

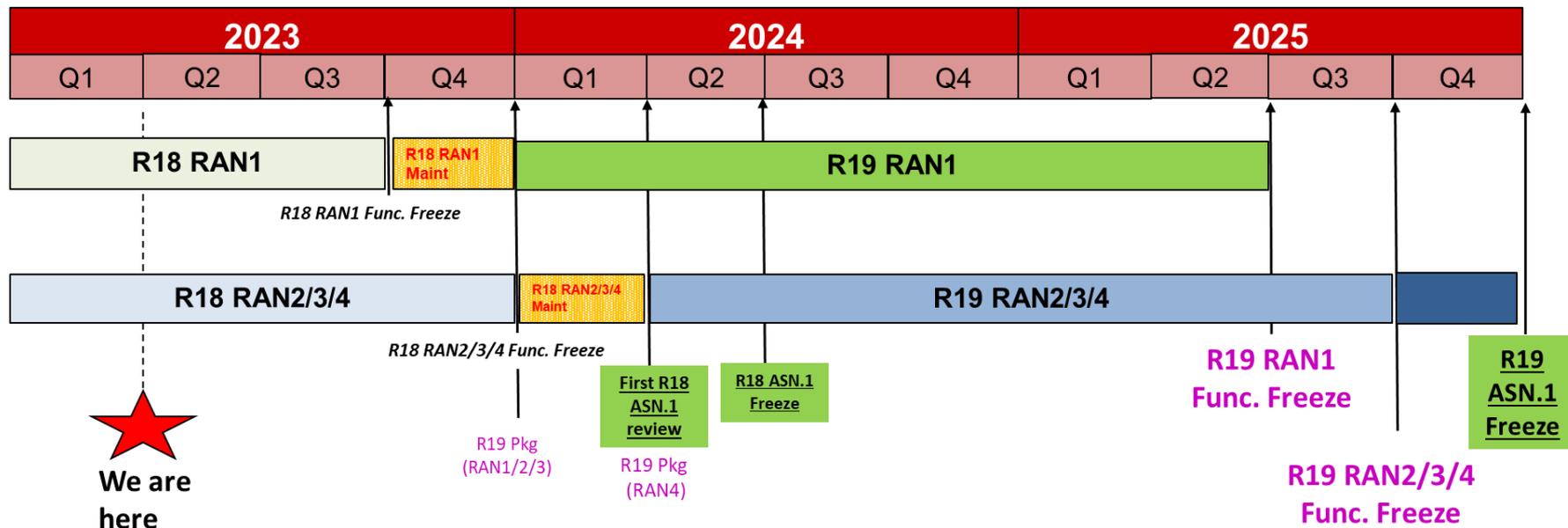
3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023
Agenda Item: 4
RWS-230234



Views on NR Rel-19

China Telecom
June 2023

Rel-19 timeline agreed in RAN#99



■ RAN1-led

- » Further NR coverage enhancements
 - **Left issues of Rel-18, DMRS bundling enh., Msg.5**
- » Multi-carrier enhancements
 - **multi-cell scheduling DCI, complementary UL-DL across cells, single cell**
- » Enhancements on network energy saving
 - **Remaining techniques in Rel-18 SI**
- » MIMO enhancement
- » AI/ML for air interface (follow-up WI)
- » Lower power WUS (follow-up WI)
- » Evolution of NR duplex operation (follow-up WI)
- » Sidelink enhancement
- » NCR enhancement
- » Positioning
- » Ambient IoT
- » Study of reconfigurable intelligent surface
- » ...

■ RAN2-led

- » AI/ML for NR air interface (new use case SI)
 - **Mobility enhancement**
- » Power saving in sidelink relay
 - **RRC_inactive, path activation/deactivation, relay reselection/connection**
- » Further enhancements on mobility
- » Further enhancements on NTN
- » Further enhancements on Multi-SIM
- » Further enhancements on XR
- » ...

■ RAN3-led

- » ISAC for NG-RAN
 - **gNB based sensing**
- » SON/MDT/QoE enhancements
- » AI/ML for NG-RAN
- » ...

- In Rel-17, following features are specified for NR coverage enhancements
 - » **PUSCH enhancements:** maximum number of repetition up to 32, available slot counting, TBoMS, DMRS bundling, inter-slot frequency hopping with DMRS bundling
 - » **PUCCH enhancements:** dynamic repetition indication, DMRS bundling, inter-slot frequency hopping with DMRS bundling
 - » Type A PUSCH repetitions for **Msg3**

- In Rel-18, following features are being studied/specified for NR coverage enhancements
 - » **PRACH enhancement:** multiple PRACH transmissions w/ same beam (Specified) and different beams (Studied)
 - » **Power domain enhancement:** Enhancements to realize increasing UE power high limit for CA and DC (Studied), MPR/PAR reduction (Studied)
 - » Dynamic switching between DFT-S-OFDM and CP-OFDM (Specified)

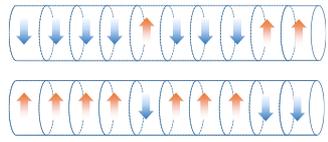
■ Motivation

- » DMRS bundling is beneficial to improve PUSCH coverage performance. However, in Rel-17, modulation order is restricted to not higher than QPSK for DMRS bundling, and only single TB is supported. The theoretical supported data rate w/ QPSK is **0.8Mbps w/ 4 repetitions, 0.4Mbps w/ 8 repetitions** for TDD DDDSU DDSUU. In Rel-17 CovEnh study, 1Mbps is the UL target data rate for urban scenario, while the target data rate is even higher than 1Mbps in practical network e.g. 2Mbps.
- » For **multiple PRACH transmission**, during the discussion in Rel-18, it can be observed that multiple PRACH transmissions with different beams will facilitate the coverage in some cases, e.g., for the case when beam correspondence is not supported. In addition, beam indication for subsequent UL transmission can be realized based on multiple PRACH transmissions with different beam, e.g., beam indication for Msg.3 transmission.
- » For **power domain enhancements**, during the discussion in Rel-18, high power transmission in CA/DC and MPR/PAR reduction are both proved to facilitate the coverage, especially for non-transparent FDSS, simulation results have shown that over 1dB gain can be obtained in some cases. However, there will be remaining issues due to limited TU in Rel-18.
- » Based on the filed test, **Msg5 PUSCH becomes the coverage bottleneck** during the initial access. The main reason lies in: Msg5 has a very large payload size, e.g. >100 Byte; repetition is not supported for Msg5 PUSCH. The situation would get worse when Msg3 repetition is implemented cause more UEs would access to the network while congested during Msg5 transmission.

■ Proposals

- » Support the following features for DMRS bundling
 - DMRS bundling for different TBs
 - High modulation order for DMRS bundling
- » Support Msg5 PUSCH repetition.
- » Further PRACH enhancement
 - Support multiple PRACH w/ different beam.
 - Enhancement on Msg3 of PUSCH w/ beam indication.
- » Further power domain enhancements

■ Motivation

- » In Rel-18 MC-Enh, the multi-cell scheduling with a single DCI objective focused on the same SCS among co-scheduled cells. However, the deployment of multi-carrier operation can have different SCS for the aggregated cells. Extending the single DCI scheduling for multiple PUSCH/PDSCH on cells with different SCS makes the **control overhead reduction** benefit applied for **more deployment scenarios**. Moreover, one aggregated TB scheduled on different cells by a single DCI can have **overhead reduction** and higher **channel coding gain**. For Rel-18 single DCI scheduling multi-cells, with the maximum DCI size limitation, up to 4 cells can be scheduled by one DCI. If the DCI payload can be split into two stages with the size of each stage not larger than the maximum size limitation, **more cells can be scheduled by the DCI**.
- » Rel-18 NR duplex enhancement at least study SBFDD operation within a single TDD carrier. There was little discussion on SBFDD operation across cells in the current Rel-18 SI, which is equivalent to different TDD UL-DL configurations across cells. **Configuring complementary UL-DL direction across different cells** makes the TDD carrier have “0” waiting time latency like FDD for both UL and DL.
- » For flexible and efficient usage of discrete spectrums, aggregating multiple carriers in one cell can have benefits from throughput improvement and power saving: **instantaneously switched spectrum utilization** of different carriers without Scell (de-)activation procedure; **no reducing of the aggregated wide BW and reduced handover** during mobility since no Scell releasing/adding procedure performed.

■ Proposals

- » Enhancement for multi-cell PUSCH/PDSCH scheduling with a single DCI
 - **Different SCS** among co-scheduled cells
 - **One aggregated TB** mapped on co-scheduled cells
 - Multi-cell PUSCH/PDSCH scheduling DCI **containing 2 stages**
- » Enhancement for the support of complementary UL-DL configurations across cells
 - The carriers for cells having complementary UL-DL configurations are inter-band/intra-band
 - **Flexible cross cell resource utilization** (e.g. cross cell hopping, cross cell HARQ retransmission, enhancement for flexible cross cell scheduling), Interference management (intra-band), collision handling (same UL-DL direction within a symbol for a UE in intra-band case)
- » Multi-carrier single cell operation with non-contiguous bandwidth of one or multiple bands mapped to single cell
 - Enhancement of idle/inactive state (initial access, mobility mechanism) and connected state operation (fast carrier switching with multiple UL/DL BWP operation) for multi-carrier mapped to the single cell
 - **More than two UL carriers associated with one DL carrier of a cell**, and **multiple UL and DL carriers mapped to single cell** can be considered

■ Motivation

- » Saving the network energy consumption is essential for reducing the OPEX in NR and the coming 6G for operators and will help achieving green and low-carbon development, which should always be concerned in the network design.
- » Many techniques for NES have been studied in Rel-18 RAN1 SI, but only a few were adopted in WI due to the limited time, the specification of the remaining techniques can be a starting point. According to the simulation results drafted in TR 38.864:
 - Adaptation of SSB/SIB1 and on-demand SSB/SIB1 can bring 30%-40% ES gain.
 - Adapting transmission/reception of other common channels/signals, can bring up to nearly 20% ES gain.
 - Adaptation of TRPs in mTRP can bring about 30%-40% ES gain.

■ Proposals

- » Specify the procedure for reducing the transmission of common channels/signals
 - The **on-demand SSB/SIB1** mechanism requested by UE.
 - The **adaptation of common channels/signals**
 - ✓ Simplification and adaptation of the SSB/SIB1 transmission.
- » Specify the **adaptation of TRPs** in mTRP scenario.
 - The mechanism UE trigger the TRP dynamically transmitting and receiving channels/signals in mTRP scenario.

■ Background

- » The ongoing Rel-18 SI named “Study on evolution of NR duplex operation” aims to identify and evaluate the potential enhancements to support duplex evolution at gNB side for NR TDD spectrum in the following aspects:
 - Subband non-overlapping full duplex (SBFD) study
 - Feasibility, performances, and impact to legacy operation
 - Inter-gNB and inter-UE CLI handling schemes specific for SBFD
 - Impact and potential enhancements for UL/DL transmissions to support SBFD
 - Discussion focused on SBFD operation within a TDD carrier, UL symbol as 2nd priority
 - Potential enhancements on dynamic/flexible TDD
 - Inter-gNB and inter-UE CLI handling schemes specific for dynamic/flexible TDD or common for SBFD and dynamic/flexible TDD, and their feasibility, performances, and impact to legacy operation
- » Work item needs to be carried out in Rel-19 for the standardization work based on the Rel-18 study outcome.

■ WI Scope

- » Specify SBFD operation within a TDD carrier
 - Indication for SBFD time and frequency location
 - Enhancement for UL/DL transmissions to support SBFD for SBFD-aware UEs
 - Inter-gNB and inter-UE CLI handling schemes
- » Specify enhancements for dynamic/flexible TDD
 - Inter-gNB and Inter-UE CLI handling schemes
 - gNB-to-gNB CLI measurement/reporting, L1/L2 based UE-to-UE CLI measurement/reporting
 - Spatial domain enhancements, e.g. beam information exchange, beam nulling
 - Coordinated scheduling
 - Power control enhancement
 - UE and gNB transmission and reception timing aspects

■ Motivation

- » Reconfigurable intelligent surface (RIS) has been studied in both academia and industry in recent years as a hot topic. Different from network-controlled repeater (NCR), RIS mainly consist of passive or nearly passive electronic units with adjustable phase and/or amplitude. Moreover, RIS may work in a reflection/refraction mode, which can directly reflect/refract the impinging signals in a beamforming manner. RIS intends to provides a low-cost, low-power consumption coverage extension & energy efficient solutions both for indoor and outdoor.

■ Proposals

- » Study RIS from the following aspects:
 - Deployment scenarios
 - E.g., O2I, I2I, O2O etc.
 - System model
 - RIS type (e.g., reflection, active/passive); RIS architecture, related component (forwarding, control); Modeling of RIS element (materials and related parameters, e.g., reflection factor)
 - For UE-transparent/UE-non-transparent RIS, study shared control mechanism with NCR (signaling, control information, beam management), RIS-specific control mechanism, if any.
 - RIS capability (MIMO, beam switching, supported beams)
 - Full duplex operation

■ Market requires early deployment of ambient IoT

- » RAN1-led ambient IoT SI+WI in Rel-19

■ SI scope

» Deployment scenario

- Scenario: Prioritize the scenario with the presence of the base station, i.e., deployment scenario 1,2,4 in TR 38.848
- Spectrum: Target the licensed FDD and licensed TDD band
- Topologies: Prioritize the topologies with the presence of the base station, i.e., topology 1,2,3 in TR 38.848

» Identify the evaluation methodology for the identified scenarios.

- Including the common design targets and specific design targets based on device types
- Existing evaluation methodology can be starting point, if possible, e.g., link budget for coverage evaluation, power consumption modelling for LP-WUS.

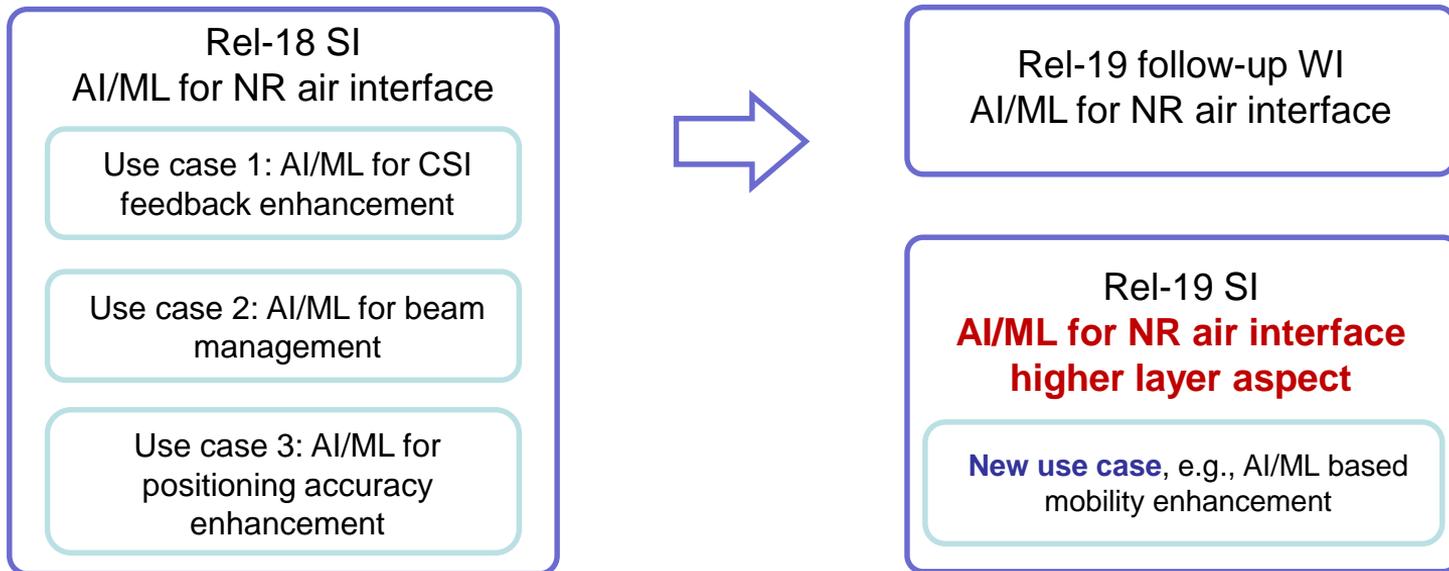
» Study and evaluate the signal for ambient IoT

- Carrier waveform generation
- Signal structure

» Study the physical procedure and higher layer protocol to support ambient IoT

- Different device types should be considered, including complexity and energy storage capability
- Potential solutions for coverage enhancements and power consumption reduction.

■ General consideration



- » AI/ML for NR air-interface study item in Rel-18 focuses on the study of three typical **physical layer use cases**. Many AI/ML enabled use cases have been drawn a lot of interests in recent research and also were raised by many companies in former Rel-18 workshop.
- » Based on the current working progress, more use cases, e.g., **higher layer use cases**, should be initiated discussion to forward the AI/ML research for pre-6G research.

Use case: AI/ML based mobility enhancement

■ Background

- » In Rel-18, the NR_AIML_Air SI would introduce the model life cycle management to enable the use cases at the air interface. Temporal beam prediction is studying and mainly focuses on **intra-cell beam prediction**, which is also helpful for improving mobility performance due to the UE trajectory prediction.
- » In Rel-18, the NR_AIML_NGRAN-Core WI specifies the AI/ML based mobility optimization. The model inference functionality resides **within the RAN node only supporting cell-level mobility prediction**. Some location-related information of UE (e.g., coordinates) will be helpful as the input of AI/ML model to improve performance, which may introduce UE privacy concerns.

■ Motivation

- » AI/ML based mobility management can be further studied and enhanced reusing the framework of NR air-interface.
- » Mobility is mainly about user movement behavior and network coverage. AI/ML is expected to be used to **construct radio channel map/fingerprint** or **process UE trajectory prediction** and make better HO decisions or parameters configuration.
- » The Model Inference functionality can reside on the UE side. Local model inference at UE side may utilize more detailed location information without privacy concerns and can reduce signaling overhead of input exchange.
- » Besides, some **specific scenarios** can also be studied such as for high-speed mobility, high-speed train or V2X scenario mobility enhancement, heterogeneous deployment, and UE group mobility enhancement.

■ Scope

- » Study AI/ML based **mobility enhancement** scenarios and sub use cases:
 - RRM measurement (e.g., RSRP, SINR) prediction, target Cell prediction, unintended events prediction
 - UE sided model [network sided model and two sided model]
 - Centralized or federated learning based model training
- » For the selected sub-use case for **evaluation**, evaluate performance benefits of AI/ML based algorithms.
- » Assess potential **specification impact**, specifically for the selected sub use cases.

■ Motivation

- » U2N relay and multi-path relay were introduced in Rel-17 and Rel-18 to help network operator extend coverage as well as enhance reliability and throughput. Sidelink relay can be considered as a promising approach to improve network performance and reduce CAPEX in 5G-A.
- » Sidelink relay is also believed to improve power efficiency for remote UE. However, from relay UE's perspective, sidelink relay will obviously increase the power consumption of relay UE, which may reduce the **willingness of UE as a relay node**. If there are not sufficient relay UEs in the network, the gain of sidelink relay might be influenced.
- » In order to promote the **commercial and industrial development** of sidelink relay technology, it is necessary to study and enhance UE power saving techniques in sidelink relay scenarios, including specific power saving techniques for remote UE and/or relay UE.

■ Potential Scope

- » Potential solutions to allow **relay UE in RRC_INACTIVE** to perform unicast data transmission for remote UE to save power for both relay UE and remote UE
- » **Dynamic path activation/deactivation or path dormancy mechanism** based on service requirements to reduce unnecessary power consumption of relay UE in multi-path scenarios
- » Potential solutions to reduce **relay reselection or connection re-establishment** for remote UE, such as CHO-like solution or pre-configuration of candidate relays

■ Motivation

- » L1/L2 triggered mobility(LTM) was introduced to reduce handover latency in Rel-18, which is only limited to intra-CU scenarios. It is meaningful to support LTM also for inter-CU scenarios.
- » Besides, in Rel-16, only CHO for Xn interface is supported, support CHO over NG interface can improve mobility robustness.
- » Moreover, although DAPS is introduced in R16 to achieve 0ms user plane interruption during handover procedures, the configuration of DAPS is quite limited. Many fundamental features, such as CA, DC, SUL, CHO etc., shall be released or disabled during DAPS handover, which may influence not only the mobility performance but also user experience.

■ Potential scope

- » Support L1/L2 triggered mobility(LTM) for inter-CU cases to further reduce latency of inter-gNB HO
- » Support CHO over NG interface to enhance robustness of NG-based handover
- » Optimize DAPS configuration to enable the coexistence with fundamental features, such as (at least DL) CA, DC, CHO etc.

- Non-Terrestrial Network introduced spec impacts from SI to WI in Rel-17 with basic functions to adapt to the specific characteristic of satellites, such as long propagation and high Doppler shift. Further enhancement in Rel-18 NTN is to improve NTN capability from the aspect of coverage, mobility and security. However, there are still some enhancements needed to achieve better performance for capacity, spectrum efficiency and latency in NTN.
- Basic architecture of Rel-19 NTN:
 - » GSO and NGSO (LEO and MEO) with regeneration payload.
 - » Earth fixed & Quasi-Earth fixed & Earth moving cells
 - » FDD/TDD mode
 - » FR1/FR2
- The potential objectives of Rel-19 work item include:
 - » Support for Dual-Connectivity of satellites
 - Address different delay and/or network topology between the different access points/satellite nodes
 - Handling different time and frequency compensation
 - Master node versus secondary node selection.
 - » Support regenerative payload with ISL
 - » Support spectrum re-use/sharing between TN and NTN

■ Motivation

- » Per UE gap patterns that was defined in Rel-17 will cause service interruption and throughput loss in USIM A even if the UE supports multiple Tx/Rx transceivers, CCs, CGs and MIMO layers for both Rel-17 and Rel-18 MUSIM UEs
- » Besides, two USIMs in one MUSIM UE connect to the same network(or even same cell) from one operator are quiet common scenarios, duplicate handover and measurement report procedure will bring unnecessary signaling interaction.

■ Potential scope

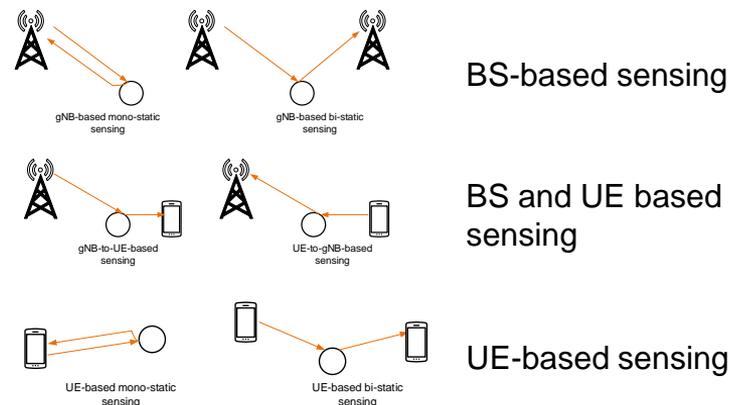
- » Support finer granularity gap per TxRx transceivers /CCs/CGs/MIMO layers for both Rel-17 and Rel-18 MUSIM UEs.
- » Support Further RAN4 requirements based on the finer granularity gap
- » Support several performance enhancements, e.g. combined TAU, handover, measurement relaxation and optimized paging method for intra-operator MUSIM UEs

- With the use of higher frequency bands (from mm-Wave to THz), wider bandwidth, and denser distribution of massive arrays in 5G and future 6G systems, the network has the possibility to enable the ISAC (Integrated Sensing and Communication) in a system and make them mutually enhance each other.
 - **Sensing exploration:** With sensing ability, the 5G system can serve as a sensor and explore the radio wave transmission, reflection, and scattering in order to better understand the physical world and provide more information to assist vertical industry.
 - **Communication enhancement:** The capabilities of high-accuracy localization, imaging, and environment reconstruction obtained from sensing could help network improve the communication performance such as more accurate beamforming, faster beam failure recovery, and less overhead to track the channel state information (CSI).

Typical use cases for ISAC



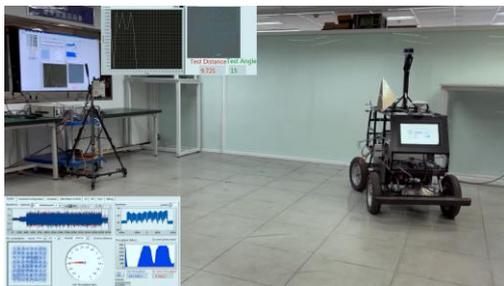
Typical sensing mode



Advantages of **BS-based sensing**

- Relatively easy to be implemented compared with BS and UE based ISAC;
- Sensing function applied for both legacy UEs and new UEs;
- Easy for operator deployment, only need to update RAN and CN;

Performance of BS-based sensing in lab test



Resolution of ranging	Ranging accuracy	Resolution of angle	Accuracy of angle	Throughput
0.488 m	$\pm 0.4\text{m}$ (long distance) $\pm 0.1\text{m}$ (short distance)	5°	$\pm 5^\circ$	2.86Gbps

Scope:

- Identify **use cases** that BS-based ISAC could well applies for, with selecting suited sensing modes;
- Study standardization impacts on the sensing service **interfaces and procedures** towards sensing establishment, control and data reporting; The **message design** for data reporting should be common and **easy extension for future extension** to support more sensing modes and algorithms;
- Study standardization impacts on the **interference handling** between sensing signals and between sensing and communication signals;
- Study standardization impacts on the support for Multi-gNB **collaborative sensing** functions;
- Study standardization impacts on the support for sensing service continuity in mobility scenario, if any;
- Study the necessity to introduce local sensing function within NG-RAN node from e.g. latency point.

The studies should be focused on the existing NG-RAN architecture and interfaces to enable sensing functions, reducing the impact on 5G current system as much as possible.

Thanks!
