FRAUNHOFER VIEW ON RELEASE 17

3GPP RAN Plenary #84 Release 17 Workshop, June 4th 2019, Newport Beach (CA), USA

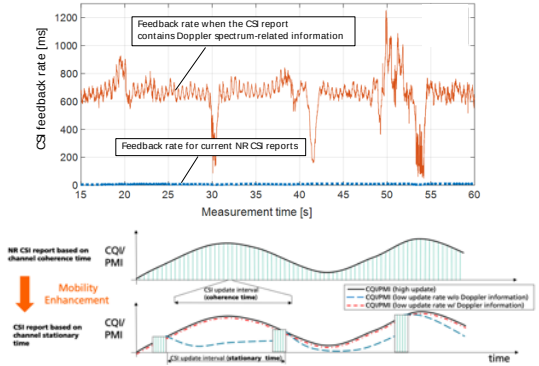
We advocate 5G enhancements to make Rel-17 become a basis for new markets:

5G for Verticals

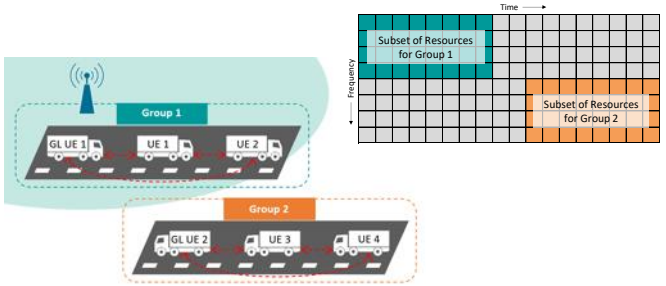
Industry 4.0, automotive, PPDR, satellites, drones, ...

NR Mobility Enhancements

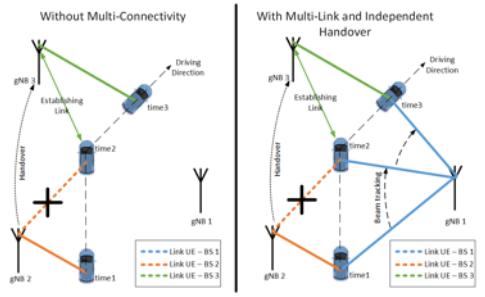
- CSI Enhancements for mobility at FR1 & FR2 — details in RP-191340
  - **Justification:** Current NR system experiences **30%** performance loss at **30 km/h** (FR1) and at **3-5 km/h** (FR2). **Objective**: Increased performance, reduced CSI update rate, lower feedback overhead, longer UE battery life
  - **Relevant for FR1**: High-speed train, Highway, V2X **& FR2:** Industrial, V2X
  - **Scope:** Include Doppler spectrum-related information in the CSI report



- Sidelink Groupcast Enhancements for V2X
  - **Justification:** Efficient group communication for in- and out-of-coverage **Objective**: Enhance information flow for group management, increase reliability and reduce feedback overhead
  - **Relevant for:** V2X use cases like platooning and extended sensor sharing
  - **Scope:** Enhance SL procedures for enhanced groupcast resource utilization



- Multi-TRP for Enhanced Mobility — details in RP-191341
  - **Justification:** FR2 links suffer from blockage in mobility scenarios **Objective**: increased link reliability, faster handover
  - **Relevant for:** FR1: Moving hotspots, drone communication, FR2: blockage mitigation, multi-link anchoring in network
  - **Scope:** Extend Multi-TRP Concept for Mobility and Reliability



Enhancements for NR-U, IoT and URLLC

- IoT Enhancements

  details in RP-191342

  - Support small data transmission in preconfigured, shared uplink-resources
  - Latency improvements for narrow band IoT applications
  - Coverage extension via relaying (dedicated or dual-use UE)
- URLLC Enhancements
  - For improved capacity, consider multiple UEs sharing the same configured grant (CG) resources
  - DMRS based detection and decoding performance to be studied to ensure reliability
- NR-U Extensions
  - Larger Bandwidth > 100 MHz for millimeter wave band e.g. 37 GHz and 60GHz
  - LBT enhancements, e.g. beam based access and directional LBT
  - URLLC support for IIoT/factory automation in unlicensed bands , e.g. faster channel access and assistance feedback, HARQ enhancements
  - NB-IoT services in the sub-GHz unlicensed frequency spectrum for larger coverage
  - Narrowband operation together with NR-U eMBB coexistence for IoT services

NR – Extensions

RAN Extensions

- NR NTN
  - RAN Extensions for direct access over satellites
  - Link coordination mechanisms between terrestrial RAN and NTN
  - Start work item in RAN1-RAN4

- eIAB
  - Objective: mobilty support, lower latency and higher spectral efficiency
  - Relevant for: moving hotspots, group communication in V2X, …
  - Scope: radio link failure and multi-connectivity, full duplex, QoS, in-band and out-band operation for FR1 and FR2

Features and Technologies

- Full Duplex Radio (FDR) details in RP-191343
  - Relevant for: eIAB, flexible Duplexing on TDD and FDD, distributed RRUs with CRAN
  - Develop schemes for mixed operation with non-FDR capable UEs

- NR Positioning
  - Network based positioning support down to cm-level
  - Enhanced positioning RS to be included in NR framework

Fraunhofer Focus for Rel-17

NR Enhancements for Vertical Applications

NR Mobility Enhancements:

- CSI Enhancements for Mobility at FR1 & FR2
- Sidelink Groupcast Enhancements for V2X
- Multi-TRP for Enhanced Mobility

NR – Extensions:

- NR NTN
- eIAB
- Positioning
- FDR

Enhancements for NR-U, IoT and URLLC:

- Extension aspects of IoT
- NR-U extension for larger BW and URLLC
- URLLC Enhancements

More details to be found in annex

QUESTIONS?

CSI Enhancements for mobility at FR1 & FR2 (1/3)

Justification

- Increasing demand for seamless connectivity and very high data rate in UE mobility scenarios (at FR1: High-speed train, High-Way, Automotive and at FR2: Industrial <10km/h, Automotive)
- In current NR systems, performance drops down when the UE already moves at medium speeds compared to non-moving UE performance
  - Up to **30%** performance loss at **30 km/h** UE speed (FR1) and at **3-5 km/h** UE speed (FR2)

- In UE mobility scenarios, the following is observed:
  - CSI (CQI and/or PMI) feedback rate depends on fast fading channel variations
  - A large performance loss when CSI measurement and update rate is too small
  - Very high CSI (CQI) update rate required to handle fast fading channel variations (even for low UE speeds at FR2)
  - Increased use of DL and UL resources due to frequent CSI measurements and reporting
  - Increased UE battery consumption

CSI enhancements for UE mobility are required

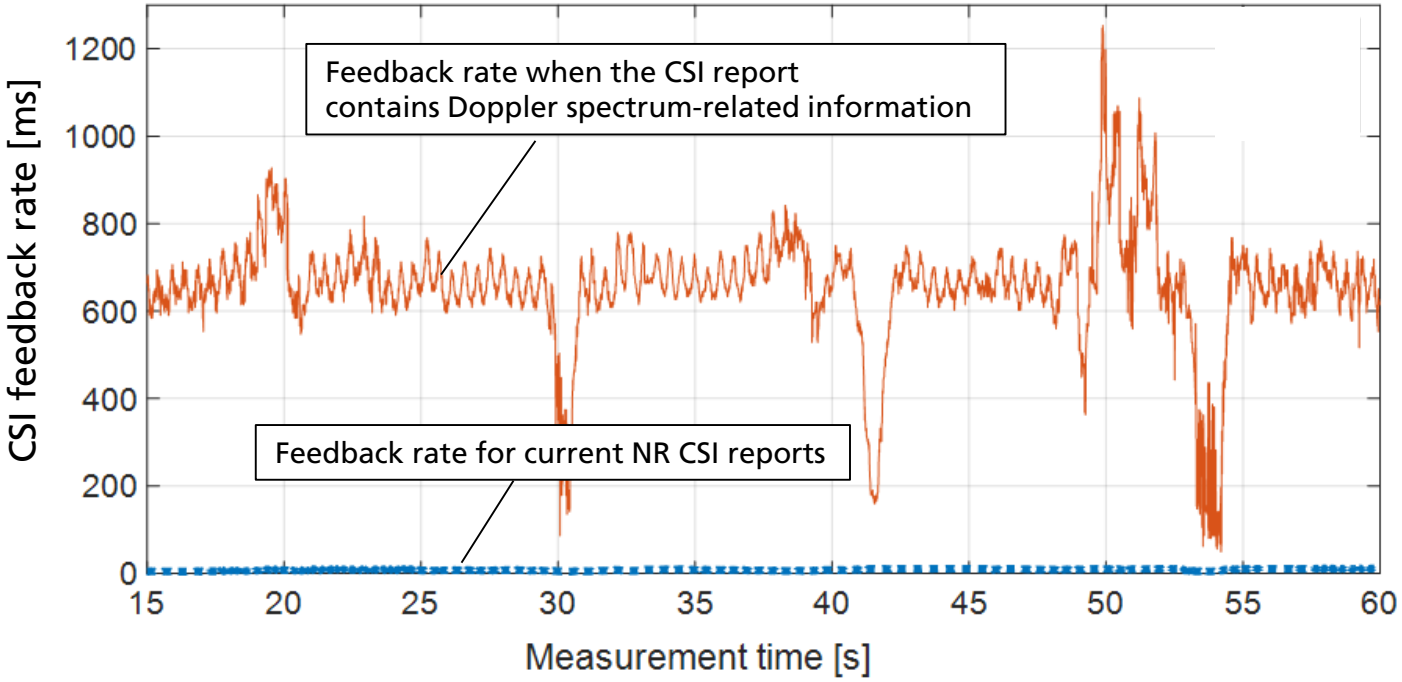
further details in RP-191340

CSI Enhancements for mobility at FR1 & FR2 (2/3)

Objective

- Decouple CSI feedback rate from fast fading channel variations by including a Doppler spectrum-related information in the CSI report

V2X highway measurements at 2.53 GHz and 20 MHz system bandwidth



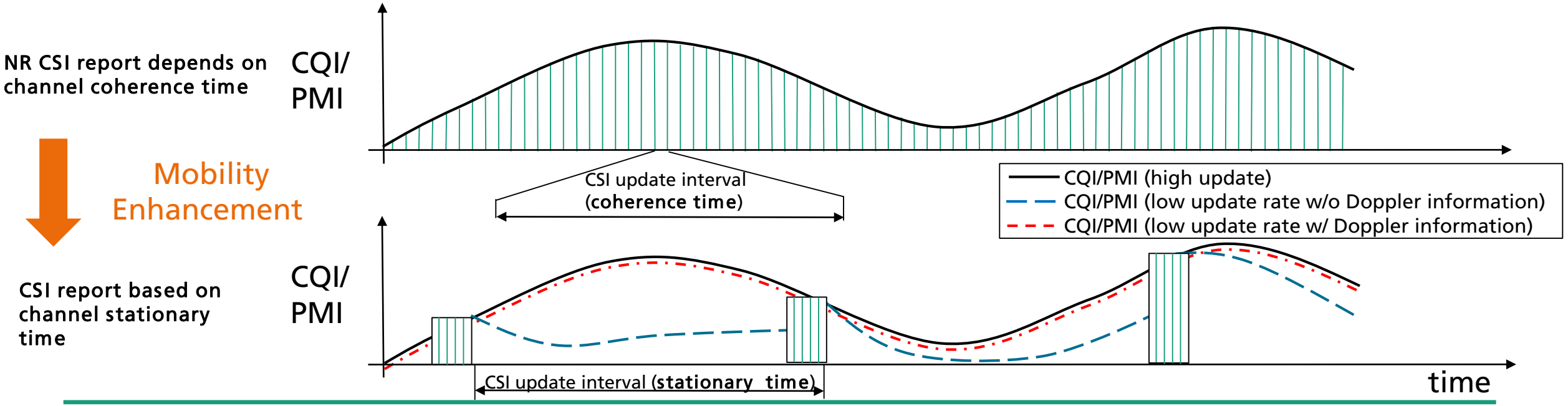
- CSI update rate can drastically be reduced by factor 50-100
- Significant overhead reduction
- Less UE complexity and UE battery consumption (Green Tech)
- Increased performance

- **Proposal:** Study in Rel. 17 CSI enhancements for UE mobility scenarios at FR1 and FR2.

CSI Enhancements for mobility at FR1 & FR2 (3/3)

Justification & Scope

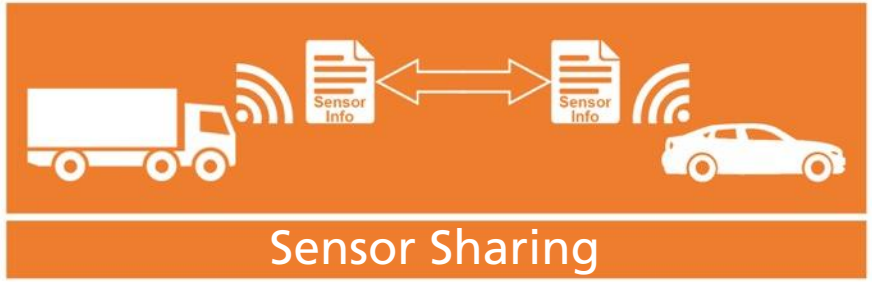
- Current NR CSI report contains only information of the current channel state. With mobility the fast fading channel variations increase and channel coherence time is drastically reduced:
  - A very high CSI (CQI and/or PMI) update rate is required at FR2, or in high-mobility scenarios at FR1
- CSI reporting should be based on stationarity time (stationarity time >> coherence time)
- Significant feedback overhead reduction and better performance is expected



V2X Enhancements (1/2)

Motivation and Objective

- Motivation
  - Advanced V2X use cases demand tight integration between vehicles
    - Platoons require operations in close proximity in a coordinated manner
    - Accurate positioning, e.g. to facilitate merging and departure of vehicles in a given lane
    - Collection of information regarding road hazards and events based on sharing of sensor data within group members

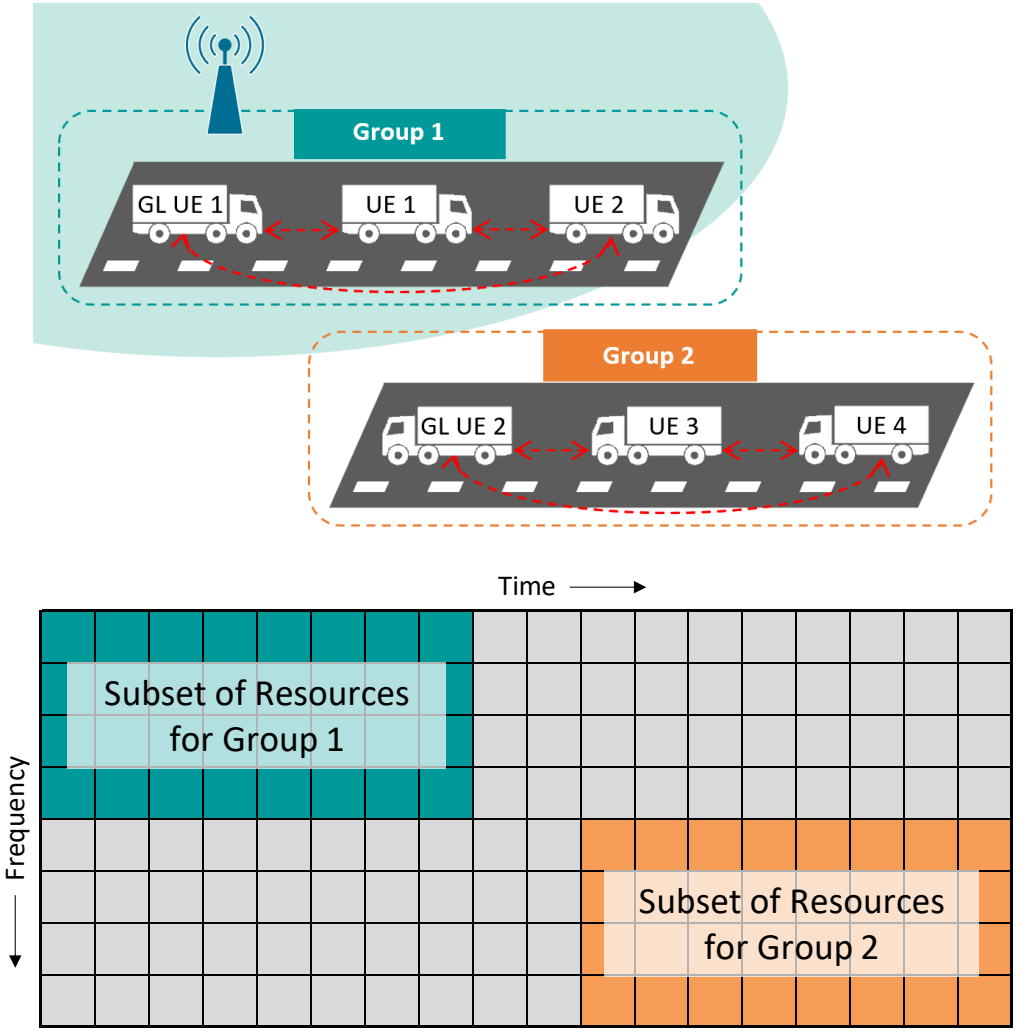


- Objectives
  - Enable efficient information flow and group management
  - Implement sidelink relative positioning to achieve high accuracy (cm-level) and relaying to enhance the coverage

V2X Enhancements (2/2)

Scope of SID

- Physical layer SL procedures for enhanced groupcast resource utilization in Mode 1 and Mode 2
  - Coordinated resource allocation of dedicated resources by a single entity within group
  - Support of group resource management and advanced sensing concepts
- New positioning techniques on the sidelink to improve the positioning accuracy
- Coverage enhancements by relaying over sidelink
- Enhanced handover techniques and predictive QoS by means of AI / ML
- Enhance throughput and reliability by supporting multiple carriers
- Support multicast on the Uu interface



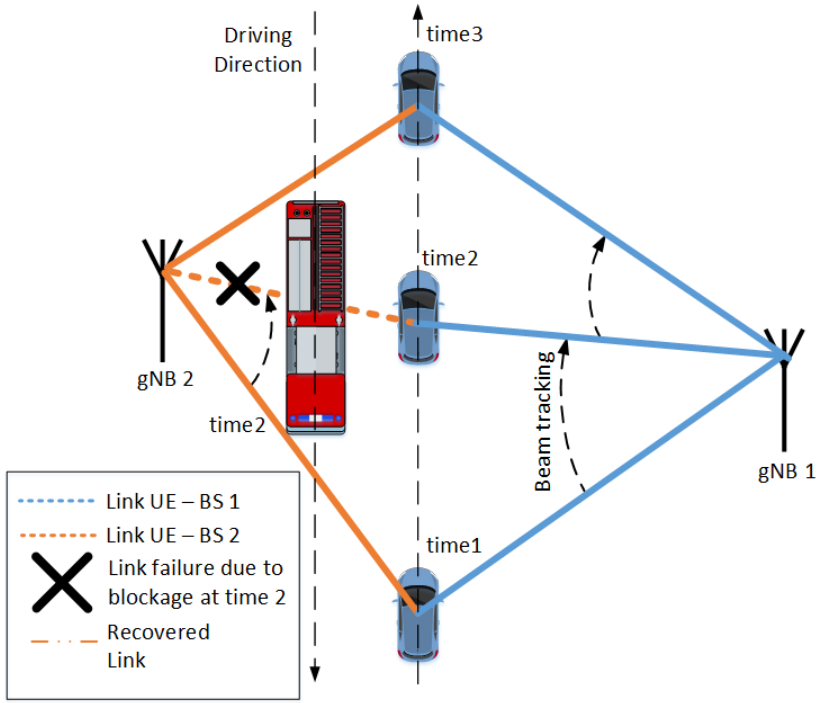
Multi-TRP for Enhanced Mobility Support (1/2)

- Scenarios: V2X, IIoT and Aerials in FR2 and beyond
- Objective: Ensure reliable communication for these scenarios
- Scope:
  - Study multi-TRP concepts with joint physical layer enhancements to increase the mobility support of NR, e.g. multi-TRP beam coordination
  - Study different antenna geometries/sectorizations
  - Study spatial diversity and resilience against blockage due to simultaneous multi-TRP connectivity
  - Study independent/sequential handovers to guarantee continuous connectivity
  - UE-driven link aggregation/selection, e.g. handling multiple PCells and SCells at the same time
  - Other concepts are not precluded

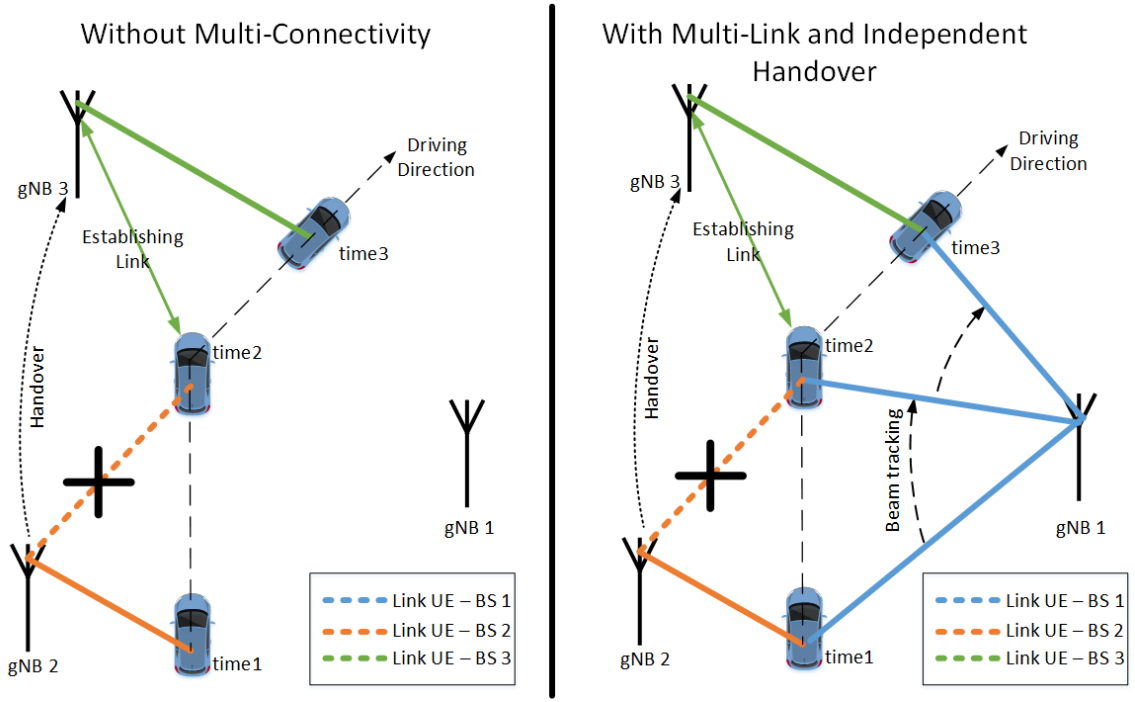
further details in RP-191341

Multi-TRP for Enhanced Mobility Support (2/2)

Based on R1-1900737



Link blockage due to sudden appearance of obstacle.



Left hand side: Handover situation in mobility scenario without multi-connectivity, for mission critical data transmission. **Right hand side:** Handover situation in mobility scenario with multi-connectivity and independent handover per link, guaranteeing seamless network connection for mission critical data transmission.

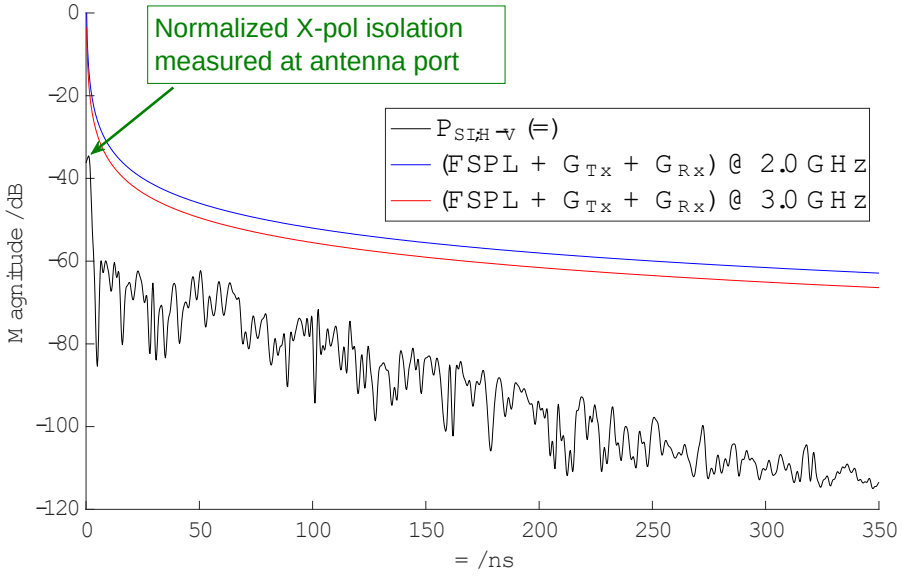
Full Duplex Radio – a Flexible Duplexing Scheme

Motivation & Justification

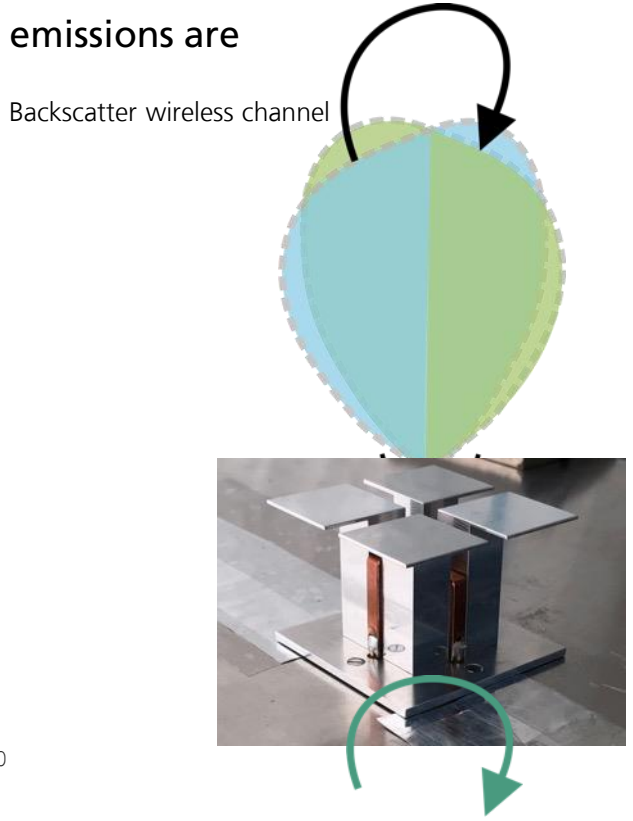
- Low latency bidirectional link enabled by DL and UL data channels coexistence over the same frequency band
- Reuse of the frequency spectrum recourses, and accordingly doubling the aggregated – DL and UL – data throughput
- Efficient spectral utilization while *less spectrum pollution is occurred;* due to the fact that OOB emissions are centered around single unpaired spectral band

Justification: self-interference channel characteristics & viable cancellation technique

- Passive isolation technique can achieve sufficient RF self-interference cancellation isolation
- The residual self-interference signal due to the reflected back energy from the MPC channel can be suppressed by means of digital cancellation techniques.



Averaged PDP of measured self-interference radio channel in indoor office environment.



further details in RP-191343

Full Duplex Radio – a Flexible Duplexing Scheme

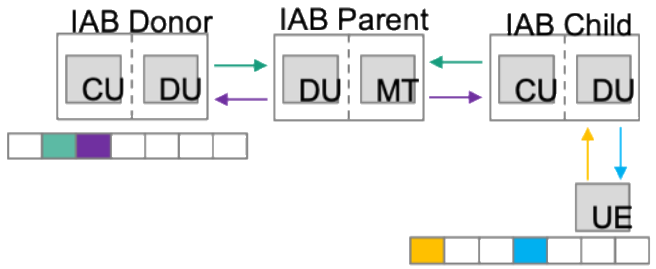
Use Cases and Application Scenarios

Enhanced IAB for Multi-Hop Backhaul Link

Based on the channel caused leakage among the MT and DU in a IAB, the concurrent resources can be allocated: Either concurrent reception or concurrent transmit and receive.

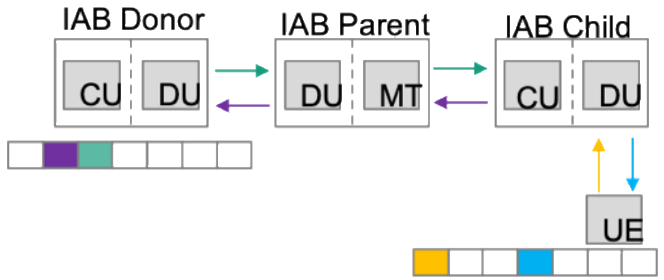
[Option A] In presence of no interference among the DU and MT at the IAB node

- Simultaneous reception of time-slots for DU and MT at IAB node
- Simultaneous transmission of time-slots for DU and MT at IAB node



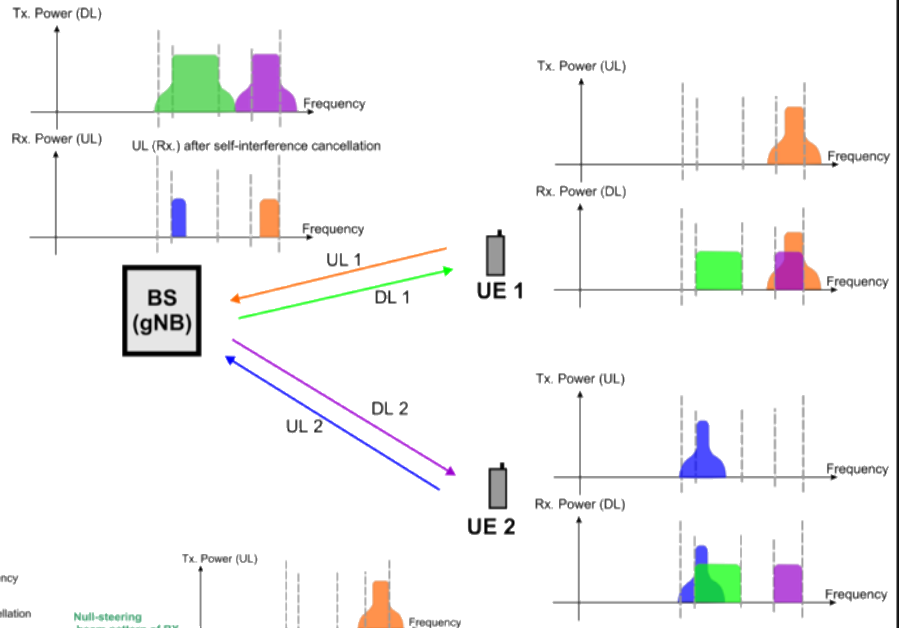
[Option B] In **presence** of interference among the DU and MT at the IAB node

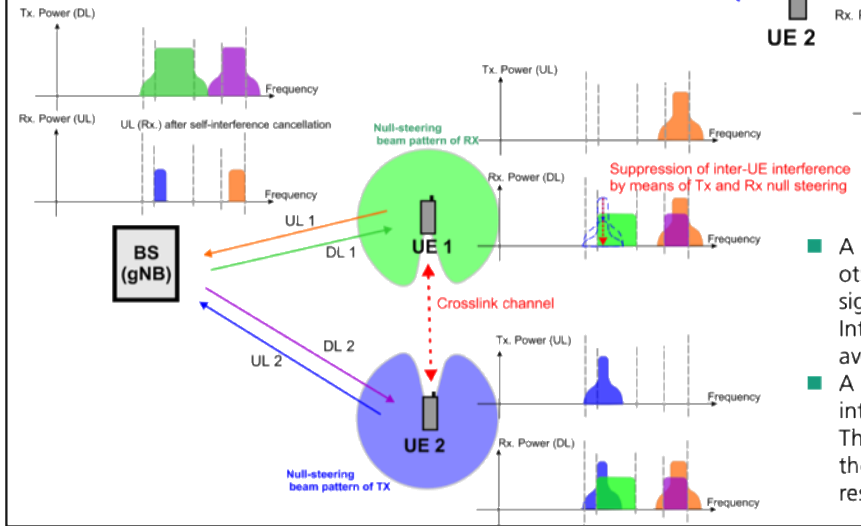
- Self-interference cancellation for the residual self-interference via leak channel
- Simultaneous transmit and receive of time-slots for DU and MT at IAB node



Full-duplex gNB and multi-user FDM uplink (flexible FDD UEs)

- UL and DL share the same band (unpaired spectrum)
- Flexible UL and DL band allocation within the shared band





- A UE subject to interference from other UE might hold a spatial signature that can exploit at the Interfered UE to be avoided/suppressed
- A UE can implement a proactive inter-UE avoidance techniques. These technique can signaled to the UE by the BS to configure with respect to maximum interfered UE

NR IAB Enhancements for Rel-17 (1/2)

Motivation and Objectives

Motivation

- NR IAB Rel-16 focused on the specification of fixed IAB node. A diverse range of scenarios may be supported by a mobile IAB to improve the QoS for users on moving platforms, as well as to augment V2X & services in proximity.
- NR IAB Rel-16 is the first release of WID, hence only the aspects specified within the SI are being addressed within Rel-16 timeframe. It is not expected that all potential enhancements will even be identified within Rel-16.

Objectives

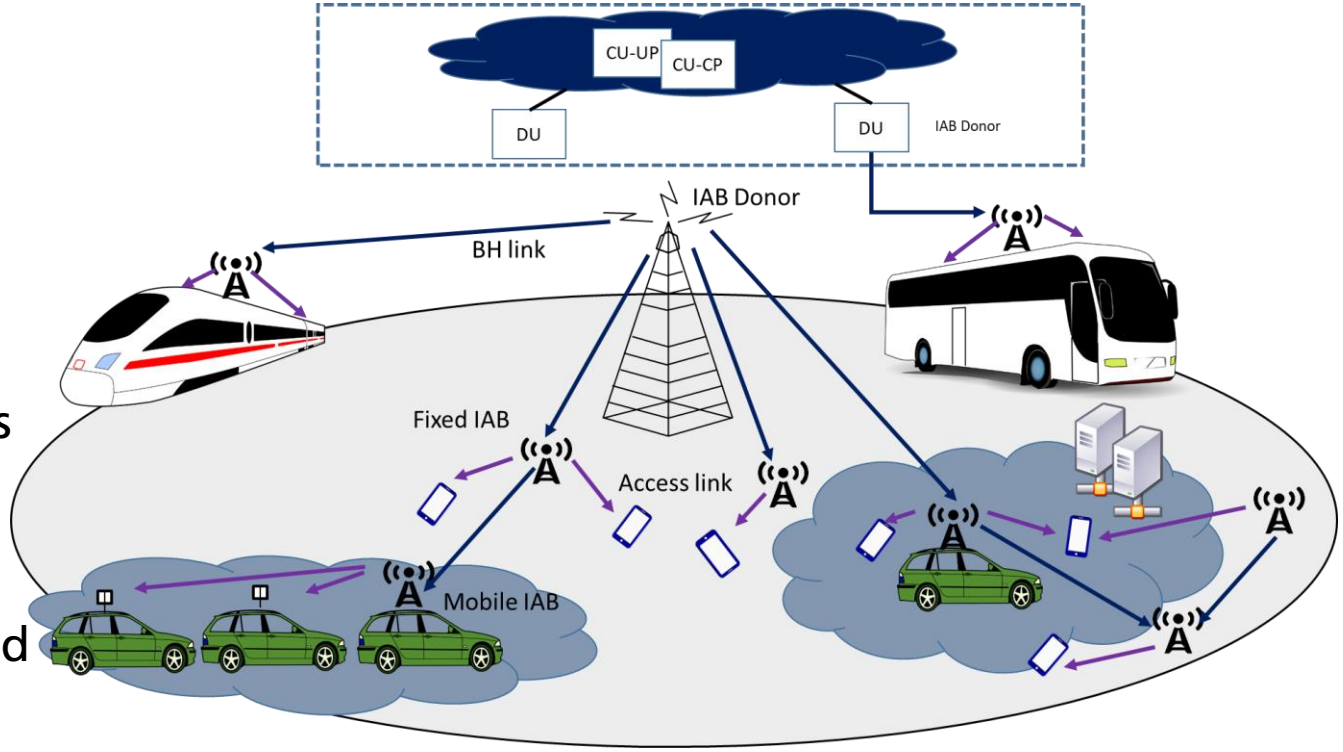
- Identify scenario(s) & requirements to for mobile IAB, focusing on the delta between mobile & fixed IAB
- Enhance the work from Rel-16 focusing on the following items:
  - Identify and specify necessary enhancements on Radio Link Failure
  - Identify and specify necessary enhancements on Multi-connectivity

NR IAB Enhancements for Rel-17 (2/2)

Application Scenarios and Spectrum

Scenarios

- Cellular services to a mobile group of UEs on trains, in cars and busses
- Augmenting V2X services through a group leader concept, supporting broadcast & multicast services
- Augmenting capacity & coverage through a creation of ad-hoc backhaul links & hot-spots



Spectrum Usage

- Sub-6GHz and FR2 (cm/mmWave) in-band and out-of-band operation
- Enhanced spectrum usage using Full Duplexing

NR-based Access to Unlicensed Spectrum

Motivation

- Utilize large bandwidths in FR2 ranges, e.g. , 60 GHz
  - Data offloading from licensed to large bandwidths in unlicensed spectrum
- Industrial-IoT/factory automation applications in unlicensed spectrum
  - Expanding URLLC services over licensed and unlicensed bands
- IoT services in the sub-GHz unlicensed frequency spectrum
  - Large coverage areas

NR-based Access to Unlicensed Spectrum
Objectives

- NR-U supporting 37 GHz and 60 GHz band
  - Wideband operation enhancements
  - LBT enhancements, e.g., beam-based access and directional-LBT
- NR-U enhancements to reduce latency and to enhance reliability for URLLC services
  - Channel access enhancements, e.g., fast channel access and assistance feedback
  - HARQ enhancements
- Enhancements for IoT services in unlicensed spectrum
  - UE power saving enhancements and coverage expansion
  - Narrowband operation together with NR-U eMBB coexistence

Enhancements for IoT (1/2)

Objective and Basic Concept of Segmentation

Objective: Support transmission of small data packets in preconfigured, shared uplink-resources

- Enable massive number of users with small message sizes and strict energy constrains w/o dedicated previous request/grant
- Analyse the use of bit sequence segmentation mapped to T/F UL resources with access pattern
- Increase system capacity compared to EDT (which is limited to RACH)

- Coverage Extension via Relaying (dedicated or dual-use UE)

Concept Basics: Access patterns

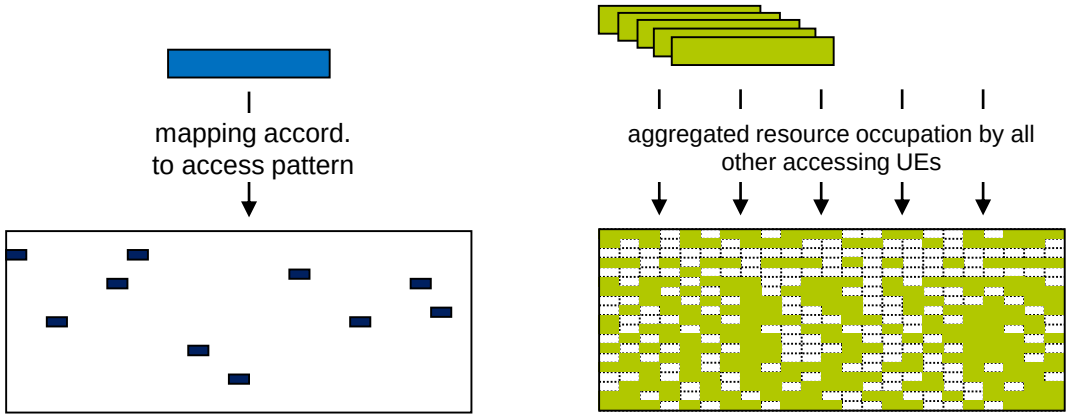
- An access pattern precisely defines how sub-packets are mapped to physical (T/F) resources
- A set of access patterns is assigned to UEs (or groups of UEs) once

- UEs picks an access pattern from above set arbitrarily or following a certain rule
  - eNodeB is not aware which access pattern is used by a specific UE
  - eNodeB is not aware which access patterns are actually in use („on air“); Pattern detection required at eNodeB
- Different access patterns may use (partly) the same physical resources
  - access patterns are not necessarily „orthogonal“ to each other (contention based access!)
  - sub-packet collisions (losses) may occur, yet message is recovered due to FEC
- Smart design of set(s) of access patterns is crucial for achievable capacity / performance

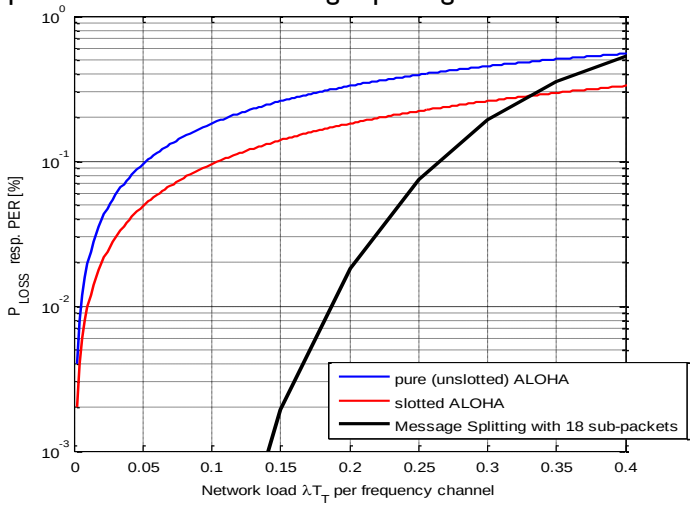
Enhancements for IoT (2/2)

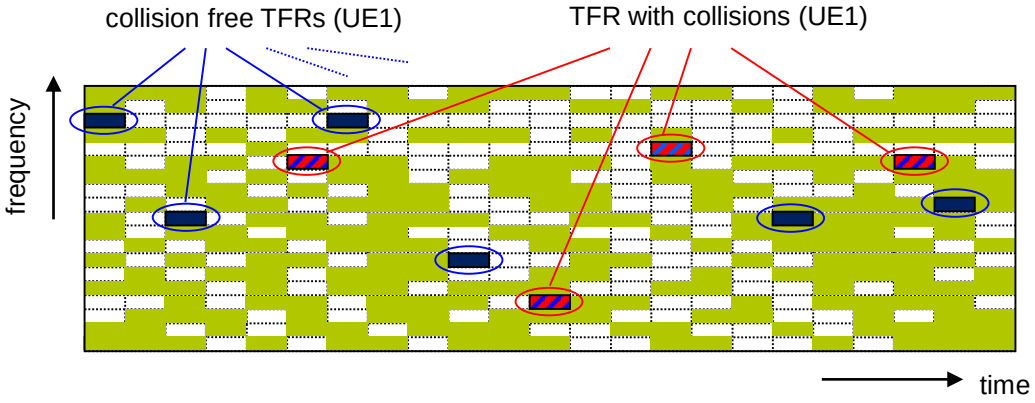
High Load: Example for T/F Resource Collisions due to Multiple Access

- With increasing load an increasing number of T/F resources (TFR) have collisions with TFR from other UEs
  - Smart design of access patterns allows for minimum possible number of collisions
  - Collisions (on TFR level) tolerated due to FEC redundancy



packet error rate of message splitting versus slotted ALOHA





(T_T is the time duration of the unsplitted message; λ is the arrival rate of the unsplitted message per second)

Worldwide Direct Access via 5G Satellite

- Motivation
  - The ongoing space race accelerates innovations in the space segment, which leads to new business opportunities utilizing a direct access via satellites
  - Increasing interest in non-terrestrial networks (NTN) related studies within 3GPP
  - Successfully closed study and work items:
    - SA1: FS_5GSAT and 5GSAT (service requirements)
    - RAN/RAN1: FS_NR_nonterr_nw (channel model, identification of technical issues)
  - Ongoing studies:
    - SA2: FS_5GSAT_ARCH (identification of key issues)
    - SA5: FS_5GSAT_MO (management and orchestration)
    - RAN3/RAN2/RAN1: FS_NR_NTN_solutions (key issues and solutions)

Worldwide Direct Access via 5G Satellite

- Objective
  - Implement solutions for non-terrestrial networks in 5G specifications based on the findings of current study items
- Scope
  - RAN1: physical layer control procedures (e.g. power control, CSI feedback, Doppler compensation), timing advance and PRACH, HARQ deactivation/enhancements
  - RAN2: mobility handling, paging, tracking areas, cell selection/reselection, RACH, feeder link switch, handover, HARQ, etc.
  - RAN3: tracking area management, registration update, paging, mobility architecture, transport aspects, network identity handling, user location, feeder link switch, operations and maintenance
  - RAN4: performance evaluation, RRM requirements, define satellite frequency bands

Rel 17- Positioning WID

- Justification:
  - Additional work in Release 17 is necessary to finalize Release 16 objectives since some of the work is not expected to completed in Release 16.
  - Diverse positioning applications have been identified by SA1 in TS 22.261 (Service requirements for the 5G system). Accordingly, TS 22.104 recognizes positioning as essential to enable that tracking of mobile devices/assets for Factories of the Future. Further analysis and potential enhancements are needed to support the identified positioning requirements which includes availability and latency in addition to accuracy.
- Objectives:
  - Continue the work from Rel-16 focusing on the following items:
    - Identify and specify necessary enhancements on NR-PRS measurement
    - Identify and specify any necessary related enhancements to sounding reference signals
    - Identify and specify necessary enhancements on UL and DL transmit beam operation and the necessary feedback mechanisms for multi-TRP positioning operation

Rel 17- Positioning WID

- Address technologies and enhancements to support the positioning applications for industrial scenarios :
  - Define a representative scenario and analyze achievable performance based on Rel-16 channel models for indoor industrial scenarios
  - Extend analysis to include reliability, battery lifetime and latency requirements
  - Specify network architecture and interfaces to support one or more of the following:
    - Possible approaches for coordinated scheduling, interference coordination, flexible UL and DL resource allocation
    - Identify additional impacts to specifications that are relevant to the following:
      - Physical Layer procedures
      - Protocols (LPP, NRPPa ,…)
      - UE capabilities
      - UE and gNB requirements
- Support IoT use cases for low power devices and narrow BW UEs (< 5MHz)
- Study further enhancement through :
  - Sidelink-ranging aided positioning
  - Study potential enhancements by supporting positioning transmission and/or reception points
  - Positioning of UEs within the same geographical area for better performance and reduced signaling overhead

URLLC Enhancements

- Motivation:
  - Resources are partially under-utilized when using Configured Grants (CG)
  - For improved spectral efficiency, consider multiple users sharing the same resource

- Scope:
  - CG enhancements for this case need to study:
    - Study whether DMRS based detector performance is sufficient, and if necessary, consider enhancements
    - Study mechanisms to reduce / avoid / randomize collisions
    - Study performance of Interference Rejection Combining Receivers to improve the capacity