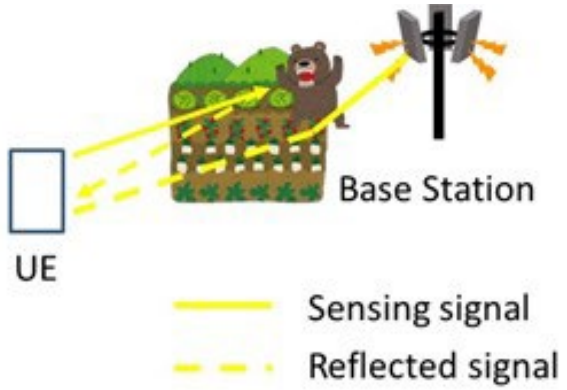
Parameters	Assumptions
Channel	InH scenario
Pathloss	TR 38.901, $L(d_1, d_2) = PL(d_1) + PL(d_2) + 10log\frac{c^2}{4\pi f^2}$
Tx Power	24 dBm for gNB, 23 dBm for UE
Noise Figure	5 dB for gNB, 7 dB for UE
Ant. Gain	5 dBi for gNB, 0 dBi for UE



- **Observations:**
  - gNB mono-static has a poor coverage but offers a high accuracy in the sensing range.
  - gNB-to-UE or UE-to-gNB has a wide coverage but offers a compatibly low accuracy in sensing range due to the uncertainty of the timing and UE location.
  - Bi-static and gNB mono-static modes can ***complementally*** help each other.
- **Proposal: Prioritize the following sensing modes for the study of NR sensing in Rel-19**
  - **Bi-static sensing mode: gNB-to-UE, UE-to-gNB**
  - **gNB mono-static mode**

Use Cases and Corresponding KPIs

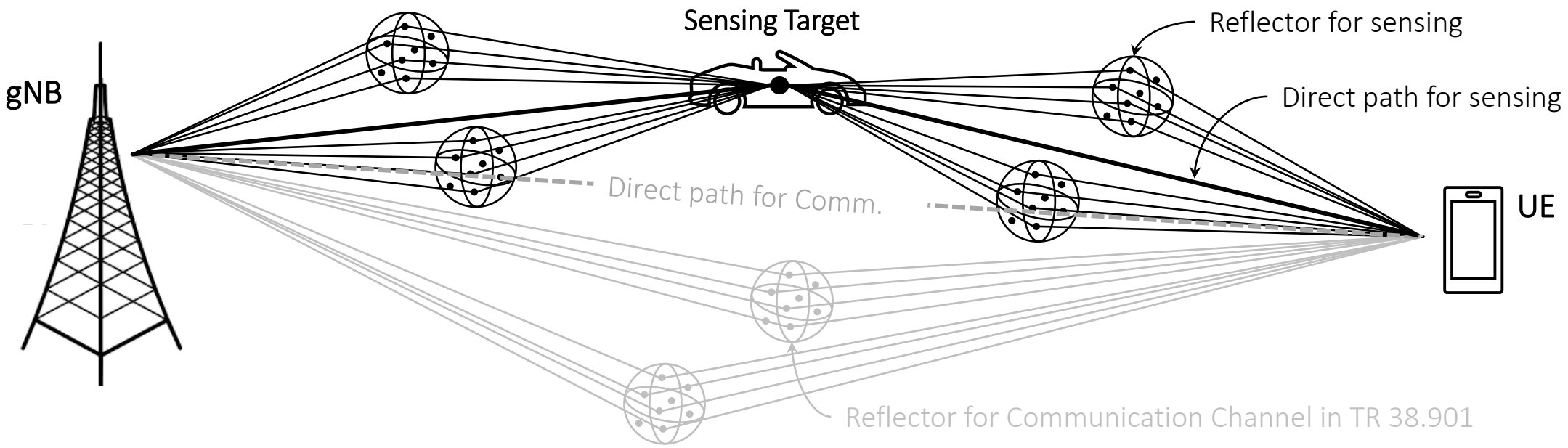
- So far, there are 32 use cases studied in SA1 (TR 22.837). Among them, the intruder detection in SA1 is a typical use case, realized by bi-static and/or mono-static sensing mode.

Highway/railway intruder detection	Yard intruder detection
■ Highway  ■ Railway 	■ Yard 
■ BS monostatic mode ➢ Use case 5.2 / 5.7: Highway / Railway intruder detection ■ KPIs (based on use case 5.2 / 5.7): ➢ Confidence level (95% / 95%), ➢ Accuracy of positioning in Horizontal (≤1m / ≤1.5m), ➢ Missed detection (5% / 2%), and False alarm (5% / 2%).	■ BS-UE bistatic mode ➢ Use case 5.6: Yard intruder detection ■ KPIs (based on use case 5.6): ➢ Confidence level (95%), ➢ Accuracy of pos. in Horizontal (≤2m), ➢ Missed detection / False alarm (0.1% / 5%).

- **Proposal: Study sensing use cases and corresponding KPIs in Rel-19 (SA1 as a baseline).**

Channel Model: gNB-UE bi-static

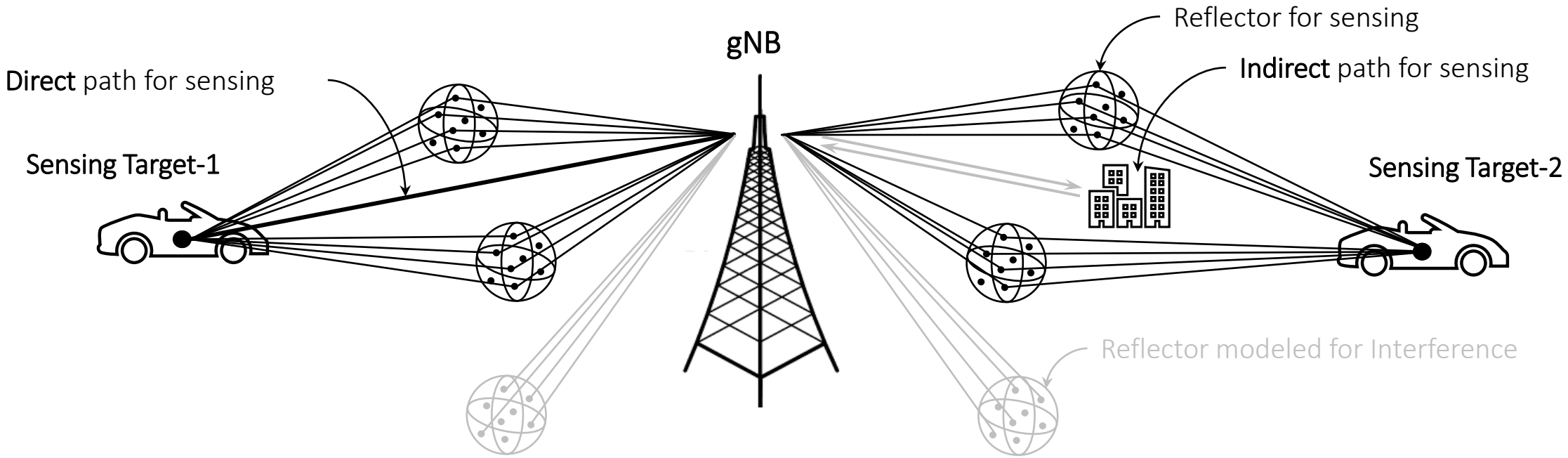
- 3GPP TR 38.901 already supports the communication channel with UE-involved bi-static models but lacks the modeling of sensing target(s).
- The sensing channel can be modeled by additionally introducing the sensing target cluster(s), and its general framework can follow-up TR38.901.



- **Conclusion**: The channel model for gNB-to-UE or UE-to-gNB bi-static based on TR 38.901 requires the moderate workload and its study can be completed within Rel-19 work plan.
- **Proposal: Design channel model(s) for gNB-to-UE and/or UE-to-gNB sensing modes in Rel-19.**

Channel Model: gNB mono-static

- The key step to generate the channel for gNB mono-static mode is to determine the propagation environment, e.g., LOS or NLOS (with/without a direct path for sensing channel).

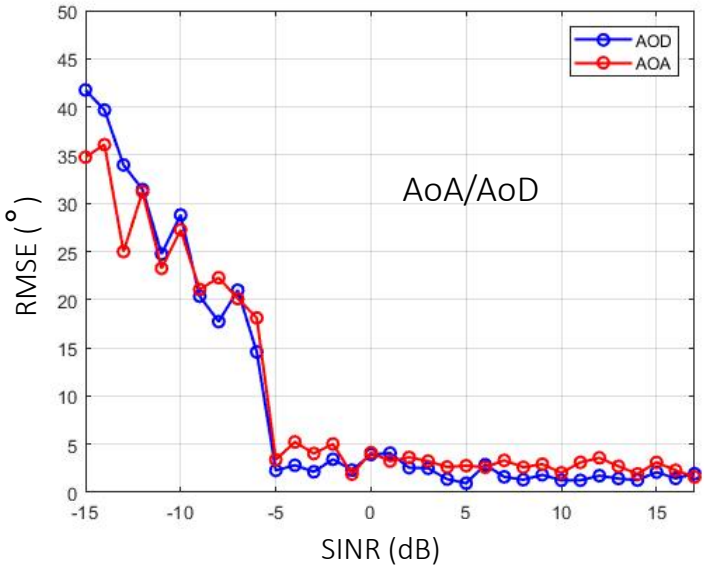


- **Conclusion**: TR 38.901 currently does not support a channel model for self-transmitting and self-receiving mode for gNB/UE, thus a new channel modeling framework and method are required.
- **Proposal: Design channel model for gNB mono-static sensing modes in Rel-19.**

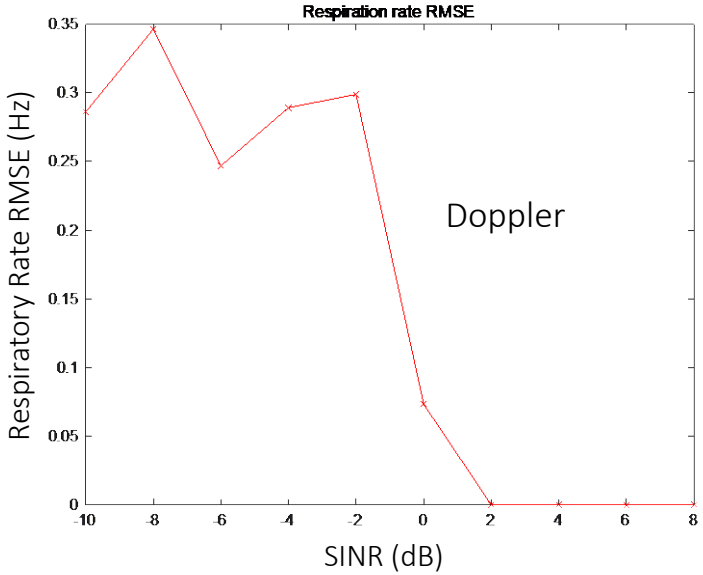
Performance Evaluations

- The specification impact study on ISAC is based on the current NR architecture (Uu/Self-transmission link), targeting minimum specification changes.
- Sensing signal: Based on our initial studies in [RP-230378], the legacy CSI-RS, SRS and PRS can be flexibly configured for estimation of range, AoA/AoD, and Doppler frequency.

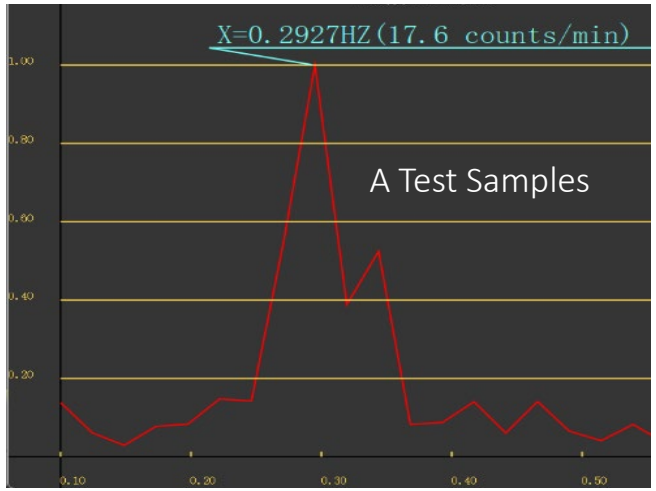
A) CSI-RS-based Simulation



B-1) CSI-RS-based Simulation



B-2) CSI-RS-based Experiment



Respiratory Rate

- **Observation**: Legacy CSI-RS is capable of offering enough accuracy in sensing.
- **Proposal: Evaluate the performance of at least gNB-to-UE or UE-to-gNB bi-static sensing using the legacy signals, such as CSI-RS, SRS, and PRS, as a start point.**

Specification Impact

- Sensing signal design and measurements in RAN1
  - Reuse legacy RS (CSI-RS, SRS, PRS, etc.), or newly design sensing signal
  - Delay (positioning), Doppler (velocity), AoA and AoD as major sensing parameters

- **Proposal: Study the sensing signal and measurements in RAN1.**

- Network-controlled sensing management in RAN3
  - Identification and authorization
- Sensing procedure in RAN2

- **Proposal: Study the higher layer impacts of NR sensing.**

Scope of NR sensing study in Rel-19

- Use cases, KPIs, and sensing modes:
  - Identify use cases of interests and the corresponding target KPIs for representative use cases [RAN1].
  - Identify target sensing modes for the study with potential prioritization as [RAN1].
    - gNB-to-UE bi-static sensing, UE-to-gNB bi-static sensing, gNB mono-static sensing.

- Evaluation:
  - Study on ISAC channel models based on TR 38.901 [RAN1].
    - The studies should consider the identified use cases and the interested sensing modes.
  - Evaluate performance of different solutions against the identified KPIs for the representative use cases [RAN1].

- Specification impact:
  - Identify potential specification impact for the representative use cases and sensing modes [RAN1].
    - Consider aspects relative to the potential specification of sensing signal and measurement, e.g., whether to reuse legacy RS (CSI-RS, SRS, PRS, etc.) or design new sensing signal, and/or measurement quantities, and accuracies.
  - Study higher layer impacts of NR sensing, e.g. identification, authorization, sensing procedures [RAN2/RAN3]

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THANK YOU.
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