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NR V2X Summary Report (RAN1-AH_1901)

[NR Sidelink V2X]

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Keywords

3GPP, 5G, NR, NR V2X, NR Sidelink, Sidelink Unicast, Sidelink Groupcast, Sidelink Broadcast, Uu-based Sidelink

Highlights from RAN plenary

There are a lot of study items that need to be completed by March 2019. It was clearly stated that offline discussions are only for structuring the online session and not necessarily for reaching agreements. Decisions are always made online. Delegates who missed (parts of) the offline sessions have the opportunity to comment on offline session outcome in the online session. The offline sessions should be no more than 4 hours. The feature leads objective is to better structure the discussions. The study items that need to be completed are listed below:

1. Power Saving
2. eURLLC
3. NR V2X

RAN1 target completion date should be 3 months ahead of RAN2 and RAN4 core requirements. RAN1 CRs and required RRC parameters shall be formally approved at the RAN1 freezing milestone (Dec/2019 for Rel-16). It is proposed to plan the Release-17 package approval for December 2019 (RAN#86).

Incoming LSs

R1-1900002 LS on NR V2X agreements RAN2, Huawei
Nothing to report on this LS since the information was already was handled.

R1-1900003 LS on Intra-UE Prioritization/Multiplexing RAN2, Nokia
This is related to FS_NR_IIOT and there will be offline discussions to handle it.

R1-1900004 LS on RAN2 agreed TPs RAN2, Huawei
R1-1900005 Reply LS on redundant transmission for URLLC RAN2, Huawei
R1-1900006 Reply LS on TSN requirements evaluation RAN3, Nokia

R1-1900007 LS on NR ATF to include per branch relative phase UE measurement RAN4, Keysight Technologies
This is a LS on MIMO_OTA_test measurements that is related to UE measurements. The approved test method in [1] for Rel-15 NR UE demodulation requirements at FR2 uses a subset of the Radiated Two Stage over-the-air (OTA) test method. The RTS method is enabled by measurement made by the UE which are generally referred to as the Antenna test Function (ATF). The Rel-15 UE FR2 demodulation requirements are defined for a non-spatial line-of-sight test signal. To calibrate a wireless connection to the UE, a new per branch synchronization signal RSRP (SS-RSRPB) was defined in subclause 4.2.

This definition of a per branch amplitude measurement is a subset of the full RTS ATF, which also includes the relative phase per branch. In Rel-15, since the only use for the ATF was line of sight testing without need for UE antenna pattern measurement, only the SS-RSRPB was required. However, in Rel-16 it is planned to include requirements that include spatial channel models like what was done with SCME for LTE. For the harmonized RTS method which is referenced in the new specificatopm, it will be necessary to extend the ATF definition for NR to include the equivalent of the Reference Signals Antenna Relative Phase (RSARP) measurement defined for LTE in [6].

R1-1900008 Reply LS on wideband carrier operation for NR-U RAN4, Ericsson
R1-1900009 LS to RAN1 on TP to TR 38.889 from RAN4 RAN4, Ericsson
R1-1900010 Reply LS on NR V2X RF parameters for RAN1 physical layer design aspects RAN4, LG Electronics

Nothing to report on this LS since it should handle the RF parameters that are for evaluation.

R1-1900011 Reply LS on LS to SA WG2 on unicast, groupcast and broadcast in NR sidelink SA2, Qualcomm

Nothing has been agreed on the number of bits for Destination IDs. It was stated that it may be around 24 bits that would be suitable for handling the number of bits. We should wait for response from RAN2 and we don't need to do anything related to this LS.

R1-1900012 Combinations of Uu QoS characteristics values for V2X services SA2, Huawei

SA2 provided us with information of two need QoS characteristic values that are needed for V2X services. HW will provided a response LS to SA2.

R1-1900013 LS on RAN Impact analysis due to TSN SA2, Nokia

This is also related to FS_NR_IIOT and a response LS is needed. The questions are mostly related to RAN2 and maybe we should wait until RAN2 have the opportunity to reply. Need to further discuss offline since not all companies are in agreement that a response LS should come from RAN1 or if we should just wait for RAN2 to response.

R1-1900014 LS on MTSI Client Profiles SA4, Intel

Nothing for RAN1; this is noted.

R1-1900157 LS to 3GPP RAN1 on NR-U Interpretations for EN 301 893 ETSI TC BRAN

Nothing to do, as this is noted.

R1-1900869 Discussion SA2 LS on RAN Impact analysis due to TSN Qualcomm Incorporated

R1-1900923 Discussion of ETSI TC BRAN LS on NR-U Qualcomm Incorporated

It is proposed to ban the use of no LBT short control signalling transmission, and instead, introduce a short LBT mechanism to initiate a COT that use 1% of time (instead of 5% in the current version of regulation for short control signalling transmission). Currently LTE-LAA or NR-U do not directly use this mechanism for any transmissions. The Cat 2 LBT mechanism introduced for some transmissions, including DRS, is designed within the requirement of ETSI short control signalling transmission. In some sense, we can understand the DRS transmission as following a "stronger" requirement than the short control signalling transmission. For LTE-LAA, which is now deployed, the DRS transmission exceeds 1% of time, as the design was targeting the 5% requirement. For NR-U, though the design is not yet finalized, the agreement from the study item phase as captured in NR-U Technical Report [2] is "When the DRS duty cycle ≤1/20, and the total duration is up to 1 ms, 25 μs Cat 2 LBT is used (as in LAA)". Therefore, we have concerns regarding tightening the regulation from 5% to 1%.

R1-1901020 Discussion on SA2 LS on RAN Impact analysis due to TSN Nokia, Nokia SB
R1-1901021 [DRAFT] Reply LS on RAN Impact analysis due to TSN Nokia, Nokia SB
R1-1901103 Reply LS on TSN requirements evaluation SA1, Qualcomm
R1-1901260 Draft response to LS on Combinations of Uu QoS characteristics values for V2X services Huawei, HiSilicon
R1-1901261 Evaluation results on Combinations of Uu QoS characteristics values for V2X services Huawei, HiSilicon

R1-1901321 LS from IEEE 802.11 WP on NR-U, IEEE 802.11 WP

LAA was not based on 1%and thinks tightening the regulation from 5% to 1% may be of concern to some companies. There needs to be some understanding between WiFi and 3GPP for coordination to see how we

can response to ETSI BRAIN and IEEE. However, we need to take into consideration these views and the impact on the 3GPP specifications.

1. NR V2X Overall Summary

1.1. Sidelink Design

1.1.1 Physical Layer Structure

Including waveform, RS, control/data mux, resource pool, etc.

R1-1901438 Feature lead summary for agenda item 7.2.4.1.1 Physical layer structure LGE

1.1.1.1 Physical channels

A sidelink physical channel corresponds to a set of resource elements carrying information originating from higher layers. The following sidelink physical channels are defined:

- PSCCH
- PSSCH
- PSBCH

1.1.1.2 Reference signals

- DM-RS: DM-RS defined in Rel-15 NR Uu is the starting point.
  - Multiple DMRS patterns in time domain are supported for PSSCH
    - FFS: Whether a DMRS pattern is selected based on the subcarrier spacing
    - FFS: Single or multiple DMRS pattern(s) per a resource pool
    - FFS: How TX UE and RX UE can be aligned in terms of the DMRS pattern used for PSSCH
    - FFS: RE mapping, sequence generation
  - Continue to study DMRS pattern in frequency domain for PSSCH
    - E.g. Whether multiple patterns are supported, whether PDSCH/PUSCH DMRS configuration 1 or 2 is reused.
- PT-RS for PSSCH for FR2

<u>DMRS design issues</u>

Issue 2-1: DMRS pattern for PSSCH

- Company's proposal: Multiple DMRS pattern in time is supported for PSSCH (9 companies)
  - Rationale:
    - Considering various scenario regarding doppler spread
    - Rel. 15 NR DMRS structure can be reused **Error! Reference source not found.**
- Company's proposal: Fixed DMRS pattern in time is supported for PSSCH (1 company)
  - Rationale:
    - Optimized DMRS pattern can be used to reduce overhead
- Company's proposal: Multiple DMRS pattern in frequency is supported for PSSCH (2 companies)
  - Rationale:
    - UE can adaptively improve resource utilization or performance according to the situation
    - Reduce frequency domain density to increase time domain density when needed without extra overhead
- Company's proposal: Fixed DMRS pattern in frequency is supported for PSSCH (2 companies)
  - Rationale:

- ❖ Optimized DMRS pattern can be used to reduce overhead **Error! Reference source not found.**

Issue 2-2: DMRS pattern for PSCCH

- Company's proposal: Fixed DMRS pattern is supported for PSCCH (6 companies)
  - Rationale:
    - Blind decoding complexity
    - Throughput is rather low and reliability is the most important criterion
- Company's proposal: DMRS structure of NR PDCCH is baseline (4 companies)
  - Rationale:
    - Small specification effort
    - Sufficient detection performance Issue 2-3: Others
- Company's proposal
  - 15kHz SCS should not be considered for ultra high-speed scenarios for NR V2X FR1.
- Company's proposal **Error! Reference source not found.**
  - Consider to support up to 8 antenna ports from system perspective to support reception of multiple interfering transmissions as well as spatial multiplexing
  - Design DMRS patterns to optimally support 64-QAM at least till 120 km/h relative speed and 16-QAM till 240 km/h
  - NR V2X PSCCH sidelink physical structure and DMRS take into account benefits of multiple decoding attempts for PSCCH transmissions collided on the same resource
- Company's proposal
  - At least a DMRS pattern specific for CP-OFDM is supported
  - Better PSCCH demodulation performance can be achieved by removing DMRS symbols in PSCCH and using PSSCH DMRS to demodulate PSCCH.
- Company's proposal
  - Physical layer ID is used for randomization of scrambling code and DMRS generation.
- Company's proposal
  - Common design for PSCCH DMRS and PSSCH DMRS should be further studied
- Company's proposal
  - Discuss the support for orthogonal DM-RS signals for potential colliding UEs.
  - Discuss the solution to mitigate the impact of aperiodic packets on the sidelink channel measurement and UE resource selection. S-RSSI measurement based on DMRS could be considered.

Observation

- Majority companies support multiple DMRS patterns in time-domain for PSSCH.

1.1.1.3 Synchronization signals

The SL primary synchronization signal (S-PSS) and SL secondary synchronization signal (S-SSS) design is based on the following:

- The sequence type for S-PSS is the same type as the M-sequence used for NR-PSS
- The sequence type for S-SSS is the same type as the Gold sequence for NR-SSS

1.1.1.4 S-SSB

- The study of NR V2X synchronization includes synchronization based on S-SSB
- The study also includes use of other sidelink signals/channels (e.g., other RSs in the SL, using PSSCH, using PSCCH, etc.) for the sidelink synchronization

The frequency location for S-SSB is based on:

- The frequency location for S-SSB is (pre-) configured
  - Note: it implies that there is no intended hypothses detection in frequency location of S-SSB performed by the UE for a carrier in a given band
  - Note: the potential frequency locations for the (pre-)configured frequency location may be restricted, up to RAN4

1.1.1.5 Sidelink Numerology

- For PSCCH/PSSCH in FR1, NR V2X supports normal CP for 15kHz, 30kHz, 60kHz, and extended CP for 60kHz.
  - For PSCCH/PSSCH in FR2, NR V2X supports normal CP for 60kHz and 120kHz, and extended CP for 60kHz
- Only one combination of CP length and SCS is used in a carrier at a given time for NR V2X UEs communicating with each other using SL

1.1.1.6 Sidelink Waveform

- CP-OFDM supported
- No consensus in supporting DFT-S-OFD

1.1.1.7 BWP

Issue 3-1: The number of configured SL BWP for RRC connected NR V2X UE (regarding WA)

- Company's proposal: Confirm the working assumption (only one SL BWP is configured in a carrier for a NR V2X UE)
  - Rationale:
    1) UE would miss some message due to SL BWP switching because there is no signalling in SL for SL BWP activation/deactivation
    2) Using resource pool can be an alternative
    3) Dynamic SL BWP switching cause switching latency and make SL BWP operation more complex

Issue 3-2: Relationship between SL and Uu BWP

- Company's proposal: SL BWP and Uu BWP are independently configured.
  - Rationale:
    1) gNB can configure UL BWP and SL BWP to ensure the UL BWP and resource pool(s) or SL BWP are within UE's RF bandwidth
    2) All UEs with potentially different active Uu BWP needs to have the same active SL BWP
- Company's proposal: Further study is necessary in terms of handling switching latency (if exists) between Uu BWP(s) and SL BWP.
- Company's proposal: It could be beneficial to restrict UE RF BW covering Uu BWP(s) and SL BWP, and align numerology of Uu BWP(s) and SL BWP in terms of reducing switching latency among them.

Proposal for agreement:

- Confirm the working assumption
  - Working assumption: only one SL BWP is configured in a carrier for a NR V2X UE
- RAN1 assumes that configuration signalling for SL BWP is separated from Uu BWP configuration signalling.
  - UE is not expected to use different numerology in the configured SL BWP and active UL BWP in the same carrier at a given time.
    - FFS the time scale
    - FFS relation to DL BWP including initial Uu BWP
    - FFS relation in terms of frequency location and bandwidth

1.1.1.8 Resource Pool

Issue 4-1: How resource pool in time-domain is defined

- Company's proposal: Support symbol-level resource pool consisting of contiguous or non-contiguous symbols
  - Rationale:
    - Shared carrier between Uu and NR sidelink [2][15][18]

Issue 4-2: How resource pool in frequency-domain is defined

- Company's proposal: Support resource pool consisting of contiguous RBs
  - Rationale:
    - Simple configuration of resource pool [18]
- Company's proposal: Introduce the concept of sub-channel consisting of contiguous RBs to express resource pool in frequency domain
  - Rationale:
    - Reduced blind decoding complexity for PSCCH [15]
    - Reduced overhead to indicate PSSCH allocation [2]

Issue 4-3: Others

- Company's proposal
  - Both common resource pools (for broadcast) and UE-dedicated resource pools can be configured
- Company's proposal
  - Dedicated resource pools for control and data respectively should be supported for NR sidelink.
- Company's proposal
  - Study the configuration of resource pools based on different defined criteria
- Company's proposal
  - A common sidelink resource pool configuration scheme should be defined for both PSCCH/PSSCH multiplexing option 1b and option 3
  - Multiple resource pools can be configured within a BWP
- Company's proposal
  - Discuss whether logical or physical slot indexing is used in NR V2X sidelink
  - A SL BWP configured in a carrier always occupies whole bandwidth of the carrier
  - Resource pool configuration method of LTE V2X is baseline (time domain by bitmap, frequency domain by contiguous PRBs)
- Company's proposal
  - Although multiple resource pools can be configured to a single UE, the UE choose one TX pool within which it performs resource selection

Proposal for agreement:

- For time domain resources of a PSSCH resource pool,
  - Support the case where a pool consists of non-contiguous time resources
    - FFS details including granularity
- For frequency domain resources of a PSSCH resource pool,
  - Down select following options:
    - Option 1: A resource pool always consists of contiguous PRBs
    - Option 2: A resource pool can consist of non-contiguous PRBs

1.1.1.9 PSCCH/PSSCH multiplexing

Note that Option 3 is already made as working assumption for PSCCH/PSSCH multiplexing.

Issue 5-1: Whether one of options covers the other options

- Company's proposal:
  - Option 3 can be transformed into a structure like option 1 & 2
  - Option 1a is a special case of option 3
  - Discuss further how to realize option 1a based on option 3
  - Time resource allocation based on option 3 can be used to realize option 1b

Issue 5-2: Options to be supported

- Option 1A (Support: / Not support:
  - Pros

- Cross- and multiple-slot scheduling is possible
- Small latency **Error! Reference source not found.**
- Small size of indication for PSSCH allocation in frequency domain

- Cons
  - Scheduling restriction on PSSCH allocation
  - Variable SA frequency resource is challengeable for blind detection
  - Sensing complexity increases [15]

- Option 1B (Support: Mitsubishi / Not support:
  - Pros
    - common design for cross slot scheduling between PSCCH and PSSCH
    - Facilitate short-term sensing
    - Coverage enhancement
    - Simpler or reuse design of front-loaded DMRS in PSSCH
    - No need to same number of layer/rank and MIMO scheme between PSCCH/PSSCH
    - No power sharing issue
  - Cons
    - Transient period between PSCCH and PSSCH is needed
- Option 2 (Support: [18]/ Not support:
  - Pros
    - High coverage and higher reliability of PSCCH
  - Cons
    - Large latency
    - Constraints on PSCCH precoding/antenna virtualization

Issue 5-3: Others

- Company's proposal
  - The duration of PSCCH can be set to all OFDM symbols
  - PSCCH decoding starts from the symbol immediately following the AGC symbol
  - PSCCH decoding starts from the lowest RB index of a subchannel
- Company's proposal
  - The frequency location of PSCCH can be associated with the frequency location of the associated PSSCH.
- Company's proposal
  - Option 3 is limited to rank 1 for both PSCCH and PSSCH. Option 1B supports spatial multiplexing for PSSCH while PSCCH is limited to rank 1 as well.
- Company's proposal
  - For option 3, PSCCH and PSSCH should start on the first symbol assigned for sidelink within a slot.
  - In PSCCH/PSSCH multiplexing option 3, the RB's of PSCCH is contained inside RB's of PSSCH.
    - Case 1: The starting RB indices of the both channels have to be the same.
    - Case 2: The starting RB indices of the both channels can be different.
  - For option 1B, PSCCH should be multiplexed with PSSCH on different symbols within one slot.
  - Confirm the WA: no transient period is in need between symbols containing PSCCH and symbols not containing PSCCH of option 3.

Observation

- Majority companies do not support Option 1A. Next, it seems that majority companies support Option 1B. However, some companies argue that transient period may be necessary between PSCCH and PSSCH. Regarding Option 2, companies have divergent views on the necessity of coverage enhancement at the expense of large latency.

Proposal for agreement:

- For PSCCH/PSSCH multiplexing
  - Option 1A is not supported

- Working assumption: Option 1B is supported
  - RAN1 to discuss whether to confirm this working assumption based on the RAN4 LS on the need of transient period.
- Continue discussion on the need of Option 2

1.1.1.10 PSCCH

Issue 6-1: SCI format

- Company's proposal: multiple SCI formats are carried by PSCCH, also supported by Mitsubishi (9 companies)
  - Rationale:
    1) To enable flexible and efficient sidelink transmission
    2) The large discrepancy in terms of bit size (e.g., to support of transmission with or without feedback)

Issue 6-2: Blind decoding complexity

- Company's proposal: Fixed or (pre-)configured size (time/frequency) and/or location (4 companies)
  - Rationale:
    1) To reduce blind decode complexity
- Company's proposal: Support 2-stage SCI; one for anonymous UE(s), and the other for dedicated UE (5 companies)
  - Rationale:
    1) To support multiple SCI format with different size with acceptable BD complexity
    2) Pre-emptive reservation, announcement of resource pool by group leader, coexistence between in- and out-of-coverage UE
    3) Forward compatibility

Issue 6-3: Which information is conveyed on PSCCH other than SCI for PSSCH reception

- Company's proposal:
  - Information related to reserved resources
  - Resource allocation for transmission of another UE

Issue 6-4: Transmission scheme for PSCCH

- Company's proposal: single-port transmission with transparent TxD scheme (3 companies)
  - Rationale:
    - Consider NR PDCCH as baseline
- Company's proposal: multi-port transmission (1 company)
  - Rationale:
    - Better link budget performance

Proposal for agreement:

- For SCI design, down select following options
  - Option 1: Single SCI format size across different resource pool
    - FFS: Single or multiple SCI format with different set of fields
  - Option 2: Single SCI format size per a resource pool, but SCI format size can be different across resource pools
    - FFS: Single or multiple SCI format with different set of fields
  - Option 3: Multiple SCI format sizes per a resource pool
    - FFS: How to utilize different SCI format size in a resource pool (e.g. 2-step SCI, multiplexing sidelink transmission with different characteristics such as MIMO scheme, HARQ-ACK feedback scheme, etc.)
  - For down-selection, following aspects are investigated:
    - Blind decoding complexity
    - Detection performance of SCI

Proposal for agreement:

- Support at least single-port transmission for PSCCH
  - FFS TxD schemes

1.1.1.11 Feedback channel

Issue 7-1: Multiplexing PSFCH and other SL channel(s)

- Company's proposal: TDM between PSFCH and other SL channels (5 companies)
  - Rationale:
    - To allow a fast feedback
    1) Half duplex operation
- Company's proposal: FDM between PSFCH and other SL channels (4 companies)
  - Rationale:
    - Resource efficiency
    - AGC impact
- Company's proposal: FDM and/or TDM between PSFCH and other SL channels (3 companeis)
  - Rationale:
    - High scheduling flexibility

Issue 7-2: PSFCH format structure

- Company's proposal: Reuse sequence-based HARQ feedback (NR PUCCH format 0/1) (6 companies)
  - Rationale:
    - Sequences are good enough to be orthogonal
    1) Small specification effort
    2) To increase spectral efficiency
    3) Reduced overhead and complexity

Issue 7-3: SFCI format

- Company's proposal: Multiple formats are supported for SFCI format (2 companies)
  - Rationale:
    - CSI and/or HARQ feedback is supported
    - SL-CSI, SL-SR as well as HARQ-feedback in included
- Company's proposal: Single format is supported for SFCI format (1 company)
  - Rationale:
    - SFCI format does not contain CSI

Issue 7-4: Others

- Company's proposal
  - Feedback information other than SL HARQ (e.g., long-term channel quality measurement) is conveyed via PSSCH.
  - If SL transmission with PSFCH and SL transmission without PSFCH are allowed to be multiplexed in the same pool, at least the following issues need to be further studied.
    - How to reduce additional AGC during PSSCH reception
    - Collision avoidance between PSSCH and PSFCH
- Company's proposal
  - SL CSI can be sent via PSSCH rather than PSFCH
- Company's proposal
  - Multiple PSFCH formats should be introduced and one format is dynamically selected depending on payload size and/or reliability
    - PUCCH formats in NR Uu are considered as starting point for PSFCH formats.
  - NR SL supports sequence-based HARQ feedback, for both TB-based and CBG-based cases.
- Company's proposal
  - RAN1 study the impact on multiplexing between PSCCH/PSSCH and PSFCH when determining time domain resource for PSFCH.
- Company's proposal

- NR SL supports sequence-based HARQ feedback, for both TB-based and CBG-based cases.
- The presence of PSFCH is signalled in the SCI scheduling the corresponding PSSCH.
- RAN1 prioritizes deterministic time relation between PSFCH and its associated PSSCH.

Proposal for agreement:

- Study further PSFCH format(s) for HARQ feedback. The following PSFCH formats are supported:
  - Format 1: Short PSFCH format
    - Rel. 15 NR Uu PUCCH format 0 or 2 is a starting point.
  - Format 2: Long PSFCH format
    - Details FFS
  - FFS whether/how PSFCH format is related to the resource allocation
- FFS: PSFCH format for other feedback contents (if supported)

1.1.1.12 AGC/switching period handling

Issue 8-1: Whether to support AGC training signal

- Company's proposal: Support AGC training signal (2 company)
  - Rationale:
    - Reduced AGC settling time
    - In higher SCS, the duration of symbol becomes shorter and one OFDM symbol length might not be enough for AGC training
    - Could be used for AGC training, channel tracking, along with DMRS for channel estimation, and CSI acquisition
    - Channel clearance detection for LBT
- Company's proposal: No support AGC training signal (4 companies)
  - Rationale:
    - The same principle as LTE-V can be used
    - AGC retraining is not always needed
    - High required density of DMRS and presence of AGC and guard period

Issue 8-1: Others

- Company's proposal
  - CSI-RS symbols can be placed at the beginning of a slot and also serve as AGC training signals.
- Company's proposal
  - Comb-like resource mapping on the first and last OFDM symbol can be supported in NR-V2X.
- Company's proposal
  - Use the first half OFDM symbol for tx/rx switching and the second half OFDM symbol for AGC adaptation in a slot for 15 and 30 kHz SCS
  - Use the last OFDM symbol for tx/rx switching and the first OFDM symbol for AGC adaptation for 60 kHz SCS
  - Transmit PSCCH on at least the first three symbols or transmit training signal in the first symbol considering the performance degradation of PSCCH due to AGC impact
- Company's proposal
  - The guard period and AGC protection can be integrated in a single symbol to reduce the overhead.
- Company's proposal
  - It can be considered to adopt merging AGC/Tx-Rx switching in one OFDM symbol or LTE-V2X-like way

Proposal for agreement:

- For AGC symbol, consider following options for data and/or RS mapping based on RAN4 LS on the AGC time.
  - Option 1: NR sidelink channels are mapped without consideration of AGC symbol
  - Option 2: Comb-like resource mapping is applied
    - Option 2-1: For PSCCH/PSSCH, data is mapped on AGC symbol

- Option 2-2: For PSCCH/PSSCH, DMRS is mapped on AGC symbol
- Option 3: NR sidelink channels are not mapped
  - Option 3-1: Preamble is mapped on AGC symbol
  - Option 3-2: RS other than DMRS is mapped on AGC symbol

1.1.1.13 Measurement RS

Issue 10-1: Whether to support CSI-RS

- Company's proposal: Support CSI-RS (7 companies)
  - Rationale:
    - Channel estimation to provide better spectrum efficiency
- Company's proposal: No support CSI-RS (1 company)
  - Rationale:
    - Sufficient performance can be achieved using DMRS

Issue 10-2: Whether to support PT-RS

- Company's proposal: Support PT-RS (6 companies)
  - Rationale:
    - Phase noise reduction
    - Doppler/CFO reduction
- Company's proposal: Further study whether to support PT-RS in FR2 (1 company)
  - Rationale:
    - Need to check whether phase noise of doppler effects are dominant in high carrier frequency
- Company's proposal: No support PT-RS (2 companies)
  - Rationale:
    - Proper DMRS patterns are enough in FR1
    - High required density of DMRS and presence of AGC and guard period

Issue 10-3: Others

- Company's proposal: SL CSI-RS can be transmitted either with or without data
- Company's proposal: Support both periodic and aperiodic RS for CSI measurement

Observation

- Majority companies support CSI-RS for NR sidelink.
- Majority companies support PT-RS for NR sidelink in FR2.

Proposal for agreement:

- Decide whether to support CSI-RS based on the progress in 7.2.4.1.2

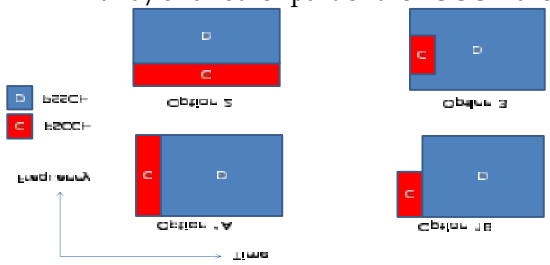
In RAN1 #94, the following agreements were made for physical layer design:

Agreement for physical layer design:

- At least PSCCH and PSSCH are defined for NR V2X. PSCCH at least carries information necessary to decode PSSCH.
  - Note: PSBCH will be discussed in the synchronization agenda.
- RAN1 continues study on the necessity of other channels.
- Further study on
  - Whether/which sidelink feedback information is carried by PSCCH or by another channel/signal.
  - Whether/which information to assist resource allocation and/or schedule UE's transmission resource(s) is carried by PSCCH or by another channel/signal.
  - PSCCH format(s) and content(s) for unicast, groupcast, and broadcast
- RAN1 continues study on the necessity, benefits and relationship between bandwidth part and resource pool.
- RAN1 to continue study on the physical channel considering at least the following aspects:
- Waveform
  - Candidates: CP-OFDM, DFT-s-OFDM
    - Proposals from companies:
      - CP-OFDM only
      - Support both

- Consideration points:
  - Different channel can have different waveform?
  - Benefit and impact of supporting only one waveform and supporting both waveforms

- Subcarrier spacing
  - Candidates for further study are:
    - FR1: 15 kHz, 30 kHz, 60 kHz, 120 kHz
    - FR2: 30 kHz, 60 kHz, 120 kHz, 240 kHz
- Companies are encouraged to consider the potential issues and benefit of introducing new subcarrier spacing.
- CP length
- RS design
  - Candidates are:
    - DM-RS: DM-RS defined in Rel-15 NR Uu is the starting point.
    - PT-RS
    - CSI-RS
    - SRS
    - AGC training signal
- Channel coding
  - For data, channel coding defined for data in Rel-15 NR Uu is the starting point.
  - For control, channel coding defined for control in Rel-15 NR Uu is the starting point.
- Modulation
- RE mapping and rate-matching
- Scrambling
- RAN1 to continue study on multiplexing physical channels considering at least the above aspects:
- Multiplexing of PSCCH and the associated PSSCH (here, the "associated" means that the PSCCH at least carries information necessary to decode the PSSCH).
- Study further the following options:
  - **Option 1:** PSCCH and the associated PSSCH are transmitted using non-overlapping time resources.
  - **Option 1A:** The frequency resources used by the two channels are the same.
  - **Option 1B:** The frequency resources used by the two channels can be different.
  - **Option 2:** PSCCH and the associated PSSCH are transmitted using non-overlapping frequency resources in the all the time resources used for transmission. The time resources used by the two channels are the same.
  - **Option 3:** A part of PSCCH and the associated PSSCH are transmitted using overlapping time resources in non-overlapping frequency resources, but another part of the associated PSSCH and/or another part of the PSCCH are transmitted using non-overlapping time resources.



In RAN1 #94bis, the following agreements were made for physical layer design:

Agreement for physical layer design:

- NR sidelink supports the SCSs supported by Uu in a given frequency range, i.e., {15, 30, 60 kHz} in FR1 and {60, 120 kHz} in FR2.
  - **FFS the supported CP length**
  - Baseline is that a UE is not required to receive sidelink transmissions using different SCSs simultaneously in a given carrier.
    - **FFS if this applies to sidelink synchronization signals/channels**
  - Baseline is that a UE is not required to transmit sidelink transmissions using different SCSs simultaneously in a given carrier.

        - **FFS if this applies to sidelink synchronization signals/channels**
- Continue discussion on the **waveform (only CP-OFDM or both CP-OFDM and DFT-S-OFDM)** till next meeting – companies are encouraged to perform more analysis/evaluations.
- For PSCCH and associated PSSCH multiplexing
    - At least one of Option 1A, 1B, and 3 is supported.
        - **FFS whether some options require transient period between PSCCH and PSSCH.**
    - **FFS whether to support Option 2**
- Sidelink control information (SCI) is defined.
    - SCI is transmitted in PSCCH.
    - SCI includes at least one SCI format which includes the information necessary to decode the corresponding PSSCH.
        - **New data indicator (NDI), if defined, is a part of SCI**
- Sidelink feedback control information (SFCI) is defined.
    - SFCI includes at least one SFCI format which includes HARQ-ACK for the corresponding PSSCH.
        - **FFS whether a solution will use only one of "ACK," "NACK," "DTX," or use a combination of them.**
    - **FFS how to include other feedback information (if supported) in SFCI.**
    - **FFS how to convey SFCI on sidelink in PSCCH, and/or PSSCH, and/or a new physical sidelink channel**
- **FFS in the context of Mode 1:**
    - Whether/how to convey information for SCI on downlink
    - Whether/how to convey information of SFCI on uplink
- At least resource pool is supported for NR sidelink
    - Resource pool is a set of time and frequency resources that can be used for sidelink transmission and/or reception.
        - **FFS whether a resource pool consists of contiguous resources in time and/or frequency.**
        - A resource pool is inside the RF bandwidth of the UE.
        - **FFS how gNB and other UEs know the RF bandwidth of the UE**
    - **FFS if BWP (if defined) can be used to in defining at least part of resource pool**
    - **FFS if the numerology of a resource pool is indicated as a part of (pre-)configuration for resource pool, carrier, band, or BWP (if defined)**
    - UE assumes a single numerology in using a resource pool.
    - Multiple resource pools can be configured to a single UE in a given carrier.
        - **FFS how to use multiple resource pools when (pre-)configured.**
- **FFS BWP is supported for NR sidelink**
    - **FFS whether RAN1 can assume that at most one BWP is configured in a carrier from the system perspective.**
    - It is RAN1 understanding that, in some cases, the entire system bandwidth is covered by a single BWP.
    - **FFS the details of BWP configurations, including the possibility of restricting the number of BWPs**
    - **FFS whether BWP for TX and RX is separated or a common BWP applied to both TX and RX**
    - There is at most one activated sidelink BWP for a UE in a given carrier as in the Uu case
        - Further study the feasibility, benefit, and impact of sidelink BWP switching
    - Aim to conclude in RAN1#95
        - **Companies are encouraged to provide more analysis, including checking current Rel-15 specification regarding BWP related text**

In RAN1 #95, the following agreements were made for physical layer design:

Agreement for physical layer design:

- At least CP-OFDM is supported.
- Continue study on whether to support DFT-S-OFDM including the potential issues and the following potential benefit:
    - Synchronization coverage enhancement

- PSCCH coverage enhancement, e.g., with Option 2 of PSCCH/PSSCH multiplexing with the restriction that PSCCH and PSSCH use adjacent frequency resources
- Feedback channel coverage enhancement

- A single waveform is used in all the sidelink channels in a carrier.
  - Note: A sequence based channel can be supported in any waveform.
  - (Pre-)configuration will be used to determine the used waveform if the specification supports multiple waveforms.

- For PSCCH/PSSCH in FR1, NR V2X supports normal CP for 15kHz, 30kHz, 60kHz, and extended CP for 60kHz.
  - FFS extended CP for 30 kHz in FR1.
- FFS CP for PSCCH/PSSCH in FR2
  - E.g., NR V2X supports normal CP for 60kHz and 120kHz, and extended CP for 60kHz
    - FFS extended CP for 120 kHz in FR2.
- Only one combination of CP length and SCS is used in a carrier at a given time for NR V2X UEs communicating with each other using SL

- BWP is defined for NR sidelink.
  - In a licensed carrier, SL BWP is defined separately from BWP for Uu from the specification perspective.
    - FFS the relation with Uu BWP.
  - The same SL BWP is used for both Tx and Rx.
  - Each resource pool is (pre)configured within a SL BWP.
  - Only one SL BWP is (pre)configured for RRC idle or out of coverage NR V2X UEs in a carrier.
  - For RRC connected UEs, only one SL BWP is active in a carrier. No signalling is exchanged in sidelink for activation and deactivation of SL BWP.
    - Working assumption: only one SL BWP is configured in a carrier for a NR V2X UE
      - Revisit in the next meeting if significant issues are found
  - Numerology is a part of SL BWP configuration.

Note: This does not intend to make restriction in designing the sidelink aspects related to SL BWP.
Note: This does not preclude the possibility where a NR V2X UE uses a Tx RF bandwidth the same as or different than the SL BWP.

Working assumption:

- Regarding PSCCH / PSSCH multiplexing, at least option 3 is supported for CP-OFDM.
  - RAN1 assumes that transient period is not needed between symbols containing PSCCH and symbols not containing PSCCH in the supported design of option 3.
  - FFS how to determine the starting symbol of PSCCH and the associated PSSCH
  - FFS for other options. e.g. whether some of them are supported to increase PSCCH coverage.

Working assumption:

- For RAN1 evaluation purpose only, until RAN4 response on AGC and switching time, it is assumed that one symbol is used for AGC and another one symbol is used for TX/RX switching.

Note: TX/RX switching includes transition in the power amplifier.

In RAN1 #AH_1901, the following agreements were made for physical layer design:

Agreement for physical layer design:

R1-1901322 Feature lead summary for agenda item 7.2.4.1.1 Physical layer structure LG Electronics

R1-1901438

Proposals**:**

- No consensus in supporting DFT-S-OFDM for NR SL in Rel-16

To conclude in RAN1#96

Conclusion:

- No extended CP is supported for 30 kHz in FR1 in Rel-16
- No extended CP is supported for 120 kHz in FR2 in Rel-16

Agreements:
- Confirm the working assumption
  - Working assumption: only one SL BWP is configured in a carrier for a NR V2X UE

Agreements:
- Configuration for SL BWP is separated from Uu BWP configuration signalling.
  - UE is not expected to use different numerology in the configured SL BWP and active UL BWP in the same carrier at a given time.
    - FFS the time scale
    - FFS relation to DL BWP including initial Uu BWP
    - FFS relation in terms of frequency location and bandwidth

Agreements:
- For time domain resources of a resource pool for PSSCH,
  - Support the case where the resource pool consists of non-contiguous time resources
    - FFS details including granularity
- For frequency domain resources of a resource pool for PSSCH,
  - Down select following options:
    - Option 1: The resource pool always consists of contiguous PRBs
    - Option 2: The resource pool can consist of non-contiguous PRBs

Agreements:
- Multiple DMRS patterns in time domain are supported for PSSCH
  - FFS: Whether a DMRS pattern is selected based on the subcarrier spacing
  - FFS: Single or multiple DMRS pattern(s) per a resource pool
  - FFS: How TX UE and RX UE can be aligned in terms of the DMRS pattern used for PSSCH
  - FFS: RE mapping, sequence generation
- Continue to study DMRS pattern in frequency domain for PSSCH
  - E.g. Whether multiple patterns are supported, whether PDSCH/PUSCH DMRS configuration 1 or 2 is reused.

Agreements:
- Support PT-RS for PSSCH for FR2

Conclusion:
- RAN1 to conclude on the need of physical channel for discovery in RAN1#96.

1.1.2 Physical Layer Procedure

Including HARQ feedback, CSI acquisition, etc.

R1-1901323 Feature lead summary for agenda item 7.2.4.1.2 Physical layer procedures, LGE

1.1.2.1 Highlights

This is the issues list related to the physical layer procedures.

1.1.2.2 Necessary information in physical layer

Issue 2-1: How to convey Layer-1 destination ID via PSCCH? In detail, company's view and its rationale are as follows:
- Layer-1 destination ID is included in SCI [29][7][10][32][3][1][6][26][27][28][8] (11 companies)
  - Rationale:
    - Need to be capable of decoding other UE's SCI for the sensing based resource collision avoidance operation (e.g., if not, other UE's resource allocation information in SCI cannot be obtained)
    - Consideration on the increment of CRC false alarm probability when the Layer-1 destination ID is used for scrambling CRC of SCI and the UE belongs to multiple groups

(i.e., CRC descrambling should be attempted by using multiple Layer-1 destination IDs)

- Layer-1 destination ID is used for scrambling CRC of SCI [32][20] [21]
  - Rationale:
    - Avoidance of SCI payload size increment
    - Other UE resource allocation can be decoded without destination ID if two-step SCI is used.

Issue 2-2: What additional information needs to be conveyed via PSCCH at least for supporting HARQ combining in the physical layer when HARQ feedback is in use? In detail, company's view and its rationale are as follows:

- Layer-1 source ID is included in SCI [1][32][23][7][20][27][10][9][16][21][3][14][24][28][8] (15 companies)
  - Rationale:
    - To differentiate packets from different transmitter UEs when combining transmission and re-transmission (at the receiver UE side)
- HARQ process ID is included in SCI [1][14][32][23][7][20][27][21][16][9][3][6][8][17][28][26] (16 companies)
  - Rationale:
    - To identify different HARQ processes for retransmission combining (at the receiver UE side) when operating with asynchronous retransmission and multiple HARQ processes
- New Data Indicator (NDI) is included in SCI [14][23][7][21][16][3][26] (7 companies)
  - Rationale:
    - To indicate whether the data is for the initial transmission or retransmission of a HARQ process
- Redundancy Version (RV) is included in SCI [14][21][16][3][26] (5 companies)
  - Rationale:
    - To keep the same understanding of RV index between transmitter UE and receiver UE considering the possibility of missing the preceding transmission (in case of incremental redundancy HARQ operation)

Issue 2-3: Whether/how to handle inclusion partial information of Layer-1 ID to mitigate ID collision issue at physical layer?

- Supported by [16]
  - Selecting time variant randomly bit selection from the uppler layer ID
    - Rationale:
      - There can be a problematic situation where different UEs continuously use the same L-1 ID even though their upper layer IDs are different.
- Not supported by [23]
  - Selecting a fixed number of LSBs of the Layer-2 ID [23]
- Comments from [29]
  - Probability that two-proximate vehicle UEs casually have same physical layer ID and at the same time they select the same or overlapped resources shall be sufficiently small.

- Observation:
  - Majority companies support Layer-1 destination ID included in SCI compared to the option of use it in scrambling CRC.
  - There seems no objection to include information such as Layer-1 source ID, HARQ process ID, NDI, RV in SCI.
- **Proposal for agreement:**
  - **Layer-1 destination ID can be explicitly included in SCI**
    - **FFS how to determine Layer-1 destination ID**
    - **FFS size of Layer-1 destination ID**
  - **The following additional information can be included in SCI**

- **Layer-1 source ID**
  - **FFS how to determine Layer-1 source ID**
  - **FFS size of Layer-1 source ID**
- **HARQ process ID**
- **NDI**
- **RV**

- **FFS whether some of the above information may not be present etc. in some operations (e.g., depending on whether they are used for unicast, groupcast, broadcast)**

1.1.2.3 Sidelink HARQ Feedback

Issue 3-1: How to determine the PSFCH resource? In detail, company's view and its rationale are as follows:

- Flexible time/frequency relationship between PSSCH and the associated PSFCH
  - Supported by [14][20][21][18][6][3][9][26][8][7][17] (11 companies)
    - Rationale:
      - Consideration on multiple types of services with different latency requirements and different UE capabilities
      - Allow to perform channel access for the SL HARQ feedback itself or to dynamically take into account the already planned SL HARQ feedback resources and select the more suitable/less congested one for its own operation
  - Comments from [14][6][9][26][11][32][20][21][24]
    - If the transmitter UE determines the SL HARQ feedback resource,
      - The SL HARQ feedback resource may be avoided by others when there is sufficient processing time, once the SCI scheduling PSSCH is detected by the surrounding UEs
      - The transmitter does not need to blindly detect the SL HARQ feedback
    - If the SL HARQ feedback resource is determined by receiver UE,
      - The SL HARQ feedback resource could be selected taking into account current operation at the receiver UE, for example its own plans to transmit PSSCH and PSCCH, sensing information.
    - The mechanism of transmitter UE reserving feedback resources can be considered.

- Fixed or (pre)configured time/frequency relationship between PSSCH and the associated PSFCH
  - Supported by [29][27][16][23][15][7][25] (7 companies)
    - Rationale:
      - Less standardization impact and control signaling (i.e., simplifying the resource determination procedure of SL HARQ feedback)
  - Comments from[16][23]
    - It could be beneficial to avoid the resource collision in SL HARQ feedback transmission, if the time/frequency location of PSFCH is correlated with the corresponding PSSCH.
    - To reduce the overhead of TX/RX turnaround time, feedback resources appear periodically as per the configuration.

- **Proposal for agreement**
  - **For determining the resource of PSFCH containing HARQ feedback, the following options are further considered:**
    - **For time resource,**
      - **Option 1-1: Time gap between PSSCH and the associated PSFCH is not signaled via PSCCH.**
      - **Option 1-2: Time gap between PSSCH and the associated PSFCH is signaled via PSCCH**
    - **FFS how to determine the frequency resource and/or code resource.**

Issue 3-2: For groupcast HARQ feedback, which option is preferred? In detail, company's view and its rationale are as follows: (i.e., Option 1: Receiver UE transmits only HARQ NACK, Option 2: Receiver UE transmits HARQ ACK/NACK)

- For Option 1,
  - Supported by [16][23][7][2][8][10][15][20][21][24][26][32] (12 companies)

- Rationale:
  - To minimize SL HARQ feedback reporting/resource overhead (e.g., by sharing the same feedback resource among the group members)
  - Need to perform the retransmission when at least one of group members fails to decode PSSCH

- How to handle FFS points when Option1 is supported?
  - Whether to introduce an additional criterion in deciding HARQ-NACK transmission
    - Communication range or RSRP from a transmitter can allow groupcast UEs to send HAQR-NACK feedback [23][32]
    - For adjusting the threshold which determine the presence of HARQ-NACK, null resource element could be beneficial [16]
  - Whether/how to handle DTX issue
    - No need to handle [23][32]
      - Rationale:
        - UEs can always get benefitted by retransmissions caused by NACK feedback from some other UE in the group
    - To judge whether a PSCCH transmission is or not in reception time, PSCCH reference signal can be used [16]
    - Feedback to indicate the failure of control channel reception [4]
  - Whether/how to handle destructive channel sum effect
    - No need to handle [23]
      - Rationale:
        - In practical deployment situation, probability of phase difference to be exactly Pi will be quite low
    - Use randomized sequence selection per receiver UE [16]

- For Option 2,
  - Supported by [14][27][6][9][17][21][26][29][32][26][22] (11 companies)
    - Rationale:
      - HARQ-NACK only feedback mechanism may be dangerous for groupcast operation when a receiver does not even detect the transmission
      - HARQ-NACK only feedback mechanism is hardly to fulfill the requirement since its performance is limited by PSCCH detection performance

- Observation:
  - Similar level of support was observed in the two options for the HARQ feedback in groupcast. It was also observed that each option may have different use case.
- **Proposal for agreement:**
  - **For groupcast HARQ feedback, continue study the following options**
    - **Option 1 as identified in RAN1#95**
    - **Option 2 as identified in RAN1#95**
    - **Option 3 which selects one of Option 1 and 2 depending on, e.g., operations.**

Issue 3-3: Whether/how to support TX-RX distance based SL HARQ feedback? In detail, company's view and its rationale are as follows:

- Supported by [23][4][18][16] (also by Fujitsu, Panasonic, Convida, Xiaomi, Fraunhofer, HEPTA7291)
  - Rationale:
    - For certain advanced use cases, UEs in certain range of a transmitter UE are required to receive messages more reliably than UEs which are far away from the transmitter UE
    - SA2 found that in addition to 5QI metrics, minimum communication rage is an important metric to be considered in NR V2X scenarios (TR 23.786)
- Not supported by [1][27][7] (also by Kyocera, Intel, vivo, ZTE, Lenovo, Apple, AT&T, OPPO, NEC)
  - Rationale:

        - ❖ Range-based HARQ feedback cannot provide the required reliability within a group, and the consistent reliability during a service's existence that are needed for groupcast transmission
- Comments from [31]
    - For broadcast design, communication range should be taken into consideration for reducing interference in proximity

- Observation:
    - No clear majority view was observed regarding supporting TX-RX distance based SL HARQ feedback, e.g., considering the 5QI metrics defined in SA2.
        - Companies are encouraged to continue discussion considering the evaluation results submitted to this meeting.

Issue 3-4: Whether/how to report SL HARQ feedback to gNB via UL in Mode 1? In detail, company's view and its rationale are as follows:

- Supported by [1][29][24][27][17][22][4][18][6][5][11][20][21][22][8] (15 companies)
    - Rationale:
        - ❖ gNB can efficiently allocate/schedule the sidelink resource for retransmission or new transmission accordingly based on SL HARQ feedback
- Which information to send
    - HARQ ACK/NACK
        - ❖ Supported by [1][22][27][29][4][6][24][17][21] (9 companies)
    - CSI information
        - ❖ Supported by [22][4][6][24]
    - BSR to report the updated buffer status by transmitter UE
        - ❖ Supported by [1]
    - Information for close loop power control
        - ❖ Supported by [6]
    - SR and/or BSR for SL transmission
        - ❖ Supported by [14]
- Which UE reports SL HARQ feedback to gNB via UL?
    - Transmitter UE
        - ❖ supported by [1][22][27][6][11][20][21][22] (8 companies)
            - rationale:
                - It has no limitation on the location and status of receiver UE (e.g., idle/inactive state, out of coverage)
                - It introduces extra RTT as the transmitter UE should deliver SL HARQ feedback to gNB for rescheduling sidelink resource
                - Since the transmitter/receiver UEs need to exchange SL HARQ feedback over the sidelink, it will suffer the impact of half-duplex constraint
    - Receiver UE
        - ❖ supported by [17][22][27][4][24][11][8] (7 companies)
            - Rationale:
                - It can reduce the latency incurred by routing SL HARQ feedback via the transmitter UE
                - It can mitigate the half-duplex constraint as there is no need for the transmitter UE to monitor SL HARQ feedback from the receiver UE and the transmitter UE may utilize the time resource for transmitting other control or data
        - ❖ Comment from[1]
            - If the receiver UE is outside network coverage (or in idle/inactive state), then it cannot convey its SL HARQ feedback over Uu. Also if the transmitter/receiver UEs are served by different gNBs, then transport of SL HARQ feedback over Uu will become more complex
- Which channel to use
    - PUCCH

        - Supported by [17][27][1][4][6][24][21]
    - PUSCH
        - Supported by [17][4][6]

- Observation:
    - Majority companies support reporting some information to gNB to trigger retransmission resource grant in mode 1. All the companies expressed view on the channel to use support PUCCH.
- **Proposal for agreement:**
    - **It is supported that in mode 1, UE sends at least HARQ ACK/NACK to gNB to trigger scheduling retransmission resources.**
        - **At least PUCCH is used to report the information**
            - **If feasible, RAN1 reuses PUCCH defined in Rel-15**
        - **FFS whether other information is reported**

Issue 3-5: what are conditions to enable/disable SL HARQ feedback? In detail, company's view and its rationale are as follows:

- Summary of company's view/preference as follows:
    - Higher layer configuration(i.e., UE-specific signalling) [14]
    - Congestion level [14][23][16]
        - Rationale:
            - since feedback itself may consume resources, it may be disabled in some cases to improve system performance
    - QoS parameter [14][16][32]
        - Rationale:
            - Traffic types or services may be realized by mapping particular QoS attribute combinations to enabling/disabling HARQ
    - RSRP/CQI level [4]

- **Proposal for agreement:**
    - **Continue study on the conditions of enabling/disabling SL HARQ feedback in unicast and/or groupcast, including**
        - **Higher layer configuration**
        - **Congestion level**
        - **QoS parameter**
        - **RSRP/CQI level**
        - **PSSCH decoding condition**
        - **Indication in physical layer signalling**
        - **Geographical distance between TX and RX**

Issue 3-6: Whether to support SL HARQ feedback per CBG? In detail, company's view and its rationale are as follows:

- Supported by [6][32][3][5][8][27] (6 companies)
    - Rationale:
        - CBG-based HARQ feedback and re-transmission can improve resource efficiency
- Not supported by [7][15] (2 companies)
    - Rationale:
        - CBG based feedback will make the retransmission very complicated as each Rx UE may have different feedback situation for transmitted CBGs due to different radio link
        - For groupcast, CBG-based HARQ operation is not preferable. Since, gain is not clear comparing with TB-based HARQ feedback

- Observation:
    - Majority companies support CBG-based SL HARQ feedback while some of them seem to limit its applicability to a certain scenario like unicast. RAN1 can discuss whether limiting its application can address concerns expressed by some companies.
- **Proposal for agreement:**

- **Continue discussion on the CBG-based HARQ feedback including whether it is supported in a limited scenario, e.g., unicast.**

Issue 3-7: How to handle PSFCH resource in resource pool in terms of when HARQ feedback is enable or disable? In detail, company's view and its rationale are as follows:

- Summary of company's view/preference as follows: [16]
  - Further study is necessary on the following cases in terms of managing resource pool for PSFCH.
    - Option 1: Pool separation between PSFCH-enabled and -disabled pool
    - Option 2: SL transmission with PSFCH and SL transmission without PSFCH are multiplexed in the same pool

1.1.2.4 Sidelink CSI Acquisition

Issue 4-1: In the context of CSI, what kind of information is useful in sidelink operation and how can it be acquired?

- Three contributions [14][1][32] have been submitted showing different evaluation result on the benefit of short-term CSI feedback. Details are as follows:
  - System level evaluation results in [14] show that the interference variation could become quite unpredictable depending on the channel access procedures/system loading (i.e., leading to useless attempt to adapt transmission parameter) and there is no benefit of short-term PMI feedback due to the fast channel variation in time (or the delay between transmitting RS used for PMI estimation and the application of feedback information at the transmitter UE)
  - Link level evaluation results in [1] show that the appropriate channel estimation accuracy/throughput can be achieved by adjusting the CSI feedback periodicity and close-loop MIMO with feedback can outperform open-loop MIMO in terms of throughput
  - In [32] link level evaluation results, closed loop-MIMO and link adaptation with RI, PMI, CQI feedback shows good performance compared to the other schemes in terms of throughput.
- Summary of company's view/preference on the type of CSI feedback information:
  - CQI
    - Supported by [1][29][27][17][11][21][3][17][32] (9 companies)
  - PMI
    - Supported by [1][20][21][3][27][32] (6 companies)
  - RI
    - Supported by [14][1][20][27][21][3] (6 companies)
  - RSRP
    - Supported by [14][1][11][18][16][30][3][27] (8 companies)
  - RSRQ
    - Supported by [14][11][16][30]
  - LI
    - Supported by [20]
  - CRI/SRI
    - Supported by [1][30][27]
  - Doppler spread and delay spread
    - Supported by [1]
  - Interference condition
    - Supported by [3]

- Observation:
  - For the time scale of channel status measurement and feedback, link level evaluation results are submitted showing performance benefit of short-term CSI feedback while a company showed that no benefit is found in the system level evaluation of short-term CSI feedback.
  - It seems that there are no companies objecting to the introduction of long-term measurement and feedback.
- **Proposal for agreement:**

- **Long-term measurement and feedback is supported. Consider RSRP, RSRQ, RI as the initial candidates.**
- **Conclude that short-term measurement and feedback such as CQI, PMI can be beneficial in the link level and continue discussion on the system level benefit.**

Issue 4-2: For CSI measurement, which RS is used for CSI acquisition and how is such RS transmitted?

- No dedicated measurement RS (i.e. DM-RS of PSCCH and/or PSSCH is used for measurements)
  - Supported by [14]
- Dedicated measurement RS is used (e.g., Sidelink CSI-RS, SRS, AGC-RS)
  - Supported by [32][20][27][3][7][12]
  - Comments from [14]
    - When dedicated CSI-RS signal is used for measurements, the CSI-RS bandwidth may be different to the PSCCH/PSSCH bandwidth in order to be able to perform wideband estimation.

- **Proposal for agreement:**
  - **Continue discussion on the RS used for the measurement including**
    - **Reuse DM-RS of PSCCH and/or PSSCH, or define dedicated measurement RS**
    - **Bandwidth of RS used for the measurement**

Issue 4-3: Whether to support SL CSI acquisition through channel reciprocity? In detail, company's view and its rationale are as follows:

- SL CSI acquisition through channel reciprocity
  - Supported by [7][25]
    - Rationale:
      - The overhead of CSI acquisition through CSI feedbacks by the receiving UEs is too much and the benefit of sidelink link adaptation gain is limited
  - Comments from [3]
    - When channel reciprocity is used by the transmitter, feedback of short-term interference condition at the receiver is needed for the transmitter to derive the transmission MCS

1.1.2.5 Sidelink Power Control

Issue 5-1: Whether/how to enhance SL power control? In detail, company's view and its rationale are as follows:

- SL pathloss based open-loop power control
  - Supported by [32][1][24][20][27][17][3][6][7][12][18][30][21] (13 companies)
    - Rationale:
      - Limitation of interference injection to non-intended receiver UEs
      - Saving of power consumption which may be important for certain UE types (e.g. pedestrian UE)
      - Reducing the interference among UEs
  - Comments from [14][16]
    - Further consider open-loop power control techniques taking into account the impact on channel access procedures (e.g., in case of large-scale channel access with resource reservation, the measurements may be performed assuming one transmission power of UEs while during transmission and/or small scale channel access. If the transmission power of some UEs may change, it may destruct the channel sensing decisions made with another transmission power assumption)
- Closed-loop power control
  - Supported by [1][24][3][6][25][30][17][21] (8 companies)
    - Rationale:
      - To perform the fine tuning of transmission power dynamically considering e.g., sidelink channel quality between transmitter UE and receiver UE
    - Comments from [3]

- In [3] evaluation result, close-loop power control with L1 TPC feedback outperforms than without power control in terms of PRR. (i.e., a receiver UE suffering severe interference would inform the aggressor via a TPC-like L1 feedback)

- Observation:
  - Majority companies support SL pathloss based open-loop power control while two companies mentioned its potential impact.
- **Proposal for agreement**:
  - **SL pathloss based open-loop power control is supported. Further study its potential impact, e.g., on resource allocation.**
    - **FFS whether closed-loop power control is additionally needed**

1.1.2.6 Sidelink multi-antenna transmission scheme

Issue 6-1: Whether/how to support multi-antenna transmission scheme at least for the purpose of supporting high data rate and reliability in sidelink operation?

- Summary of company's view:
  - Open-loop MIMO scheme (e.g., SFBC, pre-coder cycling)
    - Supported by [1], [4]
  - Closed-loop MIMO scheme
    - Supported by [1][32][27][29]
      - Note that support of closed-loop MIMO scheme depends on whether to introduce the sidelink short-term channel quality measurement/feedback

In RAN1 #94, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

- Proposal 1: RAN1 assumes that higher layer decides if a certain data has to be transmitted in a unicast, groupcast, or broadcast manner and inform the physical layer of the decision. For a transmission for unicast or groupcast, RAN1 assumes that the UE has established the session to which the transmission belongs to. Note that RAN1 has not made agreement about the difference among transmissions in unicast, groupcast, and broadcast manner.

- Proposal 2: RAN1 assumes that the physical layer knows the following information for a certain transmission belonging to a unicast or groupcast session. Note RAN1 has not made agreement about the usage of this information.
  - ID
    - Groupcast: destination group ID, FFS: source ID
    - Unicast: destination ID, FFS: source ID
    - HARQ process ID (FFS for groupcast)
  - RAN1 can continue discussion on other information

- Proposal 3: Send LS to RAN2 and SA2 to inform Proposal 1 and 2 if agreed.

Companies discussed SL enhancements for unicast and/or groupcast. The following topics were discussed:

- Proposal 4: RAN1 to study the following topics for the SL enhancement for unicast and/or groupcast. Other topics are not precluded.
  - HARQ feedback
  - CSI acquisition
  - Open loop and/or closed loop power control
  - Link adaptation
  - Multi-antenna transmission scheme

In RAN1 #94bis, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

- Layer-1 destination ID is conveyed via PSCCH
  - **FFS how many bits are conveyed.**
  - **FFS details for each of the unicast/groupcast/broadcast cases**
- Additional Layer-1 ID(s) is conveyed via PSCCH at least for the purpose of identifying which transmissions can be combined in reception when HARQ feedback is in use.
  - **FFS whether this ID can be used for other HARQ feedback related operation.**
  - **FFS other purpose**
  - **FFS how many bits are conveyed**
- **FFS details including how to convey the ID(s), e.g., whether the ID(s) is conveyed in the SCI or used for CRC scrambling.**
- For unicast, sidelink HARQ feedback and HARQ combining in the physical layer are supported.
  - **FFS details, including the possibility of disabling HARQ in some scenarios**
- For groupcast, sidelink HARQ feedback and HARQ combining in the physical layer are supported.
  - **FFS details, including the possibility of disabling HARQ in some scenarios**
- **Conclusion:** To update the TR 37.885 by replacing "multicast" by "groupcast"
- In the context of sidelink CSI, RAN1 to study further which of the following information is useful in sidelink operation when it is available at the transmitter.
  - Information representing the channel between the transmitter and receiver
  - Information representing the interference at receiver
  - Examples for this information are:
    - CQI, PMI, RI, RSRP, RSRQ, pathgain/pathloss, SRI, CRI, interference condition, vehicle motion
  - **FFS including:**
    - **Such information can be acquired using reciprocity or feedback**
    - **Time scale of the information**
    - **Which information is useful in which operation and scenario**

In RAN1 #95, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

- Physical sidelink feedback channel (PSFCH) is defined and it is supported to convey SFCI for unicast and groupcast via PSFCH.

- When SL HARQ feedback is enabled for unicast, the following operation is supported for the non-CBG case:
  - Receiver UE generates HARQ-ACK if it successfully decodes the corresponding TB. It generates HARQ-NACK if it does not successfully decode the corresponding TB after decoding the associated PSCCH which targets the receiver UE.
  - FFS whether to support SL HARQ feedback per CBG

- When SL HARQ feedback is enabled for groupcast, the following operations are further studied for the non-CBG case:
  - Option 1: Receiver UE transmits HARQ-NACK on PSFCH if it fails to decode the corresponding TB after decoding the associated PSCCH. It transmits no signal on PSFCH otherwise. Details are FFS including the following:
    - Whether to introduce an additional criterion in deciding HARQ-NACK transmission
    - Whether/how to handle DTX issue (i.e., transmitter UE cannot recognize the case that a receiver UE misses PSCCH scheduling PSSCH)
    - Issues when multiple receiver UEs transmit HARQ-NACK on the same resource

- How to determine the presence of HARQ-NACK transmissions from receiver UEs
- Whether/how to handle destructive channel sum effect of HARQ-NACK transmissions from multiple receiver UEs if the same signal is used

- Option 2: Receiver UE transmits HARQ-ACK on PSFCH if it successfully decodes the corresponding TB. It transmits HARQ-NACK on PSFCH if it does not successfully decode the corresponding TB after decoding the associated PSCCH which targets the receiver UE. Details are FFS including the following:
  - Whether to introduce an additional criterion in deciding HARQ-ACK/NACK transmission
  - How to determine the PSFCH resource used by each receiver UE
- FFS whether to support SL HARQ feedback per CBG
- Other options are not precluded

- It is supported to enable and disable SL HARQ feedback in unicast and groupcast.
  - FFS when HARQ feedback is enabled and disabled.

- Study further whether to support UE sending to gNB information which may trigger scheduling retransmission resource in mode 1. FFS including
  - Which information to send
  - Which UE to send to gNB
  - Which channel to use
  - Which resource to use

In RAN1 #AH_1901, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

R1-1901323 Feature lead summary for agenda item 7.2.4.1.2 Physical layer procedures LG Electronics

Agreements:

- Layer-1 destination ID can be explicitly included in SCI
  - FFS how to determine Layer-1 destination ID
  - FFS size of Layer-1 destination ID
- The following additional information can be included in SCI
  - Layer-1 source ID
    - FFS how to determine Layer-1 source ID
    - FFS size of Layer-1 source ID
  - HARQ process ID
  - NDI
  - RV
- FFS whether some of the above information may not be present etc. in some operations (e.g., depending on whether they are used for unicast, groupcast, broadcast)

Agreements:

- For determining the resource of PSFCH containing HARQ feedback, support that the time gap between PSSCH and the associated PSFCH is not signaled via PSCCH at least for modes 2(a)(c)(d) (if respectively supported)
  - FFS whether or not to additionally support other mechanism(s) for modes 2(a)(c)(d)
  - FFS for mode 1

Proposals:

- When HARQ feedback is enabled for groupcast, support (options as identified in RAN1#95):
  - Option 1: Receiver UE transmits only HARQ NACK

- Option 2: Receiver UE transmits HARQ ACK/NACK
- FFS applicability of option 1 and option 2

Supported by: vivo, MTK, Intel, LGE, QC, IDC, E///, HEPTA, Nokia, NSB, CATT, Xiaomi, ITL, SONY, Lenovo, MotM, ATT, Panasonic, Apple, Convida, SS, DCM, NEC
Objected by: HW, HiSi

Working assumption:

- When HARQ feedback is enabled for groupcast, support (options as identified in RAN1#95):
  - Option 1: Receiver UE transmits only HARQ NACK
  - Option 2: Receiver UE transmits HARQ ACK/NACK
- FFS applicability of option 1 and option 2 – this part is particulary relevant to confirm (or not) the working assumption

Agreements:

- It is supported that in mode 1 for unicast, the in-coverage UE sends an indication to gNB to indicate the need for retransmission
  - At least PUCCH is used to report the information
    - If feasible, RAN1 reuses PUCCH defined in Rel-15
  - The gNB can also schedule re-transmission resource
  - FFS transmitter UE and/or receiver UE
    - If receiver UE, the indication is in the form of HARQ ACK/NAK
    - If transmitter UE, FFS

Check beam management procedure needed for FR2 or not – companies are encouraged to check R1-1900446

- Discuss further offline regarding potential TP based on the measurement results in R1-1900466 – to check later

R1-1901411 – revisit on Friday
R1-1901463

R1-1901439
Agreements:

- (Pre-)configuration indicates whether SL HARQ feedback is enabled or disabled in unicast and/or groupcast.
  - When (pre-)configuration enables SL HARQ feedback, FFS whether SL HARQ feedback is always used or there is additional condition of actually using SL HARQ feedback

Agreements:

- SL open-loop power control is supported.
  - For unicast, groupcast, broadcast, it is supported that the open-loop power control is based on the pathloss between TX UE and gNB (if TX UE is in-coverage).
    - This is at least to mitigate interference to UL reception at gNB.
    - Rel-14 LTE sidelink open-loop power control is the baseline.
    - gNB should be able to enable/disable this power control.
  - At least for unicast, it is supported that the open-loop power control is also based on the pathloss between TX UE and RX UE.
    - (Pre-)configuration should be able to enable/disable this power control.
    - FFS whether this is applicable to groupcast
    - FFS whether this requires information signaling in the sidelink.
  - Further study its potential impact, e.g., on resource allocation.
- FFS whether closed-loop power control is additionally needed

Agreements:

- Long-term measurement of sidelink signal is supported at least for unicast.

- Long-term measurement here means a measurement with L3 filtering.
- This measurement is used at least for the open-loop power control.
  - FFS for other purpose
- FFS: measurement metric
- FFS: which signal is used
- FFS: whether feedback of this measurement is needed
- FFS whether this is applicable to groupcast

1.1.3 Synchronization

R1-1901377 Summary of AI 7.2.4.1.3 NR V2X synchronization, CATT

1.1.3.1 Sidelink Synchronization Signals

Offline Agreement

The M-sequence used for NR-PSS and the Gold sequence used for NR-SSS are used as the sequences type for NR SLSS.

Most companies proposed that the M-sequence based NR SS is used as the sequences for SLSS of NR V2X with the details, such as polynomial of generator, cyclic shift, for FFS inn [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [8,ITRI] [18,Sharp] [19,Qualcomm] [22,Samsung] [24,Nokia,Nokia Shanghai Bell] [26,Convida Wireless],

Candidate schemes	Supporting Companies
M-sequence	[2,Huawei, HiSilicon], [3,vivo], [6,CATT], [8,ITRI], [10,LG], [18,Sharp], [19,Qualcomm], [22,Samsung], [24,Nokia,Nokia Shanghai Bell], [26,Convida Wireless], [27,Ericsson]
Others	None

From the table above, most companies support M-sequence as the base sequence for SLSS. No other candidate sequence were proposed for SLSS.

Two sequence lengths were proposed for NR SLSS; they are length-127 and length-255. Several companies [2,Huawei, HiSilicon] [3,vivo] [4,MediaTek] [10,LG] [27,Ericsson] proposed the length-127 M sequence for S-PSS and S-SSS. One company [6,CATT] proposed the length-255 M sequence for S-PSS and S-SSS. The evaluation results of SLSS sequence were provided by 5 companies [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] with the summary of the pro and con shown in the table below,

Candidate schemes	Length-127 SLSS	Length-255 SLSS
Supporting companies	[2,Huawei, HiSilicon], [3,vivo], [10,LG]	[6,CATT]
Pros	) Reuse the design of NR SS, such as polynomial of generator;) Power boosting can be used.	) Better detection performance than Length-127 sequence;) Only using S-SSS to demodulate the PSBCH and DMRS-free, to obtain better performance of PSBCH due to low coding rate
Cons	) Worse detection performance than Length-255 sequence;) Need DMRS to aid the demodulation of PSBCH.	) Need design new sequence.) Power boosting cannot be used.
SLID Detection probability @-6dB SNR	[2,Huawei, HiSilicon]: 97.5% [3,vivo]: 82% [6,CATT]: 57% [10,LG]: 39%	[6,CATT]: 83%

Key simulation assumptions	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 3Kmph, IFO(Initial Frequency Offset) = ±5ppm [3,vivo]: TDL-A channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 3Kmph, IFO unknown

Notes: the above table only includes the opinions of companies which provide the simulation results.

[6,CATT] provides the performance results in comparison of length-127 sequence and length-255 sequence, at -6 dB SNR. SLID detection probability can be improved from 57% to 83% for the length-255 sequence comparing to the length-127 sequence.

Proposal 2:
The SLSS sequence length considers the following two alternatives

- ***Alt 1: Length-127 M-sequences***
- ***Alt 2: Length-255 M-sequences***

No consensus in the offline discussion
The number of NR V2X SSID to be supported in NR S-SSB design is

- ***Alt1: 672***
- ***Alt2: 336***

Most companies proposed that the number of NR V2X SSID needs to be expanded to support the capacity enhancement of synchronization source identification, in-coverage/out-of-coverage, and distinguish between NR Uu and NR V2X sidelink in [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [17,InterDigital] [18,Sharp] [20,NTT DOCOMO] [22,Samsung] [23,ITL] [24,Nokia,Nokia Shanghai Bell].

Number of NR SL-SSID	Supporting Companies
672	[3,vivo], [6,CATT], [20,NTT DOCOMO]
504	[22,Samsung]

The design of NR sidelink SS sequences should be capable to distinguish from NR SS sequences by CDM/TDM/FDM, or by different CS values, different structure or different primitive polynomials in [2,Huawei, HiSilicon] [11,NEC] [14,Spreadtrum] [17,InterDigital] [18,Sharp] [23,ITL] [24,Nokia,Nokia Shanghai Bell],

1.1.3.2 Waveform for S-SSB

Two candidates of S-SSB waveform are the DFT-s-OFDM and CP-OFDM. Two companies indicated their only support of CP-OFDM waveform for the S-SSB in [3, vivo] [4,MediaTek]. Two companies proposed DFT-s-OFDM waveform for the S-SSB in [6, CATT] [16,ZTE]. One company claimed that NR V2X should support only single waveform for the sidelink SSB [12,ETRI]. The summary of Pros and Cons of CP-OFDM and DFT-s-OFDM waveforms for the S-SSB is as follows,

Candidate schemes	CP-OFDM for the waveform of S-SSB	DFT-s-OFDM for the waveform of S-SSB
Supporting companies	[4,MediaTek]	[6,CATT] [16,ZTE]
Pros	• Support flexible resource allocation mechanism • Higher spectrum efficiency	• lower PAPR • Higher coverage area
Cons	• Higher PAPR • Reduced coverage area	• Restrictions in terms of multiplexing of data and DMRS in the same OFDM symbol • Lower spectrum efficiency
Performance evaluation	[6,CATT]: CP-OFDM can only provide a little better BLER performance (less than 1dB) than DFT-s-OFDM, but DFT-s-OFDM can provide about 2.7dB CM performance gain for QPSK compared to CP-OFDM.	

Comments	[6,CATT] provides the comparison of performance between CP-OFDM and DFT-s-OFDM.

Proposal 4: Both DFT-s-OFDM and CP-OFDM should be considered in the design of S-SSB structure.

1.1.3.3 Synchronization numerology

Most Companies support a default SCS and CP length for S-SSB for a given band/carrier. [4,MediaTek], [6,CATT], [14,Spreadtrum]

Proposal 5:
A SCS is pre-configured for SLSS/PSBCH transmission for a given band

The proposals from companies are as follows,

- The adoption of the numerology for S-SSB should take into account the coverage restricted by the CP length. [4,MediaTek]
- Extended CP is not supported for S-SSB. [22,Samsung]

Proposal 6:
A SCS is pre-configured for SLSS/PSBCH transmission for a given band/carrier.

1.1.3.4 Synchronization bandwidth

Offline Agreements
The S-SSB bandwidth for further evaluation should be determined together with the design of V2X S-SSB from the following alternatives,

- ***Alt 1: 20RB***
- ***Alt2: 24RB***
- ***Alt3: 12RB***

The proposed number of RBs for S-SSB are 12, 20 and 24 in [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] [12,ETRI] [19,Qualcomm]. [24,Nokia, NSB] proposed that the bandwidth of S-SSB should be restricted. The performance results of SLSS sequence are provided by [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] with the summary of Pros and Cons shown in the table blow,

Candidate schemes	12 RB	20RB	24RB
Supporting companies		[3,vivo]	[6,CATT]
Pros	• Less minimum bandwidth than 20RB and 24RB	• Less minimum bandwidth than 24RB	• Better BLER performance than 12RB and 20RB • Support length-255 SLSS • Support waveform-independent S-SSB pattern
Cons	• Worse performance than 20RB and 24RB • Cannot support length-255 SLSS • Need more PSBCH symbols	• Worse performance than 24RB • Cannot support length-255 SLSS	• Need more minimum bandwidth than 12 RB and 20RB
PSBCH BLER @-6dB SNR	[2,Huawei, HiSilicon]: 1.5%	[2,Huawei, HiSilicon]: 0.3% [3,vivo]: 25% [6,CATT]: 0.9% [10,LG]: 6.8%	[6,CATT]: 0.4% [10,LG]: 7.2%
Key simulation assumptions	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 250Kmph [3,vivo]: TDL-A channel, 30KHz SCS, 240Kmph [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 240Kmph, @-8dB SNR [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 250Kmph		

Notes: the above table only includes the analysis with the evaluation results.

Offline Agreements

The frequency location for S-SSB should be (pre-) configured.

The proposals of S-SSB frequency location are as follows,

- The frequency location for S-SSB should be (pre-) configured or network indicated. [9,Intel] [10,LG] [11,NEC] [16,ZTE]
- The center frequency of S-SSB can be different from the center frequency of the NR sidelink carrier. [9,Intel]
- The frequency location of S-SSB should be fixed or same on one carrier for all UEs. [11,NEC] [16,ZTE]

The proposals of S-SSB Sync raster are as follows,

- Sync raster of NR SSB should be reused as the starting point. [16,ZTE]
- Coarser or low sync raster could be predefined to reduce the UE synchronization complexity as well as latency. [21,Xiaomi] [24,Nokia,Nokia Shanghai Bell]
- RAN1 shall send an LS to RAN4 to inquire the synchronization raster and channel raster for sidelink. [22,Samsung]

1.1.3.5 S-SSB Structure

Several companies had proposals in the S-SSB structure design [3,vivo] [4,MediaTek] [6,CATT] [8,ITRI] [9,Intel] [10,LG] [11,NEC] [13,Sequans] [14,Spreadtrum] [17,InterDigital] [22,Samsung] [23,ITL] [24,Nokia,Nokia Shanghai Bell]. In [13,Sequans] [17,InterDigital] [23,ITL], NR SSB structure is proposed as the starting point of NR V2X S-SSB for minimizing standardization effort and NR V2X UE detection complexity. In [3,vivo] [17,InterDigital] [22,Samsung], a unified S-SSB pattern should be considered for both FR1 and FR2.

There are proposals to have S-SSB design with low correlation to the NR SSB and to be distinguished in the manner of FDM, TDM, GSCN, S-SSB pattern, SS sequence, cyclic shifts or muting [2,Huawei, HiSilicon] [5,OPPO] [10,LG] [12,ETRI] [13,Sequans],

Two alternatives of the number of S-PSS and S-SSS symbols in a S-SSB were proposed as follows,

- Alt1: Single-symbol SLSS with S-PSS and S-SSS only occupy one symbol – [3,vivo] [5,OPPO] [6,CATT] [27,Ericsson],
  - The simulation results showed that implementation methods can improve the detection performance without additional SLSS symbol in an S-SSB [3,vivo] [6,CATT]. The method of multiple searchers in [3, vivo] and multiple hypotheses [6, CATT] were proposed and evaluated for the high speed scenarios.
- Alt2: Multi-symbol SLSS with S-PSS and/or S-SSS occupy at least two symbols - [2,Huawei, HiSilicon] [4,MediaTek] [10,LG] [14,Spreadtrum] [19,Qualcomm] [24,Nokia, NSB].
  - The simulation results showed better detection performance of multiple SLSS symbols in a S-SSB comparing with that of one SLSS symbols within one S-SSB [2,Huawei, HiSilicon] [10 LG].

Detection Performance of NR SLSS

The performance evaluation results of the designed SLSS sequence from [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] are shown in the table below,

Candidate schemes	Single-symbol SLSS	Multi-symbols SLSS
Supporting companies	[3,vivo] [6,CATT]	[2,Huawei, HiSilicon] [10,LG]
Pros	- Lower overhead than multiple-symbols SLSS. - Similar performance can be obtained with implementation methods to improve the performance	- Better detection performance than one-symbol SLSS without using implementation methods to improve the performance - Reduce the complexity of detection
Cons	- The complexity of detection will increase after using the implementation methods, but can be controlled in a reasonable way	- Higher overhead than one-symbol SLSS

Performance @-6dB SNR	[3,vivo]: 82% [6,CATT]: 83%	[2,Huawei, HiSilicon]: 97.5% [10,LG]: 39%
Key simulation assumptions	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 3Kmph, IFO(Initial Frequency Offset) = ±5ppm [3,vivo]: TDL-A channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 3Kmph, IFO unknown	

Notes: the above table only includes the opinions of companies which provide the simulation results.

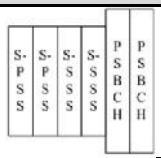
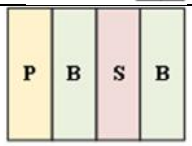
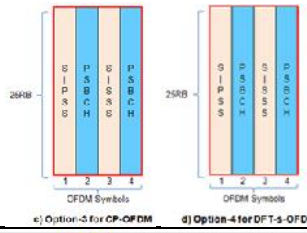
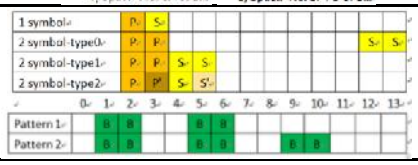
Offline agreements

For the design of S-SSB structure, the number of symbols for S-PSS/S-SSS should be determined for design of S-SSB pattern

- ***Option 1: Each of S-PSS and S-SSS could use two or three symbols in a S-SSB.***
- ***Option 2: Single symbol for S-PSS/S-SSS in a S-SSB.***

S-SSB patterns were proposed by[2,Huawei, HiSilicon] [3,vivo] [4,MediaTek] [5,OPPO] [6,CATT] [10,LG] [14,Spreadtrum] [16,ZTE] [24,Nokia,Nokia Shanghai Bell] [27,Ericsson].

The simulation results of the design S-SSB pattern from [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] are shown in the table below,

Supporting Companies	S-SSB patterns	Sequence length of SLSS	Bandwidth of PSBCH	Detection Probability of SLSS@-6dB SNR	BLER of PSBCH@-6dB SNR
[2,Huawei, HiSilicon]		127	20RB	97.5%	0.3%
[3,vivo]		127	20RB	82%	25%
[6,CATT]		255	24RB	83%	0.4%
[10,LG]		127	20RB	39%	6.8%
Key simulation assumptions for SLSS	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 3Kmph, IFO(Initial Frequency Offset) = ±5ppm [3,vivo]: TDL-A channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 3Kmph, IFO unknown				
Key simulation assumptions for PSBCH	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 250Kmph [3,vivo]: TDL-A channel, 30KHz SCS, 240Kmph [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 240Kmph, @-8dB [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 250Kmph				

AGC and TX/RX switching periods should be taken into account for the design of S-SSB [3,vivo] [6,CATT] [9,Intel] [10,LG] with the options list below,

Options	AGC solutions	Supporting company

Option 1	Using the PSBCH before S-PSS to do AGC tuning	[3,vivo]
Option 2	One symbol of AGC training sequence should be added in front of each S-SSB	[6,CATT]
Option 3	SLSS (or any other known signal) transmission at the first symbol of slot as an AGC training symbol	[9,Intel]

Proposal 10: AGC and TX/RX switching periods should be taken into account in design S-SSB

- ***Option 1: PSBCH before S-PSS is used for AGC tuning***
- ***Option 2: One symbol of AGC training sequence is added in front of each S-SSB.***
- ***Option 3: SLSS (or any other known signal) transmission at the first symbol of slot as an AGC training symbol***

The proposals of supporting more than one S-SSB per slot/period are as follows

- Supported multiple S-SSB transmission in one period. [2,Huawei, HiSilicon] [6,CATT] [11,NEC] [16,ZTE] [20,NTT DOCOMO] [23,ITL]
- Whether one or multiple S-SSB is transmitted within a period depends on whether beamforming is supported. [5,OPPO].
- At least two S-SSBs per Slot for beam sweeping of 64 S-SSBs. [6,CATT]

Proposal 11:
More than one S-SSB in a slot/period is supported.

There were discussions on the support of multi-beam operation in NR sidelink as follows,

- S-SSB beam sweeping or repetition should be supported to enlarge the coverage range of S-SSB. [6,CATT] [12,ETRI] [21,Xiaomi] [17,InterDigital]
- Beam sweeping and beam identification of S-SSB is not considered at least in FR1. [10,LG]

Proposal 12: The design of S-SSB structure and resource mapping should support S-SSB sweeping
It was proposed that more than one S-SSB periodicity should be supported and with the periodicity configured by the network [3,vivo] [20,NTT DOCOMO] [21,Xiaomi]. The details should the S-SSB periodicity should be further study.

1.1.3.6 PSBCH Contents

PSBCH contents were discussed in [2,Huawei, HiSilicon] [4,MediaTek] [5,OPPO] [6,CATT] [8,ITRI] [14,Spreadtrum] [16,ZTE] [18,Sharp] [20,NTT DOCOMO] with the following parameters
Companies' proposals:

- TDD UL/DL configuration or SFI information should be included in PSBCH with reasonable overhead. [2,Huawei, HiSilicon] [5,OPPO] [6,CATT] [14,Spreadtrum] [18,Sharp] [20,NTT DOCOMO]
- InCoverage indicator can be carried in PSBCH-DMRS rather than PSBCH payload to avoid unnecessary decoding for priority group identification. [4,MediaTek] [14,Spreadtrum]
- The following PSBCH content should be considered in which a total 48 bits for the PSBCH content are supported. [2,Huawei, HiSilicon]

MasterInformationBlock-NR-V2X	**bits**	Notes
sl-Bandwidth	4	
tdd-ConfigSL	[10]	
directFrameNumber	10	
S-SSB time index	3	*L*_v2x=8
inCoverage	2	In coverage for eNB coverage or gNB coverage, or out of coverage
reserved	19	
Total	48	

Proposal 13: PSBCH for NR V2X should include SFI information with the following parameters FFS

- *DirectFrameNumber*
- *The location and bandwidth of the initial SL BWP*
- *Slot number information*
- *InCoverage Indicator*
- *S-SSB time index*

The payload size and the coding rate of PSBCH were discussed in [2,Huawei, HiSilicon] [4,MediaTek] [6,CATT] [22,Samsung] with the list of summary in the following,

Supporting Companies	The payload size of PSBCH	Rationale
[4,MediaTek] [6,CATT]	56 bits	NR V2X PSBCH channel coding can reuse the channel coding of NR PBCH, in order to reduce the standardization effort.
[2,Huawei, HiSilicon]	48 bits	See the above table
[22,Samsung]	Coding rate shall target for around 0.02 to 0.03.	NR V2X shall target for one-shot decoding of PSBCH.

Proposal 14: The payload size of NR V2X PSBCH is no more than 56 bits to reuse the channel coding of NR PBCH, which includes the following,

- ***Polar code***
- ***CRC length***
- ***Payload interleaver pattern***

1.1.3.7 Synchronization Procedures

Most companies proposed to have same priority of the gNB and eNB as the synchronization source [2,Huawei, HiSilicon] [3,vivo] [4,MediaTek] [6,CATT] [9,Intel] [25,HEPTA 7291]. There are proposals to have RSU and UE-in-platoon as a new type of synchronization sources [9,Intel] [13,Sequans]. Whether LTE UE as the NR V2X synchronization source were also discussed synchronization source with the summary in the table below,

Options	Supporting Companies	Rationale
Option 1: Supporting LTE UE as the NR V2X synchronization source	[6,CATT] [21,Xiaomi] [24,Nokia,Nokia Shanghai Bell]	) To expand the coverage range) Being beneficial on interference control) Use case is NR sidelink UE cannot receive any GNSS signals
Option 2: Do not supporting LTE UE as the NR V2X synchronization source	[4,MediaTek] [9,Intel] [20,NTT DOCOMO] [22,Samsung] [27,Ericsson]	) Mandate the inter-module tunnel between NR-V2X module and LTE-V2X module with high complexity and cost.) To reduce amount of work and standardization efforts) Don't find any practical use case

In [10,LG] [24,Nokia,Nokia Shanghai Bell], SLSS of a specific UE can have a higher priority in unicast and groupcast in the synchronization procedure.

A lot of companies discussed the issue of Priority and selection of the synchronization sources as follows,

) LTE V2X synchronization source selection mechanism can be a starting point for NR V2X. [3,vivo] [8,ITRI] [10,LG] [11,NEC] [22,Samsung] [23,ITL]

) Priority rules for sidelink sync source selection are based on type of original synchronization source / reference, number of hops and stationary of sync source. [2,Huawei, HiSilicon] [4,MediaTek] [9,Intel] [10,LG] [17,InterDigital] [20,NTT DOCOMO]

) Indication of the synchronization source type or number of hops through the S-SSB and/or PSBCH. [2,Huawei, HiSilicon] [20,NTT DOCOMO] [17,InterDigital]

Proposal 15: LTE V2X synchronization procedure and source selection priority could be reused for that of V2X procedure as in the following table as a starting point for the rule of NR V2X synchronization source selection.

GNSS-based synchronization	gNB/eNB-based synchronization

• P1: GNSS
• P2: the following UE/LTE UE has the same priority:
  • UE/LTE UE directly synchronized to GNSS
  • UE/LTE UE directly synchronized to gNB/eNB
• P3: the following UE/LTE UE has the same priority:
  • UE/LTE UE indirectly synchronized to GNSS
  • UE/LTE UE indirectly synchronized to gNB/eNB
• P4: the remaining UEs/LTE UEs have the lowest priority.
	• P1': UE/LTE UE directly synchronized to gNB/eNB
	• P2': UE/LTE UE indirectly synchronized to gNB/eNB
	• P3': GNSS
	• P4': UE/LTE UE directly synchronized to GNSS
	• P5': UE/LTE UE indirectly synchronized to GNSS
	• P6': the remaining UEs/LTE UEs have the lowest priority.

1.1.3.8 Resource Configuration for S-SSB transmission

There were discussions in time and frequency resource configuration or triggering for S-SSB transmission [2,Huawei, HiSilicon] [5,OPPO] [9,Intel] [16,ZTE] [23,ITL] [25,HEPTA 7291] [26,Convida Wireless] [27,Ericsson],.

- The same synchronization resource configuration as LTE-V2X can be applied to NR-V2X. [5,OPPO]
- S-SSB transmission can be network configured or UE triggered. [2,Huawei, HiSilicon] [9,Intel] [25,HEPTA 7291] [27,Ericsson]
- Both TDM and FDM for S-SSB transmissions from different source types can be considered. [9,Intel] [16,ZTE] [23,ITL]

1.1.3.9 Synchronization Enhancements

There were proposals on synchronization enhancement schemes [7,AT&T] [9,Intel] [10,LG] [19,Qualcomm] as follows,

- Local manager (scheduling UE) to broadcast a special SSB to identify itself to neighbour UEs.[7,AT&T]
- Non-SLSS based synchronization operation or Data-aided synchronization [9,Intel] [10,LG] [19,Qualcomm]
- Multi-cluster synchronization signal searching / tracking. A location based resource pool selection method. A method of utilizing FR1 timing to FR2 can be considered [10,LG]
- Reduced complexity synchronous-SLSS based synchronization enhancements [19,Qualcomm]

In RAN1 #94, the following agreements were made for synchronization:

Agreement for synchronization:

- NR V2X Sidelink Synchronization includes at least the following
  - Sidelink synchronization signal(s)
  - PSBCH
  - Sidelink synchronization sources and procedure(s)
    - Study potential synchronization sources –GNSS, gNB, eNB, UE, LTE UE
      - Note: this doesn't mean all of them are to be supported

In RAN1 #94bis, the following agreements were made for synchronization:

Agreement for synchronization:

- At least GNSS, gNB, NR UE, and eNB are supported as the synchronization source for NR V2X.
  - eNB as a synchronization source for NR V2X UEs supporting LTE Uu/PC5 or Uu only (no change to the eNB behaviour)
  - **Whether a source is supported is for further NR V2X UE capability consideration**

- NR V2X sidelink operation includes the following cases:
  - NR V2X sidelink is synchronized with LTE V2X sidelink
  - NR V2X sidelink synchronization procedure operates independently to the LTE V2X sidelink synchronization procedure
- The design of NR V2X sidelink synchronization signals and PSBCH uses NR SSB structure as the starting point with the following properties:
  - NR V2X synchronization signals include sidelink PSS (S-PSS) and sidelink SSS (S-SSS) and are structured with PSBCH in a block format (S-SSB)
- Periodic transmission of S-SSB in NR V2X is supported
  - **FFS: whether one/more S-SSB is transmitted in a period**
- **Working Assumption:** For the purpose of evaluation, the initial frequency error should be within ±[5] ppm with the assumption of uniform distribution [-5, 5] for NR V2X sidelink synchronization.
  - Note: This is the error of the local oscillator for the Tx and Rx with respect to the absolute carrier frequency.

In RAN1 #95, the following agreements were made for synchronization:

Agreement for synchronization:

- Confirm the working assumption that initial frequency error before synchronized to any synchronization source should be within ±5 ppm for the purpose of evaluation.

- S-SSB has the same numerology, which includes SCS and CP length, as that of control and data channels for a given carrier

- The transmission bandwidth for S-SSB is within the BW of the (pre)-configured SL-BWP.
  - FFS: The actual transmission BW for S-SSB and sync raster

- For evaluation of V2X S-SSB, the transmission bandwidth of S-SSB is in proportion to the SCS for the design of V2X S-SSB.
  - Alt1: 24 PRBs
  - Alt2: 20 PRBs
  - Other values are not precluded

- For the evaluation of S-PSS/S-SSS, the sequences and/or polynomials used in NR Uu PSS/SSS are used as the starting point of the NR V2X S-PSS/S-SSS design.
  - Others are not precluded.

- The aspects of synchronization sequence for NR V2X to be considered for the evaluation include,
  - The length of S-PSS and S-SSS sequences
  - If and how to distinguish from NR Uu PSS and SSS sequences
  - The number of NR SL-SSID targeted in the design of NR V2X S-PSS/S-SSS
    - Use cases of NR SL-SSID should be addressed

- Using the below table as a starting point for evaluation assumptions for sidelink synchronization LLS.
  - Detection probability of S-PSS/S-SSS
  - Decoding BLER of PSBCH
  - Check further offline regarding UE speeds (absolute vs. relative, including current channel model assumptions in the TR) → on Friday, confirmed to be relative speed and thus, the speeds in the table below need to be doubled
  - Discuss further offline payload size of PSBCH → to revisit in the next RAN1 meeting. Companies to report the assumed payload size of PSBCH in their evaluations

	Below 6GHz	Above 6GHz
Carrier Frequency	6 GHz	30 GHz
Channel Model	CDL channel models	
Subcarrier Spacing(s)	15, 30, 60 kHz	60, 120 kHz
SNR Range	> -6 dB	> -6 dB
UE Speed	3 km/h, 120 km/h (mandatory) 30km/h, 250 km/h (optional)	3 km/hr, 120 km/h (mandatory)
Interference model	Scenario 1: no interference Scenario 2: effect of interference includes in the model	Scenario 1: no interference
Initial Frequency Offset	TX: Uniform distribution within [-5, 5] ppm of nominal carrier frequency RX: Uniform distribution within [-5, 5] ppm of nominal carrier frequency	

Agreements:

- The study of NR V2X synchronization includes synchronization based on S-SSB
- The study also includes use of other sidelink signals/channels (e.g., other RSs in the SL, using PSSCH, using PSCCH, etc.) for the sidelink synchronization

In RAN1 #AH_1901, the following agreements were made for synchronization:

Agreement for synchronization:

R1-1901326 Summary of AI 7.2.4.1.3 NR V2X synchronization CATT

R1-1901377

Agreements**:**

- For NR SLSS, as the baseline:
  - The sequence type for S-PSS is the same type as the M-sequence used for NR-PSS
  - The sequence type for S-SSS is the same type as the Gold sequence for NR-SSS

Agreements:

- The frequency location for S-SSB is (pre-) configured
  - Note: it implies that there is no intended hypothses detection in frequency location of S-SSB performed by the UE for a carrier in a given band
  - Note: the potential frequency locations for the (pre-)configured frequency location may be restricted, up to RAN4

Further discussion offline to identify several potential options for SL-SSB in terms of combinations of # of RBs and # of symbols for S-PSS/S-SSS, for additional more focused evaluations

R1-1901448

Agreements**:**

- Combination 1:
  - Time domain: 2 symbol of length-127 S-PSS, 2 symbol of length-127 S-SSS
  - Frequency domain:11 or 12 RBs
  - BW containing S-SSB:
    - 2.5 MHz for 15 kHz SCS
    - 5 MHz for 30 kHz SCS
    - 10 MHz for 60 kHz SCS
    - 20 MHz for 120 kHz SCS
- Combination 2:

- Time domain: 2 symbol of length-127 S-PSS, 2 symbol of length-127 S-SSS
- Frequency domain: 20 RBs
- BW containing S-SSB:
  - 5 MHz for 15 kHz SCS
  - 10 MHz for 30 kHz SCS
  - 20 MHz for 60 kHz SCS
  - 40 MHz for 120 kHz SCS

- Combination 3:
  - Time domain: 1 symbol of length-127 S-PSS, 1 symbol of length-127 S-SSS
  - Frequency domain: 20 RBs
  - BW containing S-SSB:
    - 5 MHz for 15 kHz SCS
    - 10 MHz for 30 kHz SCS
    - 20 MHz for 60 kHz SCS
    - 40 MHz for 120 kHz SCS
- Combination 4:
  - Time domain: 1 symbol of length-255 S-PSS, 1 symbol of length-255 S-SSS
  - Frequency domain: 24 RBs
  - BW containing S-SSB:
    - 5 MHz for 15 kHz SCS
    - 10 MHz for 30 kHz SCS
    - 20 MHz for 60 kHz SCS
    - 40 MHz for 120 kHz SCS
- Other combinations are not precluded.
- Note: Company should specify the assumptions, such as total energy per SSB, when the performance results are compared between different combinations.

R1-1901414

Agreements**:**

- Design Target for NR S-PSS/S-SSS:
  - At least for 15 kHz SCS NR S-PSS/S-SSS, same or better coverage to that of LTE under the same Tx/Rx configuration
    - Coverage: measured in terms of coupling loss
      - MCL = P_Tx – (NF + N_floor + SINR)
        - N_floor = -174 +10 log (BW)
        - P_Tx = 23 dBm
        - NF = 9 dB
        - SINR = -6 dB for LTE as the reference
    - Companies to report detailed assumptions e.g. the detection method/probability/etc. for the target SINR

Agreements**:**

For the evaluation at next meeting, sequence length of S-PSS/S-SSS for all evaluated SCS is assumed the same as that of S-PSS/S-SSS with 15 kHz SCS

- Other sequence lengths are not precluded

Agreements:

- At least for single-carrier operation:
  - For the SL synchronization procedure, each type of synchronization reference has a respective sync priority
    - FFS the priority between eNB and gNB (if necessary)
  - For the SL synchronization procedure, among the available references, a UE selects the synchronization reference with the highest priority as the reference to derive its transmission timing
    - FFS other potential usage

- FFS how to handle the case when there are two or more references of a same priority to be selected as the highest priority

1.1.4 Resource Allocation

R1-1901375 Summary of Contributions and Initial Outcome of Offline Discussion for NR-V2X AI - 7.2.4.1.4 Resource Allocation Mechanism, Intel

1.1.4.1 Sidelink Resource Allocation Mode-2 and the Sub-Modes

Based on the outcome of the offline discussion the following proposal is suggested to be confirmed online.

Proposal for online discussion

- Mode-2 supports the sensing and resource (re)-selection procedures according to the definitions made at the previous meeting
- Notes:
  - sidelink measurements does not preclude the case of DMRS blind detection to determine DMRS ID
  - resource does not preclude pattern of resources
  - does not preclude procedures for assisting/scheduling of other UEs

1.1.4.1.1 Mode-2(a)

Majority of companies discuss sensing and resource selection mechanisms for Mode-2(a) operation. Different levels of design details are proposed, however all companies discuss necessity of sensing and resource selection for NR-V2X communication.

The Mode-2(a) is criticized in [Huawei], where concerns on latency, reliability and hidden node issues are raised. In [Kyocera] the resource reservation message transmission and its forwarding by other UEs is proposed. The work in [vivo] suggest dynamic reservation mechanism for aperiodic traffic on top of semi-persistent resource reservation for periodic one. The priority and resource allocation information is assumed to be included in SCI to identify occupied resources. In [MediaTek], it is proposed to support long-term and short term sensing methods, decoded resource allocation and resource reservation information in control channel. In addition, to alleviate IBE problem, it is proposed to use weighting function in resource selection procedure based on RSRP difference between UE and occupied resource. Paper [OPPO] proposes resource preemption/reservation for higher priority messages as well as short term sensing and resource selection with increased number of PSCCH transmissions. The preamble based dynamic resource allocation scheme is proposed in [CATT] on top of semi-persistent scheme (similar to LTE-V2X), although the details of preamble based design and information extracted from preamble based approach are not fully described. In [Sony], it is proposed that Mode-2(a) is designed based on LTE-V2X and at least time/frequency data resources, reservation information and packet priority information should be extracted from SCI decoding. Support of both long-term and short-term sensing is assumed with timescale FFS. The feedback (e.g. ACK/NACK, collision reports and reselection requests) are proposed to be considered in resource selection procedure as a conditions to trigger for resource reselection.

The use of joint long-term and short-term sensing for periodic and aperiodic traffic sharing the same pool is proposed in [Lenovo]. The work in [CMCC] elaborates on principle of using assistance information for Mode-2(a) operation. It is suggested that either gNB or TX UE configures measurement configuration to RX UE that is expected to conduct measurements and report them back to gNB/TX UE (e.g. recommended resource for selection, or RSRP/RSSI metrics on measured resources, etc.). In addition, the NACK based triggering of resource reselection is proposed. The long-term indicator for resource pool selection is proposed in [AT&T] to guide UE behavior on pool selection. The work in [Intel] provides evaluation of different resource allocation schemes aiming to optimize system performance for periodic and aperiodic traffic. Analysis has shown that performance of LTE-V2X solution based on long-term sensing can be improved for aperiodic traffic if the short term sensing component is added and RSSI averaging is removed jointly with prioritization of early in time

candidate resources for transmission. It was also shown that performance is sensitive to amount of control channels allocated and number of decoding attempts performed by UE.

The work in [Panasonic] discusses SFCI is used for the sensing procedure of PSCCH/PSSCH and concludes that PSFCH's resource is associated with PSCCH/PSSCH and is not based on sensing. In addition, approaches for coexistence of periodic and aperiodic traffic and corresponding resource allocation schemes are discussed. The work in [LGE] proposes sensing based on PSCCH decoding and sidelink measurements as well as support of multi-slot transmissions. It is also proposed that latency determines duration of resource selection window. In addition, UE assistance information is discussed where either UE restricts the resource pool of another UE or UE sends assistance information to be taken into account by recipient UE.

Type B: There is no hierarchy between UEs. A UE sends assistance information to another UE, and the receiving UE could refer to this information in its resource allocation. Support of zone based principle for resource allocation, congestion control is proposed. Study of preemption mechanisms as well as adaptive retransmission number is proposed. The support of LTE Mode-4 for periodic traffic is proposed in [NEC]. The SCI decoding provides resource reservation information with the following four cases discussed:

- Case 1: resources reserved semi-statically;
- Case 2: resources reserved for retransmission of a TB;
- Case 3: resources reserved dynamically for initial transmission of a TB in upcoming slot;
- Case 4: resources reserved dynamically for initial transmission of a TB in the same slot.

The scheme described in [Apple,] is based on LBT procedure and proposes additional stage of collision detection based on listening after talk (LAAT) principle, where transmitting UE performs additional LBT, if collision is detected during LAAT. To support LAAT, NR V2X utilizes the slot format that allows Tx/Rx switching within a slot.

In [Interdigital], the LBT-based resource allocation scheme for Mode 2a based on the following principles is proposed: 1) Subchannel-based LBT sensing, different transmission start times within a slot are (pre)-configured based on priority and CBR, 3) backoff is used to avoid collisions between UEs performing resource selection simultaneously, 4) SCI of the initial transmission is used to reserve resource for the retransmissions. The transmission of forward booking reservation is proposed, where multiple forward booking transmission are possible and independent procedure used to select resource for forward booking transmission.

The SCI decoding based scheme is proposed for Mode-2(a) in [ZTE] where indication of SPS period and time interval b/w SCI and reserved resources is assumed for periodic and aperiodic traffic respectively.

Contribution in [Qualcomm] suggests dynamic resource selection for each TB transmission, sub-channelization for resource pool. In addition, slot aggregation is proposed with the indication of the number of aggregated slots in control channel transmission. Resources for retransmission are reserved during initial and subsequent transmission of a given TB and UE is expected to monitor ACK/NACK signaling from target receivers. Finally, the control channel based exclusion taking into account distance based criteria and counter based channel access mechanism is proposed.

The support of Mode-2(a) sensing and resource selection is proposed in [Asustekwhere it is additionally pointed out that UE needs to acquire resource(s) for sidelink retransmission based on HARQ feedback and that resource sensing and selection on PSFCH is needed in case of flexible timing relationship b/w PSSCH and PSFCH. In [Xiaom], for support of Mode 2(a), the assistance from RX side on collision avoidance and high interference indication is proposed, at least for unicast/groupcast. The Mode-2(a) based on 2-step resource selection is also proposed in [Samsung]. The work in [Nokia] suggests that Mode 2(a) inherits functionalities of LTE V2X mode 4 to serve periodic traffic efficiently, including support of SCI format for resource reservation to assist resource allocation in case of periodic and aperiodic traffic. The long-term and short-term sensing is assumed to operate all the time to handle periodic and aperiodic traffic. The support of short-term and long-term sensing based on measurements and SCI decoding is also proposed in [HEPTA 7291], [Convida Wireless], including UE assistance in the form of sharing sensing information.

Finally, the paper [Ericsson] proposes to support Mode-2(a) together with short term reservation signals as a baseline including long term reservation principles. It is also proposed to use a single resource allocation procedure for unicast, groupcast and broadcast as well as support pre-emption mechanisms. It was observed that reservation-based resource allocation outperforms other schemes in terms of PRR for broadcast and unicast communication in both highway and urban deployments.

Based on analysis of contributions, the following proposals can be made as a starting point to trigger discussion on Mode-2(a):

List of proposals for discussion

- NR V2X supports Mode-2(a)

- Mode-2(a) sensing procedure utilizes SCI decoding from other UEs to extract information on sidelink resources used by other UEs
  - FFS for PSFCH/SFCI
  - FFS other sidelink transmission parameters: priority, QoS attributes, etc.

Mode-2(a) sensing procedure utilizes SL-RSRP measurements from sidelink transmission / UE
- FFS SL-RSSI measurements
- FFS for which sidelink channels the SL-RSRP is defined (i.e. PSCCH, PSSCH, PSFCH)

Mode-2(a) sensing and resource selection windows are defined to describe Mode-2(a) operation
- The resource selection window is bounded by packet delay budget
- FFS definition of sensing and resource selection windows

Mode-2(a) resource selection or reselection procedure is used to determine resources for sidelink transmission once the resource (re)-selection is triggered and includes
- Resource exclusion based on control channel processing and SL-RSRP measurements
  - FFS if distance-based control exclusion is supported by NR V2X
  - FFS whether and how QoS attributes (e.g. priority, reliability, latency) are taken into account
- Construction of a candidate resource set(s) for sidelink PSCCH and PSSCH transmission within resource selection window
- Selection of a resource for at least sidelink PSCCH and PSSCH transmission from the candidate resources set
  - FFS scheme for actual resource selection from the candidate resource set (e.g. backoff / counter based or any other randomization mechanism)
- FFS whether and how UE location information is taken into account in Mode-2(a) resource selection procedure

Mode-2(a), supports the following schemes for resource selection
- Semi-persistent scheme: resource(s) are selected for multiple transmissions of different TBs
- Dynamic scheme: resource(s) are selected for each TB transmission

Mode-2(a), supports reservation of resources for initial transmission and retransmission of a given TB indicated by SCI
- FFS details, e.g. whether UE reselecting resources monitors PSFCH to detect ACK/NACK transmission or any other mechanism is used to take into account resources for retransmission in resource selection procedure

Mode-2(a) supports resource reservation signaling on top of scheduling assignments
- FFS details (standalone SCI transmission, integrated to SCI transmission, etc.)

The following alternatives are studied with respect to Mode-2(a) PSFCH transmission:
- Alt.1: PSFCH resource is selected and indicated by transmitting UE
- Alt.2: PSFCH resource is selected by target receiver UE

- Alt.3: PSFCH resource is associated with PSCCH/PSSCH resource used by transmitting UE

RAN1 to further study benefits of assistance data from target receiver UE and whether and how UE reselecting resource takes it into account
- PSFCH feedback from target receiver(s)
- Sensing results from target receiver(s)
- Resource restriction or resource recommendation information from target receiver(s)
- Location of target receiver(s)
- Other options are not precluded

1.1.4.1.2 Mode-2(c)

The extensive discussion and evaluation of Mode-2(c) is provided in [Huawei] where it is shown that non-sensing-based pattern selection for Mode-2(c) outperforms Mode-2(a), while opposite evaluation results were observed in [Qualcomm], [Intel], [LG Electronics], where random pattern selection was analyzed. In addition, evaluation of Mode-2(c) was provided in [Ericsson], [Samsung] with a conclusion that its performance is worse than Mode-2(a). The work in [Huawei] further suggested that "sensing and resource selection procedures of Mode-2(a) should be studied in a way which can also be used for the other sub-modes in Mode-2".

The similar framework on frequency-time resource pattern design that aims to minimize half-duplex problem for Mode-2(c) was also proposed in [Fujitsu]. The scheme based on UE geographical location information is utilized for pattern selection. Evaluation results show that proposed scheme outperforms Mode-(2a) based on step 1~9 with full sensing configuration (section 14.1.1.6 of TS 36.213 LTE-V2X).

In [vivo], multiple questions on Mode-2(c) were raised including: how to define and select the resource pattern, how to change the pattern and how to support coexistence of UEs having different pattern structures. In [Mediate] kit is observed that benefit of Mode-2(c) is not clear and that it can be regarded as Mode-2(a) with preconfigured resource pools. It is concluded that more evaluations are needed to justify the benefit. The paper [CATT] argues that sub-mode 2(c) cannot achieve the gain of latency reduction, there are no obvious gain for in-coverage case and that collision avoidance and flexibility of resource utilization would be difficult to be achieved for out-of-coverage case. The work in [Sony], asks for further clarification on benefits of Mode-2(c) resource allocation. The system level evaluation and comparison b/w sensing based Mode-2(a) and Mode-2(c) with random pattern assignment was done in [Intel,] and [Qualcomm], where significant gap with respect to Mode-2(a) is observed. The contribution [LGE] states that Mode-2(c) is not preferred considering that sidelink transmission pattern management is not clear at least in terms of handling aperiodic traffic with time-varying packet size. In [NEC], it is proposed to support Mode-2(c) as one option of Mode 1 for resource allocation of periodic traffic or control channel. The work in [Spreadtrum] suggests to support random selection as a baseline and further study other options including LBT. The discussion in [ZTE] outlines that advantages of using TFRP for Mode-2(c) are not confirmed.

Paper [NTT DOCOMO], suggests to further study resource allocation pattern definition and pattern selection mechanism for Mode-2(c), with respect to the following aspects: collision avoidance b/w UEs selecting the same pattern, and how to adapt pattern to traffic attributes (different packet sizes). In [Samsung], it is debated whether introduction of Mode-2(c), in addition to Mode -2(a), can be justified to obtain potential gain under certain scenario. Finally, in [Ericsson], it is argued that Mode 2(c) is better suited for operation under network coverage. In this respect, the difference between Mode 2-(c) and Mode-1 is blurry. Other contributions do not have specific proposals for Mode-2(c) support.

Based on summary of submitted contributions that discuss Mode-2(c), it seems there is no converged view on benefits of Mode-2(c) support over Mode-2(a) and Mode-1. Many companies have raised technical questions on Mode-2(c) support and asked for further clarification. Based on analysis of contributions, the following proposals can be made as a starting point to trigger discussion on Mode-2(a):
The following proposal below was discussed during RAN1 WG offline discussion

List of proposals for discussion
The following design options of Mode-2(c) transmission pattern selection are FFS

- Option 1: Random pattern selection (UE randomly picks pattern from the pre-configured pool of patterns)
- Option 2: Pattern selection is based on UE geographical location information
- Option 3: Sensing based pattern selection (e.g. UE selects unused pattern based on sensing results)

The following outcome of the offline discussion was reached:

Proposal for online discussion

The following design option of Mode-2(c) transmission pattern selection is proposed

- Sensing based pattern selection (e.g. UE selects unused pattern based on sensing results)
  - ❖ UE geographical location information can be used to assist pattern selection

List of proposals for discussion

The following aspects are further studied for Mode-2(c)

- Relationship between traffic attributes and resource pattern
- Number of patterns to be configured for UE communication in out of coverage communication scenario
- Procedure for UE pattern (re)-selection, if any in out of coverage scenario
- Applicability / benefits for in-coverage, when Mode-1 is also available
- Handling of mixed scenarios with various requirements on packet latency, reliability, aperiodic packet arrival time and variable packet size
- Control of channel access priority of sidelink transmission in out of coverage scenario

RAN1 to discuss and select among the following three options on Mode-2(c) support

- Option 1: Support Mode-2(c) as a distinct mode with sensing procedures
- Option 2: Do not support Mode-2(c) as a standalone mode for sidelink communication
  - ❖ FFS whether to apply patterns as a resource signaling approach in Mode-2(a)
- Option 3: Continue study benefits on Mode-2(c) including differentiating factors with respect to Mode-1 and Mode-2(a) with preconfigured sidelink resource pool

1.1.4.1.3 Mode-2(d)

The views on support of Mode-2(d) are quite diverse and range from the "support" to "do not support". The Mode-2(d) centric discussions are provided in [AT&T], [NTT DOCOMO,], [MediaTek], [Fraunhofer].

Mode-2(d) Centric Papers

In [AT&T] it is argued that Mode-2(d) can be supported w/o any architecture change when scheduling UE is appointed by network and that there is no need for full connection establishment. It is assumed that scheduling UE needs to periodically monitor the usage of the assigned resource and associated UE needs to monitor the broadcast channel from scheduling UE. The PSCCH can carry information for transmission (SCI-T) / reception (SCI-R). The inter-group interference coordination is expected to be managed by the network through assigning orthogonal or overlapped resource to different scheduling UEs. In addition it is proposed to allow network to supervise the scheduling UEs based on UE report including dynamic or semi-persistent resource allocation between gNBs and scheduling UEs. The main use case is an efficient management of sidelink resources at high frequency.

In [NTT DOCOMO] it is argued that Mode-2(d) is applicable to general eV2X use cases and is considered as a standalone resource allocation mode. It is assumed, that for platooning use case, scheduling UE selection as well as association to scheduling UE is determined by application layer. Contribution proposes to study feasibility of self-nomination-based determination of scheduling UE as well as configuration of scheduling UE by eNB/gNB and higher layer signaling. Scheduling UE discovery procedure based on SL-SSB transmission is proposed. In addition, radio-layer procedure for association to scheduling UE is suggested with technical details open for further studies. Support of resource set selection mechanism per scheduling UE (FFS if it is sensing based) as well as scheduling request/grant procedures is proposed. Contribution provides evaluation results demonstrating that Mode-2(d) outperforms LTE Mode-4up to 5% and 10% in urban and freeway scenario for periodic traffic; and random resource selection up to 15% and 20% for aperiodic traffic.

In [MediaTek], it is argued that Mode-2(d) can be useful in case of high system loading and the switching b/w Mode-2(a) and Mode-2(d) based on channel occupancy ratio is proposed. The contribution proposes details of multiple procedures for Mode-2(d) support: resource scheduling in Mode-2(d), selection of scheduling UE, joining a cluster, leaving a cluster, scheduler UE handover the right to become a member, UE handover to another cluster, scheduler UE disappears, cluster dissolution. It is assumed that scheduling UE can use location or velocity information from other UEs to form a group and concluded that Mode-2 (d) should be supported in NR V2X.

In [Fraunhofer], the Mode-2(d) is discussed in the context of groupcast communication targeting platooning use case. Contribution proposes to use sensing as a feature that can be employed across the Mode 2 sub-modes. In terms of resource allocation, it is assumed that the subset of resources is assigned for a particular group of UEs and group leader (GL) allocates subset of resources as well as resources within a subset to group members. Group leader UE is expected to determine resources for group through collection of sensing reports from group members and advanced sensing and announcement procedures. Contribution also discusses two options for resource allocation within a group: 1) assigned by group leader 2) based on sensing within a subset of group resources announced by group leader. The description is provided at the conceptual level and proposes to study multiple design aspects without support by evaluation.

Papers favoring Mode-2(d) support

Additional paper favouring support of Mode-2(d) can be found in [TOYOTA], [CATT], [Sony] , [Spreadtrum], [Interdigital]. The contribution [TOYOTA] proposes the vehicular micro clouds which are tied to a certain geographical area and used to assist forming and managing a group of vehicles. The principle is similar to zoning introduced in LTE R14 but aims to support Mode-2(d) within a zone and targets scenarios with high congestion. Paper in [CATT] considers support of Mode-2(d) for unicast and groupcast communication. It proposes steps for scheduling UE determination, scheduling request, orthogonal in time resource allocation and new SCI format for scheduling. Work in [Sony] suggests the following options for scheduling UE determination: configuration by gNB or application layer or pre-configuration. The determination of a set of sidelink resources for scheduling is either based on sensing procedure by scheduling UE or configured by gNB if scheduling UE is in-coverage. Physical layer signalling for transmission/reception scheduling of other UEs is assumed once association with scheduling UE is established. Mode-2(a)(c) is used before association. The paper [Spreadtrum] proposes to use dedicated resource pool for Mode-2(d) which can be (pre)configured or informed to the group member UEs through PC5 RRC. Finally work in [InterDigital] it is proposed that selection of Mode-2(a) or Mode-2(d) depends on the traffic type (unicast/groupcast Mode-2(d) and Mode-2(a) possible for all traffic types). Higher layers determine whether mode 2d should be used for transmissions within a specific group and selects the scheduling UE for the group. The scheduling UE uses sensing to determine resources used for mode 2d transmission, within the resource pool used also by Mode-2(a) and supports both dynamic and semi-persistent resource allocation schemes and SCI signaling to determine resources reserved by scheduling UE.

Papers questioning benefits of Mode-2(d) support or restricting it operation

In [vivo] multiple challenges to support Mode-2(d) were discussed assuming selection of scheduling UE is up to application layer. The following challenges were highlighted: how to ensure the security for the election of scheduling UE and how to transmit the reported information without a significant increase in overhead. As an alternative scheduling by RX UE is mentioned. The work in [OPPO] states that much of functionalities of Mode-2(d) initialization are upper layers procedures and their outcomes or decisions should be indicated to L1. It is observed the degree of scheduling within a unicast or a groupcast session should be at the coordination level quasi-statically to avoid heavy signaling overhead. The next paper [NEC, Nokia], considers Mode-2(d) support only for platooning use case and proposes that scheduling UE should be configured by gNB, or selected by application layer. Regarding the set of resources used by scheduling UE, it is proposed to be semi-statically configured or pre-configured.

In [ZTE], it is stated that introduction of Mode-2(d) will increase complexity of sidelink protocol but may not offer a reasonable performance advantage. At the same time, it is noticed that it may cause extra signaling overhead and the reports, interference among groups. Another set of issues, which are mentioned in [LGE] include latency and signaling overhead (e.g., caused by exchanging messages such as SR, BSR, grant) as well as the resultant half-duplex problem. Difficulty in avoiding resource collision among UEs scheduled by

different scheduling UEs (e.g., high interference from neighboring UE's transmission can appear in the scheduled resource when the neighboring UE is outside of the group controlled by the scheduling UE).

In [Ericsson based on analysis and evaluation it is stated that "mode 2d is not specified". Evaluation results show that sub-mode 2d has worse performance than sub-modes 2a or 2c. In addition, multiple practical challenges and technical disadvantages in application to NR V2X use cases are discussed.

Finally, in [Intel] the following RAN2 WG agreement is referred "No AS-level mechanism to determine a group manager (i.e. head UE) is stuided. FFS for platooning, on the visibility of a group manager (head UE) to AS and AS-level functionalities." Based on this agreement it was proposed that the following identified by RAN1 WG potential procedures are outside of the radio-layer scope:

- Initialization of Mode-2(d)
- Procedures to become/serve as a scheduling UE
- UE behavior to (re)-select scheduling UE(s)
- UE behavior to associate to scheduling UE(s)
- Setting relationship between scheduling UE and UE groups from upper layer perspective
- Procedures to activate/switch to Mode-2(d) operation

Based on the overview of the submitted contributions, the following observations can be made:

- Mode-2(d) is not applicable to all scenarios and eV2X use cases
- Mode-2(d) requires support of Mode-2(a)/(c) and can be viewed as additional functionality on top
- Mode-2(d) requires extra signaling overhead comparing to Mode-2(a)
- Mode-2(d) may require definition of multiple radio-layer procedures without significant incremental gains with respect to Mode-2(a), if any.
- There are different motivations behind support of Mode-2(d) among proponents:
  - Management of resources mainly targeting efficient sidelink communication in FR2
  - Mode-2(a) / Mode-2(d) adaptation to better support high system loading conditions/congestion
  - Management of resources within a group to improve overall sidelink resource allocation framework
  - Beneficial for general V2X use cases
- RAN2 made the following agreement: "No AS-level mechanism to determine a group manager (i.e. head UE) is stuided. FFS for platooning, on the visibility of a group manager (head UE) to AS and AS-level functionalities." This agreement automatically rules out multiple potential radio-layer procedures identified by RAN1 at the previous WG meeting. Whether group leader is visible to AS for platooning use cases is subject to ongoing e-mail discussion in RAN2 WG.

Based on review of submitted contributions the following proposals can be used as a starting point to facilitate further RAN1 WG discussion:

List of proposals for discussion

RAN1 assumes that Mode-2(d), if it is supported, is defined on top of Mode-2(a) / (c) functionality

---------- Procedures proposed to be out of RAN1 scope ----------

- RAN1 assumes that at least the following potential procedures (identified at RAN1#95) are outside of radio-layer scope for NR-V2X communication design
  - Procedures to become/serve as a scheduling UE for in-coverage and out-of-coverage scenarios
    - The following options are identified for further study:
      - Scheduling UE is configured by gNB
      - Application layer or pre-configuration selects scheduling UE
      - Receiver UE schedules transmissions of the transmitter UE during the session
      - Scheduling UE is decided by multiple UEs including the one that is finally selected
        - UE may autonomously decide to serve as a scheduling UE (self-nomination) / offer scheduling UE functions
  - UE behavior to (re)-select scheduling UE(s)
  - UE behavior to associate to scheduling UE(s)

- UE behavior when scheduling UE stop scheduling
- Relationship between scheduling UE and UE groups from upper layer perspective
  - Whether UEs from the same upper layer group are served by the same scheduling UE

---------- Procedures that may have impact on RAN1 scope ----------

- RAN1 assumes that at least the following potential procedures (identified at RAN1#95) may have impact on radio-layer design for NR-V2X communication
  - Procedure to determine a set of sidelink resources a scheduling UE can use for scheduling of other UEs
    - The following options are identified:
      - Based on sensing procedure by scheduling UE
      - Configured by gNB if scheduling UE is in-coverage
      - Pre-configured if scheduling UE is out of coverage
      - Transmitting UE provides information about sidelink resources to scheduling UE
  - Behavior of scheduling UE to signal scheduling decisions for transmission/reception of other UEs
    - The following options are identified:
      - Physical layer signaling
      - Higher layer signaling
  - Resource management to address collision/interference and half-duplex issues b/w UEs scheduled by different scheduling UEs
  - Resources used for communication before UE is associated with a scheduling UE
  - Procedures to switch between Mode-2(d) from/to other sub-modes
  - FFS behavior/algorithm of scheduling UE

---------- Further work on procedures that may have impact on RAN1 ----------

- Considering ongoing RAN1 discussion on visibility of group leader UE (head UE) to AS RAN1 need to discuss and decide b/w the following two options
  - Option 1: Continue work on procedures where potential RAN1 impact is identified and reconsider those later taking into account future RAN2 progress
  - Option 2: Wait for RAN2 decision on visibility of group leader UE to AS

- Discuss and select among the following options for procedure to determine a set of sidelink resources a scheduling UE can use for scheduling of other UEs RAN1 is to select among the following options
  - Option 1: Based on sensing procedure by scheduling UE
  - Option 2: Configured by gNB if scheduling UE is in-coverage
  - Option 3: Pre-configured if scheduling UE is out of coverage
  - Option 4: Transmitting UE provides information about sidelink resources to scheduling UE

- Discuss and select among the following options for behavior of scheduling UE to signal scheduling decisions for transmission/reception of other UEs UEs RAN1 is to
  - Option 1: Physical layer signaling
  - Option 2: Higher layer signaling
  - Option 3: Both physical and higher layer signaling

- Regarding resource management to address collision/interference and half-duplex issues b/w UEs scheduled by different scheduling UEs
  - RAN1 is to continue discussion on this aspect

- Regarding resources used for communication before UE is associated with a scheduling UE
  - Conclude that Mode-2(a)/(c) resources are used in this scenario

- Discuss and select among the following options for procedures to switch between Mode-2(d) from/to other sub-modes:

- Option 1: Discuss switching mechanism after determination of basic solution for each resource allocation mode
- Option 2: Up to higher layer (outside of AS) to control mode of UE operation
- Option 3: Switching between Mode-2(a)/(c) and Mode-2(d) depends on channel occupancy ratio or traffic load
- Option 4: Switching between Mode-2(a)/(c) and Mode-2(d) depends on establishment of association with scheduling UE

- Regarding behavior/algorithm of scheduling UE, RAN1 to select b/w options
  - Option 1: RAN1 to continue discussion on which aspects of scheduling UE behavior/algorithm need to be standardized
  - Option 2: RAN1 assumes that no scheduling UE behavior/algorithm is to be standardized at radio-layers for Mode-2(d)

- RAN1 is to continue analysis on the relative gains and performance / complexity tradeoffs with respect to other Mode-2 sub-modes: Mode-2(a) and Mode-2(c)

1.1.4.1.4 Sidelink Resource Configuration and Resource Pools

Companies also discuss sub-channelization of sidelink resource pools and multi-slot transmission (slot aggregation) within sidelink resource pool. In addition some companies mention association of resource pools with traffic types (periodic, aperiodic) or communication types (unicast, groupcast, broadcast). Finally, resource pool attributes such as numerology/SCS, QoS, etc. were mentioned in selected contributions.

List of proposals for discussion

- Sub-channelization of sidelink resource pool is supported
  - Sub-channel is the minimum resource allocation granularity in frequency for sidelink PSSCH transmission
- Sidelink transmission of a given TB can be rate-matched across resource allocation spanning multiple slots
- FFS details of sidelink resource pool configurations including the following aspects:
  - Configuration details for PSCCH/PSSCH resource(s) for sidelink resource allocation Mode-1 and Mode-2
  - Amount of sidelink resource pools
  - On demand allocation of sidelink resource pool
  - Whether dedicated pools can be allocated for sidelink unicast/groupcast/broadcast communication types
  - Whether dedicated pools can be allocated for given traffic type or QoS attribute (e.g. periodic/aperiodic, low latency)

1.1.4.1.3 Other Aspects

Other aspects mentioned in contributions are:

- Multi-slot scheduling for large packets [vivo]
- Cross-slot scheduling [vivo]
- IBE in resource selection – weighting function based on RSRP [MediaTek]
- Multiple PSCCH transmissions are associated with PSSCH [OPPO]
- Feedback as a trigger to reselect resources [Sony]
- Assistance information and sharing of sensing information [CMCC, Convida Wireless, HEPTA 7291]
- Pool selection criteria [AT&T]
- Dedicated resource pools for periodic and aperiodic traffics [ITRI, Panasonic]
- SFCI for sensing + association of PSCCH/PSSCH and PSFCH resources [Panasonic]
- Impact of distributed antenna on resource allocation [LGE]
- Adaptation of the reporting and CDRX configuration based on UE speed [Apple]
- Mode-1 / Mode-2 resource pool sharing [Intel]

In RAN1 #94, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

- At least two sidelink resource allocation modes are defined for NR-V2X sidelink communication
  - Mode 1: Base station schedules sidelink resource(s) to be used by UE for sidelink transmission(s)
  - Mode 2: UE determines (i.e. base station does not schedule) sidelink transmission resource(s) within sidelink resources configured by base station/network or pre-configured sidelink resources
- Note:
  - eNB control of NR sidelink and gNB control of LTE sidelink resources will be separately considered in corresponding agenda items.
  - Mode-2 definition covers potential sidelink radio-layer functionality or resource allocation sub-modes (subject to further refinement including merging of some or all of them) where
    - a) UE autonomously selects sidelink resource for transmission
    - b) UE assists sidelink resource selection for other UE(s)
    - c) UE is configured with NR configured grant (type-1 like) for sidelink transmission
    - d) UE schedules sidelink transmissions of other UEs
- RAN1 to continue study details of resource allocation modes for NR-V2X sidelink communication

In RAN1 #94bis, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

- Sidelink sensing and resource selection procedures are studied for Mode-2(a)
  - The following techniques are studied to identify occupied sidelink resources
    - decoding of sidelink control channel transmissions
    - sidelink measurements
    - detection of sidelink transmissions
    - other options are not precluded, including combination of the above options
  - The following aspects are studied for sidelink resource selection
    - how a UE selects resource for PSCCH and PSSCH transmission (or other sidelink physical channel/signal, if it is introduced)
    - which information is used by UE for resource selection procedure
- The following aspects about assistance information are studied for Mode 2(b)
  - Which assistance information is used and how it is acquired
  - Which UE sends assistance information
  - How to deliver assistance information, including physical channel and UE behavior
  - How assistance information is taken into account in determination of sidelink resource for transmission
- RAN1 to further study whether some or all of Mode-2(b) functionality is a part of Mode-2(a)(c)(d)
- The following aspects are studied for Mode 2(c)
  - How to assign resource(s) for UE sidelink transmission to mitigate collisions and half-duplex impacts
  - Whether any sensing or resource selection procedure is used on top of configured grant(s)
  - Whether and how to use any granted but unused resources
  - How to adapt to traffic variation
  - How it is different from Mode-1 operation for in-coverage scenario
  - How it is different from Mode-2(a), when Mode-2(a) uses dedicated resource pool with dedicated sidelink resource pool configuration
  - Whether and how this mode operates out of network coverage
- RAN1 to further study whether some or all of Mode-2(c) functionality is a part of Mode-2(a)(b)(d)
- The following aspects are studied for Mode 2(d)
  - In which use cases/scenarios this mode is applicable
  - What is the overall architecture for Mode-2(d) operation

- How to decide which UE schedules which other UE(s) and how to maintain this relationship
- What is the procedure of UE(s) when the scheduling UE disappears
- What is the scheduling UE behavior and signaling mechanism to schedule sidelink resources for transmission/reception for other UEs
- Which resources can be used to schedule other UEs
- Inter- and intra-UE collision handling and sidelink resource allocation mechanisms across groups

- RAN1 to further study whether or not some or all of the above aspects are applicable to 2(b)

In RAN1 #95, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

- Sensing procedure is defined as SCI decoding from other UEs and/or sidelink measurements
  - FFS information extracted from SCI decoding
  - FFS sidelink measurements used
  - FFS UE behavior and timescale of sensing procedure
  - Note: It is up to further discussion whether SFCI is to be used in sensing procedure
  - Note: Sensing procedure can be discussed in the context of other modes
- Resource (re)-selection procedure uses results of sensing procedure to determine resource(s) for sidelink transmission
  - FFS timescale and conditions for resource selection or re-selection
  - FFS resource selection / re-selection details for PSCCH and PSSCH transmissions
  - FFS details for PSFCH (e.g. whether resource (re)-selection procedure based on sensing is used or there is a dependency/association b/w PSCCH/PSSCH and PSFCH resource)
  - FFS impact of sidelink QoS attributes on resource selection / re-selection procedure
- For Mode-2(a), the following schemes for resource selection are evaluated, including
  - Semi-persistent scheme: resource(s) are selected for multiple transmissions of different TBs
  - Dynamic scheme: resource(s) are selected for each TB transmission

- Mode-2(b) to be studied as a functionality that can be a part of Mode-2(a)(c)(d) operation, when one UE assists sidelink resource selection for other UE(s)
- Note: Mode-2(b) is not supported/studied as a standalone sidelink resource allocation mode
- For out of coverage operation, Mode-2(c) assumes (pre)-configuration of single or multiple sidelink transmission patterns (patterns are defined on each sidelink resource pool).
- For in-coverage operation, Mode-2(c) assumes that gNB configuration indicates single or multiple sidelink transmission patterns (patterns are defined on each sidelink resource pool)
- FFS pattern design in time and frequency for periodic and aperiodic traffic
- If single pattern is configured to transmitting UE there is no sensing procedure executed by UE
- If multiple patterns are configured to transmitting UE there is a possibility of sensing procedure executed by UE
- Pattern is defined as follows
  - Size of the resource in time and frequency
  - Position(s) of the resource in time and frequency
  - Number of resources
- FFS pattern selection procedure by UE

- For Mode-2(d) operation, further study the following potential radio-layer procedures including at least the following
  - Procedures to become/serve as a scheduling UE for in-coverage and out-of-coverage scenarios
    - The following options are identified for further study:
      - Scheduling UE is configured by gNB
      - Application layer or pre-configuration selects scheduling UE

- Receiver UE schedules transmissions of the transmitter UE during the session
- Scheduling UE is decided by multiple UEs including the one that is finally selected
  - UE may autonomously decide to serve as a scheduling UE (self-nomination) / offer scheduling UE functions

- Initialization of Mode-2(d) operation is FFS
- For Mode-2(d) operation, further study the following potential radio-layer procedures including at least the following
  - Procedure to determine a set of sidelink resources a scheduling UE can use for scheduling of other UEs
    - The following options are identified:
      - Based on sensing procedure by scheduling UE
      - Configured by gNB if scheduling UE is in-coverage
      - Pre-configured if scheduling UE is out of coverage
      - Transmitting UE provides information about sidelink resources to scheduling UE
  - FFS behavior/algorithm of scheduling UE
  - Behavior of scheduling UE to signal scheduling decisions for transmission/reception of other UEs
    - The following options are identified:
      - Physical layer signaling
      - Higher layer signaling
  - UE behavior to (re)-select scheduling UE(s)
  - UE behavior to associate to scheduling UE(s)
  - UE behavior when scheduling UE stop scheduling
  - Resource management to address collision/interference and half-duplex issues b/w UEs scheduled by different scheduling UEs
  - Relationship between scheduling UE and UE groups from upper layer perspective
    - Whether UEs from the same upper layer group are served by the same scheduling UE
  - Resources used for communication before UE is associated with a scheduling UE
  - Procedures to switch between Mode-2(d) from/to other submodes

In RAN1 #AH_1901, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

R1-1901375

Agreements:

Mode-2 supports the sensing and resource (re)-selection procedures according to the previously agreed definitions.

- FFS resource granularity for sensing & resource (re)-selection, e.g., PRB(s), slots, resource patterns (when applicable), etc.
- FFS detailed conditions when these procedures can apply

Agreements:

- For the purpose of performance evaluation for Mode-2(c), the following Mode-2(c) transmission pattern selection is used when a UE is configured with a pool of patterns:
  - Sensing based pattern selection (e.g. UE selects unused pattern based on sensing results)
    - Additional information to assist pattern selection is not precluded, e.g., by using UE geographical location information

Agreements:

- Sub-channel based resource allocation is supported for PSSCH
  - FFS details for sub-channels

- FFS other use cases for sub-channel (e.g., measurement, interaction with PSCCH, etc.)

R1-1901462

Agreements**:**

- SCI decoding applied during sensing procedure provides at least information on sidelink resources indicated by the UE transmitting the SCI

Agreements:

At least for the purpose of evaluation, in Mode-2(d), at least for group operation, a member UE transmits on resources configured by another UE (S-UE) within the same group

- High layer signaling is assumed between S-UE and a member UE

1.2 Evaluation of Uu for advanced V2X use cases

No additions included

A couple of contributions discuss the issue of identifying which of the multiple CGs a specific signalling refers to:

- R1-1900027 (Huawei, HiSilicon) proposes that each CG configuration has its own set of higher layer parameters and that a resource index (L2 signalling for Type-1 CG and L1 signalling for Type-2 CG) is included to identify the CG.
- R1-1900485 (Intel) proposes to have multiple RRC configurations of CG per BWP and use a DCI field to identify CGs.

However, given the following existing agreements, it is not clear what else is needed:

Agreements**:**

- For Uu for advanced V2X use cases, NR supports having multiple active UL configured grants in a given BWP in a given cell.
  - Details FFS

Agreements:

- DCI is used to identify the type-2 UL configured grant to be activated or released.
  - FFS Single DCI for multiple type-2 UL configured grants.

These agreements leave FFS whether a single DCI may activate/release multiple type-2 UL configured grants. This issue is discussed in multiple contributions, with some companies in favour of supporting the feature and some against it. From the discussion in the contributions, it seems that the following aspects need to be considered:

- Payload increase for DCI (CG indices and other fields transmitted during activation).
- Alignment of DCI format size or increase in the number of blind decodes.
- Overhead (at system level) and latency of having single configuration per DCI

At this point, there is no consensus on this issue. The following positions are reported in the contributions:

- Single DCI activates/releases multiple type-2 UL configured grant:
  - MediaTek, OPPO, ZTE, Sanechips, and Nokia, Nokia Shanghai Bell (at least for the case that no new DCI format is introduced).
- Single DCI may activate/release single type-2 UL configured grants:
  - Qualcomm, Intel, Ericsson

- Also supported by Huawei, HiSilicon

We note also that at least one contribution (R1-1900651, LGE) discusses the issue without stating a position and another contribution (R1-1901059, Samsung) proposes to leave the discussion to the eURLLC SI.

The following proposal (along the lines of Nokia's proposal) is a possible compromise.
In addition, three contributions discuss signalling aspects related to the activation/release of Type-2 CGs:

- R1-1900200 (Mediatek) proposes to use HARQ field to identify CG and activation/release.
- Related to the previous aspect, R1-1900485 (Intel) proposes to have HARQ ID offset as part of each CG configuration.
- R1-1900800 (Interdigital) proposes to study implicit and explicit activation/release signalling.

Given the implications in terms of payload of choosing one or another signalling method these aspects should be discussed together with the support of single/multiple CGs per DCI.

Offline conclusion:

- **Discuss signalling details and whether single DCI can activate/release multiple CGs during WI.**

One contribution (R1-1900200, MediaTek) discusses the maximum number of type-2 CG configurations, proposing to limit it to at most 8 CGs. Given that this was the value used in LTE, it seems normal to support at least 8 CGs. The decision is a trade-off between flexibility and signalling overhead

Similarly, another contribution (R1-1900485, Intel) discusses the maximum number of simultaneous transmissions that may be scheduled by different CGs. In this case, the issue is essentially related to hardware limitations. These two aspects need to be considered. The proposals from the two contributions may be used as a starting point.

Offline consensus

- **A UE is not expected to transmit simultaneously according to more than one UL grant (e.g., dynamic or CG) in a given BWP.**

In the past, it was agreed to support UE reports of assistance information to the gNB.

Agreements:
- NR supports that UE reports assistance information to the gNB, consisting of at least (with details FFS):
  - UE-related geographic information (e.g., position).
  - Reports of Uu V2X traffic-related information (at least for periodic traffic).

Agreements:
- From RAN1 perspective, NR UE reporting on Uu that include at least traffic periodicity, timing offset, and message size is beneficial at least for the purpose of managing multiple UL configured grants.

Agreements:
- NR supports UE reporting over Uu of sidelink traffic-related information.
  - FFS contents.

Multiple contributions list possible reports but in general there is little technical discussion. The following reports are proposed by different companies:

- Traffic periodicity (OPPO, ZTE, Sanechips)
- Timing offset (OPPO, ZTE, Sanechips)
- Message size (OPPO, Interdigital, ZTE, Sanechips)
- Latency (OPPO, ZTE, Sanechips)
- CBR per resource pool (OPPO, Ericsson)
- Information about the utilization of the PC5 pool (OPPO, Ericsson)
- QoS requirement (QC, CATT)
  - Reliability (ZTE, Sanechips)

    - Priority (ZTE, Sanechips)
- Communication range (QC)
- Speed and direction (Ericsson, also supported by Huawei, HiSilicon)

The first three reports, although mentioned in an existing agreement, are not explicitly supported yet. Moreover, their usefulness was already confirmed for LTE V2X so there is no need to repeat the discussion here.

A second group of reports includes parameters related to sidelink transmissions, something that is already agreed by RAN1 (although details are FFS). At this point, many aspects of PC5 resource allocation are not defined. Consequently, it is impossible to capture a detailed agreement on the reports. The following proposal, captures the main aspects of the proposals, leaving the details for a later discussion.

A third group of reports includes QoS parameters:

In the list of proposals, reports with a single supporting contribution have been omitted. In addition, on the topic of UE reports, one contribution (R1-1901215, Ericsson) discusses having a framework that does not leave reporting up to UE implementation.

Finally, one contribution (R1-1900027, Huawei, HiSilicon) discusses the use of UE geographic information reports to configure resource pools for NR SL. From the proposal itself, it seems that this is exclusively a SL configuration issue.

Several companies discuss other enhancements for NR Uu. One enhancement that is discussed in many contributions is broadcast/multicast. One contribution (R1-1900027, Huawei, HiSilicon) proposes to capture some conclusions on the relevance of Uu broadcast/multicast for V2X. A second contribution (R1-1901059, Samsung) proposes to capture in the TR the necessity of groupcast via Uu link to support NR V2X use cases. It also proposes to study SC-PTM as well as some HARQ and feedback aspects. Another contribution (R1-1900200, Mediatek) argues that NR Uu broadcast/multicast design is excluded from NR V2X SI scope but that the feasibility of candidate methods to support Uu multicast/broadcast transmissions in V2X should be studied. One contribution (R1-1900994, ZTE, Sanechips) states that groupcast and multicast should be supported on NR Uu. Two contributions (R1-1900325, CATT and R1-1901215, Ericsson) argue that Uu broadcast/multicast are not in scope of the SI. Another contribution (R1-1901160, Nokia, Nokia Shanghai Bell) proposes to discuss whether
such enhancements are in scope of the SI or not.

Proposed conclusion:

- **Continue discussing on broadcast/multicast and whether any observation regarding Uu broadcast/multicast is captured in the TR and, if so, the contents.**

Continue discussing whether BC/MC is beneficial for V2X use cases.
In addition, the following enhancements are presented in a single contribution:

- UL mobility measurements (R1-1900027, Huawei, HiSilicon)
- gNB frequency offset adjustment commands (Intel, R1-1900485)
- Enhancements to DL SPS configurations (Ericsson, R1-1901215):
    - New periodicities
    - Support for multiple simultaneously active DL SPS configuration.
- Enhancements to confirmation of UL SPS and DL SPS upon activation/release via DCI (Ericsson, R1-1901215).
- Mapping rule between LTE QoS and NR QoS (R1-1900325, CATT)
- Enhancements to pre-emption, repetition and retransmission (R1-1900994, ZTE, Sanechips)

Proposed conclusion:

- **RAN1 to continue further discussion on the need of other enhancements**

Regarding potential enhancements for LTE, one contribution (Huawei, HiSilicon) discusses feasibility and possible enhancements with different degrees of specification impact, proposing to focus on those with no/little impact. Discussion on the topic is needed.

Proposed conclusion:

- **RAN1 to discuss the feasibility of supporting V2X use cases using LTE Uu and, if necessary, identify a list of enhancements of interest to focus the study.**

In addition, given that only one contribution has treated this topic, it should not be controversial to focus on enhancements with no or minor specification impact, if any.

Proposed agreement:

- **RAN1 focuses on enhancements with no/little specification impact, if any.**

In RAN1#94, the following agreements has been made on Uu for advanced V2X use cases:

Agreements on Uu for advanced V2X use cases:

- No agreements were made.

In RAN1#94bis, the following agreements has been made on Uu for advanced V2X use cases:

Agreement on Uu for advanced V2X use cases:

- **NR supports that UE reports assistance information to the gNB, consisting of at least (with details FFS):**
  - UE-related geographic information (e.g., position).
  - Reports of Uu V2X traffic-related information (at least for periodic traffic)
- For Uu for advanced V2X use cases, NR supports having multiple active UL configured grants in a given BWP in a given cell.
  - **Open discussions on details**
  - LS sent to RAN2 on this agreement.

In RAN1#AH_1901, the following agreements has been made on Uu for advanced V2X use cases:

Agreement on Uu for advanced V2X use cases:

R1-1901383 Feature lead summary on Evaluation of Uu for advanced V2X use cases Ericsson

Conclusion:

- For type 2 configured grant, discuss signalling details and whether single DCI can activate/release multiple configured grants during WI (if included in the WI).

Agreements:

- A UE is not expected to transmit simultaneously according to more than one UL grant (e.g., dynamic or CG) in a given BWP.

1.3 Uu-based sidelink resource allocation/configuration

Including LTE/NR controlling NR sidelink & NR Uu controlling LTE sidelink

1.3.1 LTE Uu enhancements to controls NR sidelink

1.3.1.1 LTE Uu schedules NR sidelink mode 1

For LTE Uu controlling NR sidelink mode 1, some issues were raised. The issues include:

- NR sidelink has stringent latency/reliabilities requirement (R1-1900201, R1-1900778, R1-1900801, R1-1901216)
- NR supports unicast/groupcast and HARQ-feedback (R1-1900486, R1-1901060, R1-1900801)
- NR supports different numerologies (R1-1900486, R1-1900889, R1-1900801)
- Timing between DCI and sidelink transmission (R1-1901060)
- NR supports different BSR signalling format (R1-1900889)
- LTE Uu provides configuration for NR sidelink mode 2 (R1-1900201, R1-1900860, R1-1900801, R1-1900889, R1-1900966)

These issues and solutions proposed are analysed in Section 2.1.
Four sources (R1-1900860, R1-1900407, and R1-1900326) presented some scenarios showing that LTE Uu controlling NR sidelink mode 1 was beneficial/needed. Three sources (R1-1900860, R1-1900407) also analyzed that LTE Uu controlling NR sidelink 1 does not cause additional specification efforts on top of NR Uu controlling NR sidelink mode 1.

NR sidelink is designed to support shorter latency and higher reliability V2X services. The latency is as low as 3ms, and many use cases have latency requirements of 10ms. Using the current LTE Uu interface, supporting NR sidelink mode 1 may be challenging and would likely require some changes to the LTE Uu (R1-1900201, R1-1900778, R1-1900801).
One source (R1-1901216) points out that LTE Uu controlling NR sidelink mode 1 will take away the latency gain due to SR-SG round trip times which is dominant by LTE processing time.

It is noted that not all advanced V2X services require such stringent latency and NR sidelink also supports mode 2 that UE autonomously selects resources for transmissions.
Suggested offline proposal 1: For LTE Uu scheduling NR sidelink mode 1, it is necessary for the network to be able to enabled and disable the feature.

LTE Uu was designed to support only broadcast for LTE sidelink but NR sidelink supports unicast/groupcast, as pointed out by one source (R1-1900486).

One source (R1-1901060) states HARQ-ACK information may be sent to BS for fine controlling of NR sidelink but worries the designed HARQ-ACK feedback mechanism or resource allocation mechanism may not be easily extended to LTE Uu.

It is noted that the unicast/groupcast transmission happens on sidelink between UEs. When LTE Uu controls NR sidelink, NR sidelink can still support unicast/groupcast, and it may not involve specification changes when if HARQ-ACK feedback is turned off. Designing resources for HARQ-ACK feedback sent to eNB will imply specification changes to LTE.

Suggested offline proposal 2: For LTE Uu to schedule NR sidelink mode 1, one of the following is necessary:
- **Option 1: HARQ-ACK feedback is turned off for NR sidelink unicast/groupcast, or**
- **Option 2: LTE Uu enhancement is designed to support HARQ-ACK feedback procedure/resources to eNB.**

LTE only support 15 kHz subcarrier spacing but NR sidelink supports 30, 60, 120 kHz SCS as well. Two sources (R1-1900889, R1-1900486) point out this issue.
One source (R1-1900801) states it will be hard for LTE Uu to support the scheduling of NR sidelink with subcarrier spacing other than 15 kHz. Alternatively, the LTE Uu interface can still be used to schedule NR V2X sidelink transmissions with some restrictions, e.g., NR sidelink BWP has the subcarrier spacing of 15 kHz.

One source (R1-1900028) states even though NR sidelink and LTE uses different numerologies, the subframes/slot boundaries can be aligned if the two systems are synchronized, and the issue to be solved is the timing.

Suggested offline proposal 3: For LTE Uu to schedule NR sidelink mode 1, it is necessary for the eNB to configure the BWP/resources pool associated to a subcarrier spacing:

- **Option 1: the subcarrier spacing is chosen from {15, 30, 60} for FR1, {60, 120} for FR2, or**
- **Option 2: the subcarrier spacing is fixed to be 15 kHz.**
- When LTE Uu controls LTE sidelink mode 3, the fixed timing between DCI reception and sidelink transmission is not earlier than 4 subframes. However, NR sidelink will likely support flexible timing in the control of NR Uu.
- One source (R1-1901060) states dynamic scheduling delay is expected to be introduced in NR V2X. One source (R1-1900860) states the timing, or set of possible timings, defined in NR Uu controlling NR mode-1 SL should be kept the same in LTE Uu control of NR mode-1 SL, in order not to change the basic NR mode-1 SL procedure when the Uu control is switched.
- **Suggested offline proposal 4: For LTE Uu to schedule NR sidelink mode 1, the timing between DCI receptions to NR mode 1 sidelink transmission is flexible and up to eNB indication/configuration.**
- When LTE Uu controls LTE sidelink mode 3, the UE reports the BSR to the eNB. The BSR signaling format may be different than the one designed for NR sidelink mode 1 in the control of NR Uu.
- One source (R1-1900889) states that the UE has to deal with incompatible BSR signaling formats when LTE Uu controls NR sidelink mode 1.
- **Suggested offline proposal 5: For LTE Uu to schedule NR sidelink mode 1, it is necessary for LTE Uu to support UE reporting BSR for NR sidelink mode 1.**

As pointed out early, four sources (R1-1900860, R1-1900407, and R1-1900326) presented some scenarios showing that LTE Uu controlling NR sidelink mode 1 was beneficial/needed. Three sources (R1-1900860, R1-1900407) also analyzed that LTE Uu controlling NR sidelink 1 does not cause additional specification efforts on top of NR Uu controlling NR sidelink mode 1. In addition, solutions of reasonable complexity were identified. It is thus suggested the following:

The following proposal was discussed offline.

- **LTE Uu to schedule NR sidelink mode 1 is supported:**
  - **NR sidelink mode 1 is based on type 1 configured grant at least for broadcast**
  - **FFS whether DCI based is supported**
  - **This is restricted to 15kHZ SCS for NR**

1.3.1.2 LTE Uu provides configuration for NR sidelink mode 2

It has been agreed that it is supported that LTE Uu provides at least necessary semi-static configuration for NR mode-2 sidelink communications, with details FFS.
One source (R1-1900201) states only the essential configuration parameters need to be considered for LTE Uu broadcast signaling at least as a first step to provide baseline NR mode-2 sidelink configurability via LTE Uu.

One source (R1-1900860) proposes that NR sidelink mode 2 configuration in the control of NR Uu can be a starting point for the case of LTE Uu provides configurations for NR sidelink mode 2.

One source (R1-1900801) states LTE V2X supports the sidelink configurations of neighboring frequencies (e.g., the IE *v2x-InterfreqInfoList*) and a similar approach could be extended for configuring NR V2X sidelink. The configuration could be sent over common configurations, e.g., a new LTE SIB. The dedicated

configurations for NR V2X sidelink may need to be further studied. It proposes that LTE Uu at least supports the resource pool configuration for NR mode 2 UE sidelink transmission.

One source (R1-1900889) proposes SIB26 is enhanced to contain semi-static configuration in Rel-16 for NR V2X sidelink mode 2.

One source (R1-1900966) assumed that the UE location and UE capability (e.g., whether the UE has scheduling capability) can be reported to eNB, and eNB will send configuration signaling (e.g., via high layer signaling) to inform the UE serving as scheduling UE for NR sidelink mode 2d.

Suggested offline proposal 7: When LTE Uu provides configuration for NR sidelink mode 2,

- **It is necessary that LTE Uu existing higher layer signalling (e.g., SIB) is enhanced to included semi-static configuration for NR sidelink mode 2. Details up to RAN2**

1.3.2 NR Uu enhancements to enable NR sidelink mode 1

1.3.2.1 NR SL resource allocation

Companies proposed DCI-based dynamic resource allocation for NR SL mode 1: [2] [5] [8] [17] [20] [21] [23]. Most proposals are related to DCI and SR design for NR SL mode 1. While [21] proposes that the DCI format 5A can be reused, [2] [5] [8] [17] and [20] propose new DCI format for NR SL mode 1. [2] [5] [12] [17] [20] [21] propose to have resource allocation information in the DCI including PSSCH, PSCCH, and PSFCH. Transmission type (uni-/group-/broadcast) is also proposed to be included by [2] [5] [17]. [2] and [17] further propose to have indicators related to inter-rat and resource pools. [8] considers also having Rx UE information in DCI. Regarding SR, [12] and [21] propose a new framework, while [2] [8] and [20] propose adding extra information to existing BSR. Differentiation of SL SR from UL SR is also proposed by [2] and [20]. Finally, no contributions argue explicitly against DCI-based dynamic resource allocation.

Suggested offline proposal 8:

- **DCI-based dynamic resource allocation for NR SL mode 1 is supported.**
- **New DCI format(s) to be designed.**

1.3.2.2 NR SL configured grant resource allocation

15 companies have proposals regarding configured grant resource allocation for NR SL mode 1 [1] [2] [3] [5] [6] [11] [12] [15] [16] [17] [18] [20] [21] [22] [23]. Out of the 15 companies, 6 companies support both type-1 and type-2 configured grants [1] [3] [6] [21] [22], whereas 8 companies support type-2 configured grants only [2] [5] [10] [12] [16] [17] [18] [20] [23].

Five companies propose to have multiple configured grants for NR SL mode 1 [1] [2] [11] [12] [21]. Furthermore, [1] and [16] propose the repetition of the configured grants, whereas [1] proposes the use of TFRPs for both type-1 and type-2 configured grants.

scheme to support already happened for MBB with similar arguments, the offline proposal is to support both allocations.

Suggested offline proposal 9:

- **Type-1 and type-2 configured grant for NR SL mode 1 are supported.**
- **Multiple configured grants per UE are supported.**

1.3.2.3 UE assistance for NR SL mode 1 resource allocation

In RAN-1 #95, the following was agreed:

"Physical sidelink feedback channel (PSFCH) is defined and it is supported to convey SFCI for unicast and groupcast via PSFCH.
Study further whether to support UE sending to gNB information which may trigger scheduling retransmission resource in mode 1. FFS including

- Which information to send
- Which UE to send to gNB
- Which channel to use
- Which resource to use"

Related to RAN-1 #95 agreement above, in RAN-2 #104 it was agreed that:

"The UE assistance reporting mechanism for LTE V2X sidelink communication is taken as the baseline."

14 companies proposed UE assistance for SL mode 1 resource allocation, whether in terms of HARQ feedback, reporting SL measurements, or additional information to the gNB by the UE: [2] [3] [5] [7] [9] [11] [12] [14] [15] [16] [18] [20] [21] [22].

Different HARQ mechanisms are proposed in [2] [4] [5] [14] [16] [18] [20] [21]. [2] [4] [5] propose that HARQ includes ACK, NACK and/or DTX.. Furthermore, [2] and [5] propose to include SCI information (PMI, RI, beam information, etc.) in the HARQ mechanism. [2] [5] [14] propose to discuss whether source or destination UE sends the HARQ feedback, and [5] [14] [16] [18] [20] have proposals on which channel/resource should be used for the feedback.

Reporting measurements and other information to gNB is proposed in [1] [2] [3] [7] [9] [11] [12] [15] [18] [20] [22]. CSI of SL resources is proposed to be reported by [1] [7] [9] [12], including RSRP, RSSI, CR, CBR of the (preferred) SL resources, or the SL resource index. [1] [3] [22] propose to report the information regarding UE mobility. Moreover, to help scheduling of NR SL mode 1 communications, the following proposals for UE reporting to gNB are made:

- [3] proposes to report the information for selecting scheduling UE,
- [18] to report message size,
- [11] to report information for modifying SL grants,
- [12] to send a request for reserving SL resources.

[7], [11] and [12] discuss which UE to report the information to the gNB.

Suggested offline proposal 10:

- **HARQ feedback to the gNB is supported for NR SL mode 1 for unicast and groupcast transmissions.**

Suggested offline proposal 11:

- **Reporting SL related information is supported. At least information about used resources is reported to gNB.**

1.3.2.4 Inter-operation of NR SL mode 1 with mode 2

RAN-2 #104 agreed that a UE can simultaneously operate NR SL mode 1 and mode 2:

"RAN2 will support the case a UE can be configured to perform both mode-1 and mode-2 at the same time assuming RAN1 does not have concern on it."

Related to the agreement, five companies proposed to support or study shared resource pools between NR SL mode 1 and mode 2 [2] [5] [7] [12] [22]. For a smooth co-existence of both modes, companies have several proposals regarding the configuration and usage of the associated resources. [1] and [23] consider configuring NR SL mode 2 resources associated with a validity area (i.e., across cells), including out-of-coverage. Uu control on switching NR SL modes, and control of associated resources are proposed by [1],

[2], [4] and [12]. [12] proposes prioritization of mode 1 SL transmissions over other SL receptions, whereas [2] proposes seperation of resources for two modes in time when operated simultaneously by a UE.

Suggested offline proposal 12:

- **Resource pool can be shared between mode 1 and mode 2 UEs**

1.3.2.5Shared NR Uu/NR SL carrier

Eight companies propose that NR Uu carrier be shared with NR SL mode 1 [2] [3] [5] [6] [7] [15] [18] [21]. Seven companies propose that at least UL symbols are shared, whereas [7] proposes to introduce dedicated slot format for SL.

Suggested offline proposal 13:

- **At least UL symbols can be shared between UL and SL**

1.3.3 NR Uu enhancements to control LTE sidelink

1.3.3.3 Separate signaling for LTE sidelink and NR sidelink e.g., SIB, DCI formats

When LTE sidelink is in the control of NR Uu, the signalling designed for NR Uu controlling NR sidelink may not be compatible with the signalling designed for LTE sidelink in the control of LTE Uu, e.g., SIB for configurations, DCI formats.

The necessary enhancement raised by one source (R1-1900201) is that NR base stations use separate signaling for LTE sidelink and NR sidelink (e.g., potentially including a new SIB, a new DCI format, a new SS structure, etc.)

One source (R1-1900326) proposes a new DCI format for NR (e.g. DCI 2_0) can be designed with the same contents as that of LTE DCI 5A for NR Uu managing LTE sidelink mode-3. One source (R1-1900801) states that the new NR DCI format should support both dynamic scheduling and SPS.

Two sources (R1-1900326, R1-1900778) describe one approach where a common DCI format is designed for both NR sidelink mode 1 and NR controlling LTE sidelink mode 3 and with one indication bit in the DCI content to indicate to which sidelink it applies. Another approach could be based on RNTI, i.e., gNB could allocate one RNTI for LTE mode 3 and another RNTI for NR mode 1.

One source (R1-1900889) states that L1 signaling design in NR Uu ePDCCH to control PC5 interface should have a unified design for both LTE and NR sidelink. The sidelink grant formats and how to interpret the contents of the sidelink grant are different for NR sidelink and LTE sidelink. For example, this requires the translation of OFDM numerology from NR to LTE and vice versa (assuming different SCS is used).

One source (R1-1901060) views that DCI format can be transmitted in either common SS (search space) or USS (UE-specific search space). The CRC of that DCI format is scrambled with a RNTI assigned for LTE sidelink transmission.

Suggested offline proposal 15: For NR Uu to schedule LTE sidelink mode 3, it is necessary to select one of the two options:

- **Option 1: a new different DCI format is designed, which has the same/similar contents as that of LTE DCI 5A, or**
- **Option 2: a common/unified DCI format to schedule either NR or LTE SL is designed, FFS how to differentiate scheduling between LTE sidelink and NR sidelink.**

If a new DCI format is designed when LTE sidelink mode 3 is controlled by NR Uu that is of different size than the DCI format designed for NR Uu controlling NR sidelink mode 1. The blind decoding attempts may increase.

One source (R1-1900326) proposes to solve the blind decoding issue by padding the new DCI format (e.g. DCI 2_0) until the size is the same as the DCI format that used by NR Uu to manage NR sidelink mode-1.

One source (R1-1900801) views to reduce the blind decoding of NR DCI, the payload size of the new NR DCI format should be aligned with some existing NR DCI formats. It is preferred to pad as few zeros as possible for the new NR DCI format to align with the payload size of an existing NR DCI format. This could improve the transmission reliability of the new NR DCI format. Two options for the new NR DCI format payload size could be aligned to DCI format 0_0 or compact DCI format. Propose NR Uu interface supports a new DCI format to schedule (including both dynamic scheduling and SPS) mode 3 UEs in LTE sidelink.

One source (R1-1900854) views that NR has defined mechanisms of managing the number of UE blind decodes, e.g., configuring the search space, aggregation level, candidates, DCI formats that UE needs to monitor, which could be applied in addition to the option of padding to the same size of other formats if UE monitoring DCI 5A' possibly increases the complexity of blind decoding.

No offline proposal is suggested, since the decision is dependent on which option of proposal 15 is chosen.

1.3.3.2 Different numerologies and timing

LTE sidelink uses the fixed 15kHz subcarrier spacing but NR Uu supports flexible numerologies. When LTE Uu controls LTE sidelink mode 3, the fixed timing between DCI reception and sidelink transmission is not earlier than 4 subframes. NR Uu supports flexible timing between DCI and PUSCH/PDSCH and the timing between DCI and NR sidelink transmission is probably flexible as well.

When NR Uu controls LTE sidelink, 2 contributions (R1-1901216, R1-1900486) point out that RAN1 WG needs to discuss timing relationship between NR Uu DCI transmission and LTE sidelink PSCCH/PSSCH transmission for all NR Uu numerologies and timing relationships.

In addition, NR Uu should be added as a sidelink synchronization source for LTE V2X.
One source (R1-1900854) discusses the timing regarding to all NR Uu numerologies and provides two options. Option 1 is to align to LTE SL timing of four subframes at 15 kHz SCS so the timing offset depending on the numerology of NR Uu is $n + 4 \times 2^{\mu}$, where n is the nth slot where DCI 5A' is received and μ^{P} equals to 0, 1, 2 corresponding to 15, 30, and 60 kHz, respectively. Alternatively, option 2 uses afixed timing offset independent of NR Uu numerology, e.g., $n + 4$. It also points out that if the SL transmission timing is defined as n+4 for each numerology, processing may need to be faster than the 4ms used for LTE.

<u>Suggested offline proposal 16</u>: For NR Uu to schedule LTE sidelink mode 3, it is necessary to define the LTE Uu timing between DCI and SL as:

- **$n + 4 \times 2^{\mu}$, where n is the slot where DCI 5A' is received and μ^{P} is 0, 1, 2, 3, 4 corresponding to 15, 30, 60, 120, and 240 kHz, respectively.**

1.3.3.3 NR Uu supports flexible slot formats

NR UE is configured with a reference subcarrier spacing configuration of «$_{SFI}$ and a corresponding slot format and can derive the slot format for the active BWP of subcarrier spacing configuration of « with « | «$_{SFI}$. The slot format issue only exists when LTE mode-3 SL shares the carrier with NR Uu. The issue is whether NR Uu can still be configured flexible slot formats without changing LTE mode-3 SL procedure.

One sources (R1-1900028) provides two direction to solve this issue: one direction is that the slot format configured for NR Uu shall be compatible with LTE TDD configurations, so that from UE operating mode-3 SL perspective it is the legacy procedure for determining the subframe pool without change. Alternatively, NR Uu is free to be configured any of slot formats defined but LTE mode-3 SL UE procedure for determining subframe pool needs change to be able to preclude the DL subframes or subframes with DL/flexible symbols that are not compatible with LTE TDD configurations. Any change to LTE SL procedure is undesirable. Therefore, the first direction is recommended.

Suggested offline proposal 17: For NR Uu to schedule LTE sidelink mode 3, it is necessary that slot formats configured for NR Uu are assumed to be compatible with LTE TDD configurations.

In order to support NR Uu scheduling LTE sidelink mode 3, Intel pointed out that at the UE side, afast inter-RAT interface will be required and may even need to be standardized as a cross-RAT adaptation layer.

One source (R1-1901216) views the inter-RAT signalling as increasing UE complexity, which is not desirable. DCI processing may be faster for NR UEs, especially for larger SCS but processing of the sidelink TB remains unchanged. This separate processing also requires some internal UE interfaces and signalling, adding some further processing time.

Suggested offline proposal 18: For NR Uu to schedule LTE sidelink mode 3, it is necessary to define to define capability signaling for the LTE UE.

To facilitate eNB/gNB scheduling the resources for LTE/NR sidelink transmission, the UE may report some assistance information to the eNB/gNB. In LTE-V2X, UE reports traffic assistance information and congestion control related information as well as sidelink scheduling request and BSR. For NR-V2X, it has not been agreed what information the UE would report to the gNB but the reporting could probably additionally include other assistance information. One NR Uu interface will support UE reporting assistance information from LTE sidelink and NR sidelink (R1-1900486, R1-1900889).

One source (R1-1900486) points out that NR Uu will need to implement TX Profile selection concept in order to be able switch between LTE Mode-3 R14 and R15 transmission formats. In addition, R15 Mode-3 UEs support Mode-4 sensing and reporting to assist eNB scheduling. All LTE Mode-3 UE also report traffic assistance information and congestion control related information as well as sidelink scheduling request and BSR which are also required for eNB Mode-3 scheduling decisions. All of these functionality may need to be duplicated in NR Uu if dynamic scheduling is supported.

One source (R1-1900889) views it is cumbersome to support two different BSR formats in one interface. However, if only one format is defined, how to interpret the BSR has to be added in the specification.

Suggested offline proposal 19: For NR Uu to schedule LTE sidelink mode 3, consider NR Uu enhancements to support UE reporting assistance information similar to what has been specified in LTE.

When LTE sidelink mode 3 controls NR Uu, the gNB needs to provide the necessary configurations for sidelink transmission.

One source (R1-1901060) proposes that the NR module needs to use system information (for example RMSI) and RRC signaling to configure the configuration parameters for LTE V2X, similar to the configuration process in LTE.

Suggested offline proposal 20: For NR Uu to schedule LTE sidelink mode 3, consider NR Uu enhancement to provide necessary configuration for LTE sidelink mode 3.

RAN1 has to decide whether to support NR Uu scheduling LTE sidelink mode 3. Given that some companies have shown scenarios where such a feature would be useful, and that other companies has shown that it would require reasonable standardization work, it is proposed to support the feature.

1.3.3.4 NR Uu provides configuration for LTE sidelink mode 4

NR Uu provides necessary semi-static configuration for mode-4 LTE sidelink. From RAN1 perspective, signaling should be similar to LTE in terms of UE-specific or cell-specific, with signaling details up to RAN2.

One source (R1-1900889) proposes that the SIB in NR Uu includes resource configuration for both NR sidelink and LTE sidelink, and to reuse semi-static configurations defined for LTE sidelink in SIB21/SIB26 for NR Uu configuration of LTE sidelink.

Suggested offline proposal 22: When NR Uu provides LTE sidelink mode 4, consider reusing semi-static configurations defined for LTE sidelink in SIB21/SIB26 for NR Uu enhancement. Details up to RAN2

1.3.4 DCI formats defined in NR

The DCI formats defined in table 7.3.1-1 are supported. As described in TS 38.211. For sidelink the most important DCI formats are DCI format 0_0 and DCI format 0_1.

Table 7.3.1-1: DCI formats

DCI format	Usage
0_0	Scheduling of PUSCH in one cell
0_1	Scheduling of PUSCH in one cell
1_0	Scheduling of PDSCH in one cell
1_1	Scheduling of PDSCH in one cell
2_0	Notifying a group of UEs of the slot format
2_1	Notifying a group of UEs of the PRB(s) and OFDM symbol(s) where UE may assume no transmission is intended for the UE
2_2	Transmission of TPC commands for PUCCH and PUSCH
2_3	Transmission of a group of TPC commands for SRS transmissions by one or more UEs

The fields defined in the DCI formats below are mapped to the information bits a_0 to a_{A-1} as follows. Each field is mapped in the order in which it appears in the description, including the zero-padding bit(s), if any, with the first field mapped to the lowest order information bit a_0 and each successive field mapped to higher order information bits. The most significant bit of each field is mapped to the lowest order information bit for that field, e.g. the most significant bit of the first field is mapped to a_0.

If the number of information bits in a DCI format is less than 12 bits, zeros shall be appended to the DCI format until the payload size equals 12.

– ConfiguredGrantConfig

The IE *ConfiguredGrantConfig* is used to configure uplink transmission without dynamic grant according to two possible schemes. The actual uplink grant may either be configured via RRC (type1) or provided via the PDCCH (addressed to CS-RNTI) (type2).

***ConfiguredGrantConfig* information element**

```
-- ASN1START
-- TAG-CONFIGUREDGRANTCONFIG-START
```

```
ConfiguredGrantConfig ::=           SEQUENCE {
    frequencyHopping                        ENUMERATED {intraSlot, interSlot}
OPTIONAL,   -- Need S,
    cg-DMRS-Configuration               DMRS-UplinkConfig,
    mcs-Table                           ENUMERATED {qam256, qam64LowSE}
OPTIONAL,   -- Need S
    mcs-TableTransformPrecoder          ENUMERATED {qam256, qam64LowSE}
OPTIONAL,   -- Need S
    uci-OnPUSCH                         SetupRelease { CG-UCI-OnPUSCH }
OPTIONAL,   -- Need M
    resourceAllocation                  ENUMERATED { resourceAllocationType0,
resourceAllocationType1, dynamicSwitch },
    rbg-Size                                ENUMERATED {config2}
OPTIONAL,   -- Need S
    powerControlLoopToUse               ENUMERATED {n0, n1},
    p0-PUSCH-Alpha                      P0-PUSCH-AlphaSetId,
    transformPrecoder                   ENUMERATED {enabled, disabled}
OPTIONAL,   -- Need S
    nrofHARQ-Processes                  INTEGER(1..16),
    repK                                    ENUMERATED {n1, n2, n4, n8},
    repK-RV                             ENUMERATED {s1-0231, s2-0303, s3-0000}
OPTIONAL,   -- Need R
    periodicity                         ENUMERATED {
                                                sym2, sym7, sym1x14, sym2x14, sym4x14, sym5x14,
sym8x14, sym10x14, sym16x14, sym20x14,
                                                sym32x14, sym40x14, sym64x14, sym80x14, sym128x14,
sym160x14, sym256x14, sym320x14, sym512x14,
                                                sym640x14, sym1024x14, sym1280x14, sym2560x14,
sym5120x14,
                                                sym6, sym1x12, sym2x12, sym4x12, sym5x12, sym8x12,
sym10x12, sym16x12, sym20x12, sym32x12,
                                                sym40x12, sym64x12, sym80x12, sym128x12, sym160x12,
sym256x12, sym320x12, sym512x12, sym640x12,
                                                sym1280x12, sym2560x12
    },
    configuredGrantTimer                INTEGER (1..64)
OPTIONAL,   -- Need R
    rrc-ConfiguredUplinkGrant           SEQUENCE {
        timeDomainOffset                        INTEGER (0..5119),
        timeDomainAllocation                    INTEGER  (0..15),
        frequencyDomainAllocation           BIT STRING (SIZE(18)),
        antennaPort                         INTEGER (0..31),
        dmrs-SeqInitialization              INTEGER (0..1)
OPTIONAL,   -- Need R
        precodingAndNumberOfLayers          INTEGER (0..63),
        srs-ResourceIndicator               INTEGER (0..15)
OPTIONAL,   -- Need R
        mcsAndTBS                           INTEGER (0..31),
        frequencyHoppingOffset              INTEGER (1.. maxNrofPhysicalResourceBlocks-1)
OPTIONAL,   -- Need R
        pathlossReferenceIndex              INTEGER (0..maxNrofPUSCH-PathlossReferenceRSs-1),
        ...
    }
OPTIONAL,       -- Need R
    ...
}

CG-UCI-OnPUSCH ::= CHOICE {
    dynamic                             SEQUENCE (SIZE (1..4)) OF BetaOffsets,
    semiStatic                          BetaOffsets
}

-- TAG-CONFIGUREDGRANTCONFIG-STOP
-- ASN1STOP
```

ConfiguredGrantConfig field descriptions
antennaPort Indicates the antenna port(s) to be used for this configuration, and the maximum bitwidth is 5. See TS 38.214, section 6.1.2, and TS 38.212, section 7.3.1.
cg-DMRS-Configuration DMRS configuration, corresponds to L1 parameter 'UL-TWG-DMRS' (see TS 38.214, section 6.1.2).
configuredGrantTimer Indicates the initial value of the configured grant timer (see TS 38.321,) in number of periodicities.
dmrs-SeqInitialization The network configures this field if transformPrecoder is disabled. Otherwise the field is absent.
frequencyDomainAllocation Indicates the frequency domain resource allocation, see TS 38.214, section 6.1.2, and TS 38.212, section 7.3.1).
mcsAndTBS The modulation order, target code rate and TB size (see TS38.214, section 6.1.2). The NW does not configure the values 28~31 in this version of the specification.
nrofHARQ-Processes The number of HARQ processes configured. It applies for both Type 1 and Type 2. See TS 38.321, section 5.4.1.
p0-PUSCH-Alpha Index of the P0-PUSCH-AlphaSet to be used for this configuration.
…
powerControlLoopToUse Closed control loop to apply. Corresponds to L1 parameter 'PUSCH-closed-loop-index' (see TS 38.213, section 7.7.1).
rbg-Size Selection between configuration 1 and configuration 2 for RBG size for PUSCH. When the field is absent the UE applies the value config1. The NW may only set the field to *config2* if *resourceAllocation* is set to *resourceAllocationType0* or *dynamicSwitch.* Note: rbg-Size is used when the transformPrecoder parameter is disabled.
repK-RV The redundancy version (RV) sequence to use. See TS 38.214, section 6.1.2. The network configures this field if repetitions are used, i.e., if repK is set to n2, n4 or n8. Otherwise, the field is absent.
repK The number or repetitions of K.
resourceAllocation Configuration of resource allocation type 0 and resource allocation type 1. For Type 1 UL data transmission without grant, "resourceAllocation" should be resourceAllocationType0 or resourceAllocationType1.
rrc-ConfiguredUplinkGrant Configuration for "configured grant" transmission with fully RRC-configured UL grant (Type1). If this field is absent the UE uses UL grant configured by DCI addressed to CS-RNTI (Type2). Type 1 configured grant may be configured for UL or SUL, but not for both simultaneously.
srs-ResourceIndicator Indicates the SRS resource to be used.
timeDomainAllocation Indicates a combination of start symbol and length and PUSCH mapping type, see TS 38.214, section 6.1.2 and TS 38.212, section 7.3.1.
timeDomainOffset Offset related to SFN=0, see TS 38.321, section 5.8.2.
transformPrecoder Enables or disables transform precoding for type1 and type2. If the field is absent, the UE enables or disables transform precoding in accordance with the field msg3-transformPrecoder in RACH-ConfigCommon, see 38.214, section 6.1.3.
uci-OnPUSCH Selection between and configuration of dynamic and semi-static beta-offset. For Type 1 UL data transmission without grant, *uci-OnPUSCH* should be set to *semiStatic.*

Type 1 configured grant, the actual uplink grant can be configured via RRC (type1). Configuration for "configured grant" transmission with fully RRC-configured UL grant (Type1).

Type 2 configured grant, the actual uplink grant can be provided via the PDCCH (addressed to CS-RNTI) (type2). If the *rrc-ConfiguredUplinkGrant* field is absent the UE uses UL grant configured by DCI addressed to CS-RNTI (Type2).

In RAN1 #94, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

- NR Uu can assign NR sidelink resources for the following:
  - Shared licensed carrier between Uu and NR sidelink
  - Dedicated NR sidelink carrier
- Study at least the following NR sidelink resource allocation techniques:
  - Dynamic resource allocation
  - Activation/deactivation based
    - E.g., semi-persistent scheduling allocation or NR grant free type-2
  - RRC (pre-)configured
    - E.g., configured NR grant type-1, UE autonomous selection of resource(s) from resources configured by RRC
- RAN1 will study the level of network control, e.g., whether the UE may select other parameters (e.g., MCS) and/or the exact transmission resources, and whether the selection is autonomous or not

In RAN1 #94bis, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

- **Enhancements of LTE Uu and NR Uu to control NR sidelink**
  - It is supported that LTE Uu provides at least necessary semi-static configuration for NR mode-2 SL communications
    - **Open discussions on details**
  - Further study impact and benefits of LTE Uu managing NR model-1 SL communications
  - It is supported that NR Uu provides necessary semi-static configuration for mode-4 LTE SL communications
    - From RAN1 perspective, signalling should be similar to LTE in terms of UE-specific or cell-specific
    - Signalling details up to RAN2
  - **Further study feasibility, benefits (others than ones already identified for LTE) and impact of NR Uu managing LTE mode-3 SL communications**
  - Further study feasibility Send LS to RAN2 informing them of the two agreements:
  - **For the 1st agreements, RAN1 continues working on identifying necessary details, including parameters**
  - For the 2nd agreements, ask RAN2 to work on signalling

In RAN1 #95, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

In RAN1 #94, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

- RAN1 will study the level of network control, e.g., whether the UE may select other parameters (e.g., MCS) and/or the exact transmission resources, and whether the selection is autonomous or not

In RAN1 #94bis, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

- **Enhancements of NR Uu to control LTE sidelink**
  - Continue studying NR sidelink resource allocation techniques by NR Uu for mode-1:
  - Dynamic resource allocation
  - Semi-persistent scheduling allocation or NR grant type-2 (activation/de-activation by physical layer signaling)
  - Grant free transmission i.e., configured NR grant type-1
  - Study further which resources to use for SL transmission and other network-control sidelink issues (e.g., power control) in the case of shared carrier.

In RAN1 #95, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

The following NR sidelink resource allocation techniques by NR Uu for mode-1 are supported:

- Dynamic resource allocation
- Configured grant.
  - FFS whether type-1 and/or type-2
- In continuing evaluating NR Uu scheduling of LTE sidelink mode-3, consider at least:
  - What will be required on the UE side to support such feature
  - DCI design (e.g., whether DCI 5A can be reused)
  - Deployment scenarios where it is beneficial

In RAN1 #AH_1901, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

R1-1901393 Feature lead summary for AI 7.2.4.3: Uu-based sidelink resource allocation/configuration Huawei

Agreements:

- When NR Uu schedules NR SL mode 1, both type 1 and type 2 configured grants are supported for NR SL

Agreements:

- LTE Uu to schedule NR sidelink mode 1 is supported:
  - The support is done based on type 1 configured grant with configuration restricted to time/frequency resources & periodicity, with the condition that no additional function/procedure is to be introduced for LTE Uu
  - Both DCI based scheduling and type 2 configured grant scheduling are not supported for scheduling NR sidelink mode 1
- Send an LS to RAN2 – Phillipe (HW), **R1-1901410,** which is approved with the final LS in R1-1901445

1.4 QoS

Including congestion control

1.4.1 Issue 1: Minimum Required Communication Range (meters)

Some general guidance on this parameter can be found in SA2's TR 23.786, the most recent version is V1.0.0. The current status appears to be that it is used in groupcast and is provided by the V2X layer to the AS layer along with the QoS parameters (see Solution #21: Group communication enhancement for NR PC5).

The issue to address is if this parameter is relevant for RAN1 studies; and, if the answer is yes, how it might be used. The following proposals were found in the contributions reviewed for this summary:

- Used for power control: R1-1900291, R1-1901217, R1-1900358, R1-1900770
- Used for control of other sidelink TX parameters, e.g. MCS: R1-1900358
- Used to avoid HARQ feedback by UEs outside target communication range: R1-1900653, R1-1900890
- not clear how it can be used in physical layer procedures: R1-1900029

The majority view seems to be that this parameter is relevant for RAN1 studies.

Topics for discussion:

Further study use of minimum required communication range in physical layer procedures when provided by the higher layer.

- For some, but not necessarily all, potential uses, it may need to be studied how to translate minimum required communication range (which is provided in metres) into the physical layer
- This does not imply that any specific uses will be agreed by RAN1.

1.4.2 Issue 2: Sidelink Congestion Metric(s)

Several contributions discuss sidelink congestion metric(s).
In LTE V2X, Channel busy ratio (CBR) was specified as measurement of the resource utilization state of a resource pool. Several companies propose to reuse this metric for the NR sidelink.

Options:

- CBR (R1-1900029, R1-1900358, R1-1900653, R1-1900704, R1-1900770, R1-1900890, R1-1900967, R1-1901162, R1-1901217)
- New metric in addition to CBR (R1-1900254)

If CBR is to be reused for the NR sidelink then some adaptations may be required; e.g. LTE's CBR is defined in terms of subchannels, but the subchannel concept has not been agreed for the NR sidelink yet.

Moreover, enhancements to CBR can be considered:

- Study if the CBR sensing window should be adapted based on QoS requirements (R1-1900358)
- NR V2X CBR calculation is based on the resource granularity of a sidelink transmission (R1-1900770)

There appears to be consensus to use CBR at least as starting point for one sidelink congestion metric.

Topics for discussion:
CBR, adapted to the NR sidelink, is defined as sidelink congestion metric.
Additional metrics for the resource utilization/congestion state of a resource pool are not precluded.

- FFS details on how to adapt the definition of CBR to the NR sidelink

1.4.3 Issue 3: Sidelink Congestion Control

The LTE V2X sidelink congestion control mechanism uses measurement of channel busy ratio CBR and channel occupancy ratio CR, and, based on current CBR, can require a UE to adapt its TX parameters (MCS, number of PSSCH subchannels, number of ReTX, transmit power) and to limit its CR.

Several companies propose reuse of the LTE V2X congestion control or using it at least as starting point (R1-1900029, R1-1900653, R1-1900770, R1-1900779, R1-1900890, R1-1900967).

Introduce at least one congestion metric for NR sidelink

- FFS details – will discuss during WI phase
- Nothing else to do in SI phase

RAN1 concludes that congestion control is supported at least for sidelink mode 2.

- Note: congestion control will be covered in the work item phase, not in this SI.
- Nothing else to do in SI phase

1.4.4 Issue 4: Sidelink Resource sharing/Coexistence among different QoS levels

Rel-12 ProSe sidelink supported resource segregation based on QoS by associating a priority list with each resource pool (priority-based resource pool selection). No such mechanism was defined for the LTE V2X sidelink.

This issue was raised again in one contribution:

- Study QoS based resource pool segregation and selection (R1-1900358)

Topics for discussion:
Discuss if QoS-based resource pool segregation should be supported.

1.4.5 Issue 5: Sidelink Preemption

Several contributions (R1-1900291, R1-1900327, R1-1900358, R1-1900704, R1-1900653, R1-1900967, R1-1901162, R1-1901217) proposed under this AI to study or support preemption by a high priority/short latency transmission of one UE of a lower-priority/longer latency transmission of another UE; however, for mode 2, this concept was also proposed under AIs "Physical layer structure" and "Resource allocation mechanism", for mode 1 this concept is also proposed under AI "Uu-based sidelink resource allocation/configuration".

Topics for discussion:
To avoid overlap, discuss sidelink preemption mechanisms in the appropriate other agenda item(s), discuss how and when to use such preemption mechanisms in the QoS Management agenda item.

1.4.6 Issue 6: For sidelink, are QoS-related attributes signaled over the air (e.g. in SCI)?

One of the intended uses of QoS-related attribute "priority" is for resolution of inter-UE contention for resources.

In LTE V2X, PPPP was included in SCI format 1 for this purpose (field "Priority"). Note that LTE's PPPP encodes both priority and latency.
R1-1900487 proposed that priority be signaled over the air.

Topics for discussion:
Further study which QoS-related attributes, if any, should be included in SCI.

1.4.7 Issue 7: Sidelink Resource Fragmentation Metric(s)

R1-1900254 made a detailed proposal for new sidelink resource fragmentation metrics, Maximum contiguous subchannel number ratio in subframe (MCSNRS) and Channel Idle Ratio (CIR).

However, there is currently no agreement that resource fragmentation needs to be taken into account in sidelink resource allocation, it may hence be premature to discuss metrics for resource fragmentation.

Topics for discussion:
RAN1 to discuss whether to take sidelink resource fragmentation into account (in the resource allocation agenda item).

1.4.8 Issue 8: Traffic Characteristics

Intel proposed: Consult with SA2 WG whether upper layers can … provide additional data on transmission rate (e.g. period / packet size or statistical information) for NR–V2X communication.
Alternatives:

- Desirable that it be specified that higher layers provide additional traffic characteristics such as packet size and packet arrival statistics.
- Can be up to UE implementation (similar to e.g. deriving resource reservation interval in LTE V2X).

Topics for discussion:
Discuss if RAN1 needs to liaise with SA2 on providing detailed traffic characteristics.

In RAN1#94, the following agreements has been made on QoS Management:
Agreements on QoS:

- From RAN1 perspective, at least the following QoS-related parameters relevant to physical layer studies are considered:
  - Priority
  - latency
  - reliability

In RAN1#94bis, the following agreements has been made on QoS Management:

Agreements on QoS:

- RAN1 studies further how to use:
  - Priority,
  - Latency,
  - Reliability,
  - **Minimum required communication range (as defined by higher layers) if agreed to use**
- In the physical layer aspects of at least:
  - Resource allocation,
  - Congestion control and
  - Resolution of in-device coexistence issues and
  - Power control

In RAN1#95, the following agreements has been made on QoS Management:

Agreements on QoS:

Conclusion:

- Selection of QoS model (QoS Flow or per-packet QoS) for the NR V2X sidelink is outside the scope of RAN1

In RAN1#AH_1901, the following agreements has been made on QoS Management:

Agreements on QoS:

R1-1901290 Feature Lead Summary for 7.2.4.4 QoS Management Nokia

Agreements:

- Introduce at least one congestion metric for NR sidelink
  - FFS details – to be done in WI phase (if included)

Agreements:

- Congestion control is supported at least for sidelink mode 2
  - Note: details of congestion control can be covered in the work item phase, not in this SI.

1.5 Coexistence

Including feasibility of coexistence mechanisms & advanced V2X services provided by NR V2X under co-existence

1.5.1 Coexistence issues

Companies also discussed the details of the TDM solutions on top of agreements in previous meetings including the information exchanges that may be needed to enable long term or short-term coordination between the two RAT implementation modules. It was considered that short term coordination required a lot of information exchanges between the modes but provided some benefits in managing the coexistence. Issues regarding AGC, managing prioritization between services etc were raised. Long term coordination was considered to be simpler for implementation but there are concerns on whether latency requirements would be impacted.

1.5.1.1 Issue 1: TDM Solution for NR V2X Coexistence

Most contributions discussed the TDM solution for coexistence with differing levels of support. The specific details and options among many contributions overlap and an attempt has been made to capture all the different options below.

Based on a brief offline session some progress was made towards defining TDM solutions for potential inclusion in the TR. However, we ran out of time before consensus could be achieved on the wording of the agreement. The text below shows the status at the end of the offline discussion.

Issue 2-1: short time scale TDM solutions assuming SPS scheduling for LTE V2X:

Topics for discussion:

Assuming SPS scheduling (mode -3 or mode-4) for LTE V2X, short time scale TDM solution for in-device coexistence for V2X is feasible from RAN1 point of view if:

- Information exchange between LTE and NR sidelinks can occur in a short time scale
- Priority of Rx operation can be determined

Assuming SPS scheduling for LTE V2X, for short time scale TDM solutions for in-device coexistence for V2X operation between LTE and NR mode 1,

- UE informs the network about potential coexistence issues (either between different sidelinks or between Uu and sidelink)
  - FFS details of the signalling

Assuming SPS scheduling for LTE V2X, for short time scale TDM solutions for in-device coexistence between LTE and NR V2X:

- Types of information that can be exchanged between LTE and NR V2X are:
  - Sidelink resource allocations
  - synchronization information
  - Active resource utilizations
  - Sensing information

Other issues to take into consideration are listed below:

- Slot level alignment is applicable for both short term and long-term time scale TDM solutions
- If only LTE SPS scheduling is considered, then it is feasible to design NR resource selection to enable short-term TDM solutions for coexistence
  - It is feasible to determine LTE Rx priority in this case
  - If LTE Rx has higher priority, then NR avoids those slots for resource selection and potential NR transmissions
- If LTE one-shot scheduling is considered, then short term TDM solutions for coexistence are NOT feasible

1.5.1.2 Issue 2: FDM Solution for NR V2X Coexistence

Most companies also discussed the FDM solution for coexistence with some differing levels of support. We've agreed in RAN1 to define both solutions and so discussion of the details of both solutions is warranted. The details of the FDM solutions as proposed by all the contributions have been captured below as much as possible.

Issue 2-1: FDM solutions for intra-band coexistence:

We had a proposal at the last meeting, but was not able to made any agreements on intra-band coexistence. The discussion should continue based on the following:

Topics for discussion:

- Intra-band FDM solutions for coexistence

- Timing alignment
  - Symbol level synchronization is assumed?
- Issues raised regarding intra-band FDL simulations
  - AGC impact on Rx when LTE and NR V2X transmissions overlap
  - Phase discontinuities between overlapped and non-overlapped transmissions
- FFS on how these issues are resolved

Issue 2-2: Power sharing rules for FDM solutions for coexistence:

Topics for discussion:

- Power sharing rules
  - Static allocation
    - Fixed separation of allocated power levels for LTE and NR V2X
  - Semi-static allocation
    - Allocation of max power levels for LTE and NR V2X is based on (pre-)configuration
  - Dynamic distribution of power between LTE and NR V2X
    - EN-DC power control/sharing mechanisms are assumed as a baseline
    - Priority based power allocation
      - FFS whether QoS/PPPP should be considered for dynamic power allocation
      - FFS mapping rules between 5QI and PPPP for NR and LTE V2X

Issue 2-3: Other aspects of FDM solutions:

Topics for discussion:

- Send LS to RAN4 asking them about the necessary frequency separation requirement such that there are no half-duplex limitations when FDM solutions are considered in NR V2X
- FFS how to handle intermod and reverse intermod distortions to meet emission requirements when LTE and NR transmissions occur simultaneously
  - Can equal PSD be assumed given that PSCCH is power boosted by 3dB in LTE V2X?
- FFS whether there is any impact on NR-V2X resource allocation mechanisms so as to align the transmissions of NR and LTE V2X

1.5.1.3 Issue 3: Network Involvement in resolving UE Coexistence when in-coverage

Several companies discussed network involvement in coordinating LTE and NR N2X procedures within the UE. A summary of the proposals made regarding network involvement when co-existence is considered are captured below.

Topics for discussion:

- Solutions that involve the eNB/gNB are supported for coexistence between LTE and NR V2X
  - eNB/gNB provides a solution for coexistence (e.g., by dynamically reallocating resources)
- UEs can inform the network about any potential coexistence issues (either between different sidelink modules or between Uu and sidelink),
- UEs also provide assistance information to the network to resolve the indicated coexistence issues.
  - FFS the details of the assistance information
  - FFS whether the UE informs the network about selected resources in another RAT

1.5.1.4 Issue 4: Determination of priority between LTE and NR V2X

Some companies discussed mechanisms to determine priority between LTE and NR V2X modules if there are occasions whether there are overlaps between LTE and NR sidelink Tx/Rx. The intention mentioned is to use these priorities to determine dropping the packet in the case of TDM solutions or reducing the power level in case of FDM solutions.

Topics for discussion:

The following aspects are taken into account when determining priority between LTE and NR SL V2X transmissions:

- Service level priority of V2X applications
- Sidelink transmission priority (5QI)
  - Consider mapping rules for associating NR QoS with LTE PPPP metrics
- Radio layer conditions (e.g., CBR measurements indicating congestion)
- Transmission/reception of sidelink synchronization signals

A couple of companies also suggested that prioritization rules between Uu and SL need to be defined. It was also suggested that this prioritization could also be based on configuration.

- Prioritize NR Uu UL transmissions over NR PC5 SL or LTE PC5 SL
- Prioritize LTE Uu UL transmissions over NR PC5 SL or LTE PC5 SL

1.5.1.5 Issue 5: Other Aspects

The following aspects were also considered in some contributions but there was no consensus on these topics. Companies are invited to consider these topics and provide their views.

Topics for discussion:

- Switching to Uu Air-interface from PC5 when coexistence issues are identified
- Satisfaction of service latency requirement, resource utilization due to TDM solutions
- Mapping applications to LTE/NR V2X transmissions
- Cross-carrier/-sidelink sensing and reservation can be considered for mitigating the limited Tx/Rx capability issues
- Recovery mechanisms to resolve co-existence issues after they arise by:
  - RRC signaling to request a solution by the network
  - Sidelink signaling to request assistance from other UEs

In RAN1#94, the following agreements has been made on coexistence:

Agreements on co-existence:

- For the study of LTE-V2X and NR-V2X sidelink co-existence, at least the following scenarios are considered from the UEs perspective:
  - LTE sidelink and NR sidelink do not have any coordinated procedures
  - LTE sidelink and NR sidelink have coordinated procedures and half-duplex constraints are assumed
    - RAN1 will focus on this scenario in the SI
- RAN1 focus on at least the following potential solutions for coexistence at least until the next meeting:
  - TDM of LTE V2X and NR V2X sidelink transmissions
  - FDM of LTE V2X and NR V2X sidelink transmissions

In RAN1#94bis, the following agreements has been made on coexistence:

Agreements on co-existence:

- In the context of in-device coexistence between NR and LTE V2X sidelinks (not co-channel, which could include both adjacent channel and channels that are sufficiently far apart.)
  - TDM solutions are those that prevent overlapping or simultaneous NR and LTE V2X sidelink transmissions.
  - FDM solutions are those that involve simultaneous transmissions of NR and LTE V2X sidelink transmissions and defining mechanisms for sharing the total device power between the two.
- For TDM solutions, LTE and NR V2X sidelinks are assumed to be synchronized
  - **FFS accuracy of time alignment/synchronization**
  - **FFS alignment whether slot level and/or direct frame number (DFN) based alignment is needed**
- For TDM solutions, the following aspects are studied in RAN1:
  - Long term time-scale coordination

- ❖ Potential transmissions in time of LTE and NR V2X are statically/quasi-statically determined
- ❖ **UE behaviour when LTE and NR V2X sidelink transmissions overlap in time is FFS**

- Short time-scale coordination
- **Transmissions in time of LTE and NR V2X are known to each RAT (details FFS)**
- **UE behavior when LTE and NR V2X sidelink transmissions overlap in time is FFS**

- **FFS coordination details**
- **FFS UE assistance for coordination**

In RAN1#95, the following agreements has been made on coexistence:

Agreements on co-existence:

- Consider solutions for sidelink coexistence for the following:
  - Potential LTE V2X Tx and NR V2X Tx
  - Potential LTE V2X Tx and NR V2X Rx
  - Potential LTE V2X Rx and NR V2X Tx
- FFS the case of potential LTE V2X Rx and NR V2X Rx, e.g., whether or not it can be handled implementation

RAN1 will identify both TDM and FDM solutions for coexistence. The specific support for each solution is FFS.

For FDM solutions:

- For both dynamic and semi-static power allocation solutions, RAN1 assumes synchronization between NR and LTE V2X sidelinks, for a NR V2X UE when NR and LTE V2X sidelinks are intra-band
- The case of inter-band is FFS

Note: If the identified solutions can be applied to systems that are not synchronized, then RAN1 may revisit this assumption.

In RAN1#AH_1901, the following agreements has been made on coexistence:

Agreements on co-existence:

R1-1901392

Agreements:

- For TDM solutions for in-device coexistence between LTE and NR V2X:
  - Time Alignment
    - Subframe boundary alignment is required between LTE and NR V2X sidelinks
    - Both LTE and NR V2X sidelinks are aware of the time resource index (e.g., DFN for LTE) in both carriers

R1-1901425

Agreements:

- For long term time scale TDM solutions for in-device coexistence between LTE and NR V2X:
  - For a UE with coexistence impact, non-overlapping (in time domain) resource pools are (pre-)configured for NR V2X and LTE V2X sidelinks
    - No information is exchanged between LTE and NR sidelinks within the UE
- Long term time scale TDM solution is feasible from RAN1 point of view
  - Note: although feasible, it is expected that such a solution may have impact on latency, reliability and data rate requirements for some applications
  - No additional modifications to LTE specifications are needed

Agreements:

Assuming SPS scheduling (mode -3 or mode-4) for LTE V2X, for short time scale TDM solutions for in-device coexistence for V2X,

- For each occurrence of Tx/Tx overlap, one RAT is prioritized over another
  - This requires some information exchange between LTE and NR sidelinks within the UE
  - FFS: whether the information exchange between LTE and NR sidelinks can support this requirement
  - FFS: if there is impact to RAN1 LTE specification with this agreement
  - FFS: whether this solution can be up to UE implementation
- For each occurrence of Tx/Rx overlap, one RAT is prioritized over another
  - This requires some information exchange between LTE and NR sidelinks within the UE
  - FFS: if there is impact to RAN1 LTE specification with this agreement
  - FFS: whether this solution can be up to UE implementation
  - FFS: If determination of priority for Rx operation is feasible and whether the information exchange between LTE and NR sidelinks can support this requirement

Agreements:

- Inter-band FDM Solutions for coexistence
  - For static power assignment of Pc,max for each carrier
    - Synchronization is not assumed for inter-band coexistence of NR sidelink and LTE sidelink.
    - This FDM solution is feasible for resolution of Tx/Tx coexistence conflicts
    - If the band separation is large enough (based on RAN4 indication), then this FDM solution for coexistence is feasible for Tx/Rx coexistence
    - If the band separation is NOT large enough, then this FDM solution is not feasible for resolution of Tx/Rx coexistence conflicts
  - For dynamic power sharing between carriers,
    - FFS details of FDM solutions and whether they are feasible

Assuming SPS scheduling (mode -3 or mode-4) for LTE V2X, for short time scale TDM solutions for in-device coexistence for V2X,

- For each occurrence of Tx/Tx overlap, one RAT is prioritized over another
  - This requires some information exchange between LTE and NR sidelinks within the UE
  -
- For each occurrence of Tx/Rx overlap, one RAT is prioritized over another
  - This requires some information exchange between LTE and NR sidelinks within the UE

- Inter-band FDM Solutions for coexistence
  - For dynamic power sharing between carriers,
    - FFS details of FDM solutions and whether they are feasible