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Technical Report

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Contents

Foreword

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1 Scope

The present document is a technical report for NR V2X services with sidelink operation in Rel-16. The purpose is to specify radio solutions that are necessary for NR to support advanced V2X services (except the remote driving use case which was studied in TR 38.824) based on the study outcome captured in TR 38.885.

1. NR sidelink: Specify NR sidelink solutions necessary to support sidelink unicast, sidelink groupcast, and sidelink broadcast for V2X services, considering in-network coverage, out-of-network coverage, and partial network coverage.

   The solutions should cover both the operating scenario where the carrier(s) is/are dedicated to V2X services and the operating scenario where the carrier(s) is/are licensed spectrum and also used for NR Uu/LTE Uu operation.

   NR sidelink design starts with frequencies in FR1, and NR sidelink in FR2 is supported by applying the design for FR1 and PT-RS to the numerologies agreed for FR2. No FR2 specific optimization is supported in this WI except PT-RS. No beam management is supported in this work.

   For the scenarios of NR sidelink carrier, this work will consider a single carrier for the NR sidelink transmission and reception.

   In this work, 2Rx antennas as well as 4Rx antennas are supported. The full range of speeds defined in SA1 (TS 22.186) needs to be supported in FR1.

2. Specify support for NR Uu to provide control for LTE sidelink

3. Specify UE report to assist gNB scheduling

4. Specify support for QoS management

This Technical Report focus on NR sidelink UE Tx/Rx RF requirements and contains the adjacent channel coexistence evaluation results for NR sidelink operation at both licensed bands and the dedicated ITS spectrum for V2X service.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 30.007: "Guideline on WI/SI for new Operating Bands".

[3] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[4] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

[5] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios".

[6] R4-1910400, "TP on adjacent channel co-existence scenarios and parameters for NR V2X service on FR1"

[7] R4-1911489, " [V2X] NR V2X coexistence simulation results for ITS spectrum case1 and case3"

[8] R4-1911490, “ [V2X] NR V2X coexistence simulation results for ITS spectrum case2 and case4”

[9] R4-1910402, “Initial coexistence simulation results of NR V2X for ITS band”

[10] R4-1912473, “NR V2X RF Coex Simulation results”

[11] R4-1911491, “[V2X] NR V2X coexistence simulation results for licensed band”

[12] R4-1912865, “Coexistence simulation results in licensed bands”

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

ACLR Adjacent Channel Leakage Ratio
ACS Adjacent Channel Selectivity
AGC Automatic Gain Control
A-MPR Additional Maximum Power Reduction
BLER BLock Error Rate
BS Base Station
CBW Channel Bandwidth
CDF Cumulative Distribution Function
CP-OFDM Cyclic Prefix-OFDM
DMRS Demodulation Reference Signal
DSRC Dedicated Short-Range Communications
EIRP Equivalent Isotropically Radiated Power
EVM Error Vector Magnitude
FDD Frequency Division Duplex
FDM Frequency Division Multiplexing
FR1 Frequency Range 1
FR2 Frequency Range 2
ITS Intelligent Transportation System
LDPC Low Density Parity Check
LTE Long Term Evolution
LOS Line-Of-Sight
MPR Maximum Power Reduction
NF Noise Figure
NLOS Non-Line-Of-Sight
NR New Radio
OLPC Open Loop Power Control
PC Power Control
PRB Physical Resource Block

PRR	Package Reception Ratio
PSCCH	Physical Sidelink Control CHannel
PSSCH	Physical Sidelink Shared CHannel
REFSENS	Reference Sensitivity
RF	Radio Frequency
SCS	Sub-Carrier Spacing
SINR	Signal to Interference plus Noise Ratio
SL	Sidelink
SNR	Signal-to-Noise Ratio
TDD	Time Division Duplex
TDM	Time Division Multiplexing
UE	User Equipment
UL	Uplink
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything

4 Background

4.1 Justification

To expand the 3GPP platform to the automotive industry, the initial standard on support of V2V services was completed in September 2016. Enhancements that focusing on additional V2X operation scenarios leveraging the cellular infrastructure, are completed in March 2017 as 3GPP V2X phase 1 for inclusion in Release 14 LTE. In Rel-14 LTE V2X, a basic set of requirements for V2X service in TS 22.185 derived from TR 22.885 has been supported, which are considered sufficient for basic road safety service. Vehicles (i.e., UEs supporting V2X applications) can exchange their own status information through sidelink, such as position, speed and heading, with other nearby vehicles, infrastructure nodes and/or pedestrians.

3GPP V2X phase 2 in Rel-15 introduces a number of new features in sidelink, including: carrier aggregation, high order modulation, latency reduction, and feasibility study on both transmission diversity and short TTI in sidelink. All these enhanced features in 3GPP V2X phase 2 are primary base on LTE and require co-existing with Rel-14 UE in same resource pool.

SA1 has completed enhancement of 3GPP support for V2X services (eV2X services) in Rel-15. The consolidated requirements for each use case group (see below) are captured in TR 22.886, and a set of the normative requirements are defined in TS 22.186 in Rel-15.

SA1 has identified 25 use cases for advanced V2X services and they are categorized into four use case groups: vehicles platooning, extended sensors, advanced driving and remote driving. The detailed description of each use case group is provided as below.

> **Vehicles Platooning** enables the vehicles to dynamically form a group travelling together. All the vehicles in the platoon receive periodic data from the leading vehicle, in order to carry on platoon operations. This information allows the distance between vehicles to become extremely small, i.e., the gap distance translated to time can be very low (sub second). Platooning applications may allow the vehicles following to be autonomously driven.
>
> **Extended Sensors** enables the exchange of raw or processed data gathered through local sensors or live video data among vehicles, RSUs, devices of pedestrians and V2X application servers. The vehicles can enhance the perception of their environment beyond what their own sensors can detect and have a more holistic view of the local situation.
>
> **Advanced Driving** enables semi-automated or fully-automated driving. Longer inter-vehicle distance is assumed. Each vehicle and/or RSU shares data obtained from its local sensors with vehicles in proximity, thus allowing vehicles to coordinate their trajectories or maneuvers. In addition, each vehicle shares its driving intention with vehicles in proximity. The benefits of this use case group are safer traveling, collision avoidance, and improved traffic efficiency.

Remote Driving enables a remote driver or a V2X application to operate a remote vehicle for those passengers who cannot drive themselves or a remote vehicle located in dangerous environments. For a case where variation is limited and routes are predictable, such as public transportation, driving based on cloud computing can be used. In addition, access to cloud-based back-end service platform can be considered for this use case group.

SA1 has considered both LTE and NR for the candidates of 3GPP RATs in supporting eV2X.

The SA2 study has been progressed to identify and evaluate potential architecture enhancements of EPS and 5G System design needed to support advanced V2X services identified in TR 22.886, based on vehicular services requirements defined in SA1 V2X (TS 22.185) and eV2X (TS 22.186) and determine which of the solutions can proceed to normative specifications. SA2 has completed the study and started the normative work on the architecture solutions for V2X.

TSG RAN has already agreed in TR 38.913 that it is not intended for NR V2X to replace the services offered by LTE V2X. Instead, the NR V2X shall complement LTE V2X for advanced V2X services and support interworking with LTE V2X. At least from 3GPP RAN technology development standpoint, the focus and scope of NR V2X is to target advanced V2X use cases. However, this does not imply that NR V2X cannot support basic safety use cases. It is clearly up to the regional regulators and the stakeholders involved (i.e. Car OEMs and automotive ecosystem in general) to decide on the technology of choice for any service and any use case.

NR V2X is destined as 3GPP V2X phase 3 and would support advanced V2X services beyond services supported in LTE Rel-15 V2X. The advanced V2X services would require enhanced NR system and new NR sidelink to meet the stringent requirements. NR V2X system is expected have a flexible design in support of services with low latency and high reliability requirements. NR system also expects to have higher system capacity and better coverage. The flexibility of NR sidelink framework would allow easy extension of NR system to support the future development of further advanced V2X services and other services. RAN WGs have conducted the feasibility study on NR V2X, and it was concluded in TR 38.885 that it is feasible to support advanced V2X services using the technical solutions identified during the study. It is noted that the study on the remote driving use case was conducted in TR 38.824. Meanwhile, it was noted that solutions defined for V2X can also be used for public safety when the service requirement can be met.

4.2 Objective

The objective of this work item is to specify radio solutions that are necessary for NR to support advanced V2X services (except the remote driving use case which was studied in TR 38.824) based on the study outcome captured in TR 38.885. RAN4 should focus on the RAN WG4 work scope in the approved WID [1] as below

1. NR sidelink: Specify NR sidelink solutions necessary to support sidelink unicast, sidelink groupcast, and sidelink broadcast for V2X services, considering in-network coverage, out-of-network coverage, and partial network coverage.

Solutions for ‘not co-channel’ in-device coexistence between LTE and NR sidelinks

TDM-based solutions as per the study outcome [RAN1, RAN2, RAN4]

FDM-based solutions with static power allocation as per the study outcome [RAN4]

This will not consider the case where LTE and NR sidelinks are in the same frequency band.

No impact to LTE specifications at least from RAN1 and RAN2 perspective.

UE Tx and Rx RF requirement [RAN4]

This requirement should ensure

coexistence between sidelink and Uu interface in the same and adjacent channels in licensed spectrum

coexistence with other V2X technologies in the adjacent channel in ITS spectrum in 5.9 GHz, without assuming that 5.9 GHz spectrum will be universally available nor that it will be universally available in sufficient quantity to support NR V2X advanced use cases

RRM core requirement [RAN4]

The solutions should cover both the operating scenario where the carrier(s) is/are dedicated to V2X services and the operating scenario where the carrier(s) is/are licensed spectrum and also used for NR Uu/LTE Uu operation.

NR sidelink design starts with frequencies in FR1, and NR sidelink in FR2 is supported by applying the design for FR1 and PT-RS to the numerologies agreed for FR2. No FR2 specific optimization is supported in this WI except PT-RS. No beam management is supported in this work.

For the scenarios of NR sidelink carrier, this work will consider a single carrier for the NR sidelink transmission and reception.

In this work, 2Rx antennas as well as 4Rx antennas are supported. The full range of speeds defined in SA1 (TS 22.186) needs to be supported in FR1.

It is assumed that any co-channel coexistence requirements and mechanisms of NR sidelink with non-3GPP technologies will not be defined by 3GPP.

4.3 V2X operating scenarios

4.3.1 Operation Aspects

Scenarios considered by RAN4 for NR V2X sidelink operation are as follows:

- **(Aspect 1) Operation bands used as test points for evaluation**
  - Case 1A: 5.9 GHz (for ITS spectrum)
  - Case 1B: 3.5 GHz (TDD) or 2GHz (FDD) (for licensed bands operation at FR1)
  - Case 1C: 28 GHz (for licensed bands operation at FR2)
- **(Aspect 2) gNB deployment including the possibility of network control**
  - Case 2A: UE autonomous resource allocation, at least mode 2, based on semi-statically netw ork-configured/pre-configured radio parameters including no gNB coverage case.
  - Case 2B: gNB providing more UE specific or/and more dynamic resource allocation includin g Mode 1 compared to case 2A.

Within RAN4 for this NR V2X WI, analysis and specification of single carrier operation is defined as a first priority compare to con-current operation in Aspect3. (E.g. specify transmission and reception requirements for ITS spectrum and licensed bands).

RAN4 should focus on the 5G V2X UE RF core requirements as 1st priority

- Specify RF core requirements in the ITS spectrum,
- Specify RF core requirements for NR SL (at n47) and LTE SL (at B47) as TDM for Tx transmission and simultaneous receptions,
- Specify RF core requirements for licensed bands in which the entire band is allocated for SL operation in a region.
  - Sidelink operation in partial bandwidth in licensed band is not precluded in WI

- **(Aspect 3) Con-current operation**

In 5G V2X WI, the multi-carrier V2X with sidelink operation is excluded in rel-16. Only possible to support the con-current operation for V2X service between 5G V2X sidelink and LTE/NR Uu operation.

After the single carrier 5G V2X operation with sidelink, RAN4 support the con-current NR V2X operation will be defined as second priority in the NR V2X WI.

The expected con-current operation for V2X service support a number of configurations including the following example band combinations:

1) Inter-band con-current operation:

   – NR V2X SL (at n47) + LTE/NR Uu (at licensed bands)
   – LTE V2X SL (at B47) + NR Uu (at licensed bands)
   – NR V2X SL (at licensed band A) + LTE/NR Uu (at licensed band B)

2) Intra-band con-current operation

   – NR V2X SL (at n47) + LTE V2X SL (at B47): only TDM operation is allowed
   – NR V2X SL (at licensed bands) + NR/LTE V2X Uu (at licensed bands)

Based on these operating scenarios, following Cases are decribed as below

Table 4.3.1-1 Con-current operation for NR V2X service

	CC1 (NR PC5) / CC2 (NR or LTE)	NR/LTE Band (n47/B47) (PC5 V2X)	NR/LTE Licensed Band X (Uu V2X) e.g.) B3/B8…
Inter-band Con-current operation	NR/LTE Band (n47/B47) (PC5 V2X)	- N/A	- Case 3A: NR n47 (PC5) +NR Band X(Uu) - Case 3A: NR n47 (PC5) +LTE Band X(Uu) - Case 3B: LTE Band 47 (PC5) + NR Band X(Uu)
	NR Licensed band Y (PC5 V2X)	- N/A in rel-16: NR Band Y(PC5) + NR n47 (PC5) - N/A in rel-16: NR Band Y(PC5) + LTE B47 (PC5)	- Case 3C: NR Band Y(PC5) + NR Band X(Uu) - Case 3C: NR Band Y(PC5) + LTE Band X(Uu)
Intra-band Con-current operation	NR Band (n47) (PC5 V2X)	- N/A in rel-16: NR n47 (PC5) + NR n47 (PC5)	N/A
	NR Licensed band X (PC5 V2X)	- N/A	- Case 3E: NR Band X(PC5) +NR Band X(Uu) - Case 3E: NR Band X(PC5) + LTE Band X(Uu)

Based on the Table 4.3.1-1, RAN4 analyze on the con-current operations with multi-carrier as 2nd priority in V2X WI since the single carrier SL operation should be specified for NR V2X service with sidelink or licensed band in rel-16. The con-current operation of V2X service will be reflected the request of preferred band combinations from interested operator.

The con-current operation between 5G NR V2X SL and other system can be treated as 2nd priority. And 2nd & 3rd priority are proposed as following for con-current operation.

- 2nd priority in con-current operation:

  - Case 3A: NR V2X PC5 (at n47) + NR/LTE Uu (at licensed bands) on inter-band con-current operation

  - NR V2X PC5 (at n47) + NR Uu(at licensed bands)
  - NR V2X PC5 (at n47) + LTE Uu(at licensed bands)
- Case 3C: NR V2X SL (at licensed band Y) + LTE/NR Uu (at licensed band X) on inter-band con-current operation
  - NR V2X PC5 (at licensed band Y) + NR Uu(at licensed band X)
  - NR V2X PC5 (at licensed band Y) + LTE Uu(at licensed band X)

- 3rd Priority for con-current operation (without ITS spectrum):
  - Case 3B: LTE Band 47 PC5 + NR Uu (at licensed bands) : need to study on RAN4 impact when NR Uu control the LTE sidelink operation since the agreed WID did not reflect RAN4 impact
  - Case 3E: NR V2X PC5 (at licensed band) + LTE/NR Uu (at licensed band) on intra-band combination
    - NR V2X PC5 (at licensed band X) + LTE Uu (at licensed band X)
    - NR V2X PC5 (at licensed band X) + NR Uu (at licensed band X)

5 Evaluation of adjacent channel co-existence

5.1 General

In this section, the adjacent channel system coexistence evaluation was studied for NR V2X services. The operating scenarios include both the cases where the carrier is dedicated to NR V2X service in ITS spectrum (e.g. 5.9GHz) and cases where the carrier is deployed for NR V2X service in licensed spectrum. For the ITS spectrum (e.g. 5.9GHz), the coexistence evaluation include LTE based V2V operation and/or DSRC/IEEE 802.11p operation on the adjacent carrier of NR V2X. For the licensed carrier, the coexistence evaluation include LTE or NR Uu on the adjacent carrier of NR V2X.

5.1.1 Adjacent channel coexistence scenarios

The adjacent channel coexistence evaluation scenarios for NR V2X service are shown in Table 5.1.1-1

Table 5.1.1-1: The adjacent channel coexistence scenarios for NR V2X service

NR V2X operating frequency		Deployment scenarios (Aggressor-to-Victim)
FR1	V2X service at ITS spectrum (sidelink: 5.9GHz)	- Case1: NR V2X UE-to-DSRC UE - Case2: DSRC UE-to-NR V2X UE - Case3: NR V2X UE-to-LTE V2X UE - Case4: LTE V2X UE-to-NR V2X UE
	V2X service at licensed bands (TDD: 3.5GHz)	- Case5: NR V2X UE-to-NR Uu BS - Case6: NR Uu UE-to-NR V2X UE
	V2X service at licensed bands (FDD: 2GHz)	- Case7: NR V2X UE-to-LTE Uu BS - Case8: LTE Uu UE-to-NR V2X UE
FR2	V2X service at licensed bands	- Case9: NR V2X UE-to-NR Uu BS - Case10: NR Uu UE-to-NR V2X UE

Basic simulation parameters are below

- Deployment scenarios: Urban Manhattan grid model
- Simulation Block Size :
  - Urban : Manhattan grid model: 3*433m, 3*250m

- RAN1 dependent parameter
  - Power control scheme, RAN4 can revisit the PC according to RAN1 decision, but following is initial
    - ✓ In licensed spectrum, OLPC in TR36.786 is used or no power control is used
    - ✓ In ITS spectrum, worst case of no power control is used
  - For licensed band, NR SL operation in Uplink band in FDD, UL opportunity in TDD is considered.
  - For SINR calculation in partial overlapping between aggressor and victim, worst case SINR should be considered.

The details of the deployment scenarios are presented in the following clauses.

5.2 Co-existence simulation assumptions

5.2.1 Co-existence simulation parameters in ITS spectrum

5.2.1.1 Layout model

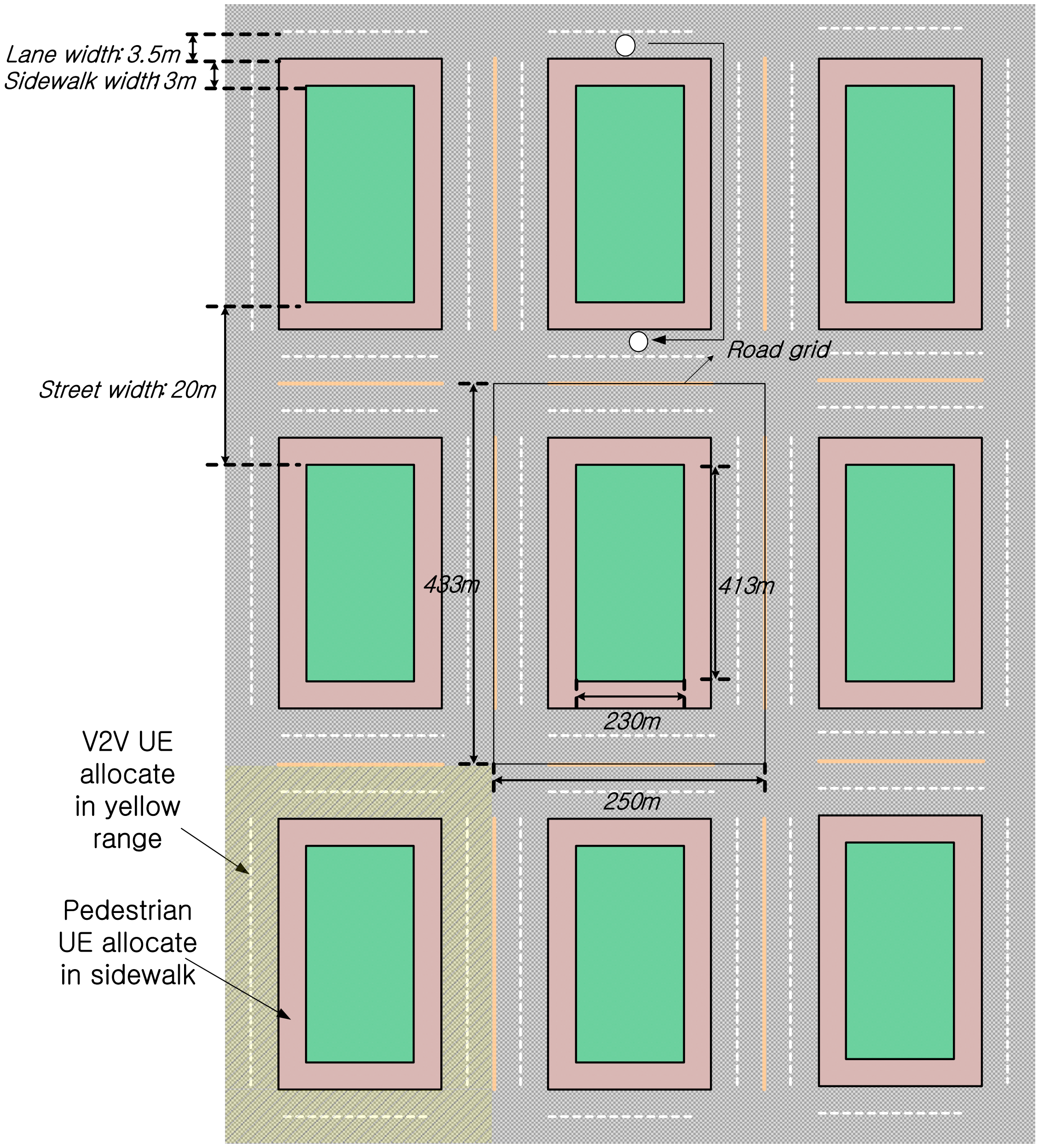


Figure 5.2.1.1-1 Network layout model for NR V2X coexistence simulation in ITS spectrum

Table 5.2.1-1: Simulation layout model in ITS spectrum

<table>
<tr><th>Parameter</th><th>Value</th></tr>
<tr><td>carrier frequency</td><td>5.9GHz</td></tr>
<tr><td>Deployment scenarios</td><td>Urban Mahathan grid model</td></tr>
<tr><td>Simulation Block Size</td><td>3*433m, 3*250m</td></tr>
<tr><td>Velocity of vehicles</td><td>15km/h or 60km/h
Note1: Fixed location will be considered for adjacent channel coexistence evaluation.
Note2: Velocity is only used to decide the UE’s density.</td></tr>
<tr><td>Pathloss model for
- DSRC UE-to-DSRC UE
- LTE V2X UE-to-LTE V2X UE

- NR V2X UE-to-DSRC UE
- DSRC UE-to-NR V2X UE
- NR V2X UE-to-LTE V2X UE
- LTE V2X UE-to-NR V2X UE</td><td>
<table>
<tr><td>LOS/NLOS/NLOSv</td><td>Pathloss [dB]</td><td>Shadow fading std [dB]</td></tr>
<tr><td>LOS, NLOSv</td><td>For Highway case,
$PL = 32.4 + 20 \log_{10}(d_{3D}) + 20 \log_{10}(f_c)$

For Urban case,
$PL= 38.77 + 16.7 \log_{10}(d_{3D}) + 18.2 \log_{10}(f_c)$</td><td>$\sigma_{SF} = 3$</td></tr>
<tr><td>NLOS</td><td>$PL= 36.85 + 30 \log_{10}(d_{3D}) + 18.9 \log_{10}(f_c)$</td><td>$\sigma_{SF} = 4$</td></tr>
<tr><td colspan="3">Note 1: f_c denotes the center frequency in GHz and d_{3D} denotes the Euclidean distance between TX and RX in 3D space in meters.
Note 2: The model for spatial correlation of shadow fading defined in TR 36.885 applies.</td></tr>
</table>
</td></tr>
<tr><td>Dropping vehicles (based on clause 6.1.2 from TR 37.885)</td><td>Vehicles are dropped according to the following process:
- The distance between the rear bumper of a vehicle and the front bumper of the following vehicle in the same lane is max {2 meter, an exponential random variable with the average of the speed * 2 sec}.
- All the vehicles in the same lane have the same speed.
- Vehicle type distribution is not dependent of the lane.</td></tr>
<tr><td>Total number of vehicles</td><td>It depends on vehicle UE density and block size.</td></tr>
<tr><td>vehicle UE activation rate for aggressor and victim</td><td>1% of total number of UEs</td></tr>
<tr><td>vehicle type (based on clause 6.1.2 from TR 37.885)</td><td>- Type 2 (passenger vehicle with higher antenna position): length 5 meters, width 2.0 meters, height 1.6 meters, antenna height 1.6 meters</td></tr>
</table>

5.2.1.2 Simulation parameters

Table 5.2.1.2-1: Simulation parameters in ITS spectrum

Parameter	Value		
	DSRC UE	LTE V2X UE	NR V2X UE
Tx power	23dBm	23dBm	23dBm
Channel Bandwidth	10MHz	20MHz	40MHz
Packet size	1) 190 byte packet 2) 300 byte packet	1)14 PRB (190 byte packet) 2)20 PRB (300 byte packet)	1)[70] PRB (1100 byte packet) for 15kHz SCS 2)Other options are not precluded
Traffic model	1 transmission every 100ms - 100ms message generation period - Time instance of message generation is randomized among vehicles		
Noise figure	10dB	9dB	9dB
Antenna pattern	Omni-directional with gain of 0 dBi		
Sidelink Power control	In ITS spectrum, worst case of no power control is used		
SINR-to-BLER mapping	As per link level performance model in TR 36.785 Table A-4 for 5.9GHz	As per link level performance model in TR 36.785 Table A-3 for 5.9GHz	As per link level performance model in TR 38.886 Table A-2 for 5.9GHz

Table 5.2.1.2-2: Additional simulation assumptions for DSRC UE

Parameter	Value
DSRC MCS	QPSK with r=1/2 Transmit duration of 341us (190bytes) and 488 (300bytes) without header
DSRC MAC	Coordination : DL+UL coexistence evaluation : EDCA Detection : Energy detection & preamble detection
DSRC Slot time	13us (Note specified for 10MHz [802.11 -2012])
DSRC DIFS	58us (SIFS + 2*slot_time)
DSRC SIFS	32us
DSRC Physical header size	40us
DSRC Threshold triggering physical header decoding	-98dBm
DSRC CCA-CS	-85dBm
DSRC CCA-ED	-65dBm
OFDM symbol duration	8us

5.2.1.3 ACLR and ACS

1. Option 1 (as baseline) : 1 step ACLR/ACS model

Table 5.2.1.3-1: ACLR and ACS in ITS spectrum

Parameter	Value		
	DSRC UE	LTE V2X UE	NR V2X UE
ACLR	26dB	30dB	30 + X dB
ACS	Use three candidate ACS level for DSRC : - 22/25/29dB	27dB	24+ X dB

Details for modelling:

2. Option 2: 2 steps ACLR/ACS model.

   a. ACLR:

i. If the frequency offset between transmitting RB (aggressor) and receiving RB (victim) is smaller than the transmitter (aggressor) allocated transmission bandwidth bandwidth then ACLR1 applies.

ii. If the frequency offset between transmitting RB (aggressor) and receiving RB (victim) is larger than the transmitter (aggressor) allocated transmission bandwidth bandwidth then ACLR2 applies

b. ACS

i. If the frequency offset between transmitting RB (aggressor) and receiving channel edge (victim) is smaller than 10MHz then ACS1 applies.

ii. If the frequency offset between transmitting RB (aggressor) and receiving channel edge (victim) is larger than 10MHz then ACS2 applies.

NOTE: 10MHz offset velue is derived from LTE V2X definition of ACS and inband blocking requirement, as will as DSRC adjacent and alternate adjacent channel rejection requirement definition

Table 5.2.1.3-2: ACLR1/2 and ACS1/2 in ITS spectrum

Parameter	Value		
	DSRC UE	LTE V2X UE	NR V2X UE
ACLR1	26dB	30dB	30 + X dB
ACLR2	[39]dB	[43]dB	[43]dB
ACS1	Use three candidate ACS level for DSRC : - 22/25/29dB	27dB	24+ X dB
ACS2	ACS1 + 16 (NOTE 1)	43dB (NOTE 2)	[40]dB + X(NOTE 3)
NOTE 1: following definition of alternate adjacent channel rejection requirement of DSRC [EN 302 571] NOTE 2: following definition of in band blocking requirement, case 1 of LTE CV2X [TS 36.101] NOTE 3: following definition of in band blocking requirement, case 2 of NR and apply same tightening as for LTE V2X.			

5.2.2 Coexistence simulation parameters in FR1 FDD licensed spectrum

5.2.2.1 Network layout model

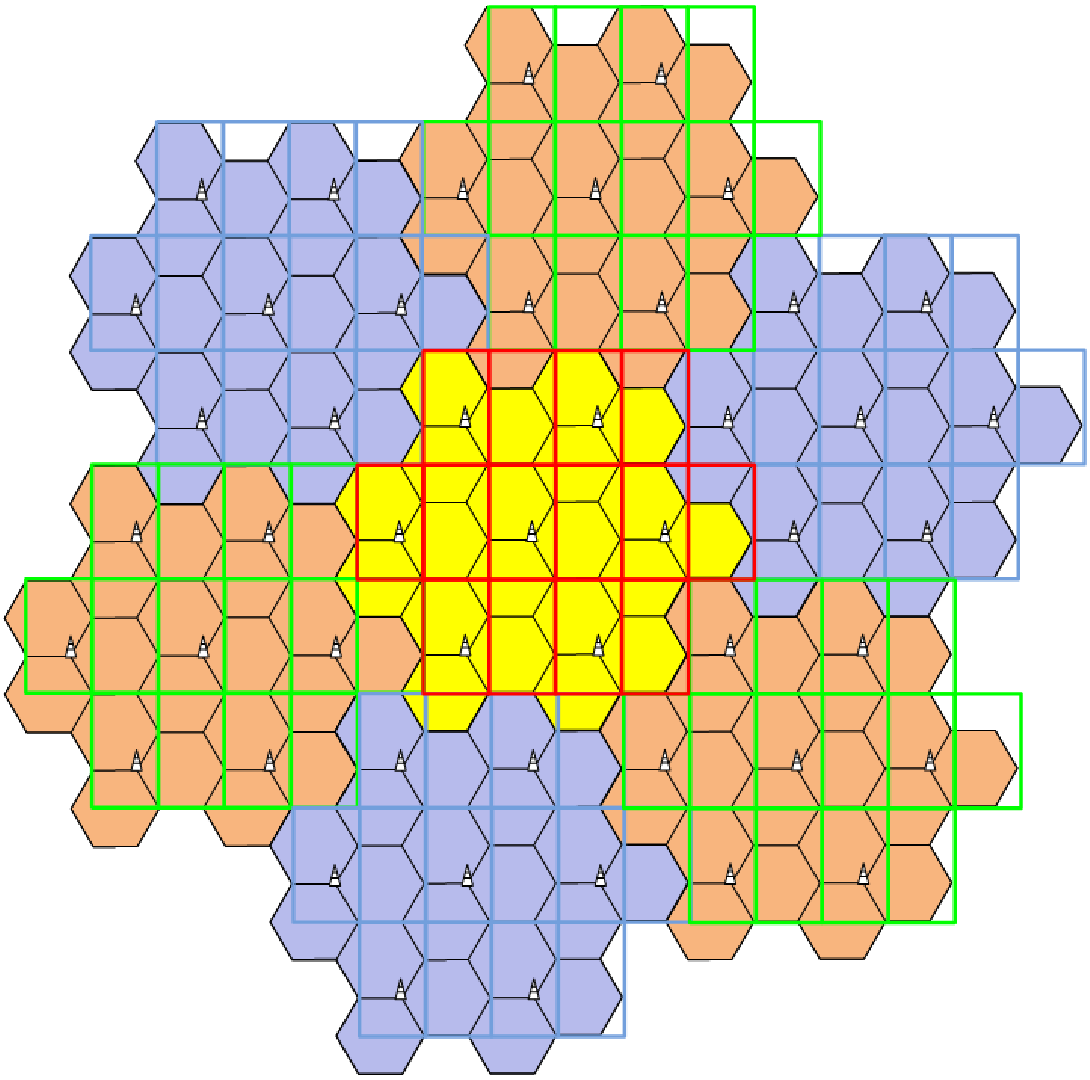


Figure 5.2.2.1-1 Network layout model for NR V2X coexistence simulation for case7 and case8

Table 5.2.2-1: Simulation network layout model for case7 and case8

<table>
<tr><th>Parameter</th><th>Value</th></tr>
<tr><td>carrier frequency</td><td>2GHz</td></tr>
<tr><td>The first layout for LTE WAN</td><td>layer with 7 hexagonal cell with wrap around</td></tr>
<tr><td>Inter-BS distance</td><td>500m</td></tr>
<tr><td>LTE WAN UL scheduler algorithm</td><td>Round robin with full buffer</td></tr>
<tr><td>RBs allocated per active WAN UE</td><td>For LTE UE-to-LTE Uu BS: 32 PRBs</td></tr>
<tr><td>Number of active WAN UEs</td><td>3UEs</td></tr>
<tr><td>Number of LTE WAN UEs</td><td>20UEs/Cell, 100% outdoor
(UEs are dropped with the equal inter-UE distance in the middle of the sidewalk)</td></tr>
<tr><td>Minimum coupling loss (for V2X/WAN UEs from BS)</td><td>As per clause 4.5.1 in TR 36.942:
MCL : 70dB for Urban area</td></tr>
<tr><td>Pathloss model for
- LTE UE-to-LTE Uu BS

- NR V2X UE-to-LTE Uu BS</td><td>Follow TR 37.885 for FR1
<table>
<tr><th colspan="2">FR1</th></tr>
<tr><th>LOS</th><th>NLOS</th></tr>
<tr><td>Urban:
TR 38.901 UMa LOS

Highway:
TR 38.901 RMa LOS</td><td>Urban:
TR 38.901 UMa NLOS

Highway:
N/A</td></tr>
</table></td></tr>
<tr><td></td><td></td></tr>
<tr><td>The second layout for NR V2X</td><td>Urban Mahathan grid model</td></tr>
<tr><td>Simulation Block Size</td><td>433m, 250m</td></tr>
<tr><td>Velocity of vehicles</td><td>15km/h or 60km/h
Note1: Fixed location will be considered for adjacent coexistence evaluation.
Note2: Velocity only used to decide the UE density.</td></tr>
<tr><td>Pathloss model for
- LTE Uu UE-to-NR V2X UE</td><td>
<table>
<tr><th>LOS/NLOS/NLOSv</th><th>Pathloss [dB]</th><th>Shadow fading std [dB]</th></tr>
<tr><td>LOS, NLOSv</td><td>For Highway case,
$PL = 32.4 + 20 \log_{10}(d_{3D}) + 20 \log_{10}(f_c)$

For Urban case,
$PL= 38.77 + 16.7 \log_{10}(d_{3D}) + 18.2 \log_{10}(f_c)$</td><td>$\sigma_{SF} = 3$</td></tr>
<tr><td>NLOS</td><td>$PL= 36.85 + 30 \log_{10}(d_{3D}) + 18.9 \log_{10}(f_c)$</td><td>$\sigma_{SF} = 4$</td></tr>
<tr><td colspan="3">Note 1: f_c denotes the center frequency in GHz and d_{3D} denotes the Euclidean distance between TX and RX in 3D space in meters.
Note 2: The model for spatial correlation of shadow fading defined in TR 36.885 applies.</td></tr>
</table></td></tr>
<tr><td>Dropping vehicles (based on clause 6.1.2 from TR 37.885)</td><td>Vehicles are dropped according to the following process:

- The distance between the rear bumper of a vehicle and the front bumper of the following vehicle in the same lane is max {2 meter, an exponential random variable with the average of the speed * 2 sec}.

- All the vehicles in the same lane have the same speed.

- Vehicle type distribution is not dependent of the lane.</td></tr>
<tr><td>Total number of vehicles</td><td>It depends on UE density and block size. All vehicles are NR V2X UEs.</td></tr>
<tr><td>Vehicle UE activation rate</td><td>1% of total number of vehicles</td></tr>
<tr><td>vehicle type (based on clause 6.1.2 from TR 37.885)</td><td>- Type 2 (passenger vehicle with higher antenna position): length 5 meters, width 2.0 meters, height 1.6 meters, antenna height 1.6 meters</td></tr>
</table>

5.2.2.2 Simulation parameters

Table 5.2.2.2-1: Simulation parameters for case7 and case8

Parameter	Value		
	LTE UE	LTE BS	NR V2X UE
Max Tx power	23dBm	NA	23dBm
Channel Bandwidth	10MHz	10MHz	40MHz
Packet size	1)[16] PRB for 15kHz SCS 2)Other options are not precluded		1)[70] PRB (1100 byte packet) for 15kHz SCS 2)Other options are not precluded
Traffic model	Full buffer	Full buffer	Reference table 5.2.1.2-1
Noise figure	NA	5dB	9dB
Antenna pattern	Omni-directional with gain of 0 dBi	From clause 4.2.1.1 of TR 36.942 $A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, A_m\right]$ where $-180 \le \theta \le 180$ $\theta_{3dB} = 65$ degrees, and $A_m = 20dB$	Omni-directional with gain of 0 dBi
SINR-to-BLER mapping for NR V2X	NA	NA	As per link level performance model in TR 38.886 Table A-2 for 2GHz
SINR-to-rate mapping for LTE	NA	As per link level performance model in TR 36.942 (Table A.2)	NA

5.2.2.3 ACLR and ACS

Table 5.2.2.3-1: ACLR and ACS for case7 and case8

Parameter	Value		
	LTE UE	LTE BS	NR V2X UE
ACLR	30 dB	NA	30 + X dB
ACS	NA	46 dB	24+ X dB

5.2.2.4 Power control

For LTE WAN UE transmit power control, the following power control equation shall be used for the initial uplink coexistence simulations:

$$P_t = P_{\max} \times \min\left\{1, \max\left[R_{\min}, \left(\frac{CL}{CL_{x-ile}}\right)^{\gamma}\right]\right\}$$

where $P_{\max}$ is the maximum transmit power, $R_{\min}$ is the minimum power reduction ratio to prevent UEs with good channels to transmit at very low power level, CL is the path coupling loss defined as max{path loss-G_Tx-G_Rx, MCL}, where path loss is propagation loss plus shadowfading, G_TX is the transmitter antenna gain in the direction of the receiver, G_RX is the receiver antenna gain in the direction of the transmitter and $CL_{x\text{-ile}}$ is the x-percentile CL value. With this power control equation, the x percent of UEs that have the highest coupling loss will transmit at $P_{\max}$. Finally, $0<\gamma<=1$ is the balancing factor for UEs with bad channel and UEs with good channel:

As per PC set 1 and PC set 2 of TR 36.942

- Note that power control algorithm parameters (PodBm, CLxile) should be optimized for network layouts being simulated. For simplicity, power control algorithm parameters are reused in section 5.1.1.6 in TR 36.942 for all network layouts
- Rmin = -63dB for 23dBm, -66dB for 26dBm
- CLxile = 112 - 10*log10(CBW / 10) for PC set 1

PC Set	Gamma	CLxile (dBm)		
		10MHz	20MHz	40MHz
1	1	112	109	106
2	0.8	129	FFS	FFS

For NR V2X UE transmit power control, OLPC in TR36.786 is reused or no power control is used..

CLxile = 112 - 10*log10(CBW / 10) for PC set 1

5.2.3 Coexistence simulation parameters in FR1 TDD licensed spectrum

5.2.3.1 Network layout model

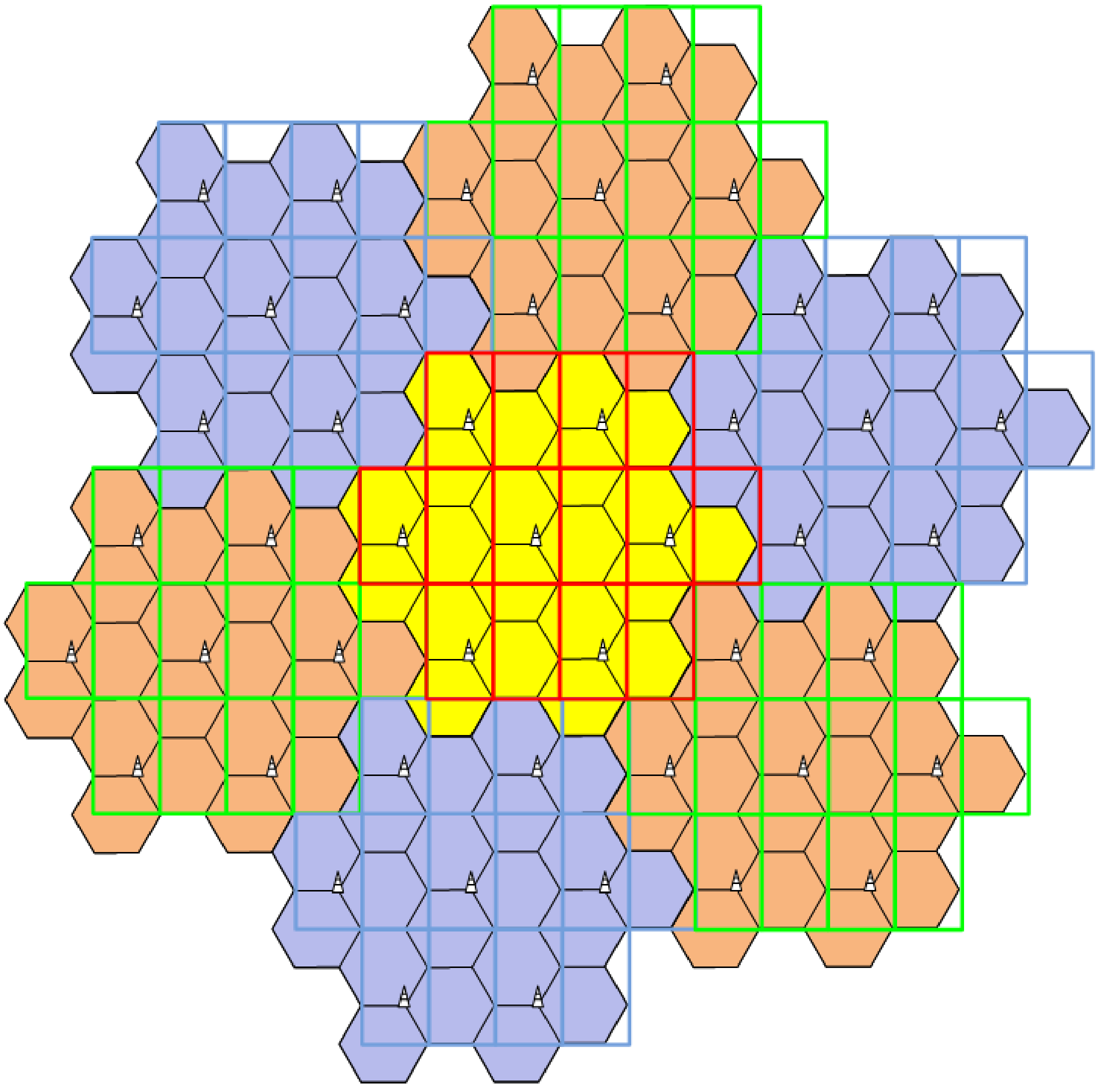


Figure 5.2.3.1-1 Network layout model for NR V2X coexistence simulation for case5 and case6

Table 5.2.3-1: Simulation network layout model for case5 and case6

<table>
<tr><th>Parameter</th><th>Value</th></tr>
<tr><td>carrier frequency</td><td>3.5GHz</td></tr>
<tr><td>The first layout for NR WAN</td><td>layer with 7 hexagonal cell with wrap around</td></tr>
<tr><td>Inter-BS distance</td><td>500m</td></tr>
<tr><td>NR WAN UL scheduler algorithm</td><td>Round robin with full buffer</td></tr>
<tr><td>RBs allocated per active WAN UE</td><td>For NR UE-to-NR Uu BS: 64 PRBs</td></tr>
<tr><td>Number of active WAN UEs</td><td>3UEs</td></tr>
<tr><td>Number of NR WAN UEs</td><td>20UEs/Cell, 100% outdoor
(UEs are dropped with the equal inter-UE distance in the middle of the sidewalk)</td></tr>
<tr><td>Minimum coupling loss (for V2X/WAN UEs from BS)</td><td>As per clause 4.5.1 in TR 36.942:
MCL : 70dB for Urban area</td></tr>
<tr><td>Pathloss model for
- NR UE-to-NR Uu BS

- NR V2X UE-to-NR Uu BS</td><td>Follow TR 37.885 for FR1
<table>
<tr><th colspan="2">FR1</th></tr>
<tr><th>LOS</th><th>NLOS</th></tr>
<tr><td>Urban:
TR 38.901 UMa LOS

Highway:
TR 38.901 RMa LOS</td><td>Urban:
TR 38.901 UMa NLOS

Highway:
N/A</td></tr>
</table></td></tr>
<tr><td></td><td></td></tr>
<tr><td>The second layout for NR V2X</td><td>Urban Mahathan grid model</td></tr>
<tr><td>Simulation Block Size</td><td>433m, 250m</td></tr>
<tr><td>Velocity of vehicles</td><td>15km/h or 60km/h
Note1: Fixed location will be considered for adjacent coexistence evaluation.
Note2: Velocity only used to decide the UE density.</td></tr>
<tr><td>Pathloss model for
- NR Uu UE-to-NR V2X UE</td><td>
<table>
<tr><th>LOS/NLOS/NLOSv</th><th>Pathloss [dB]</th><th>Shadow fading std [dB]</th></tr>
<tr><td>LOS, NLOSv</td><td>For Highway case,
$PL = 32.4 + 20 \log_{10}(d_{3D}) + 20 \log_{10}(f_c)$

For Urban case,
$PL = 38.77 + 16.7 \log_{10}(d_{3D}) + 18.2 \log_{10}(f_c)$</td><td>$\sigma_{SF} = 3$</td></tr>
<tr><td>NLOS</td><td>$PL = 36.85 + 30 \log_{10}(d_{3D}) + 18.9 \log_{10}(f_c)$</td><td>$\sigma_{SF} = 4$</td></tr>
<tr><td colspan="3">Note 1: f_c denotes the center frequency in GHz and d_{3D} denotes the Euclidean distance between TX and RX in 3D space in meters.
Note 2: The model for spatial correlation of shadow fading defined in TR 36.885 applies.</td></tr>
</table></td></tr>
<tr><td>Dropping vehicles (based on clause 6.1.2 from TR 37.885)</td><td>Vehicles are dropped according to the following process:
- The distance between the rear bumper of a vehicle and the front bumper of the following vehicle in the same lane is max {2 meter, an exponential random variable with the average of the speed * 2 sec}.
- All the vehicles in the same lane have the same speed.
- Vehicle type distribution is not dependent of the lane.</td></tr>
<tr><td>Total number of vehicles</td><td>It depends on UE density and block size. All vehicles are NR V2X UEs.</td></tr>
<tr><td>Vehicle UE activation rate</td><td>1% of total number of vehicles</td></tr>
<tr><td>vehicle type (based on clause 6.1.2 from TR 37.885)</td><td>- Type 2 (passenger vehicle with higher antenna position): length 5 meters, width 2.0 meters, height 1.6 meters, antenna height 1.6 meters</td></tr>
</table>

5.2.3.2 Simulation parameters

Table 5.2.3.2-1: Simulation parameters for case5 and case6

Parameter	Value		
	NR UE	NR BS	NR V2X UE
Max Tx power	23dBm	NA	23dBm
Channel Bandwidth	40MHz	40MHz	40MHz
Packet size	1)[72] PRB for 15kHz SCS 2)Other options are not precluded		1)[70] PRB (1100 byte packet) for 15kHz SCS 2)Other options are not precluded
Traffic model	Full buffer	Full buffer	Reference table 5.2.1.2-1
Noise figure	NA	5dB	9dB
Antenna pattern	Omni-directional with gain of 0 dBi	Antenna pattern for FR1 Macro BS from TR 38.828	Omni-directional with gain of 0 dBi
SINR-to-BLER mapping for NR V2X	NA	NA	As per link level performance model in TR 38.886 Table A-2 for 3.5GHz
SINR-to-rate mapping for NR	NA	As per link level performance model in TR 36.942 (Table A.2). α, attenuation = 0.4, $SNIR_{MIN}$, dB = -10, $SNIR_{MAX}$, dB = 22 (subclause 5.2.3.6 from TR 38.828).	NA

5.2.3.3 ACLR and ACS

Table 5.2.3.3-1: ACLR and ACS for case5 and case6

Parameter	Value		
	NR UE	NR BS	NR V2X UE
ACLR	30 dB	NA	30 + X dB
ACS	NA	46 dB	33+ X dB

5.2.3.4 Power control

For downlink scenario, no power control scheme is applied.

For NR WAN UE uplink scenario transmit power control, the following power control equation shall be used for the initial uplink coexistence simulations:

$$P_t = P_{\max} \times \min\left\{1, \max\left[R_{\min}, \left(\frac{CL}{CL_{x-ile}}\right)^{\gamma}\right]\right\}$$

where $P_{\max}$ is the maximum transmit power, $R_{\min}$ is the minimum power reduction ratio to prevent UEs with good channels to transmit at very low power level, *CL* is the path coupling loss defined as max{path loss-G_Tx-G_Rx, MCL}, where path loss is propagation loss plus shadowfading, G_TX is the transmitter antenna gain in the direction of the receiver, G_RX is the receiver antenna gain in the direction of the transmitter and $CL_{x\text{-ile}}$ is the *x*-percentile *CL* value. With this power control equation, the *x* percent of UEs that have the highest coupling loss will transmit at $P_{\max}$. Finally, $0<\gamma<=1$ is the balancing factor for UEs with bad channel and UEs with good channel:

- CLx-ile = 88 + 10*log10(200/X), where X is UL transmission BW (MHz)
- $\gamma = 1$
- $R_{\min}$ = -60dB for 23dBm

For NR V2X UE transmit power control, OLPC in TR36.786 is reused or no power control is used.

CLxile = 112 - 10*log10(CBW / 10) for PC set 1

5.2.4 PRR performance metrics for NR V2X coexistence simulation

For evaluation of co-existence performance for NR V2X, the Packet Reception Ratio (PRR) is agreed in RAN4 to be used as performance metric.

In TR 37.885, for one Tx packet, the PRR is calculated by X/Y, where Y is the number of UE/vehicles that located in the range (a, b) from the TX, and X is the number of UE/vehicles with successful reception among Y.

- CDF of PRR is used in evaluation with with a = 0, b = baseline of 320 meters for freeway and 150 meters for urban. Optionally, b = 50 meters for urban with 15 km/h vehicle speed.
- Average PRR, calculated as (X1+X2+X3….+Xn)/(Y1+Y2+Y3…+Yn) where n denotes the number of generated messages in simulation. with a = i*20 meters, b = (i+1)*20 meters for i=0, 1, …, 25

In RAN4 co-existence study for NR V2X, only urban cases with 15 km/h and 60 km/h are considered.

To align with LTE V2X's performance metric, average PRR at 50m for 15 km/h and average PRR at 150m for 60 km/h are chosen as the evaluation criteria.

5.3 Coexistence simulation results

5.3.1 Coexistence simulation results in ITS spectrum

5.3.1.1 Huawei simulation results for Case1, Case2, Case3 and Case 4

According to detail assumptions TP [6] proposed in reflector, we can obtain the simulation results which are shown as figure 5.3.1.1-1 ~ figure 5.3.1.1-4 for case1.

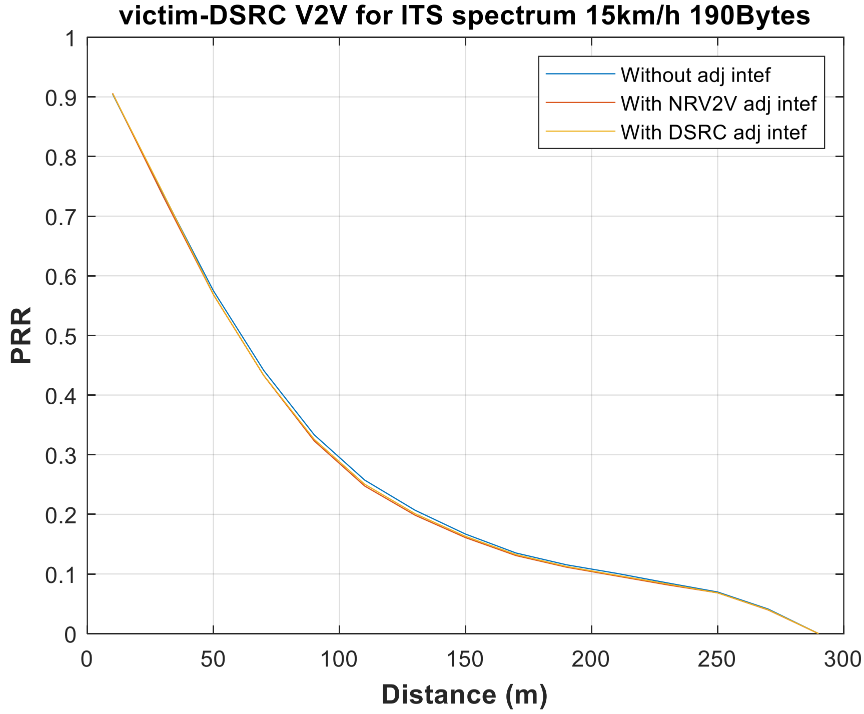


Figure 5.3.1.1-1. coexistence simulation results for case1 (15kmph 190Bytes)

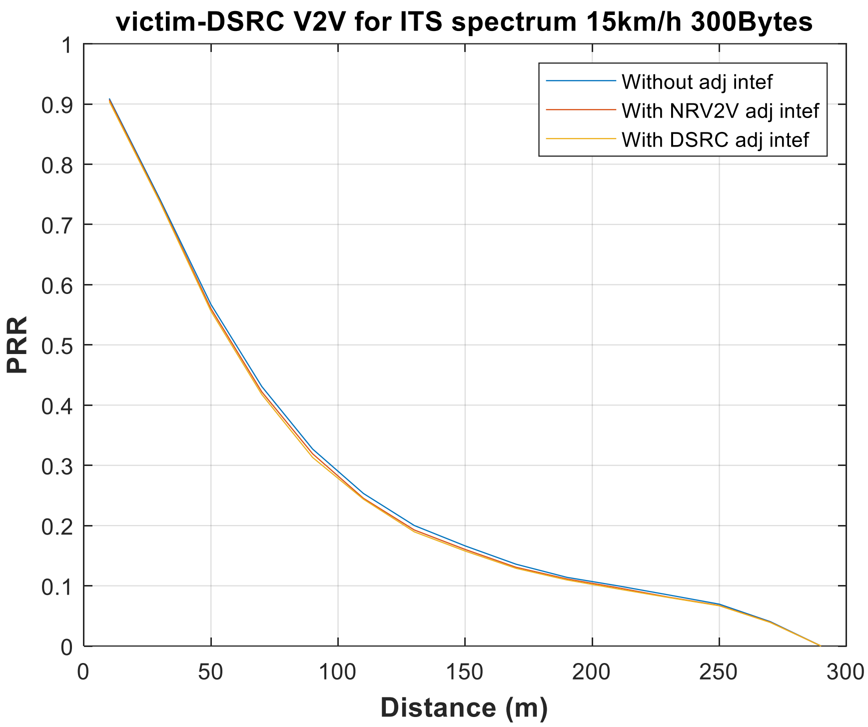


Figure 5.3.1.1-2. coexistence simulation results for case1 (15kmph 300Bytes)

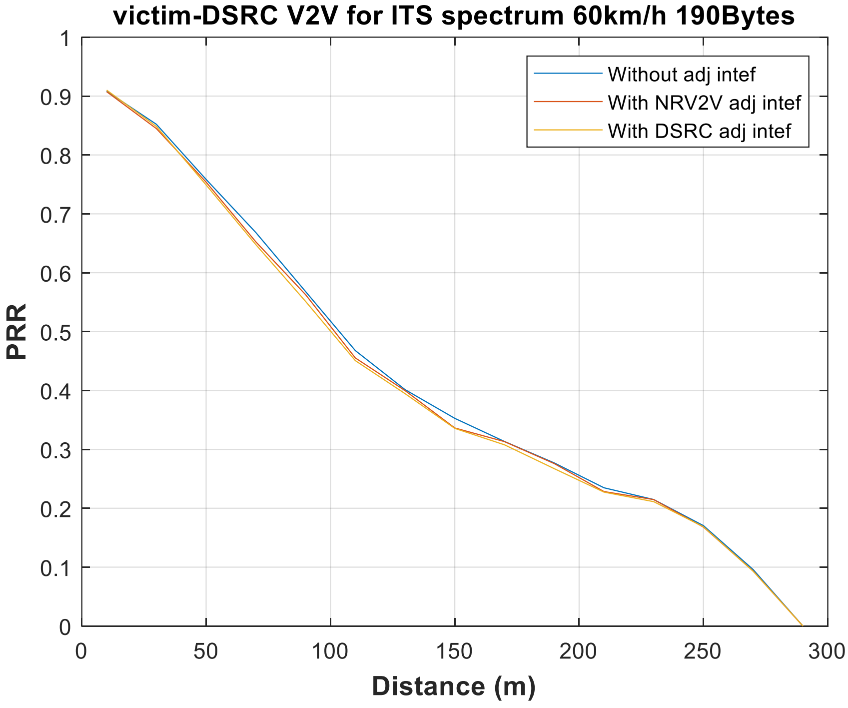


Figure 5.3.1.1-3. coexistence simulation results for case1 (60kmph 190Bytes)

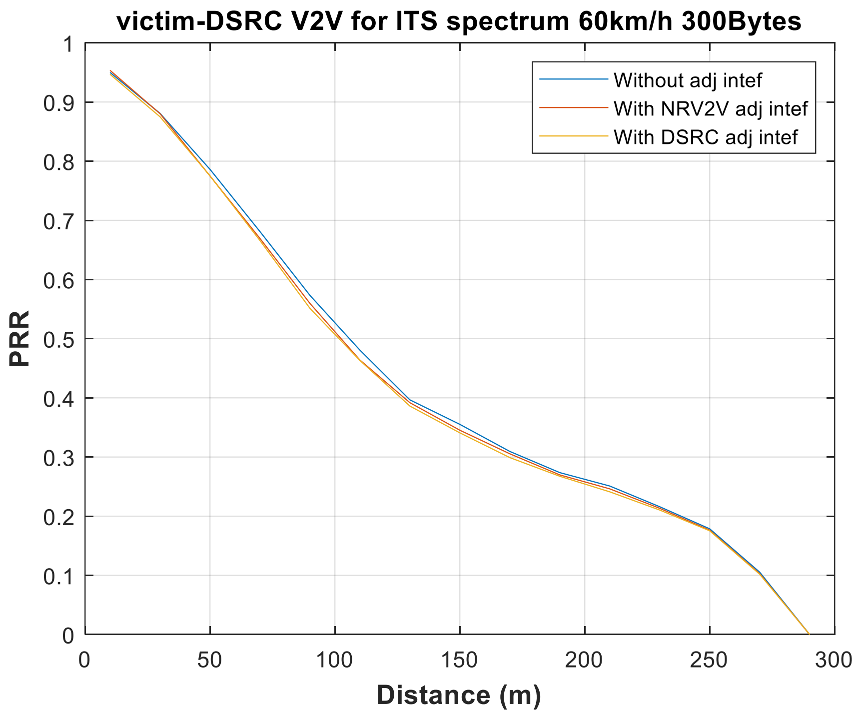


Figure 5.3.1.1-4. coexistence simulation results for case1 (60kmph 300Bytes)

According to detail assumptions TP [6] proposed in reflector, we can obtain the simulation results which are shown as figure 5.3.1.1-5 ~ figure 5.3.1.1-8 for case3.

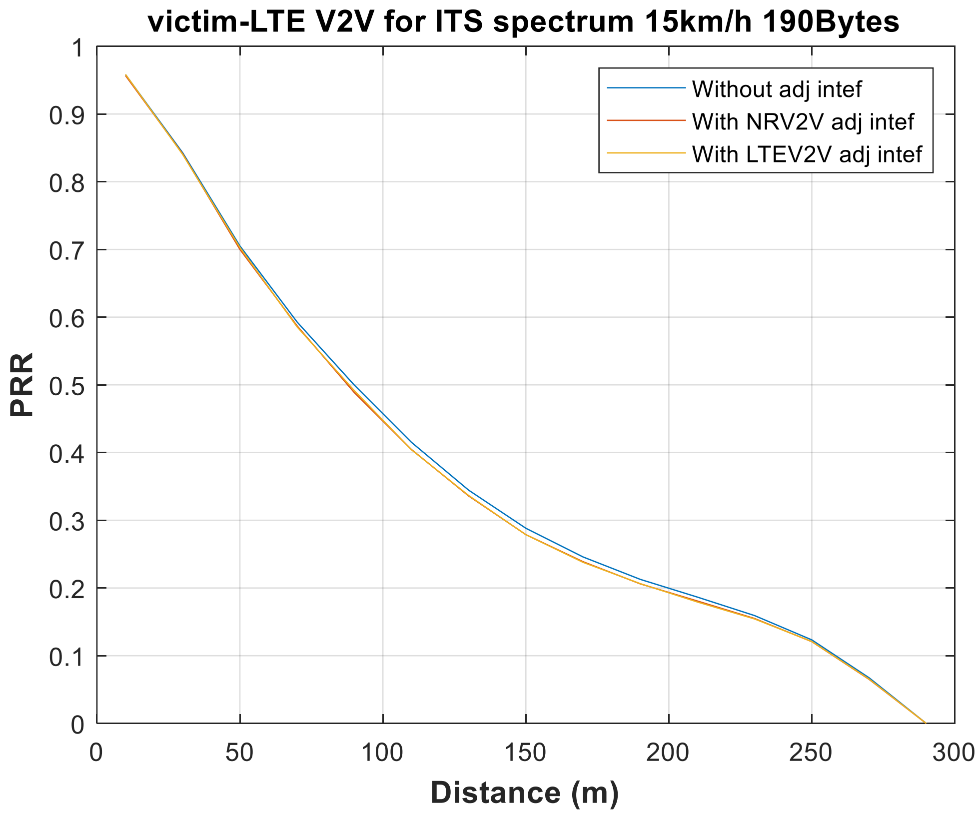


Figure 5.3.1.1-5. coexistence simulation results for case3 (15kmph 190Bytes)

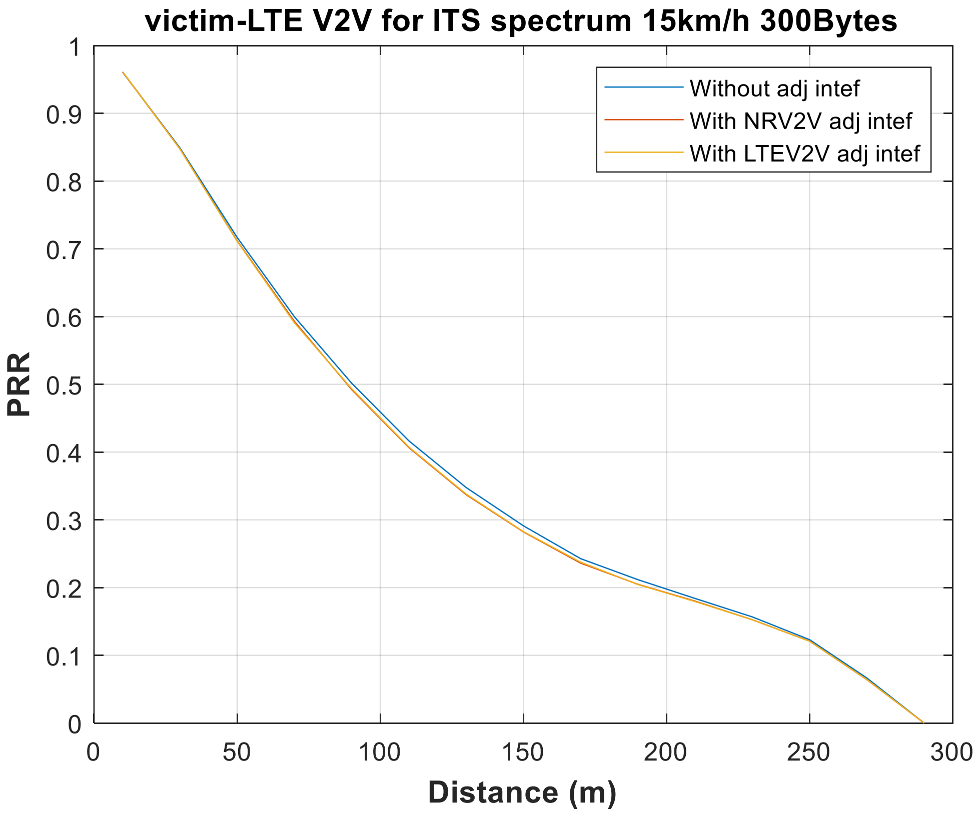


Figure 5.3.1.1-6. coexistence simulation results for case3 (15kmph 300Bytes)

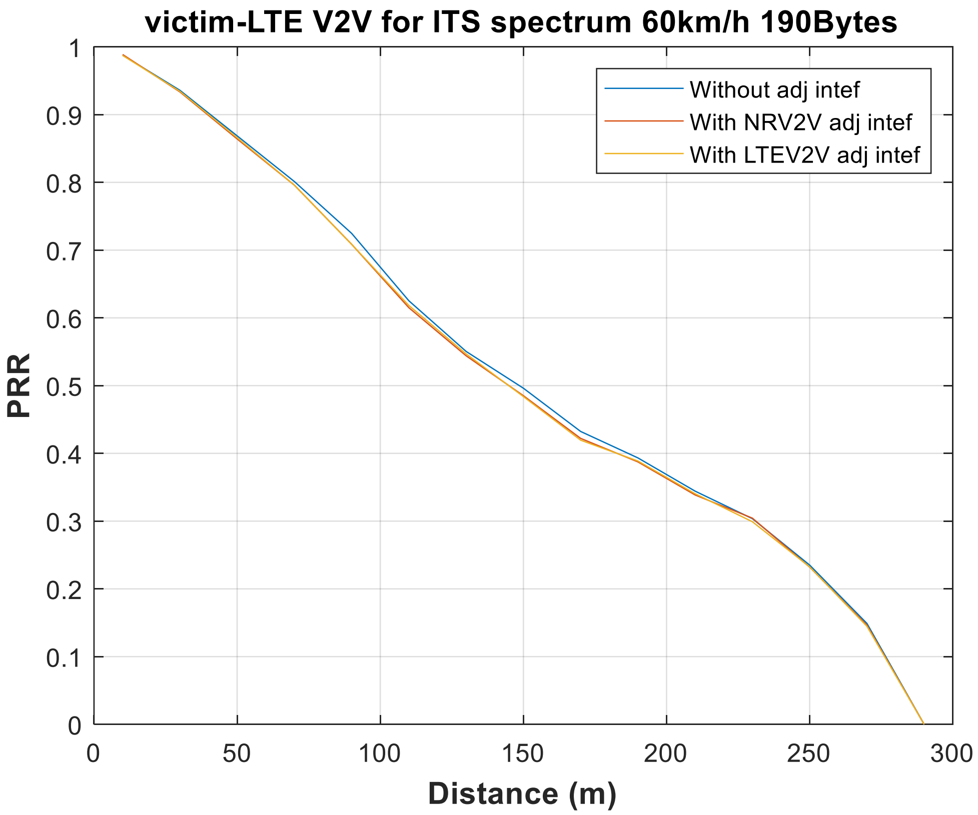


Figure 5.3.1.1-7. coexistence simulation results for case3 (60kmph 190Bytes)

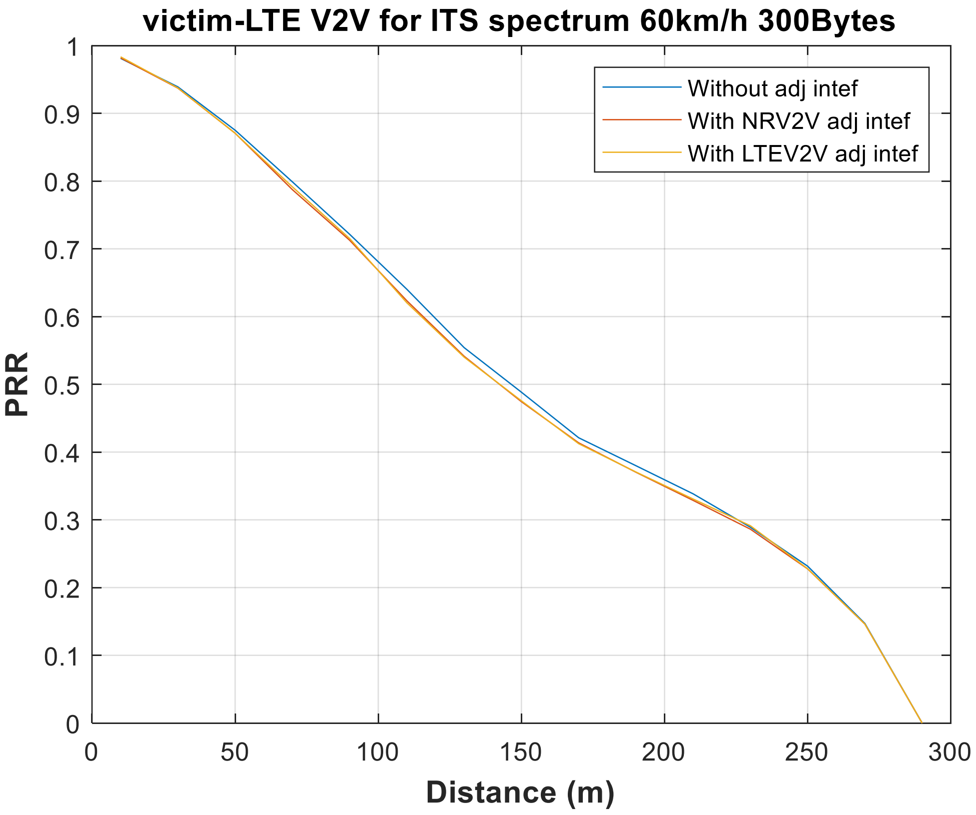


Figure 5.3.1.1-8. coexistence simulation results for case3 (60kmph 300Bytes)

According to detail assumptions TP [6] proposed in reflector, we can obtain the simulation results which are shown as figure 5.3.1.1-9 ~ figure 5.3.1.1-10 for case2 and case4.

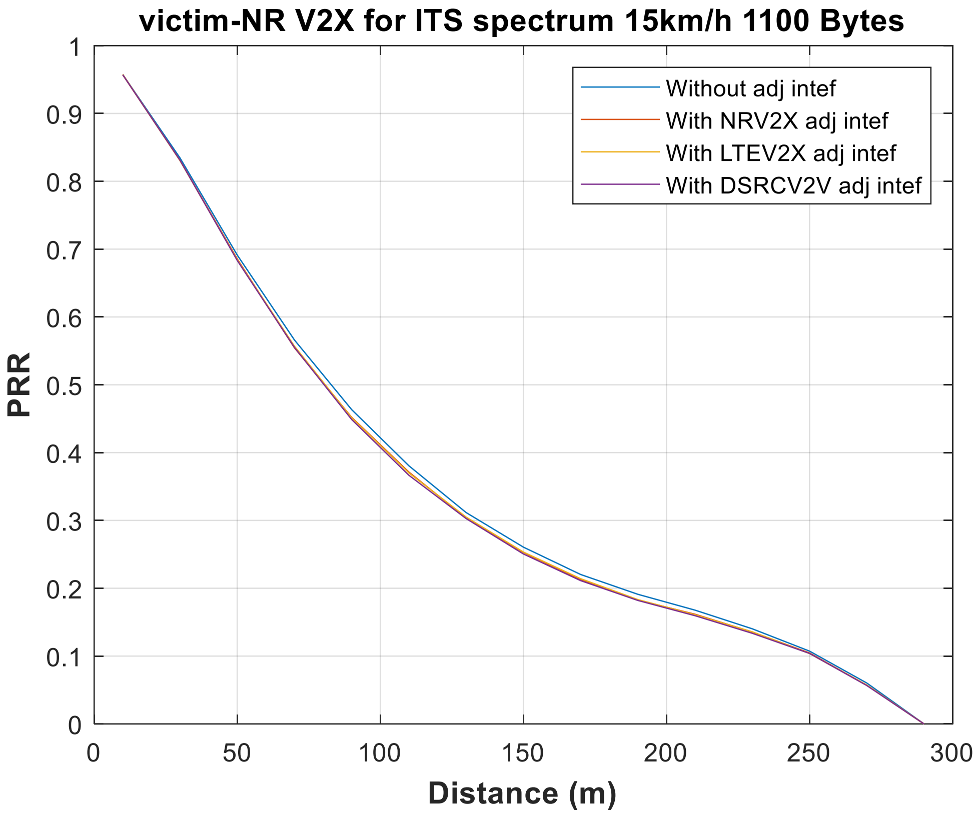


Figure 5.3.1.1-10. coexistence simulation results for case2 and case4 (15kmph 1100Bytes)

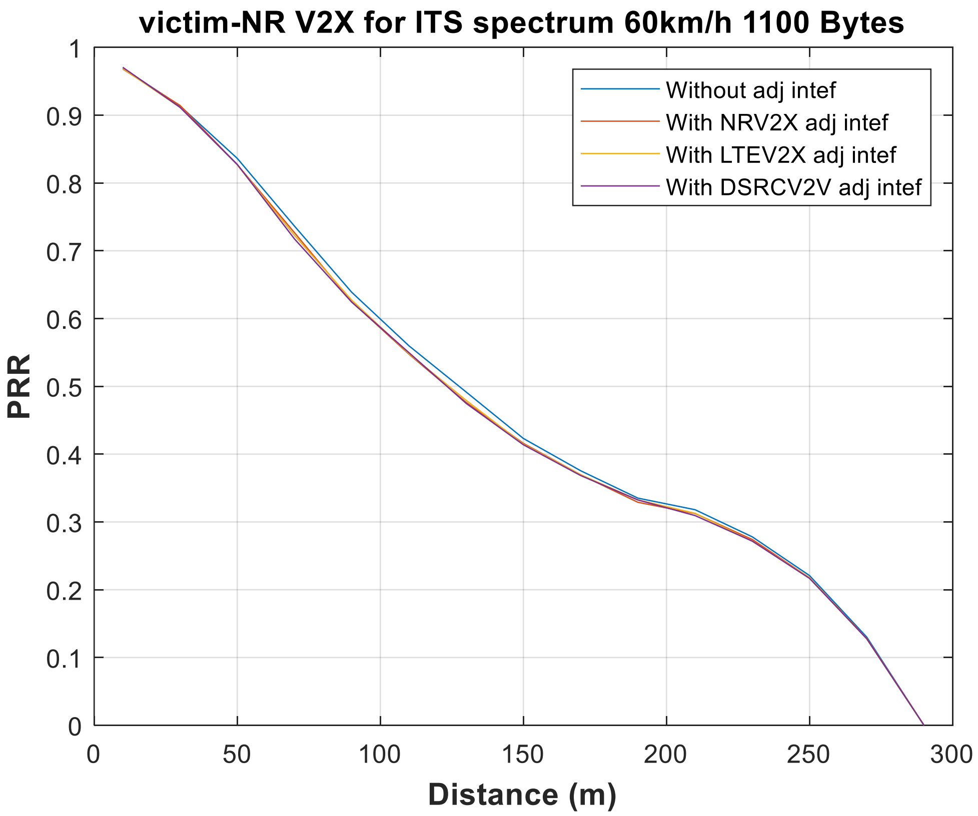


Figure 5.3.1.1-11. coexistence simulation results for case2 and case4 (60kmph 1100Bytes)

The PRR loss for case1, case2, case3 and case4 are summarized in table 5.3.1.2-1 ~ Table 5.3.1.2-6. Then, the results of DSRC to DSRC, LTE V2X to LTE V2X and NR V2V to NR V2V are listed as references.

Table 5.3.1.2-2. PRR loss for case1

PRR loss	At 50m range for 15km/h		At 150m range for 60km/h	
	NR V2V to DSRC V2V	DSRC V2V to DSRC V2V	NR V2V to DSRC V2V	DSRC V2V to DSRC V2V
190Byte	1.1%	1.1%	2.7%	3.9%
300Byte	1.2%	2%	2.8%	4%

Table 5.3.1.2-3. PRR loss for case2

PRR loss	At 50m range for 15km/h		At 150m range for 60km/h	
	NR V2V to NR V2V	DSRC to NR V2V	NR V2V to NR V2V	DSRC to NR V2V
1100Byte	0.8%	1.1%	1.7%	2.2%

Table 5.3.1.2-4. PRR loss for case3

PRR loss	At 50m range for 15km/h		At 150m range for 60km/h	
	NR V2V to LTE V2V	LTE V2V to LTE V2V	NR V2V to LTE V2V	LTE V2V to LTE V2V
190Byte	0.7%	0.3%	2.2%	2.5%
300Byte	0.7%	0.8%	2.9%	2.6%

Table 5.3.1.2-5. PRR loss for case4

PRR loss	At 50m range for 15km/h		At 150m range for 60km/h	
	NR V2V to NR V2V	LTE V2V to NR V2V	NR V2V to NR V2V	LTE V2V to NR V2V
1100Byte	0.8%	1.0%	1.7%	2.0%

Based on NR V2X co-existence simulation results for case1 and case3, the following observations are made:

- For both PRR loss at 50m range for 15km/h and at 150m range for 60km/h, NR V2X UE makes acceptable interference to DSRC victim and LTE V2X UE victim for ITS spectrum.
- For both PRR loss at 50m range for 15km/h and at 150m range for 60km/h, DSRC / LTE V2X UE makes acceptable interference to NR V2X UE victim for ITS spectrum.
- All the PRR loss is less than 5%.

Observation 1: NR V2X UE can co-existence well with DSRC system and LTE V2X system for ITS spectrum with NR ACLR requirement which is 30dBc for power class 3.

Observation 2: NR V2X UE can co-existence well with DSRC system and LTE V2X system for ITS spectrum with NR ACS requirement which is 24dB @BW=40MHz for power class 3.

5.3.1.2 LG simulation results for Case1, Case2, Case3 and Case 4

In Figure 5.3.1.2-1 ~ Figure 5.3.1.2-4, we present our simulation results for Case 1, Case 2, Case 3, and Case 4, respectively.

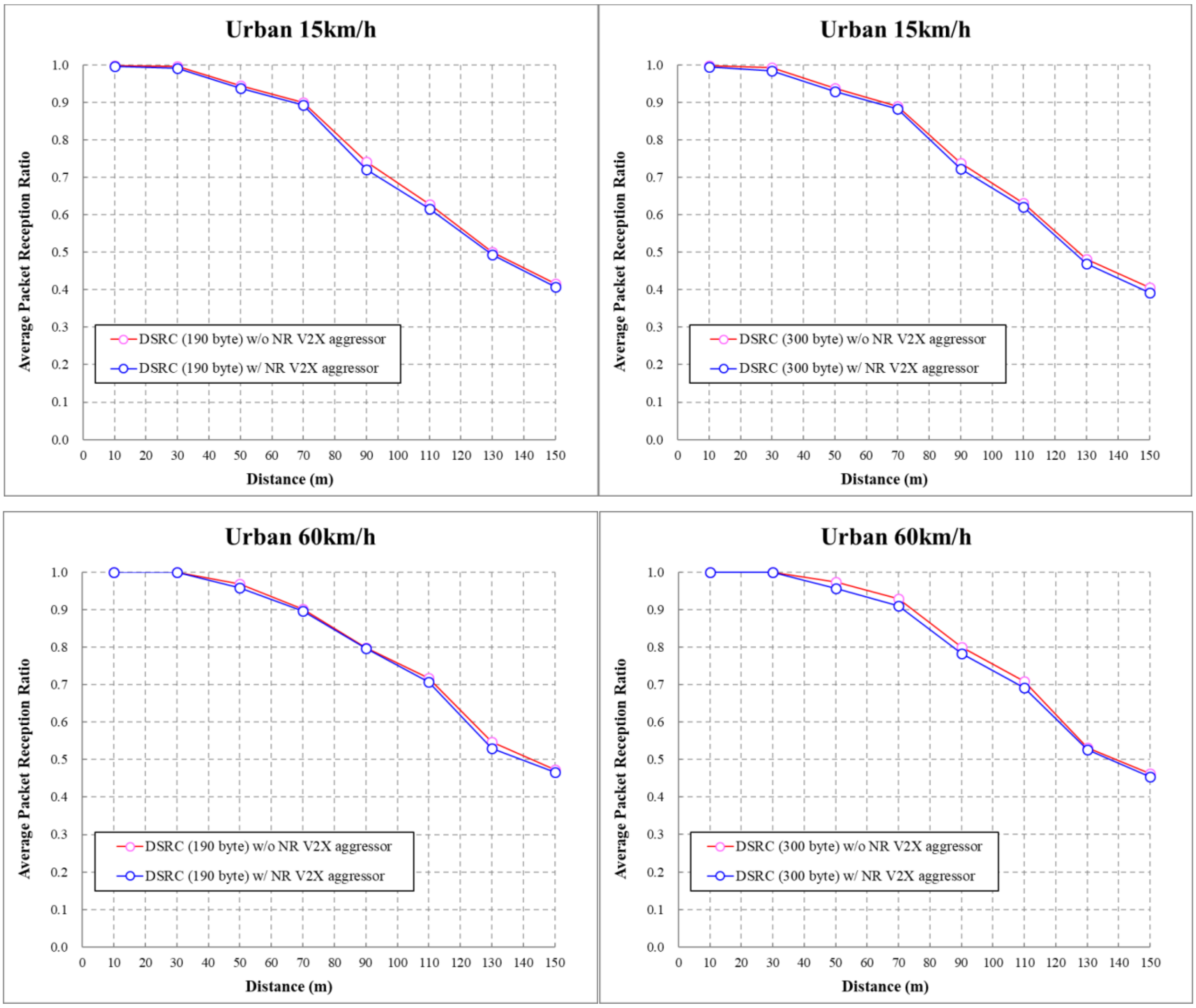


Figure 5.3.1.2-1. Coexistence simulation results of Case 1 for 15km/h and 60km/h (w/ 190 bytes and 300 bytes payload)

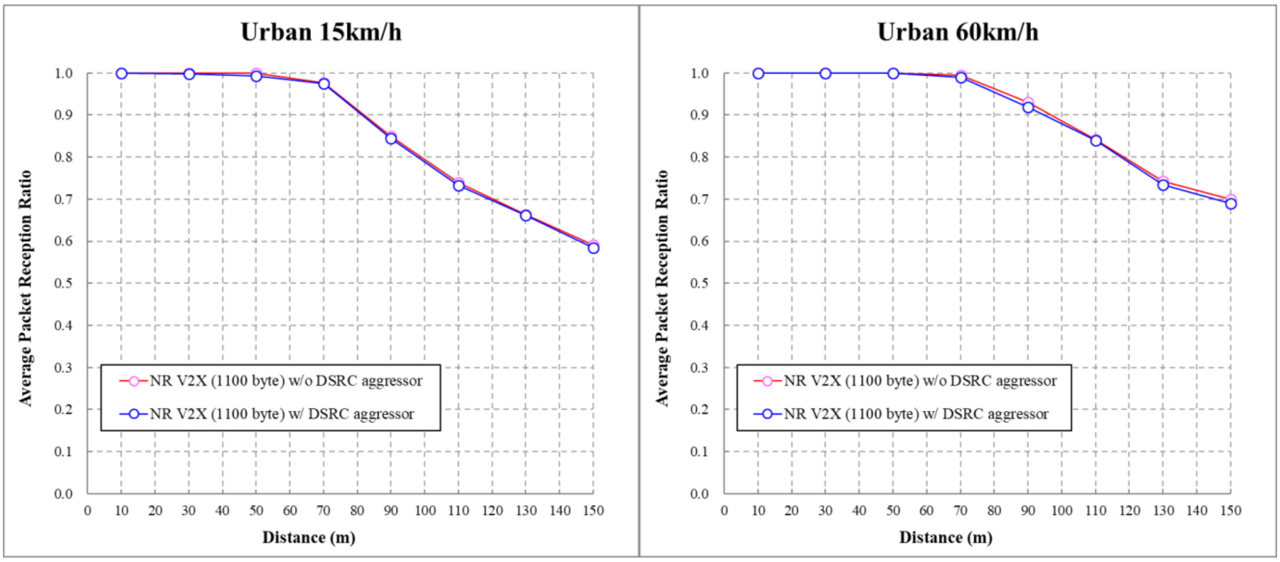


Figure 5.3.1.2-2. Coexistence simulation results of Case 2 for 15km/h and 60km/h (w/ 1100 bytes payload)

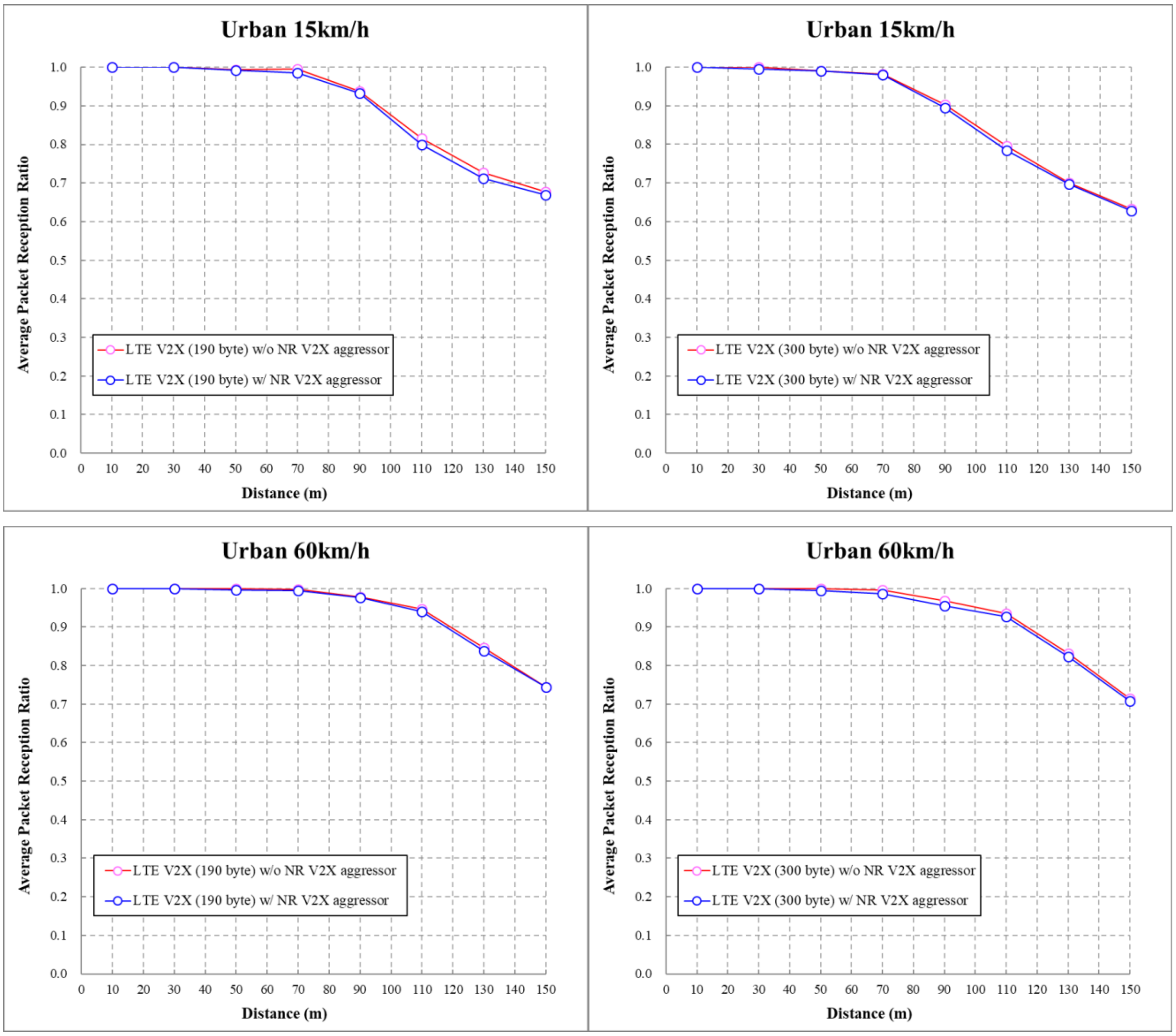


Figure 5.3.1.2-3. Coexistence simulation results of Case 3 for 15km/h and 60km/h (w/ 190 bytes and 300 bytes payload)

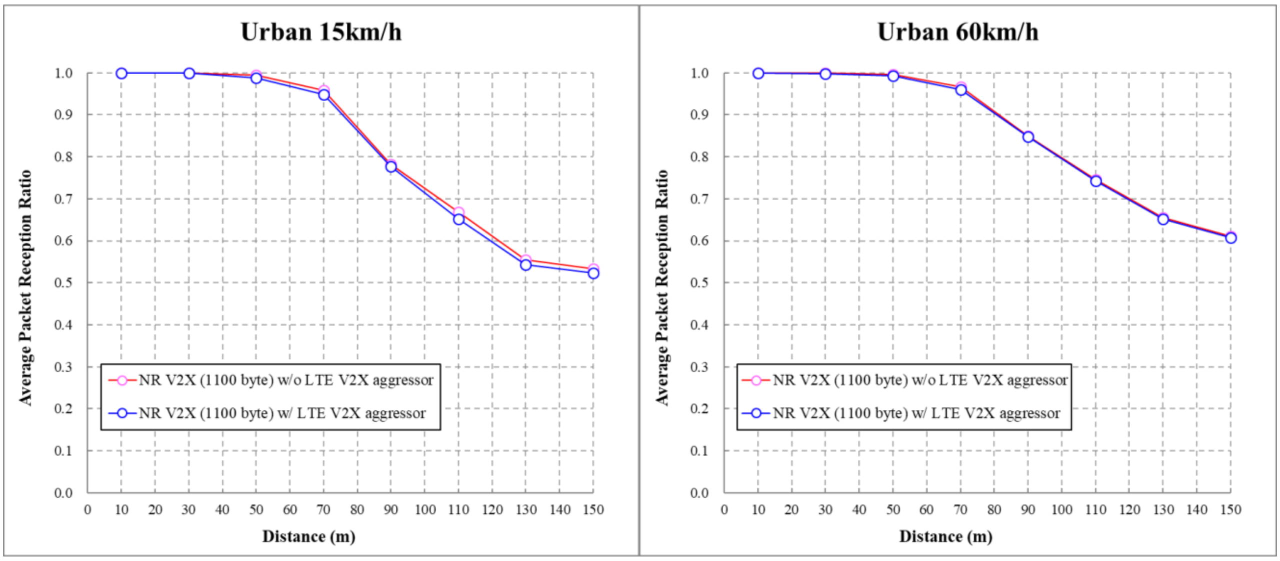


Figure 5.3.1.2-4. Coexistence simulation results of Case 4 for 15km/h and 60km/h (w/ 1100 bytes payload)

From all simulation results, we can observe there is no significant impact in terms of PRR performance when NR V2X system is deployed on adjacent channel.

Observation: No significant impact in terms of PRR performance are shown for Case 1, Case2, Case 3, and Case 4.

Also in Table 5.3.1.2-1, we present PRR loss for ITE band coexistence scenario for given summarized numeric PRR loss

Table 5.3.1.2-1. Summary of PRR loss for ITS band coexistence scenario

Scenario	Payload (byte)	50m range for 15km/h	150m range for 60km/h
Case 1	190	0.58 %	1.53 %
	300	0.86 %	1.82 %
Case 2	1100	0.56 %	1.41 %
Case 3	190	0.10 %	0.11 %
	300	0.10 %	0.93 %
Case 4	1100	0.63 %	0.47 %

Although some simulation assumption including SINR-PRR mapping table need to be updated, we think that similar conclusion will be expected considering coexistence impact is based on relative performance degradation due to adjacent channel interference from aggressor system.

5.3.1.3 Qualcomm simulation results for Case3 and Case4

In figure 5.3.1.3-1 is the performance of NR V2X Packet Reception Ratio, while figure 5.3.1.3-2 is the performance of NR V2X. We can see that under the simulation assumptions above, the degradation coming from adjacent channel aggressor is quite acceptable to both systems.

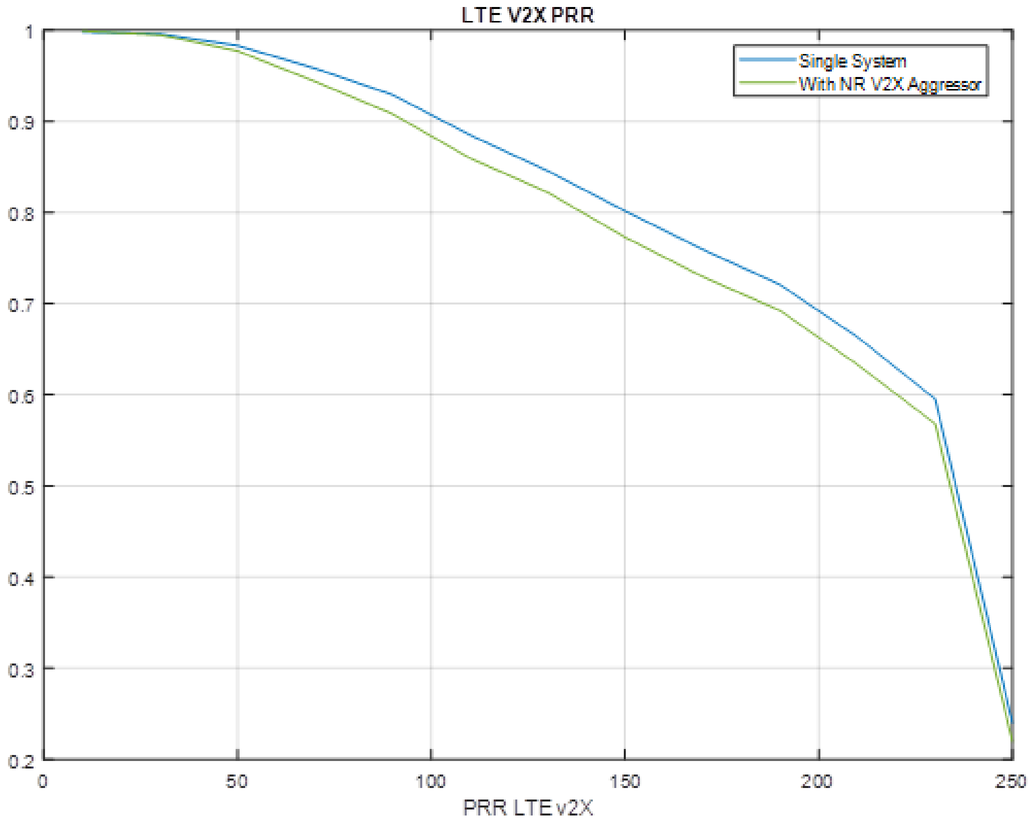


Figure 5.3.1.3-1. LTE V2X PRR Performance

Figure 5.3.1.3-2 NR V2X PRR Performance

In figure 5.3.1.3-1, we compare the PRR performance of LTE V2X under 2 different scenarios.

1. Single system: only LTE V2X operates in a 20MHz channel.
2. NR V2X aggressor, X = 0: LTE V2X operates in a 20MHz channel. NR V2X operates in the adjacent 40MHz channel. The ACLR of NR V2X is 30dB in first step and 43 dB in the second step.

In figure 5.3.1.3-2, we compare the PRR performance of NR V2X under 2 different scenarios.

1. Single system: only NR V2X operates in the 40MHz channel.
2. LTE V2X aggressor, X = 0: NR V2X operates in a 40MHz channel. LTE V2X operates in the adjacent 20MHz channel. The ACLR of LTE V2X is 30dB in first step and 43 dB in the second step.

Based on the result, the performance degradation inflicted to LTE V2X system by NR V2X and degradation inflicited to NR V2X system by LTE V2X is negligible, even without any tightening to the existing NR Uu ACLR requirement.

5.3.2 Coexistence simulation results in licensed spectrum for FR1

5.3.2.1 Huawei simulation results for Case5 and Case 6

According to detail assumptions TP [6] proposed, we can obtain the simulation results without power control which are shown as figure 5.3.2.1-1 ~ figure 5.3.2.1-3 for case5 and case6 without power control.

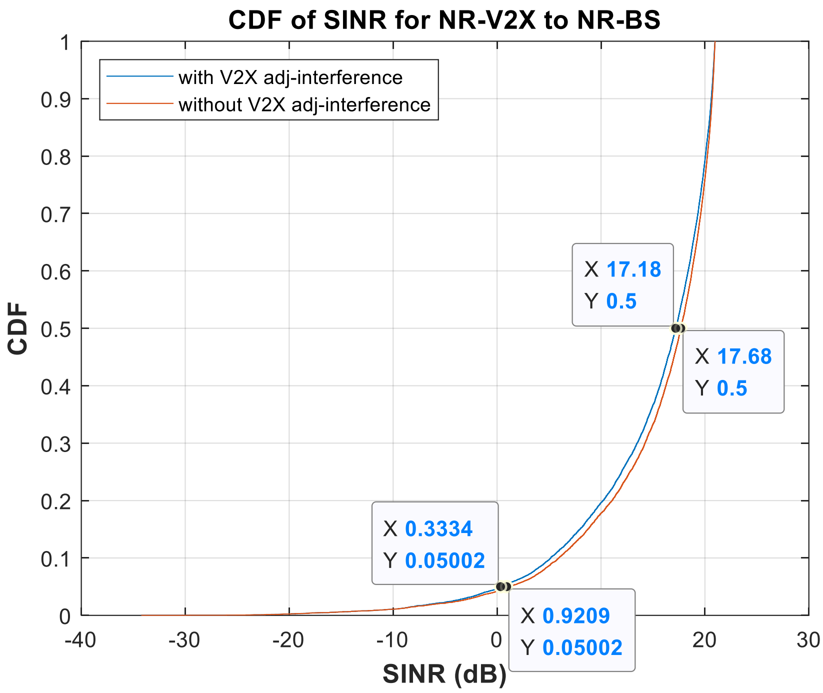


Figure 5.3.2.1-2. CDF of SINR for case5 without power control (60kmph 1100Bytes)

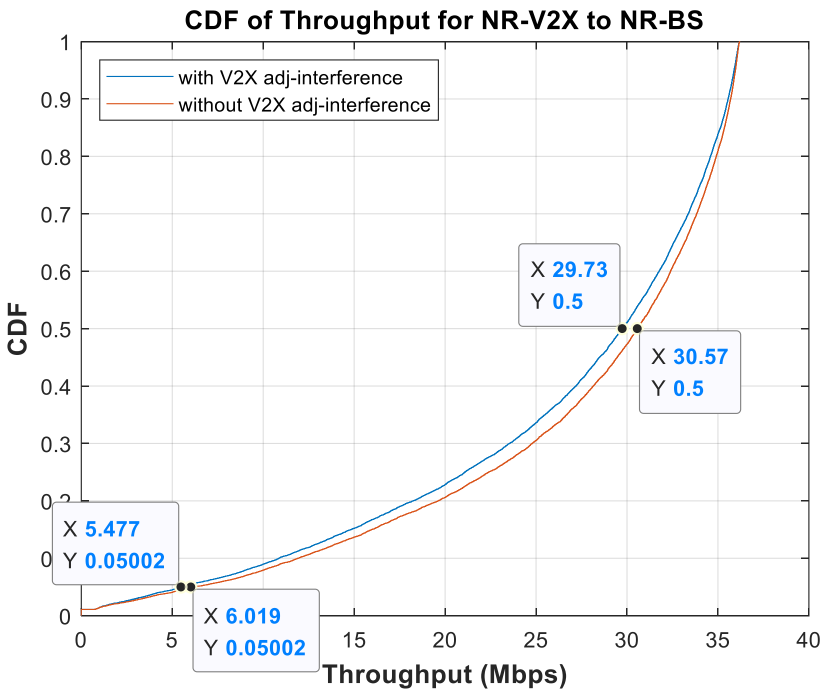


Figure 5.3.2.1-3. CDF of Through for case5 without power control (60kmph 1100Bytes)

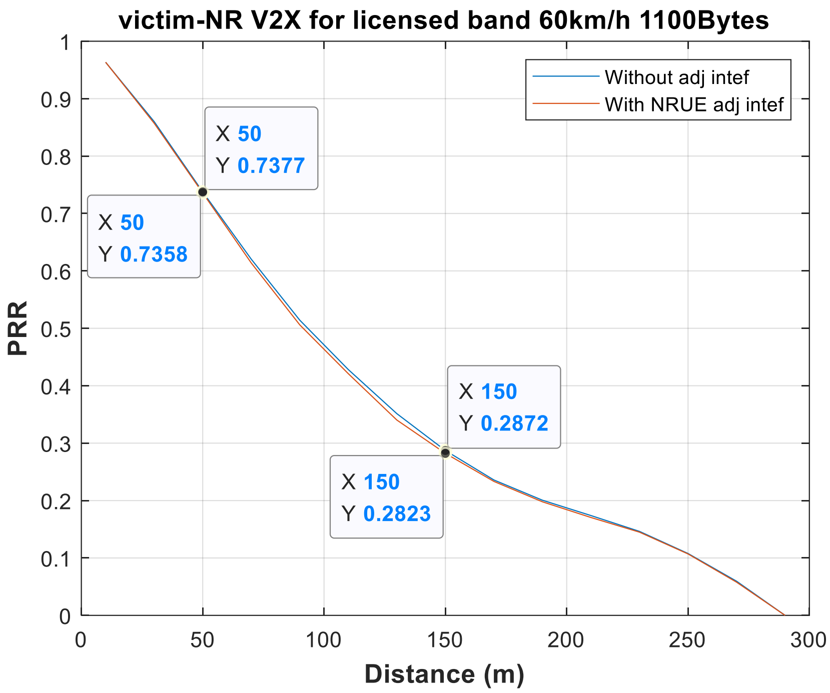


Figure 5.3.2.1-4. coexistence simulation results for case6 without power control (60kmph 1100Bytes)

According to detail assumptions TP [6] proposed, we can obtain the simulation results with power control which are shown as figure 5.3.2.1-5 ~ figure 5.3.2.1-6 for case5 and case6.

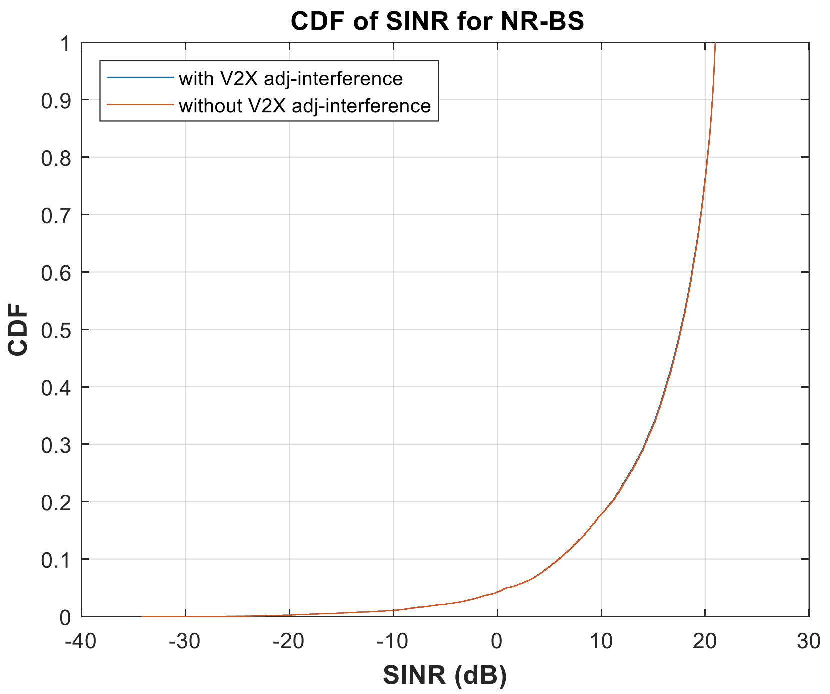


Figure 5.3.2.1-6. CDF of SINR for case5 with power control (60kmph 1100Bytes)

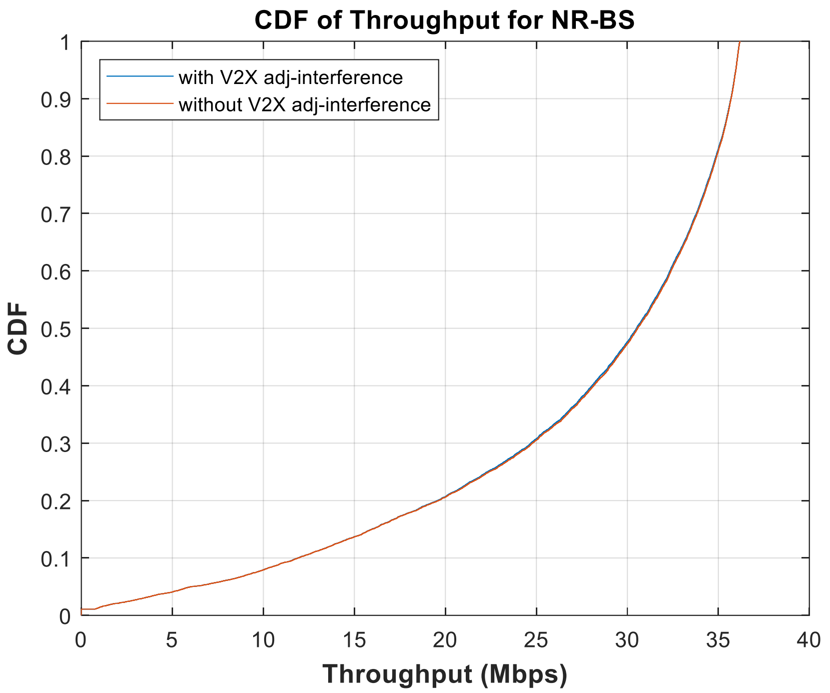


Figure 5.3.2.1-7. CDF of through for case5 with power control (60kmph 1100Bytes)

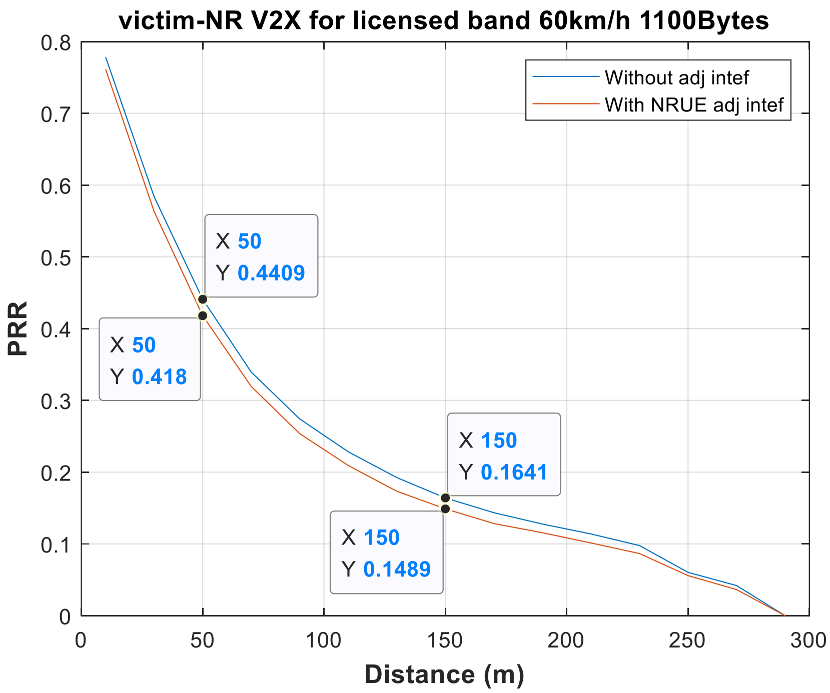


Figure 5.3.2.1-8. coexistence simulation results for case6 with power control (60kmph 1100Bytes)

Based on simulation results, the throughput loss for case5 are summarized in table 5.3.2.1-1. The PRR loss for case6 are summarized in table 5.3.2.1-2.

Table 5.3.2.1-1. Throughput loss for case5

	5% tile

Throughput loss	without power control	with power control
	9%	little performance loss

Table 5.3.2.1-2. PRR loss for case6

PRR loss (1100Byte)	At 150m range for 60km/h	
	without power control	with power control
	1.8%	9.5%

Based on NR V2X co-existence simulation results for case5 and case6, the following observations are made:

- With power control PRR loss at 150m range for 60km/h exceeds 5%, so the performance loss can't be accepted for NR V2X UE. But it is observed that there is very little performance loss for NR BS in this scenario.
- Without power control the throughput loss at 5%-tile for 60km/h exceeds 5%, so the performance loss can't be accepted for NR BS. But it is observed that there is only 1.8% PRR loss for NR V2X UE in this scenario.

Observation 1: Based on the simulation results in this paper,

- **If there is no power control scheme, throughput degradation is unacceptable for victim NR BS.**
- **The power control can mitigate the interference from NR V2X UE to NR BS, but at the expense of NR V2X system performance.**

Observation 2: Further study and discussion is needed in RAN4.

5.3.2.2 LG simulation results for Case5 and Case 6

For coexistence scenario in license bands, we evaluate simulation results for Case 5, 6, based on agreed Coexistence simulation assumption [6]. For power control in NR V2X, we didn't use any power control scheme at this stage.

For Case 5, we present our simulation results in terms of 5%-tile T-put loss in Table 5.3.2.2-1.

Table 5.3.2.2-1. 5%-tile throughput loss of NR Uu BS in Case 5

	15km/h	60km/h
5%-tile T-put loss	20.55%	7.99%

From simulation results, we can see that there exist reasonable impact on uplink performance of NR Uu BS if NR V2X UE w/o power control exist in adjacent frequency.

Observation 1. When NR V2X UE w/o power control scheme exist as aggressor in case 5, reasonable T-put loss in NR uplink was observed.

For Case 6, we present our simulation results in Figure 5.3.2.2-1 in terms of average packet reception ratio for both 15km/h and 60km/h. Also, we present PRR loss of Case 6 due to NR Uu UE as aggressor in Table 5.3.2.2-2.

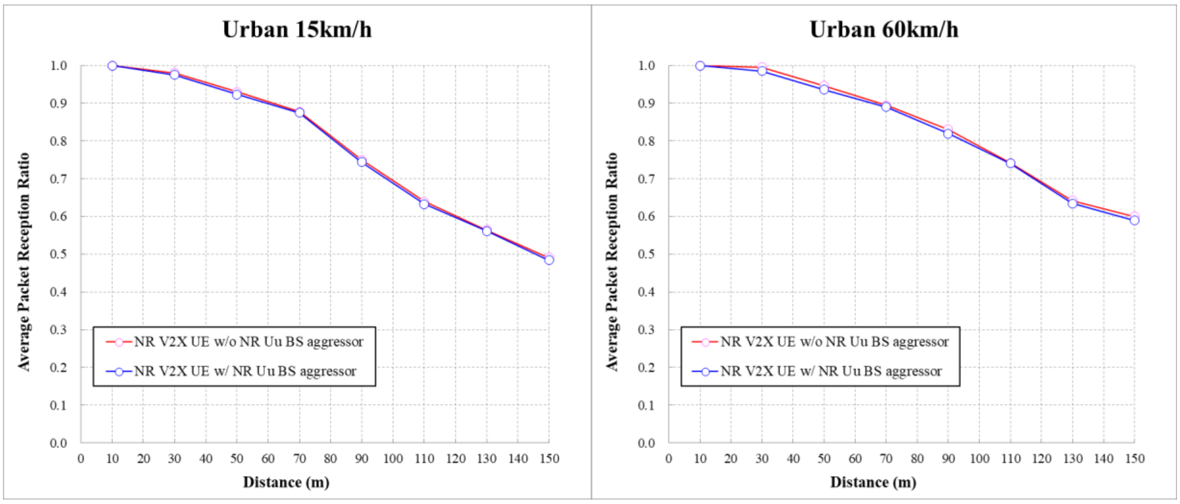


Figure 5.3.2.2-1. Average PRR of NR V2X UE in Case 6

Table 5.3.2.2-2. PRR loss of NR V2X UE in Case 6

	@50m range for 15km/h	@150m range for 60km/h
PRR Loss (1100 byts)	0.74 %	1.65 %

From simulation results, we can see that there is no reasonable performance impact on NR V2X UE, even if NR Uu exist in adjacent frequency.

Observation 2. When NR Uu UE exist as aggressor in case 6, no reasonable PRR loss in NR V2X UE was observed.

5.3.3 Coexistence simulation results in licensed spectrum for FR2

5.4 Conclusion of V2X coexistence evaluations

The PC5-based NR V2X UE coexistence evaluations are performed at 3.5GHz/5.9GHz operating frequency range in Rel-16 NR V2X WI. The adjacent coexistence simulation results are captured in sub-clause 5.3. Based on the evaluation results,

1. For coexistence in ITS spectrum of n47(Case1, Case2, Case3 and Case4), following observations are made:

- Based on the simulation results, NR V2X can coexist with LTE V2X or DSRC in ITS spectrum of n47.

2. For coexistence in license spectrum for FR1(Case 5, and Case 6), following observations are made:

- Based on the simulation results, there is no evidence that NR V2X can coexist with NR Uu in licensed spectrum without power control for FR1.
    - If there is no power control scheme in NR V2X, throughput degradation is unacceptable for victim NR BS.
- When OLPC is employed for either unicast, broadcast or groupcast in the licensed band, eNB/gNB performance degradation in the adjacent channel is negligible in FR1.

3. For coexistence in licensed spectrum for FR2(Case 9 and Case 10), no simulation result was submitted.

Based on the above analysis, the PC5-based NR V2X service will be within acceptable operating limits for adjacent channel coexistence scenarios in ITS spectrum of n47 and in licensed spectrum either when the entire band is allocated for SL in a given region or when SL operation in a TDD band in sync with the non-V2X operation in the same band.

6 Evaluation of In-device Coexistence

6.1 In-device coexistence scenarios

From the UE perspective, coexistence between LTE V2X and NR V2X SLs is studied when there are coordinated procedures between LTE and NR, and half-duplex constraints are assumed.

Solutions based on TDM or FDM between LTE and NR SLs are the focus of the study. TDM solutions are those that involve overlapping or simultaneous NR and LTE V2X SL transmissions. FDM solutions are those that involve simultaneous NR and LTE V2X SL transmissions, and define solutions for sharing the total power between the two.

RAN4 conducted indevice coexistence for two scenarios:

1. when LTE SL and NR SL in the ITS band, and without LTE or NR Uu in another band on the same device
2. when LTE SL and NR SL in the ITS band, and with LTE or NR Uu in another band on the same device

For the scenario 1: no self-interference issues are identified for TDM operation in 5.9 GHz ITS spectrum. The long-term coexistence is found feasible without any issues. For short-term switching times for TDM operation needs to be studied.

6.2 UE architecture considerations

For in-device coexistence, the UE architecture and implementation assumptions need to be considered. For this short-term switching period analysis, intra-band operation without dual PA capability can be the baseline. It may be possible that a better switching delay performance is possible by considering separate RF chains with dual PAs. However, for this analysis the baseline performance considering single PA is considered.

6.3 Switching time analysis

The switching time between NR SL and LTE SL for short-term TDM operation was analyzed as part of this study. The general ON / OFF time mask requirements in subclause 6.3.3.2 in TS 38.101-1 is applicable for NR sidelink also. In addition to the above general ON / OFF time masks, the additional switching period of about [150us] is applicable between the NR SL and LTE SL. Considering that the NR V2X CBW is 10/20/30/40 MHz and that of LTE V2X is 10/20MHz, the spectrum span for contiguous and non-contiguous transmissions would be similar, the switching time can be similar.

7 Operating bands and channel arrangement

7.1 Operating bands

7.1.1 Operating bands in FR1

NR V2X communication is designed to operate in the operating bands in FR1 defined in Table 7.1.1-1.

Table 7.1.1-1 V2X operating bands in FR1

V2X Operating Band	Sidelink (SL) Transmission operating band	Sidelink (SL) Reception operating band	Duplex Mode	Interface
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}		
n38[1]	2570 MHz - 2620 MHz	2570 MHz - 2620 MHz	HD	PC5
n47	5855 MHz - 5925 MHz	5855 MHz - 5925 MHz	HD	PC5
Note 1: When this band is used for V2X SL service, the band is exclusively used for NR V2X in particular regions.				

7.1.2 Operating bands in FR2

7.1.3 Operating bands for inter-band con-current operation in FR1

NR V2X operation is designed to operate concurrent with NR uplink/downlink on the operating bands combinations listed in Table 7.1.3-1.

Table 7.1.3-1: NR V2X inter-band con-current operation

V2X con-current operating Band	V2X Band	Interface
V2X_n71-n47	n71	Uu
	n47	PC5
NOTE 1: NR licensed Band is operated for legacy NR operation and/or V2X service		

7.2 Channel bandwidth

7.2.1 Channel bandwidth in FR1

The NR V2X Communication channel bandwidths and operating bands are shown in Table 7.2.1-1. The same (symmetrical) channel bandwidth is specified for both the TX and RX path.

Channel bandwidths defined for NR V2X licensed band should be a subset of UE channel bandwidths for the same licensed band in NR for Rel-16. If operators do have a request for introducing new channel bandwidths for NR V2X licensed bands, it can be treated in the enhanced sidelink WI for collecting operators' request and defining additional RF requirements related to these new channel bandwidths in Rel-17.

Table 7.2.1-1 V2X Communication channel bandwidth

		V2X band / V2X channel bandwidth								
V2X Operating Band	**SCS kHz**	**10 MHz**	**20 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**60 MHz**	**80 MHz**	**90 MHz**	**100 MHz**
n38	15	Yes	Yes	Yes	Yes					
	30	Yes	Yes	Yes	Yes					
	60	Yes	Yes	Yes	Yes					
n47	15	Yes	Yes	Yes	Yes					
	30	Yes	Yes	Yes	Yes					
	60	Yes	Yes	Yes	Yes					

7.2.2 Channel bandwidth in FR2

7.2.3 Channel bandwidth for inter-band con-current operation in FR1

For NR V2X inter-band con-current operation in FR1, the NR V2X channel bandwidths for each operating band is specified in Table 7.2.3-1.

Table 7.2.3-1: V2X inter-band con-current configurations

V2X con-current operating band Configuration	NR Bands	SCS kHz	5 MHz	10 MHz	15 MHz	20 MHz	30 MHz	40 MHz	50 MHz	Maximum bandwidth [MHz]	Bandwidth combination set
V2X_n71A-n47A	n71	15	Yes	Yes	Yes	Yes				60	0
		30		Yes	Yes	Yes					
		60									
	n47	15		Yes		Yes	Yes	Yes			
		30		Yes		Yes	Yes	Yes			
		60		Yes		Yes	Yes	Yes			

7.3 Channel arrangement

7.3.1 Channel arrangement in FR1

7.3.1.1 Channel raster

7.3.1.1.1 NR-ARFCN and channel raster

The NR-ARFCN and channel raster defined in subclause 5.4.2.1 in TS38.101-1 are applied for NR V2X.

For NR V2X UE, the reference frequency can be shifted by configuration.

$$F_{REF\_V2X} = F_{REF} + \Delta_{shift} + N * 5\text{ kHz}$$

where

Δ_{shift} = 0 kHz or 7.5 kHz indicated in IE (*frequencyShift7p5khz*), and

N can be set as one of following values {-1, 0, 1}, are signalled by the network in higher layer parameters or configured by pre-configuration parameters.

7.3.1.1.2 Channel raster to resource element mapping

Channel raster to resource element mapping defined in subclause 5.4.2.2 in TS38.101-1 are applied for NR V2X.

7.3.1.1.3 Channel raster entries for each operating band

The channel raster entries for each operating band defined in subclause 5.4.2.3 in TS38.101-1 are applied for NR V2X. The RF channel positions on the channel raster in each NR V2X operating band are given through the applicable NR-ARFCN in Table 7.3.1.1-1, using the channel raster to resource element mapping in subclause 7.3.1.1.2.

For NR V2X operating band n47, $\Delta F_{Raster} = I \times \Delta F_{Global}$, where $I \epsilon \{1\}$. Every I^{th} NR-ARFCN within the operating band are applicable for the channel raster within the operating band and the step size for the channel raster in table 7.3.1.1-1 is given as <*I*>.

Table 7.3.1.1-1: Applicable NR-ARFCN for NR V2X operating band

NR operating band	ΔF_{Raster} (kHz)	Uplink range of N_{REF} (First – <Step size> – Last)	Downlink range of N_{REF} (First – <Step size> – Last)
n47	15	790334 – <1> – 795000	790334 – <1> – 795000

7.3.1.2 Synchronization raster

There is no synchronization raster definition for NR V2X for both licensed bands and unlicensed bands.

7.3.2 Channel arrangement in FR2

8 Transmitter characteristics

8.1 NR V2X UE Tx requirements in FR1

When a NR V2X UE is TDM operating between NR SL and LTE SL at n47, the NR V2X UE need to satisfy the individual V2X Tx requirements of each RAT. For V2X applications the transmitter characteristics are specified at UE antenna connector without any external components that may be used to relocate the antenna away from the UE as shown in Figure 8.1-1.

Figure 8.1-1 shows a V2X integration block diagram with an example set of components external to the UE such as cables and compensator devices.

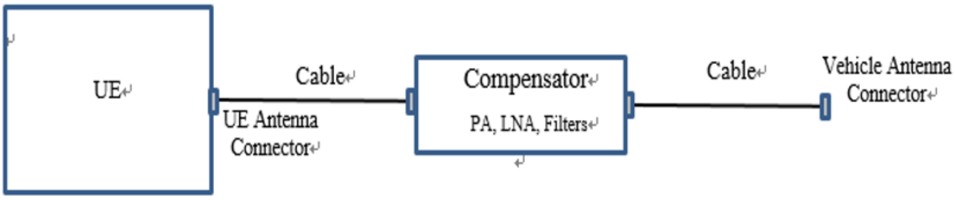


Figure 8.1-1 An Example of V2X UE intergrataion block diagram

8.1.1 Maximum output power for NR V2X UE

The following V2X UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth. The period of measurement shall be at least one sub frame (1ms).

Table 8.1-1: V2X UE Power Class

NR band	Class 1 (dBm)	Tolerance (dB)	Class 2 (dBm)	Tolerance (dB)	Class 3 (dBm)	Tolerance (dB)	Class 4 (dBm)	Tolerance (dB)
…								
n38					23	±2		
n47					23	±2		
NOTE 1: NR Band n47 is used for NR V2X Service. NOTE 2: $P_{PowerClass}$ is the maximum UE power specified without taking into account the tolerance								

8.1.2 UE maximum output power reduction

The following assumption can serve as a starting point for MPR simulation assumptions as shown in Table 8.1.2-1 and Table 8.1.2-2.

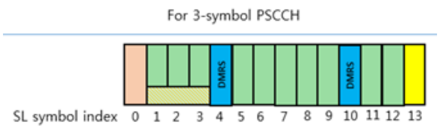
Table 8.1.2-1: MPR simulation assumption for NR V2X

parameter	Assumption
center frequency	**2.7GHz/5.9GHz**
Bandwidth	**10/20/30/40MHz**
Maximum output power	**23dBm**

numerology	**15 kHz/30kHz/60kHz**
Modulation	**QPSK/16QAM/64QAM/256QAM**
Waveform	**CP-OFDM**
Carrier leakage	**25dBc**
IQ image	**25dBc**
CIM3	**45dBc or 60dBc**
PA calibration	PA calibrated to deliver -30dBc ACLR for a fully allocated RBs in 20MHz QPSK DFT- S-OFDM waveform at 1 dB MPR. This is based to share PA between LTE V2X and NR V2X at 5.9GHz as worst case.

For NR V2X, simultaneous transmission of PSCCH and PSSCH in the same subframe is supported. The following constraints in table 8.1.2-2 can be assumed based on current RAN1's agreement.

Table 8.1.2-2: MPR simulation assumption based on RAN1's agreement

Items	Assumption
Allowed sub-channel sizes	• **Support {10, 15, 20, 25, 50, 75, 100} PRBs for possible sub-channel size.**
Allowed L_{CRB} allocation	10,15,20,25,30,40,45,50,60,70,75,80,90,100,105,110,120,130,135,140,150,160,165,170,175,180,190,195,200,210
Regarding PSCCH / PSSCH multiplexing	
PSCCH size	**10RB*3 Symbols**
PSD offset of X dB between PSCCH and PSSCH	**0dB**

For simultaneous transmission of PSFCH, RAN4 assumed as follow

- The baseline MPR simulation assumptions for multiple PSFCH transmission

- 1 RB per user
- Both Non-contiguous PSFCH RB allocation and contiguous PSFCH allocation are allowed
  - MPR will be derived by non-contiguous PSFCH RB allocation
- Total power of all users equals 23dBm
- All users have the same power per RB
- Simulation parameters as per Table 8.1.2-1 and Table 8.1.2-2
- Feedback sequences are per Section 5.2 TS 38.211
- The MPR will be specified as a formula or table based on number of allocated RBs.
- PSFCH generation shall be based on existing RAN1 agreements
- Assumption of N in RAN4 is only for MPR simulation purpose, the final number is up to RAN1 decision

Based on the simulation, RAN4 specify MPR requirements as follow

When UE is configured for NR V2X sidelink transmissions non-concurrent with NR uplink transmissions for NR V2X operating bands specified in Table 8.1-1, this subclause specifies the allowed Maximum Power Reduction (MPR) power for NR V2X physical channels and signals due to PSCCH and PSSCH simultaneous transmission.

8.1.2.1 MPR for Power class 3 V2X UE

For contiguous allocation of PSCCH and PSSCH simultaneous transmission, the allowed MPR for the maximum output power for NR V2X physical channels PSCCH and PSSCH shall be specified as inner/outer RB allocations in Table 8.1.2.1-1 for power class 3.

Table 8.1.2.1-1: Maximum Power Reduction (MPR) for power class 3 V2X (Contiguous PSCCH and PSSCH transmission)

Modulation		Channel bandwidth/MPR (dB)	
		Outer RB allocations	Inner RB allocations
CP-OFDM	QPSK	≤ 4.5	≤ 2.5
	16QAM	≤ 4.5	≤ 2.5
	64 QAM	≤ 4.5	
	256 QAM	≤ 7.0	

Where the following parameters are defined to specify valid RB allocation ranges for Outer and Inner RB allocations:

N_{RB} is the maximum number of RBs for a given Channel bandwidth and sub-carrier spacing defined in Table 5.3.2-1 in TS38.101-1.

$$RB_{Start,Low} = \max(1, \mathrm{floor}(L_{CRB}/2))$$

where max() indicates the largest value of all arguments and floor(x) is the greatest integer less than or equal to x.

$$RB_{Start,High} = N_{RB} – RB_{Start,Low} – L_{CRB}$$

The RB allocation is an Inner RB allocation if the following conditions are met

$$RB_{Start,Low} \leq RB_{Start} \leq RB_{Start,High}, \text{ and}$$

$$L_{CRB} \leq \mathrm{ceil}(N_{RB}/2)$$

where ceil(x) is the smallest integer greater than or equal to x.

The RB allocation is an Outer RB allocation for all other allocations which are not an Inner RB allocation.

For single V2X UE's PSFCH transmission for PC3 NR V2X UE, the required MPR is defined as follow

$$MPR\_{}_{PSFCH} = 3.5 \text{ dB}$$

For contiguous and non-contiguous allocation for simultaneous PSFCH transmission for PC3 NR V2X UE, the required MPR are specified as follow

$$MPR\_{}_{PSFCH} = CEIL\ \{M_{A\_PSFCH}, 0.5\}$$

Where M_A is defined as follows

$$M_{A\_PSFCH} = 7.5 \quad ; 0.00 < N_{Gap}/N_{RB} \leq 0.55$$

$$= 12.0 \quad ; 0.55 < N_{Gap}/N_{RB} \leq 1.0$$

Where

N_{Gap} is the gap RB amount between RB_{start} and RB_{end} for contiguous and non-contiguous allocation simultaneous PSFCH transmission. ($N_{Gap} = RB_{end} - RB_{start}$)

CEIL{$M_{A,}$ 0.5} means rounding upwards to closest 0.5dB.

The allowed MPR for the maximum output power for V2X physical channels on S-SSB transmission are specified as follow

Table 8.1.2.1-2: Maximum Power Reduction (MPR) for S-SSB transmission for power class 3 V2X

Channel	MPR (dB)	
	Outer RB allocations[1]	Inner RB allocations[1]
S-SSB	≤ 6.0	≤ 2.5
NOTE 1: Inner and Outer RB allocations are defined in section 8.1.2.1		

8.1.3 UE maximum output power with additional requirements

To comply the EN 302 571 standard emission mask, RAN4 need to derive A-MPR requirements considering with the additional A-SEM and A-SE requirements in EN 302 571 standard as shown in Table 8.1.3-1 and Table 8.1.3-2.

NR V2X UE shall satisfy the additional SEM and additional SE requirements when NS_33 is configured from pre-configured radio parameters or the cell and the indication from upper layers has indicated was informed.

Table 8.1.3-1: Additional SEM requirements for 10MHz channel bandwidth

Spectrum emission limit (dBm EIRP)/ Channel bandwidth		
Δf_{OOB} (MHz)	10 MHz	Measurement bandwidth
± 0-0.5	$[-13 - 12\left(\lvert\Delta fOOB\rvert/_{MHz}\right)]$	100 kHz
± 0.5-5	$[-19 - \frac{16}{9}\left(\lvert\Delta fOOB\rvert/_{MHz} - 0.5\right)]$	100 kHz
± 5-10	$[-27 - 2\left(\lvert\Delta fOOB\rvert/_{MHz} - 5.0\right)]$	100 kHz

NOTE 1: As a general rule, the resolution bandwidth of the measuring equipment should be equal to the measurement bandwidth. However, to improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth may be smaller than the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.

NOTE 2: Additional SEM for V2X overrides any other requirements in frequency range 5855-5950MHz.

NOTE 3: The EIRP requirement is converted to conducted requirement depend on the supported post antenna connector gain $G_{post\ connector}$ declared by the UE following the principle described in annex G in TS38.101-1.

Table 8.1.3-2: Additional SE requirements

n47	E-UTRA Band 1, 3, 5, 7, 8, 22, 26, 28, 34, 39, 40, 41, 42, 44, 45, 65, 68, 72, 73 NR band n77, n78 , n79	F_{DL_low}	-	F_{DL_high}	-50	1	
	Frequency range	5925	-	5950	-30 EIRP	1	38, 40, 43
	Frequency range	5815	-	5855	-30 EIRP	1	38, 43
NOTE 38: Applicable when NS_33 or NS_34 is configured by the pre-configured radio parameters. NOTE 40: In the frequency range x-5950MHz, SE requirement of -30dBm/MHz should be applied; where x = max (5925, fc + 15), where fc is the channel centre frequency. NOTE 43: The EIRP requirement is converted to conducted requirement depend on the supported post antenna connector gain $G_{post\ connector}$ declared by the UE following the principle described in annex I.							

Also, FCC had regulatory requirements for 40MHz in ITS spectrum as shown in Table 8.1.3-3

Table 8.1.3-3: Additional SEM requirements for 40MHz channel bandwidth (fc =5885 MHz)

Δf_{OOB} (MHz)	Emission Limit (dBm)	Measurement Bandwidth
±0 - 2	-32	100kHz
±2-10	-36	100kHz
±10-20	-38	100kHz
±20-40	-43	100kHz
±40 - 100	-50	100kHz

To comply the regional regulatory requirements, RAN4 specify the A-MPR requirements according to different network signalling by pre-configured radio parameters or the cell and the indication from upper layers has indicated to NR V2X UE.

The allowed additional Maximum Power Reduction (A-MPR) for the maximum output power due to higher order modulation and transmit bandwidth configuration (resource blocks) will be specified in TS38.101-1 as below.

Table 8.1.3-4: Additional Maximum Power Reduction (A-MPR) for NR V2X

Network Signalling value	Requirements (subclause)	NR Band	Channel bandwidth (MHz)	Resources Blocks (N_{RB})	A-MPR (dB)
NS_33	Table 8.1.3-1 (A-SEM) Table 8.1.3-2 (A-SE)	n47	10	Table 8.1.3.1-1 Table 8.1.3.1-2 Table 8.1.3.1-3 Table 8.1.3.1-4	
NS_52	Table 8.1.3-3 (A-SEM)	n47	40	Table 8.1.3.2-1 Table 8.1.3.2-2 Table 8.1.3.2-3	
NS_XX	Table 8.1.3-1 (A-SEM)	n47	10	Table 8.1.3.3-1 Table 8.1.3.3-2 Table 8.1.3.3-3	

8.1.3.1 AMPR for NS_33

When NS_33 is indicated by the network or pre-configured radio parameters for NR V2X UE, the additional maximum output power reduction specified as

$$\text{A-MPR} = \text{CEIL}\ \{M_A, 0.5\}$$

Where M_A is defined as follows

$$M_A = \text{A-MPR}_{Base} + G_{post\ connector} * \text{A-MPR}_{Step}$$

CEIL{$M_{A,}$ 0.5} means rounding upwards to closest 0.5dB.

A-MPR$_{Base}$ which is specified for PSCCH and PSSCH transmission\S-SSB\PSFCH below is allowed when network signalling value is provided. A-MPR$_{Base}$ is the default A-MPR value when no $G_{post\ connector}$ is declared. The supported post antenna connector gain $G_{post\ connector}$ is declared by the UE following the principle described in 38.101-1.

For the contiguous PSSCH and PSCCH transmission when NS_33 is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements.

Table 8.1.3.1-1: A-MPR for PSSCH/PSCCH by NS_33 (at Fc =5860MHz)

Carrier frequency(MHz)	Resources Blocks (L_{CRB})	Start Resource Block	A-MPR$_{base}$ (dB)		
			QPSK/16QAM	64QAM	256QAM
5860	≥ 10 and ≤ 15	0	≤ 24		
		≥ 1 and ≤ 3	≤19		
	≥ 10 and ≤ 15	≥ 26 and ≤ 38	≤6		
	≥ 10 and ≤ 20	≥ 12 and ≤ 14	≤11		
		≥ 15 and ≤ 19	≤9.5		
		≥ 20 and ≤ 25	≤8.0		
	≥ 10 and ≤ 30	≥ 4 and ≤7	≤ 16		
		≥ 8 and ≤ 11	≤ 13.5		
	≥ 20 and ≤ 30	≥ 0 and ≤ 3	≤ 22		
	25 and 30	≥ 16 and ≤ 21	≤ 9.5		
		≥ 22 and ≤ 27	≤ 8.0		
	≥ 25 and ≤ 40	≥ 12 and ≤ 15	≤ 12		
	40 and 45	0 and 1	≤ 19		

		≥ 2 and ≤ 5	≤ 16
		≥ 6 and ≤ 11	≤ 13.5
	≥ 50	≥ 0	≤ 16
Note 1: A-MPR_{step} =1.2 dB used for RB_{start} 0 and 1 and A-MPR_{step} =0.7 dB used for all other RB_{start}			

Table 8.1.3.1-2: A-MPR for PSSCH/PSCCH by NS_33 at other carrier frequency

Carrier frequency(MHz)	RB allocations	A-MPR_{base} (dB)				A-MPR_{step} (dB)
		QPSK	16QAM	64QAM	256QAM	
5870, 5880, 5890, 5900, 5910, 5920	Inner	≤ 3.0		≤ 5.0	≤ 6.0	0.5
	Outer	≤ 4.5				
NOTE 1: Inner and Outer RB allocations are defined in section 8.1.2.1						

For the simultaneous PSFCH transmission when NS_33 is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements

Table 8.1.3.1-3: A-MPR for simultaneous PSFCH by NS_33

Channel Bandwidth [MHz]	Center Frequency [MHz]	RB allocation	A-MPR_{Base} (dB)			A-MPR_{step} (dB)
			$0 \leq N_{Gap} / N_{RB} < 0.15$	$0.15 \leq N_{Gap} / N_{RB} < 0.3$	$0.3 \leq N_{Gap} / N_{RB} \leq 1$	
10	5860	N_{RB} =1	19.0			1.0
		N_{RB} > 1	22.0			
	5870, 5880, 5890, 5900, 5910, 5920	N_{RB} =1	5			0.8
		N_{RB} > 1	14	7	18.5	
Note 1: N_{Gap} is the gap RB amount between RB_{start} and RB_{end} for contiguous and non-contiguous allocation simultaneous PSFCH transmission. ($N_{Gap} = RB_{end} - RB_{start}$)						

For the S-SSB transmission when NS_33 is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements

Table 8.1.3.1-4: A-MPR for S-SSB transmission by NS_33

Carrier Frequency (MHz)	RBStart * 12*SCS [MHz]	A-MPR_{Base} (dB)	$AMPR_{Step}$ (dB)
5860	≤1.0	≤ 25	0.6
	>1.0 and ≤2.0	≤ 19	
	>2.0 and ≤3.24	≤ 12	

	>3.24 and ≤3.6	≤ 10	
	>3.6	≤ 9	
5870, 5880, 5890, 5900, 5910, 5920	≤1.0	≤ 7.0	0.85
	>1.0 and ≤1.6	≤ 6.5	
	>1.6 and ≤2.6	≤ 5.8	
	>2.6 and ≤3.24	≤ 4.5	
	>3.24 and ≤4.32	≤ 5.5	
	>4.32	≤ 6.5	

8.1.3.2 AMPR for NS_52

When NS_52 is indicated by the network or pre-configured radio parameters for NR V2X UE, the additional maximum output power reduction specified as

$$\text{A-MPR} = \text{CEIL}\ \{M_A, 0.5\}$$

Where M_A is defined as follows

$$M_A = \text{A-MPR}$$

CEIL{$M_{A,}$ 0.5} means rounding upwards to closest 0.5dB.

For the contiguous PSSCH and PSCCH transmission when NS_52 is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements.

Table 8.1.3.2-1: A-MPR for PSSCH/PSCCH by NS_52

Carrier frequency(MHz)	Modulation	A-MPR(dB)		
		Region 1	Region 2	Region 3
5885	QPSK	≤ 13.5	≤ 8.0	≤ 5.5
	16QAM		≤ 8.0	≤ 5.5
	64QAM		≤ 8.5	≤ 5.5
	256QAM		≤ 8.5	≤ 6.0

Where the following parameters are defined to specify valid RB allocation ranges for Region1, Region2 and Region3 according to RB allocations:

Table 8.1.3.2-1a: A-MPR Region definitions for PSSCH/PSCCH by NS_52

Channel Bandwidth, MHz	Carrier frequency(MHz)	A-MPR parameters for region definitions		A-MPR
		RB_{start} or RB_{end}	L_{CRB}	
40	5885	RB_{start} ≤ floor(N_{RB}*0.2) or RB_{end} ≥ N_{RB} - floor(N_{RB}*0.2)	L_{CRB} ≤floor(N_{RB}*0.2)	Region 1

		The RB allocation is in Region 2 allocation for all other allocations which are not a Region1 or Region3 allocation.		Region 2
		floor(N_{RB} /3.5) ≤ $\mathbf{RB_{start}}$ ≤ N_{RB} –floor(N_{RB} /3.5) – L_{CRB}	$\mathbf{L_{CRB}}$ ≤ceil(N_{RB}/3.5)	Region 3

N_{RB} is the maximum number of RBs for a given Channel bandwidth and sub-carrier spacing defined in Table 5.3.2-1 [3].

For the simultaneous PSFCH transmission when NS_52 is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements.

Table 8.1.3.2-2: A-MPR for simultaneous PSFCH by NS_52

Channel Bandwidth [MHz]	Carrier frequency [MHz]	A-MPR (dB)
40 MHz	5885	≤ 23.5

For the S-SSB transmission when NS_52 is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements

Table 8.1.3.2-3: A-MPR for S-SSB transmission by NS_52

Carrier Frequency (MHz)	RB_{Start} * 12*SCS [MHz]	A-MPR (dB)
5885	≤ 7	≤ 16.0
	> 7 and ≤ 12	≤ 10.5
	> 12 and ≤ 19	≤ 4.0
	> 19 and ≤ 25	≤ 10.5
	> 25	≤ 16.0

8.1.3.3 AMPR for NS_xx

When NS_xx is indicated by the network or pre-configured radio parameters for NR V2X UE, the additional maximum output power reduction specified as

$$\text{A-MPR} = \text{CEIL}\ \{M_A, 0.5\}$$

Where M_A is defined as follows

$$M_A = \text{A-MPR}$$

CEIL{$M_{A,}$ 0.5} means rounding upwards to closest 0.5dB.

For the contiguous PSSCH and PSCCH transmission when NS_xx is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements.

Table 8.1.3.3-1: A-MPR for PSSCH/PSCCH by NS_xx

Carrier frequency(MHz)	RB allocations	A-MPR (dB)			
		QPSK	16QAM	64QAM	256QAM

5860, 5870, 5880, 5890, 5900, 5910, 5920	Inner	≤ 3.0	≤ 5.0	≤ 6.0
	Outer	≤ 4.5		
NOTE 1: Inner and Outer RB allocations are defined in section 8.1.2.1				

For the simultaneous PSFCH transmission when NS_xx is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements

Table 8.1.3.3-2: A-MPR for simultaneous PSFCH by NS_xx

Channel Bandwidth [MHz]	Center Frequency [MHz]	RB allocation	A-MPR$_{Base}$ (dB)			A-MPR$_{step}$ (dB)
			$0 \le N_{Gap} / N_{RB} < 0.15$	$0.15 \le N_{Gap} / N_{RB} < 0.3$	$0.3 \le N_{Gap} / N_{RB} \le 1$	
10	5860, 5870, 5880, 5890, 5900, 5910, 5920	$N_{RB} = 1$	5			0.8
		$N_{RB} > 1$	14	7	18.5	
Note 1: N_{Gap} is the gap RB amount between RB_{start} and RB_{end} for contiguous and non-contiguous allocation simultaneous PSFCH transmission. ($N_{Gap} = RB_{end} - RB_{start}$)						

For the S-SSB transmission when NS_xx is indicated by the network or pre-configured radio parameters for NR V2X UE, the NR UE allow the follow A-MPR requirements

Table 8.1.3.3-3: A-MPR for S-SSB transmission by NS_xx

Carrier Frequency (MHz)	RBStart * 12*SCS [MHz]	A-MPR$_{Base}$ (dB)	AMPR$_{Step}$ (dB)
5860, 5870, 5880, 5890, 5900, 5910, 5920	≤1.0	≤ 7.0	0.85
	>1.0 and ≤1.6	≤ 6.5	
	>1.6 and ≤2.6	≤ 5.8	
	>2.6 and ≤3.24	≤ 4.5	
	>3.24 and ≤4.32	≤ 5.5	
	>4.32	≤ 6.5	

8.1.4 Configured transmitted power for NR V2X UE

[The NR V2X UE is allowed to set its configured maximum output power $P_{CMAX,c}$ for carrier f of serving cell c in each slot. The configured maximum output power $P_{CMAX,c}$ is set within the following bounds:

$$P_{CMAX\_L,f,c} \le P_{CMAX,f,c} \le P_{CMAX\_H,f,c} \text{ with}$$

$$P_{CMAX\_L,f,c} = \text{MIN}\{P_{EMAX,c} - \Delta T_{C,c}, (P_{PowerClass} - \Delta P_{PowerClass}) - \text{MAX}(\text{MAX}(MPR_c, \text{A-MPR}_c) + \Delta T_{IB,c} + \Delta T_{C,c} + \Delta T_{RxSRS}, \text{P-MPR}_c), P_{Regulatory,c}\}$$

$$P_{CMAX\_H,f,c} = \text{MIN}\{P_{EMAX,c}, (P_{PowerClass} - \Delta P_{PowerClass}), P_{Regulatory,c}\}$$

where

-$P_{CMAX,f,c}$ is configured for PSSCH\PSCCH, S-SSB and PSFCH, respectively;

- For the total transmitted $P_{CMAX,PSSCH\backslash PSCCH}$, $P_{CMAX,S\text{-}SSB}$ and $P_{CMAX,PSFCH}$, $P_{EMAX,c}$ is the value given by IE *maxTxPower*, defined by [TS 38.331], when the UE is not associated with a serving cell on the NR V2X carrier .

- $P_{PowerClass}$ is the maximum UE power specified in Table 6.2.1-1 in TS38.101-1 without taking into account the tolerance specified in the Table 6.2.1-1 in TS38.101-1;

- MPR_c and A-MPR_c for serving cell *c* are specified in subclause 6.2E.2 and subclause 6.2E.3 for PSSCH\PSCCH, S-SSB and PSFCH in TS38.101-1, respectively;

- $\Delta T_{IB,c}$, $\Delta T_{C,c}$, ΔT_{RxSRS}, $\Delta P_{Poweclass}$ and P-MPR_c are specified in subclause 6.2.4 in TS38.101-1

- $P_{Regulatory,c}$ = 10 - $G_{post\ connector}$ dBm the V2X UE is within the protected zone in EN 102. 792 of CEN DSRC tolling system and operating in Band n47; $P_{Regulatory,c}$ = 33 - $G_{post\ connector}$ dBm otherwise.

The maximum output power $P_{CMAX,PSSCH}$ and $P_{CMAX,PSCCH}$ are derived from $P_{CMAX,c}$ based on 0dB offset between PSSCH and PSCCH.

For the measured configured maximum output power $P_{UMAX,c}$ for NR V2X sidelink transmissions non-concurrent with NR uplink transmissions, the same requirement as in subclause 6.2.4 in TS38.101-1 shall be applied.]

8.1.5 Minimum output power for NR V2X UE

The minimum controlled output power of the NR V2X UE is defined as the broadband transmit power of the UE, i.e. the power in the channel bandwidth for all transmit bandwidth configurations (resource blocks), when the power is set to a minimum value.

When UE is configured for NR V2X sidelink transmissions non-concurrent with NR uplink transmissions for NR V2X operating bands in Table 8.1-1, it is proposed that the existing requirements as specified for legacy NR UE shall apply. The minimum output power is defined as the mean power in at least one sub-frame 1 ms.

Table 8.1.5-1: Minimum output power

Channel bandwidth (MHz)	Minimum output power (dBm)	Measurement bandwidth (MHz)
10	-30	9.375
20	-30	19.095
30	-28.2	28.815
40	-27	38.895

8.1.6 Transmit OFF power NR V2X UE

Transmit OFF power is defined as the mean power when the transmitter is OFF. The transmitter is considered to be OFF when the UE is not allowed to transmit or during periods when the UE is not transmitting a sub-frame. During DTX and measurements gaps, the UE is not considered to be OFF.

When UE is configured for NR V2X sidelink transmissions non-concurrent with NR uplink transmissions for NR V2X operating bands in Table 8.1-1, it is proposed that the existing requirements as specified for legacy NR UE shall apply. Transmit off power is defined as the mean power in at least one sub-frame 1 ms.

Table 8.1.6-1: Transmit OFF power

Channel bandwidth (MHz)	Transmit OFF power (dBm)	Measurement bandwidth (MHz)
10	-50	9.375
20	-50	19.095
30	-50	28.815
40	-50	38.895

8.1.7 ON/OFF time mask for NR V2X UE

For NR V2X service, additional requirements on ON/OFF time masks for V2X physical channels and signals are specified in this clause.

8.1.7.1 General time mask for NR V2X UE

The General ON/OFF time mask defines the observation period between the Transmit OFF and ON power and between Transmit ON and OFF power for PSCCH, and PSSCH transmissions in a subframe wherein the last symbol is punctured to create a guard period.

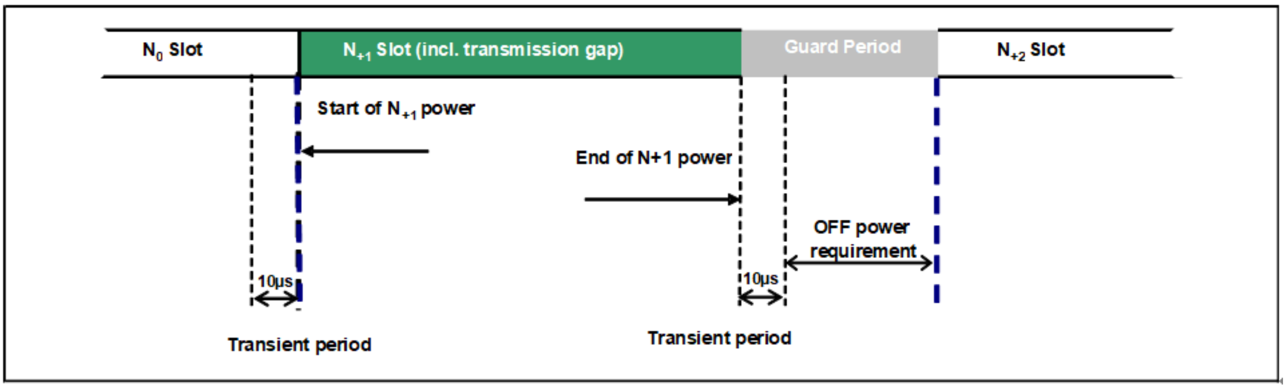


Figure 8.1.7.1-1: General PSCCH/PSSCH time mask for NR V2X UE

8.1.7.2 S-SSB time mask

The S-SSB time mask is for NR V2X UE defines the observation period between transmit OFF and ON S-PSS power and between transmit ON PSBCH and OFF power in a slot, with last symbol punctured to create a guard period.

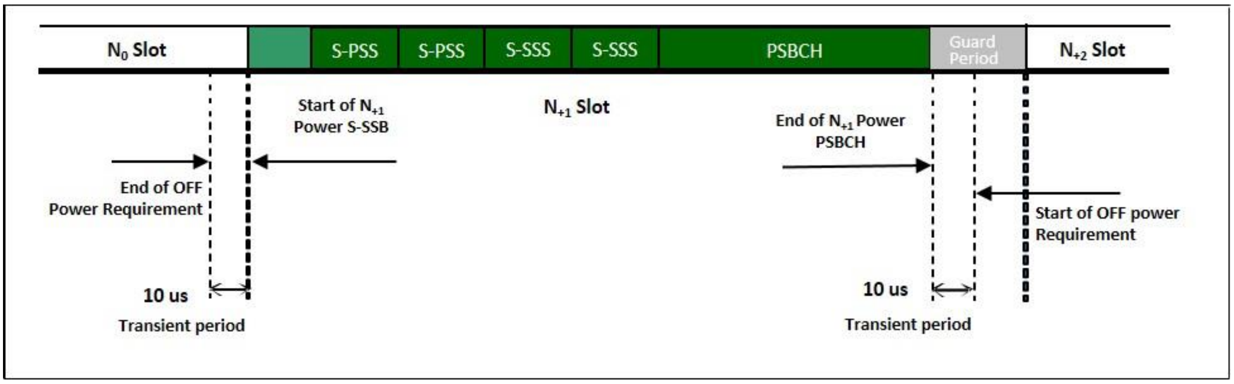


Figure 8.1.7.2-1: S-SSB time mask for NR V2X UE

8.1.7.3 Additional Time mask for TDM operation between NR SL and LTE SL at n47

When a NR V2X UE is operated with TDM between NR SL and LTE SL at n47 without dual PA capability, the maximum SL switching time is defined as 150 us and the following SL interruption is allowed as specified in TS 38.133 clause 12.9.1:
When switch from E-UTRA V2X sidelink to NR V2X sidelink occurs in NR slot ‘n’,

- UE is not expected to transmit or receive on NR V2X sidelink on the slot ‘n’.

When switch from NR V2X sidelink to E-UTRA V2X sidelink occurs in NR slot ‘n-1’,

- UE is not expected to transmit or receive on NR V2X sidelink on the slot ‘n-1’.

When switch from NR V2X sidelink to E-UTRA V2X sidelink occurs in E-UTRA subframe ‘n’,

- UE is not expected to transmit or receive on E-UTRA V2X sidelink on the subframe ‘n’.

When switch from E-UTRA V2X sidelink to NR V2X sidelink occurs in E-UTRA subframe ‘n-1’,

- UE is not expected to transmit or receive E-UTRA on V2X sidelink on the subframe ‘n-1’.

So RAN4 will not specify the specific RF switching time requirements during the switched period and also no RF test to verify the maximum SL switching time is needed.

8.1.8 Power control for NR V2X UE

When UE is configured for NR V2X sidelink transmissions non-concurrent with NR uplink transmissions for NR V2X operating bands in Table 8.1-1, the requirements in sub-clause 8.1.8.1 apply for NR V2X transmission.

8.1.8.1 Absolute power tolerance

The existing absolute power tolerance requirements of legacy NR UE shall apply for V2X transmission.

Table 8.1.8.1-1: Absolute power tolerance

Conditions	Tolerance
Normal	± 9.0 dB

8.1.9 Transmit signal quality for NR V2X UE

8.1.9.1 Frequency error

The UE modulated carrier frequency for NR V2X sidelink transmissions in Table 8.1-1 shall be accurate to within ±0.1 PPM observed over a period of 1 ms compared to the absolute frequency in case of using GNSS synchronization source. The same requirements applied over a period of 1 ms compared to the carrier frequency received from the gNB or V2X synchronization reference UE in case of using the gNB or V2X synchronization reference UE sidelink synchronization signals.

8.1.9.2 Transmit modulation quality

8.1.9.2.1 Error Vector Magnitude

For V2X sidelink physical channels PSCCH and PSSCH, the Error Vector Magnitude requirements shall be as specified for PUSCH in Table 8.1.9.2.1-1 for the corresponding modulation and transmission bandwidth for NR V2X operating bands in Table 8.1-1. When sidelink transmissions are shortened due to transmission gap of 1 symbol at the end of the slot, the EVM measurement interval is reduced by one symbol, accordingly.

Table 8.1.9.2.1-1: Minimum requirements for Error Vector Magnitude

Parameter	Unit	Average EVM Level	Reference Signal EVM Level
QPSK	%	17.5	17.5
16QAM	%	12.5	12.5
64QAM	%	8	8
256QAM	%	3.5	3.5

Table 8.1.9.2.1-2: Parameters for Error Vector Magnitude

Parameter	Unit	Level
UE Output Power	dBm	≥Table 8.1.5-1
UE Output Power for 256QAM	dBm	≥ Table 8.1.5-1 + 10dB
Operating conditions		Normal conditions

8.1.9.2.2 Carrier leakage

It is proposed that no changes to the existing NR requirements for carrier leakage are required for NR V2X UE for NR V2X operating bands in Table 8.1-1.

8.1.9.2.3 In-band emissions

For V2X sidelink physical channels PSCCH and PSSCH, In-band emissions requirements of legacy NR UE in sub-clause 6.4.2.3 shall apply according to the corresponding modulation and transmission bandwidth for NR V2X operating bands in Table 8.1-1. When V2X transmissions are shortened due to transmission gap of 1 symbol at the end of the slot, the In-band emissions measurement interval is reduced by one symbol, accordingly.

8.1.9.2.4 EVM equalizer spectrum flatness

The existing requirements for EVM equalizer spectrum flatness for NR UE in sub-clause 6.4.2.4 in TS38.101-1 shall apply for NR V2X transmissions for NR V2X operating bands in Table 8.1-1.

8.1.10 spectrum emission mask for V2X UE

For V2X, the existing NR general spectrum emission mask can be reused for all 10MHz, 20MHz, 30MHz and 40MHz channel bandwidth. The spectrum emission mask of the UE applies to frequencies (Δf_{OOB}) starting from the ± edge of the assigned NR channel bandwidth. For frequencies greater than (Δf_{OOB}), the power of any UE emission shall not exceed the levels specified in Table 6.5.2.2-1in TS 38.101-1 for the specified channel bandwidth for NR V2X operating bands in Table 8.1-1.

8.1.10.1 Additional spectrum emission mask for V2X UE

In LTE V2X WI, RAN4 already studied the additional spectrum emission mask in ITS band. So RAN4 reuse the additional spectrum emission mask in session 6.6.2.2.4 and 6.6.2.2.7 in TS36.101 for LTE V2X UE at n47.

When "NS_33" or "NS_34" is indicated in the cell, the power of any V2X UE emission shall not exceed the levels specified in Table 8.1.10.1-1.

Table 8.1.10.1-1: Additional spectrum mask requirements for 10MHz channel bandwidth

Spectrum emission limit (dBm EIRP)/ Channel bandwidth		
Δf_{OOB} (MHz)	10 MHz	Measurement bandwidth
± 0-0.5	$[-13-12\left(\lvert\Delta fOOB\rvert/_{MHz}\right)]$	100 kHz
± 0.5-5	$[-19-\frac{16}{9}\left(\lvert\Delta fOOB\rvert/_{MHz}-0.5\right)]$	100 kHz
± 5-10	$[-27-2\left(\lvert\Delta fOOB\rvert/_{MHz}-5.0\right)]$	100 kHz

When "NS_48" is indicated in the cell, the power of any V2X UE emission shall not exceed the levels specified in Table 8.1.10.1-2.

Table 8.1.10.1-2: Additional spectrum mask requirements for 40MHz channel bandwidth (fc =5885 MHz)

Δf_{OOB} (MHz)	Emission Limit (dBm)	Measurement Bandwidth
±0 - 2	-32	100kHz
±2-10	-36	100kHz
±10-20	-38	100kHz
±20-40	-43	100kHz
±40 - 100	-50	100kHz

8.1.11 ACLR requirements for V2X UE

Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency.

Based on co-existence simulation results, a 30dB ACLR can guarantee that V2X co-exists well with DSRC, i.e. the PRR degradation of V2X to DSRC is comparable with that of DSRC to DSRC. Hence the existing ACLR requirement for licensed bands can be reused for NR V2X for NR V2X operating bands in Table 8.1-1.

Table 8.1.11-1: ACLR for NR V2X

	Channel bandwidth /ACLR1 / Measurement bandwidth							
	1.4 MHz	**3.0 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**	**30 MHz**	**40 MHz**
ACLR1				30 dB		30 dB	30 dB	30 dB
NR V2X channel Measurement bandwidth				9.375 MHz		19.095 MHz	28.815 MHz	38.895 MHz
Adjacent channel centre frequency offset [MHz]				+10 / -10		+20 / -20	+30 / -30	+40 / -40

8.1.12 Spurious emission for V2X UE

General spurious emission requirement for V2X operation should be extended to 26GHz same with that in LAA BS. In addition, UE should also meet regional requirement which defined in ETSI EN 302 571 as additional spurious emission requirement for NR V2X operating bands in Table 8.1-1.

Table 8.1.12-1: Spurious emissions limits

Frequency Range	Maximum Level	Measurement bandwidth	NOTE
9 kHz ≤ f < 150 kHz	-36 dBm	1 kHz	
150 kHz ≤ f < 30 MHz	-36 dBm	10 kHz	
30 MHz ≤ f < 1000 MHz	-36 dBm	100 kHz	
1 GHz ≤ f < 12.75 GHz	-30 dBm	1 MHz	
12.75 GHz ≤ f < 5th harmonic of the upper frequency edge of the UL operating band in GHz	-30 dBm	1 MHz	1
12.75 GHz - 26 GHz	-30 dBm	1 MHz	2
NOTE 1: Applies for NR Band n22, Band n42 and Band n43. NOTE 2: Applies for NR Band n47.			

8.1.13 Spurious emission band UE co-existence for V2X UE

This clause specifies the spurious emission requirements for the specified NR V2X band, for coexistence with protected bands

Table 8.1.13-1: Requirements

NR Band	Spurious emission						
	Protected band	**Frequency range (MHz)**			**Maximum Level (dBm)**	**MBW (MHz)**	**NOTE**
…							
n38	E-UTRA Band 1, 2, 3, 4, 5, 8, 10, 12, 13, 14, 17, 20, 22, 27, 28, 29, 30, 31, 32, 33, 34, 40, 42, 43, 50, 51, 52, 65, 66, 67, 68, 72, 74, 75, 76, 85	F_{DL_low}	-	F_{DL_high}	-50	1	
	NR Band n77, n78	F_{DL_low}	-	F_{DL_high}	-50	1	
	Frequency range	2620	-	2645	-15.5	5	4,5,6
	Frequency range	2645	-	2690	-40	1	4,5
n47	E-UTRA Band 1, 3, 5, 7, 8, 22, 26, 28, 34, 39, 40, 41, 42, 44, 45, 65, 68, 72, 73	F_{DL_low}	-	F_{DL_high}	-50	1	
	NR Band n71, n77, n78, n79	F_{DL_low}	-	F_{DL_high}	-50	1	
	Frequency range	5925	-	5950	-30 EIRP	1	1,2,3
	Frequency range	5815	-	5855	-30 EIRP	1	1,3,7

NOTE 1: Applicable when NS_33 or NS_34 is configured by the pre-configured radio parameters.
NOTE 2: In the frequency range x-5950MHz, SE requirement of -30dBm/MHz should be applied; where x = max (5925, fc + 15), where fc is the channel centre frequency.
NOTE 3: The EIRP requirement is converted to conducted requirement depend on the supported post antenna connector gain $G_{post\ connector}$ declared by the UE following the principle described in annex I.
NOTE 4: These requirements also apply for the frequency ranges that are less than F_{OOB} (MHz) in Table 6.5.3.1-1 in TS36.101 from the edge of the channel bandwidth.
NOTE 5: This requirement is applicable for power class 3 UE for any channel bandwidths within the range 2570 - 2615 MHz with the following restriction: for carriers of 20 MHz bandwidth when carrier centre frequency is within the range 2597 - 2605 MHz the requirement is applicable only for an uplink transmission bandwidth less than or equal to 54 RB. For power class 3 UE for carriers with channel bandwidth overlapping the frequency range 2615 - 2620 MHz the requirement applies with the maximum output power configured to +19 dBm in the IE P-Max.
NOTE 6: For these adjacent bands, the emission limit could imply risk of harmful interference to UE(s) operating in the protected operating band.
NOTE 7: Resolution BW is 10% of the measurement BW and the result should be integrated to achieve the measurement bandwidth. The sweep time shall be set larger than (symbol length)*(number of points in sweep) to improve the measurement accuracy.

In Note 2, the frequency range with -30dBm/MHz will be further discussed.

When "NS_33" is configured from pre-configured radio parameters or the cell and the indication from upper layers has indicated that the UE is within the protection zone of CEN DSRC devices or HDR DSRC devices, the power of any V2X UE emission shall fulfil either one of the two set of conditions.

	Maximum Transmission Power (dBm EIRP)	**Emission Limit in Frequency Range 5795-5815 (dBm/MHz EIRP)**
Condition 1	10	-65
Condition 2	10	-45

8.1.14 Transmit intermodulation for NR V2X UE

When UE is configured for NR V2X sidelink transmissions non-concurrent with NR uplink transmissions for NR V2X operating bands in Table 8.1-1, the requirements in sub-clause 6.5.4 in TS38.101-1 apply for NR V2X sidelink transmission.

8.2 NR V2X UE Tx requirements in FR2

9 Receiver characteristics

9.1 NR V2X UE Rx requirements in FR1

When a NR V2X UE is TDM operating between NR SL and LTE SL at n47, the NR V2X UE need to satisfy the individual V2X Rx requirements of each RAT. For V2X applications the receiver characteristics are specified at UE antenna connector without any external components that may be used to relocate the antenna away from the UE as shown in Figure 8.1-1.

9.1.1 Reference sensitivity power level

The reference sensitivity power level REFSENS is the minimum mean power applied to the UE antenna connector at which the throughput shall meet or exceed 95% of the maximum throughput of the reference measurement channels.

The V2X UE REFSENS is defined by the following equation:

$$REFSENS_{V2X}=kTB + SNR_{V2X} +10\log_{10}(L_{CRB}*SCS*12/RX\_BW) +(NF_{V2X}+ IM) – \text{Diversity gain}$$

Where

- *kTB:* Thermal noise level is [-174dBm(kT) + 10*$\log_{10}$(RX BW)]dBm.
- NF: Noise figure. 13 dB is used for LAA and can be reused for NR V2X requirements. Assumed NF is 9dB < 3GHz, NF is 10dB>= 3GHz (e.g B42, n77, n78, n79…) at licensed bands at FR1.
- IM: 2.5 dB is assumed. When the number of RB size equal to or less than 24RBs, 0.5dB additional relaxation is allowed.
- Target SNR: -0.5 dB
- Diversity gain: 3dB

The REFSENS requirements for NR V2X Bands (PC5) are in Table 9.1.1-1.

Table 9.1.1-1: Reference sensitivity for V2X Band (PC5)

NR Operating band / SCS / Channel bandwidth / Duplex-mode						
V2X Band	**SCS kHz**	**10MHz (dBm)**	**20MHz (dBm)**	**30MHz (dBm)**	**40MHz (dBm)**	**Duplex Mode**
n38	15	-96.5	-93.2	-91.4	-90.1	TDD
	30	-96.1	-93.4	-91.7	-90.2	
	60	-96.9	-93.1	-91.9	-90.4	
n47	15	-92.5	-89.2	-87.4	-86.1	HD
	30	-92.1	-89.4	-87.7	-86.2	
	60	-92.9	-89.1	-87.9	-86.4	

Table 9.1.1-2: Sidelink TX configuration for reference sensitivity of V2X Bands (PC5)

NR operating Band / SCS/ Channel bandwidth / N_{RB} / Duplex mode						
V2X Band	**SCS (kHz)**	**10 MHz (dBm)**	**20 MHz (dBm)**	**30 MHz (dBm)**	**40 MHz (dBm)**	**Duplex Mode**
n38	15	50	105	160	216	TDD
	30	24	50	75	105	
	60	10	24	36	50	
n47	15	50	105	160	216	HD
	30	24	50	75	105	
	60	10	24	36	50	

9.1.2 Maximum input level

Maximum input level is defined as the maximum mean power received at the UE antenna port, at which the specified relative throughput shall meet or exceed the minimum requirements for the specified reference measurement channel.

For V2X, the requirement are defined for 10MHz, 20MHz, 30MHz and 40MHz. The parameters of reference measurement channel shall be changed according to the physical layer design specific to NR V2X UE in Table 8.1-1.

Table 9.1.2-1: Maximum input level for V2X

Rx Parameter	Units	Channel bandwidth			
		10 MHz	**20 MHz**	**30 MHz**	**40 MHz**
Power in Transmission Bandwidth Configuration	dBm	-25[1]	-25[1]	[-23[1]]	[-22[1]]
		-27[2]	-27[2]	[-25[2]]	[-24[2]]
NOTE 1: Reference measurement channel is A.7 for 64 QAM in TS38.101-1 NOTE 2: Reference measurement channel is A.7 for 256 QAM in TS38.101-1					

9.1.3 Adjacent Channel Selectivity (ACS)

Adjacent Channel Selectivity (ACS) is a measure of a receiver's ability to receive an NR signal at its assigned channel frequency in the presence of an adjacent channel signal at a given frequency offset from the centre frequency of the assigned channel.

ACS reflects the digital domain filter attenuation capability, which is model together with ACLR in ACIR. Based on PRR metric. In co-existence study, the existing NR ACS requirement reuse for both NR UE to V2X UE and DSRC UE to V2X UE urban interference scenarios, PRR loss is less than 5%. Therefore, it is proposed that the same ACS values shall be kept unchanged for V2X UE at n47.

In licensed band, RAN4 shall reuse the same ACS values since there was legacy NR or LTE system.

As 10MHz is typical channel bandwidth used in the V2X band, the interferer bandwidth shall be used with 10MHz for NR V2X operating bands in Table 8.1-1.

Table 9.1.3-1: Adjacent channel selectivity for V2X

		Channel bandwidth							
Rx Parameter	**Units**	**1.4 MHz**	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**	**30 MHz**	**40 MHz**
ACS	dB				33.0		27.0	25.5	24.0

Table 9.1.3-2: Test parameters for Adjacent channel selectivity for V2X, Case 1

Rx Parameter	Units	Channel bandwidth							
		1.4 MHz	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**	**30 MHz**	**40 MHz**
Power in Transmission Bandwidth Configuration	dBm	$P_{REFSENS\_V2X}$ + 14 dB							
$P_{Interferer}$	dBm				REFSENS +45.5dB		REFSENS +39.5dB	REFSENS +38.0 dB	REFSENS +36.5dB
$BW_{Interferer}$	MHz				10		10	10	10
$F_{Interferer}$ (offset)	MHz				10 / -10		15 / -15	20 / -20	25 / -25
NOTE 1: The interferer is QPSK modulated PUSCH containing data and reference symbols. Normal cyclic prefix is used. NOTE 2: The absolute value of the interferer offset $F_{interferer}$ (offset) shall be further adjusted to $\left(\left\lceil \lvert F_{\text{interferer}} \rvert / SCS \right\rceil + 0.5\right) SCS$ MHz with SCS the sub-carrier spacing of the wanted signal in MHz. The interferer is an NR signal with 15 kHz SCS.									

Table 9.1.3-3: Test parameters for Adjacent channel selectivity for V2X, Case 2

Rx Parameter	Units	Channel bandwidth							
		1.4 MHz	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**	**30 MHz**	**40 MHz**
Power in Transmission Bandwidth Configuration	dBm				-56.5		-50.5	-49.0	-47.5
$P_{Interferer}$	dBm	-25							
$BW_{Interferer}$	MHz				10		10	10	10
$F_{Interferer}$ (offset)	MHz				10 / -10		15 / -15	20 / -20	25 / -25
NOTE 1: The interferer is QPSK modulated PUSCH containing data and reference symbols. Normal cyclic prefix is used. NOTE 2: The absolute value of the interferer offset $F_{interferer}$ (offset) shall be further adjusted to $\left(\left\lceil \lvert F_{\text{interferer}} \rvert / SCS \right\rceil + 0.5\right) SCS$ MHz with SCS the sub-carrier spacing of the wanted signal in MHz. The interferer is an NR signal with 15 kHz SCS.									

9.1.4 Blocking characteristics

9.1.4.1 In-band blocking

In EN 302 571, the blocking level shall not be less than -30 dBm. And the blocking is tested at ± 50 MHz, ± 100 MHz, and ± 200 MHz frequency offset. Blocking testing shall be performed at least at 6 different frequency offset positions. The blocking level is larger than exiting case 2 blocking interferer in the specification, which is in the second alternate channel offset from the wanted signal. Considering the total 70MHz band width of the V2X band, ± 50 MHz is already outside the operating band or close at the band edge depends on the placement of the carrier.

RAN4 reuse the In-band blocking requirements in LTE V2X UE as shown in Table 9.1.4.1-1 and Table 9.1.4.1-2 NR V2X UE in Table 8.1-1.

Table 9.1.4.1-1: In band blocking parameters for V2X

Rx parameter	Units	Channel bandwidth							
		1.4 MHz	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**	**30 MHz**	**40MHz**
Power in Transmission Bandwidth Configuration	dBm	$P_{REFSENS\_V2X}$ + channel bandwidth specific value below							
					6		9	11	12
$BW_{Interferer}$	MHz				10		10	10	10
$F_{Ioffset, case 1}$	MHz				15		15	15	15
$F_{Ioffset, case 2}$	MHz				25		25	25	25
NOTE 1: The interferer is QPSK modulated PUSCH containing data and reference symbols. Normal cyclic prefix is used.									

Table 9.1.4.1-2: In-band blocking for V2X

NR band	Parameter	Unit	Case 1	Case 2
n47, n38	$P_{Interferer}$	dBm	-44	-44
	$F_{Interferer}$ (offset)	MHz	=-BW/2 – $F_{Ioffset,case 1}$ & =+BW/2 + $F_{Ioffset,case 1}$	≤-BW/2 – $F_{Ioffset,case 2}$ & ≥+BW/2 + $F_{Ioffset,case 2}$
	$F_{Interferer}$	MHz	(NOTE 2)	F_{DL_low} – 30 to F_{DL_high} + 30
NOTE 1: For certain bands, the unwanted modulated interfering signal may not fall inside the UE receive band, but within the first 15 MHz below or above the UE receive band. NOTE 2: For each carrier frequency the requirement is valid for two frequencies: a. the carrier frequency -BW/2 - $F_{Ioffset, case 1}$ and b. the carrier frequency +BW/2 + $F_{Ioffset, case 1}$ NOTE 3: $F_{Interferer}$ range values for unwanted modulated interfering signal are interferer center frequencies NOTE 4: The absolute value of the interferer offset $F_{interferer}$ (offset) shall be further adjusted to $\left(\lceil \lvert F_{\text{interferer}} \rvert / SCS \rceil + 0.5\right) SCS$ MHz with SCS the sub-carrier spacing of the wanted signal in MHz. The interferer is an NR signal with 15 kHz SCS.				

9.1.4.2 Out-of-band blocking

Out-of-band band blocking in existing specification for licensed bands is defined for an unwanted CW interfering signal falling more than 30 MHz below or above the UE receive band. For the first 15 MHz below or above the UE receive band the appropriate in-band blocking or adjacent channel selectivity shall be applied.

RAN4 reuse the Out-of- band blocking of LTE V2X UE as shown in Table 9.1.4.2-1 and Table 9.1.4.2-2 for NR V2X UE in Table 8.1-1.

Table 9.1.4.2-1: Out-of-band blocking parameters

Rx Parameter	Units	Channel bandwidth							
		1.4 MHz	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**	**30 MHz**	**40 MHz**
Power in Transmission Bandwidth Configuration	dBm	$P_{REFSENS\_V2X}$ + channel bandwidth specific value below							
					6		9	11	12
NOTE 1: Reference measurement channel is FFS									

Table 9.1.4.2-2: Out of band blocking

NR band	Parameter	Units	Frequency Range 1	Range 2	Range 3
n47	$P_{Interferer}$	dBm	-44	-30	-15
	$F_{Interferer}$ (CW)	MHz	F_{DL_low} -30 to F_{DL_low} -60	F_{DL_low} -60 to F_{DL_low} -85	F_{DL_low} -85 to 1 MHz
			F_{DL_high} +30 to F_{DL_high} + 60	F_{DL_high} +60 to F_{DL_high} +85	F_{DL_high} +85 to +12750 MHz
n38	$P_{interferer}$	dBm	-44	-30	-15
	$F_{interferer}$ (CW)	MHz	F_{DL_low} -30 to F_{DL_low} -60	F_{DL_low} -60 to F_{DL_low} -85	F_{DL_low} -85 to 1 MHz
NOTE: The power level of the interferer (PInterferer) for Range 3 shall be modified to -20 dBm for FInterferer > 4400 MHz.					

9.1.5 Spurious response

Spurious response is a measure of the receiver's ability to receive a wanted signal on its assigned channel frequency without exceeding a given degradation due to the presence of an unwanted CW interfering signal at any other frequency at which a response is obtained.

For V2X, 10MHz, 20MHz, 30MHz and 40MHz channel bandwidths are considered. RAN4 reuse the spurious response of LTE V2X UE as shown in Table 9.1.5-1 and Table 9.1.5-2 for NR V2X UE in Table 8.1-1.

Table 9.1.5-1: Spurious response parameters for V2X

Rx parameter	Units	Channel bandwidth							
		1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz	30 MHz	40 MHz
Power in Transmission Bandwidth Configuration	dBm	$P_{REFSENS\_V2X}$ + channel bandwidth specific value below							
					6		9	11	12
NOTE 1: Reference measurement channel is FFS									

Table 9.1.5-2: Spurious response for V2X

Parameter	Unit	Level
$P_{Interferer}$ (CW)	dBm	-44
$F_{Interferer}$	MHz	Spurious response frequencies

9.1.6 Intermodulation characteristics

Intermodulation response rejection is a measure of the capability of the receiver to receive a wanted signal on its assigned channel frequency in the presence of two or more interfering signals which have a specific frequency relationship to the wanted signal.

The wide band intermodulation requirement is defined using modulated NR carrier and CW signal as interferer. 10MHz channel bandwidth will be chosen as the modulated interfering signal for 10MHz, 20MHz, 30MHz and 40MHz channel bandwidth.

RAN4 reuse the intermodulation characteristics of LTE V2X UE as shown in Table 9.1.6-1 for NR V2X UE in Table 8.1-1.

Table 9.1.6-1: Wide band intermodulation

NR band	Rx Parameter	Units	Channel bandwidth							
			1.4 MHz	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**	**30 MHz**	**40 MHz**
n47	Power in Transmission Bandwidth Configuration	dBm	$P_{REFSENS\_V2X}$ + channel bandwidth specific value below							
						6		9	11	12
	$P_{Interferer\ 1}$ (CW)	dBm	-46							
	$P_{Interferer\ 2}$ (Modulated)	dBm	-46							
	$BW_{Interferer\ 2}$					10		10	10	10
	$F_{Interferer\ 1}$ (Offset)	MHz				-BW/2 – 15 / +BW/2 + 15		-BW/2 – 15 / +BW/2 + 15	-BW/2 – 15 / +BW/2 + 15	-BW/2 – 15 / +BW/2 + 15
	$F_{Interferer\ 2}$ (Offset)	MHz	$2*F_{Interferer\ 1}$							
NOTE 1: Reference measurement channel is FFS NOTE 2: The interferer is QPSK modulated PUSCH containing data and reference symbols. Normal cyclic prefix is used.										

9.2 NR V2X UE Rx requirements in FR2

10 Tx/Rx characteristics of concurrent operation

10.1 NR V2X SL operation in 5.9GHz or other potential ITS spectrum and LTE/NR Uu operation in licensed band for FR1

10.1.1 Tx requirements for inter-band con-current NR V2X operation

10.1.1.1 Maximum output power

For the inter-band con-current NR V2X operation, the following NR V2X UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth. The period of measurement shall be at least one sub frame (1ms).

Table 10.1.1.1-1: Con-current NR V2X UE Power Class for uplink inter-band combination (two bands)

NR V2X con-current operating band Configuration	Class 1 (dBm)	Tolerance (dB)	Class 2 (dBm)	Tolerance (dB)	Class 3 (dBm)	Tolerance (dB)	Class 4 (dBm)	Tolerance (dB)
V2X_n71A-n47A					23	+2/-3[4]		
NOTE 1: The con-current band combinations is used for NR V2X Service. NOTE 2: $P_{PowerClass}$ is the maximum UE power specified without taking into account the tolerance NOTE 3: For inter-band con-current aggregation the maximum power requirement apply to the total transmitted power over all component carriers (per UE). NOTE 4: [4] refers to the transmission bandwidths (Figure 5.6-1) confined within F_{UL_low} and F_{UL_low} + 4 MHz or F_{UL_high} – 4 MHz and F_{UL_high}, the maximum output power requirement is relaxed by reducing the lower tolerance limit by 1.5 dB								

10.1.1.2 UE maximum output power reduction

For the inter-band con-current NR V2X operation, the allowed maximum power reduction (MPR) for the maximum output power shall be applied per each component carrier. The legacy MPR requirements for NR Uu operation shall be applied on the CC of licensed band, the MPR requirements for NR sidelink operation shall be applied on CC of NR Band n47.

10.1.1.3 UE maximum output power with additional requirements

For the inter-band con-current NR V2X operation, the allowed additional maximum power reduction (A-MPR) for the maximum output power shall be applied per each component carrier. The legacy A-MPR requirements for NR Uu operation shall be applied on CC of licensed band, the A-MPR requirements for NR sidelink operation shall be applied on CC of NR Band n47.

10.1.1.4 Configured transmitted power

For the inter-band con-current NR V2X operation, the configured transmitted power requirements for NR V2X UE shall be applied per each component carrier. The legacy NR configured transmitted power for inter-band NR CA shall be decided by MPR_c and A-MPR_c of each CC.

If the total transmitted power is over the power class of the NR V2X UE or given P_{EMAX},c for NR V2X service, the UE shall compare the priority between the legacy NR service on licensed band and NR V2X service at n47. Based on the priority, the configured transmitted power will be decided which transmission will be applied on power scale down or dropping between the legacy NR Uu transmission and NR V2X SL transmission.

When a UE is configured for simultaneous NR V2X sidelink and NR uplink transmissions for inter-band con-current operation, the UE is allowed to set its configured maximum output power $P_{CMAX,c,NR}$ and $P_{CMAX,c,V2X}$ for the configured NR uplink carrier and the configured NR V2X carrier, respectively, and its total configured maximum output power $P_{CMAX,c}$.

The configured maximum output power $P_{CMAX\ c,NR}(p)$ in slot p for the configured NR uplink carrier shall be set within the bounds:

$$P_{CMAX\_L,c,NR}(p) \leq P_{CMAX,c,NR}(p) \leq P_{CMAX\_H,c,NR}(p)$$

where $P_{CMAX\_L,c,NR}$ and $P_{CMAX\_H,c,NR}$ are the limits for a serving cell c as specified in subclause 6.2.4.

The configured maximum output power $P_{CMAX\ c,V2X}(q)$ in slot q for the configured NR V2X carrier shall be set within the bounds:

$$P_{CMAX,c,V2X}(q) \leq P_{CMAX\_H,c,V2X}(q)$$

where $P_{CMAX\_H,c,V2X}$ is the limit as specified in subclause 6.2E.4.

The total UE configured maximum output power $P_{CMAX}(p,q)$ in a slot p of NR uplink carrier and a slot q of NR V2X sidelink that overlap in time shall be set within the following bounds for synchronous and asynchronous operation unless stated otherwise:

$$P_{CMAX\_L}(p,q) \leq P_{CMAX}(p,q) \leq P_{CMAX\_H}(p,q)$$

with

$$P_{CMAX\_L}(p,q) = P_{CMAX\_L,c,NR}(p)$$

$$P_{CMAX\_H}(p,q) = 10 \log_{10} [p_{CMAX\_H,c,NR}(p) + p_{CMAX\_H,c,V2X}(q)]$$

where $p_{CMAX\_H,c,V2X}$ and $p_{CMAX\_H,c,NR}$ are the limits $P_{CMAX\_H,c,V2X}(q)$ and $P_{CMAX\_H,c,NR}(p)$ expressed in linear scale.

The measured total maximum output power P_{UMAX} over both the NR uplink and NR V2X carriers is

$$P_{UMAX} = 10 \log_{10} [p_{UMAX,c,NR} + p_{UMAX,c,V2X}],$$

where $p_{UMAX,c,NR}$ denotes the measured output power of serving cell c for the configured NR uplink carrier, and $p_{UMAX,c,V2X}$ denotes the measured output power for the configured NR V2X carrier expressed in linear scale.

When a UE is configured for synchronous V2X sidelink and uplink transmissions,

$$P_{CMAX\_L}(p,q) - T_{LOW}(P_{CMAX\_L}(p,q)) \leq P_{UMAX} \leq P_{CMAX\_H}(p,q) + T_{HIGH}(P_{CMAX\_H}(p,q))$$

where $P_{CMAX\_L}(p,q)$ and $P_{CMAX\_H}(p,q)$ are the limits for the pair (p,q) and with the tolerances $T_{LOW}(P_{CMAX})$ and $T_{HIGH}(P_{CMAX})$ for applicable values of P_{CMAX} specified in Table 6.2E.4-1. P_{CMAX_L} may be modified for any overlapping portion of slots (p, q) and $(p+1, q+1)$.

10.1.1.5 UE Minimum output power

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy minimum output power requirements will be applied on CC of NR licensed band and the NR V2X minimum output power requirements will be applied on CC of NR Band n47.

10.1.1.6 Transmit OFF power

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy transmit OFF power requirements will be applied on CC of NR licensed band and the NR V2X transmit off power requirements will be applied on CC of NR Band n47.

10.1.1.7 ON/OFF time mask

When UE support inter-band con-current NR V2X operation in Table 10.1-1, the existing general time mask for NR UE will be applied on CC of NR licensed band. Also the existing general time mask for NR UE and additional requirements on ON/OFF time mask will be applied on CC of NR Band n47.

10.1.1.8 Power control

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy power control requirements will be applied on CC of NR licensed band and the NR V2X power control requirements will be applied on CC of NR Band n47.

10.1.1.9 Transmit signal quality

10.1.1.9.1 Frequency error

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy frequency error requirements will be applied on CC of NR licensed band and NR V2X frequency error requirements will be applied on CC of NR Band n47.

10.1.1.9.2 Transmit modulation quality

10.1.1.9.2.1 Error Vector Magnitude

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy EVM requirements will be applied on CC of NR licensed band and the NR V2X EVM requirements will be applied on CC of NR Band n47.

10.1.1.9.2.2 Carrier leakage

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy carrier leakage requirements will be applied on CC of NR licensed band and the NR V2X carrier leakage requirements will be applied on CC of NR Band n47.

10.1.1.9.2.3 In-band emissions

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy in-band emission requirements will be applied on CC of NR licensed band and the NR V2X in-band emission requirements will be applied on CC of NR Band n47.

10.1.1.9.2.4 EVM equalizer spectrum flatness

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy spectrum flatness requirements will be applied per carrier for inter-band con-current V2X operation.

10.1.1.10 Spectrum emission mask

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy general/additional SEM requirements will be applied on CC of NR licensed band and NR V2X general/additional SEM requirements will be applied on CC of NR Band n47.

10.1.1.11 ACLR requirements

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy ACLR requirements will be applied on CC of NR licensed band and NR V2X ACLR requirements will be applied on CC of NR Band n47.

10.1.1.12 Spurious emission requirements

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy general spurious emission requirements will be applied on CC of NR licensed band and NR V2X general spurious emission requirements will be applied on CC of NR Band n47.

10.1.1.13 Spurious emission band UE co-existence

This clause specifies the spurious emission requirements of the inter-band con-current V2X operation, for UE-to-UE coexistence to protect legacy protected bands

Table 10.1.1.13-1: Requirements

NR V2X con-current operating band cofiguration	Spurious emission						
	Protected band	**Frequency range (MHz)**			**Maximum Level (dBm)**	**MBW (MHz)**	**NOTE**
V2X_n71A-n47A	E-UTRA Band 4, 5, 12, 13, 14, 17, 24, 26, 30, 48, 66, 85	F_{DL_low}	-	F_{DL_high}	-50	1	
	E-UTRA Band 29	F_{DL_low}	-	F_{DL_high}	-38	1	2
	E-UTRA Band 2, 5, 41, 70	F_{DL_low}	-	F_{DL_high}	-50	1	1
	NR Band n71	F_{DL_low}	-	F_{DL_high}	-50	1	
	Frequency range	5925	-	5950	-30	1	3, 4
	Frequency range	5815	-	5855	-30	1	3

NOTE 1: As exceptions, measurements with a level up to the applicable requirements defined in Table 6.6.3.1-2 are permitted for each assigned E-UTRA carrier used in the measurement due to 2nd, 3rd, 4th [or 5th] harmonic spurious emissions. In case the exceptions are allowed due to spreading of the harmonic emission the exception is also allowed for the first 1 MHz frequency range immediately outside the harmonic emission on both sides of the harmonic emission. This results in an overall exception interval centred at the harmonic emission of (2MHz + N x L_{CRB} x 180kHz), where N is 2, 3 or 4 for the 2nd, 3rd or 4th harmonic respectively. The exception is allowed if the measurement bandwidth (MBW) totally or partially overlaps the overall exception interval.

NOTE 2: These requirements also apply for the frequency ranges that are less than F_{OOB} (MHz) in Table 6.6.3.1-1 and Table 6.6.3.1A-1 from the edge of the aggregated channel bandwidth.

NOTE 3: Applicable when NS_33 is configured by the pre-configured radio parameters for power class 3 V2X UE.

NOTE 4: In the frequency range x-5950MHz, SE requirement of -30dBm/MHz should be applied; where x = max (5925, fc + 15), where fc is the channel centre frequency.

10.1.1.14 Transmit intermodulation

Expected no need to change the requirements for inter-band con-current NR V2X UE. The legacy transmit intermodulation requirements will be applied on CC of NR licensed band and NR V2X transmit intermodulation requirements will be applied on CC of NR Band n47.

10.1.2 Rx requirements for inter-band con-current NR V2X operation

10.1.2.1 REFSENS

For the NR V2X UE RF receiver requirements, RAN4 can refer the 2DL inter-band CA to define general UE RF Rx requirements for inter-band con-current NR V2X UE.

The legacy REFSENS requirement will be applied on CC of NR licensed band and NR V2X REFSENS requirements will be applied on CC of NR Band n47 if there was no self-interference problems in own receiver frequency band by own uplink and sidelink transmission.

Table 10.1.2.1-1 and Table 10.1.2.1-2 propose the uplink test configurations for inter-band con-current NR V2X REFSENS requirements. For the uplink configuration, RAN4 consider 10MHz Channel bandwidth.

Table 10.1.2.1-1: Uplink configuration for reference sensitivity of V2X UE (PC5)

Inter-band NR V2X con-current band configuration		NR UL band / SCS/ Channel BW / N_{RB} / Duplex mode				
NR V2X band (PC5)	NR V2X band (Uu)	NR V2X UL band (Uu)	SCS (kHz)	Channel Bandwidth (MHz)	N_{RB}	Duplex Mode
n47	n71	n71	15	10	52	FDD
			30	10	24	
			60	10	11	

Table 10.1.2.1-2: SL Tx configuration for reference sensitivity of V2X UE (Uu)

Inter-band NR V2X con-current band configuration		NR UL band / SCS/ Channel BW / N_{RB} / Duplex mode				
NR V2X band (PC5)	NR V2X band (Uu)	NR V2X band (PC5)	SCS (kHz)	Channel Bandwidth (MHz)	N_{RB}	Duplex Mode
n47	n71	n47	15	10	50	HD
			30	10	24	
			60	10	10	

Table 10.1.2.1-3 is proposed UE REFSENS requirements with inter-band con-current NR V2X UE reception.

Table 10.1.2.1-3: Reference sensitivity for V2X QPSK $P_{REFSENS}$

Inter-band V2X reception			Channel bandwidth								
NR V2X Band	NR band	NR Band	SCS (kHz)	5 MHz (dBm)	10 MHz (dBm)	15 MHz (dBm)	20 MHz (dBm)		30 MHz (dBm)	40 MHz (dBm)	Duplex Mode
n47	n71	n71	15	-97.2	-94.0	-91.6	-86.0				FDD
			30		-94.3	-91.9	-87.4				
			60								
		n47	15		-92.5		-89.2		-87.4	-86.1	HD
			30		-92.1		-89.4		-87.7	-86.2	
			60		-92.9		-89.1		-87.9	-86.4	

Table 10.1.2.1-4 is proposed additional Rx insertion loss according to harmonic trap filter to reduce the harmonic problem based on specific self desense analysis according to specific NR V2X inter-band con-current operation.

Table 10.1.2.1-4: $\Delta R_{IB,c}$ (two bands)

V2X inter-band con-current band Combination	NR V2X Band	$\Delta R_{IB,c}$ [dB]
V2X_n71-n47	n71	0.0

10.1.2.2 Maximum input level

No need to define additional requirements for con-current inter-band V2X operation since NR UE shall meet the requirements per each carrier while all downlink carriers are active.

10.1.2.3 The other Rx requirements

The other Rx requirements for inter-band con-current NR V2X UE can be reused. The legacy other RX requirement will be applied on CC of NR licensed band and legacy NR V2X other RX requirements will be applied on CC of NR Band n47 since there was no difference on UE receiver aspect.

- ACS: Keep the same requirements per CC
- In band Blocking: Keep the same requirements per CC. For the inter-band con-current NR V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.
- Out-of-Band Blocking: Keep the same requirements per CC. For the inter-band con-current NR V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.
- Narrow Band Blocking: NR NBB requirements only applied on CC of NR licensed band and no requirements for NR Band n47.
- Spurious response: Keep the same requirements per CC. For the inter-band con-current NR V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.
- Wideband inter-modulation: Keep the same requirements per CC. For the inter-band con-current NR V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.

10.2 NR V2X SL operation and LTE/NR Uu operation both in licensed band for FR1

10.2.1 Tx requirements for inter-band con-current V2X operation

10.2.1.1 Maximum output power

For the inter-band con-current V2X operation at licensed bands in FR1, the following V2X UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth. The period of measurement shall be at least one sub frame (1ms).

Table 10.2.1.1-1: Con-current V2X UE Power Class for uplink inter-band combination (two bands)

V2X con-current operating band Configuration	Class 1 (dBm)	Tolerance (dB)	Class 2 (dBm)	Tolerance (dB)	Class 3 (dBm)	Tolerance (dB)	Class 4 (dBm)	Tolerance (dB)
V2X_20A_n38A					23	+2/-3[4]		

NOTE 1: The con-current band combinations is used for NR V2X Service.
NOTE 2: $P_{PowerClass}$ is the maximum UE power specified without taking into account the tolerance
NOTE 3: For inter-band con-current aggregation the maximum power requirement apply to the total transmitted power over all component carriers (per UE).
NOTE 4: [4] refers to the transmission bandwidths (Figure 5.6-1) confined within F_{UL_low} and F_{UL_low} + 4 MHz or F_{UL_high} – 4 MHz and F_{UL_high}, the maximum output power requirement is relaxed by reducing the lower tolerance limit by 1.5 dB

10.2.1.2 UE maximum output power reduction

For the inter-band con-current V2X operation, the allowed maximum power reduction (MPR) for the maximum output power shall be applied per each component carrier based on the legacy MPR requirements per CC for inter-band EN-DC at licensed bands.

10.2.1.3 UE maximum output power with additional requirements

For the inter-band con-current V2X operation, the allowed additional maximum power reduction (A-MPR) for the maximum output power shall be applied per each component carrier based on the legacy A-MPR requirements per CC for inter-band EN-DC at licensed bands.

10.2.1.4 Configured transmitted power

For the inter-band con-current V2X operation, the configured transmitted power requirements for V2X UE shall be applied per each component carrier. The legacy LTE or NR configured transmitted power for inter-band EN DC shall be decided by MPR_c and $A\text{-}MPR_c$ of each CC.

If the total transmitted power is over the power class of the V2X UE or given P_{EMAX},c for NR V2X service, the UE shall compare the priority between the legacy LTE service on licensed band and NR SL V2X service at licensed band. Based on the priority, the configured transmitted power will be decided which transmission will be applied on power scale down or dropping between the legacy LTE Uu transmission and NR V2X SL transmission at licensed band.

The $\Delta T_{IB,V2X}$ of $P_{CMAX,c,Uu}$ is considered to determine maximum output power for corresponding V2X con-current operating bands

Table 10.2.1.4-1: $\Delta T_{IB,V2X}$ for inter-band con-current V2X operation (two bands)

V2X con-current operating band Configuration	Operating Band	$\Delta T_{IB,V2X}$ [dB]
V2X_20_n38	20	0.0[1]

Note 1: The $\Delta T_{IB,V2X}$ is applied on top of $\Delta T_{IB,c}$ of DC_20A_n38A UE that is considered harmonic trap filter to reduce 3rd harmonic impact from Band 20.

10.2.1.5 UE Minimum output power

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy minimum output power requirements will be applied on each CC of LTE or NR bands.

10.2.1.6 Transmit OFF power

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy transmit OFF power requirements will be applied on each CC of LTE or NR bands.

10.2.1.7 ON/OFF time mask

When UE support inter-band con-current V2X operation in Table 10.2-1, the existing general time mask for LTE or NR UE will be applied on LTE or NR Uu operation CC in LTE or NR licensed band and the NR V2X general time mask for NR V2X UE will be applied on NR SL operation CC.

10.2.1.8 Power control

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy power control requirements will be applied on each CC of LTE or NR licensed band the NR V2X power control for NR V2X UE will be applied on NR SL operation CC.

10.2.1.9 Transmit signal quality

10.2.1.9.1 Frequency error

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy frequency error requirements will be applied on each CC of LTE or NR bands.

10.2.1.9.2 Transmit modulation quality

10.2.1.9.2.1 Error Vector Magnitude

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy EVM requirements will be applied on each CC of LTE or NR bands.

10.2.1.9.2.2 Carrier leakage

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy carrier leakage requirements will be applied on each CC of LTE or NR bands.

10.2.1.9.2.3 In-band emissions

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy in-band emission requirements will be applied on each CC of LTE or NR bands.

10.2.1.9.2.4 EVM equalizer spectrum flatness

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy spectrum flatness requirements will be applied on each CC of LTE or NR bands.

10.2.1.10 Spectrum emission mask

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy general/additional SEM requirements will be applied on each CC of LTE or NR bands.

10.2.1.11 ACLR requirements

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy ACLR requirements will be applied on each CC of LTE or NR bands.

10.2.1.12 Spurious emission requirements

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy general spurious emission requirements will be applied on each CC of LTE or NR bands.

10.2.1.13 Spurious emission band UE co-existence

This clause specifies the spurious emission requirements of the inter-band con-current V2X operation, for UE-to-UE coexistence to protect legacy protected bands

Table 10.2.1.13-1: Requirements

V2X con-current operating band cofiguration	Spurious emission						
	Protected band	Frequency range (MHz)			Maximum Level (dBm)	MBW (MHz)	NOTE
V2X_20A_n38A	E-UTRA Band 1, 3, 8, 22, 31, 32, 33, 34, 40, 43, 50, 51, 65, 67, 68, 72, 74, 75, 76	F_{DL_low}	-	F_{DL_high}	-50	1	
	E-UTRA Band 20	F_{DL_low}	-	F_{DL_high}	-50	1	2
	E-UTRA Band 42, 52, NR Band n77, n78	F_{DL_low}	-	F_{DL_high}	-50	1	1

NOTE 1: As exceptions, measurements with a level up to the applicable requirements defined in Table 6.6.3.1-2 are permitted for each assigned E-UTRA carrier used in the measurement due to 2nd, 3rd, 4th [or 5th] harmonic spurious emissions. In case the exceptions are allowed due to spreading of the harmonic emission the exception is also allowed for the first 1 MHz frequency range immediately outside the harmonic emission on both sides of the harmonic emission. This results in an overall exception interval centred at the harmonic emission of (2MHz + N x L_{CRB} x 180kHz), where N is 2, 3 or 4 for the 2nd, 3rd or 4th harmonic respectively. The exception is allowed if the measurement bandwidth (MBW) totally or partially overlaps the overall exception interval.

NOTE 2: These requirements also apply for the frequency ranges that are less than F_{OOB} (MHz) in Table 6.5.3.1-1 from the edge of the channel bandwidth.

NOTE 3: This requirement is applicable for power class 3 UE for any channel bandwidths within the range 2570 - 2615 MHz with the following restriction: for carriers of 15 MHz bandwidth when carrier centre frequency is within the range 2605.5 - 2607.5 MHz and for carriers of 20 MHz bandwidth when carrier centre frequency is within the range 2597 - 2605 MHz the requirement is applicable only for an uplink transmission bandwidth less than or equal to 54 RB. For power class 2 UE for any channel bandwidths within the range 2570 - 2615 MHz, NS_44 shall apply. For power class 2 or 3 UE for carriers with channel bandwidth overlapping the frequency range 2615 - 2620 MHz the requirement applies with the maximum output power configured to +19 dBm in the IE P-Max.

NOTE 4 For these adjacent bands, the emission limit could imply risk of harmful interference to UE(s) operating in the protected operating band.

10.2.1.14 Transmit intermodulation

Expected no need to change the requirements for inter-band con-current V2X UE. The legacy transmit intermodulation requirements will be applied on each CC of LTE or NR bands.

10.2.2 Rx requirements for inter-band con-current NR V2X operation

10.2.2.1 REFSENS

For the V2X UE RF receiver requirements, RAN4 can refer the 2DL inter-band CA to define general UE RF Rx requirements for inter-band con-current V2X UE.

The legacy REFSENS requirement will be applied on each CC of NR licensed bands if there was no self-interference problems in own receiver frequency band by own uplink and sidelink transmission.

Table 10.2.2.1-1 and Table 10.2.2.1-2 propose the uplink test configurations for inter-band con-current V2X REFSENS requirements. For the uplink configuration, RAN4 consider 10MHz Channel bandwidth.

Table 10.2.2.1-1: Uplink configuration for reference sensitivity of V2X UE (PC5)

Inter-band V2X con-current band configuration		LTE or NR UL band / Channel BW / N_{RB} / Duplex mode				
V2X band (PC5)	LTE or NR band (Uu)	LTE or NR UL band	Channel Bandwidth (MHz)	SCS (kHz)	N_{RB}	Duplex Mode
n38	B20	B20	10	15	50	FDD

Table 10.2.2.1-2: SL Tx configuration for reference sensitivity of V2X UE (Uu)

Inter-band V2X con-current band configuration			LTE or NR UL band / Channel BW / N_{RB} / Duplex mode			
V2X band (PC5)	LTE or NR band (Uu)	NR V2X band (PC5)	Channel Bandwidth (MHz)	SCS (kHz)	N_{RB}	Duplex Mode
n38	B20	n38	10	15	50	HD
				30	24	
				60	10	

Table 10.2.2.1-3 is proposed the REFSENS requirements with inter-band con-current V2X UE reception without any self-interference problem.

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Table 10.2.2.1-3: Reference sensitivity for V2X QPSK $P_{REFSENS}$

Inter-band V2X reception		Channel bandwidth								
V2X Band	LTE or NR V2X band (Uu)	LTE or NR Band	SCS (kHz)	5 MHz (dBm)	10 MHz (dBm)	15 MHz (dBm)	20 MHz (dBm)	30 MHz (dBm)	40 MHz (dBm)	Duplex Mode
n38	B20	B20	15	-97	-94	-91.2	-90			FDD
		n38	15		-96.5		-93.2	-91.4	-90.1	HD
			30		-96.11		-93.4	-91.7	-90.2	
			60		-966.99		-93.1	-91.9	-90.4	

Table 10.1.2.2-4 is proposed additional Rx insertion loss according to harmonic trap filter to reduce the harmonic problem based on specific self desense analysis according to specific NR V2X inter-band con-current operation.

Table 10.2.2.1-4: $\Delta R_{IB,V2X}$ (two bands)

V2X inter-band con-current band Combination	V2X operating Band	$\Delta R_{IB,V2X}$ [dB]	Note
V2X_20_n38	20	0.0[1]	3rd harmonic from B20 impact into n38
Note 1: The $\Delta R_{IB,V2X}$ is applied on top of $\Delta R_{IB,c}$ of DC_20_n38 UE that is considered harmonic trap filter to reduce 3rd harmonic impact from Band 20.			

10.2.2.1a Reference sensitivity exception due to UL harmonic problem

Sensitivity degradation is allowed for a band if it is impacted by UL harmonic interference from another band part of the inter-band con-current V2X UE. Reference sensitivity exceptions (MSD) for the victim band (high) are specified in Table 10.2.2.1a-1 with uplink configuration of the aggressor band (low) specified in Table 10.2.2.1a-2.

Table 10.2.2.1a-1: Reference sensitivity exceptions (MSD) due to UL harmonic for inter-band con-current operation

V2X inter-band con-current band combinations	Operating Bands / Channel bandwidth of the affected DL band / MSD					
V2X_20_n38	UL band	SL operation	10 MHz (dB)	20 MHz (dB)	30 MHz (dB)	40 MHz (dB)
	20	n38	10.7	7.7	5.8	4.7

NOTE 1: These requirements apply when there is at least one individual RE within the uplink transmission bandwidth of the aggressor (lower) for which the 3rd transmitter harmonic is within the sidelink transmission bandwidth of a victim (higher) band.

NOTE 2: The requirements should be verified for UL EARFCN of the aggressor (lower) band (superscript LB such that $f_{UL}^{LB} = \lfloor f_{DL}^{HB} / 0.3 \rfloor 0.1$ in MHz and $F_{UL\_low}^{LB} + BW_{Channel}^{LB} / 2 \le f_{UL}^{LB} \le F_{UL\_high}^{LB} - BW_{Channel}^{LB} / 2$ with f_{DL}^{HB} the carrier frequency in the victim (higher) band in MHz and $BW_{Channel}^{LB}$ the channel bandwidth configured in the low band.

NOTE 3: The MSD level applied to all supported SCSs in victim band.

Table 10.2.2.1a-2: Uplink configuration for reference sensitivity exceptions due to UL harmonic interference for inter-band con-current V2X in NR FR1

E-UTRA or NR Band / Channel bandwidth of the affected DL band / UL RB allocation of the agressor band					
UL band	SL operation	10 MHz (L_{CRB})	20 MHz (L_{CRB})	30 MHz (L_{CRB})	40 MHz (L_{CRB})
20	n38	25	50	50	50

NOTE 1: The UL configuration applies regardless of the channel bandwidth of the UL band unless the UL resource blocks exceed that specified in Table 7.3.1-2 in TS 36.101 [4] or Table 7.3.2-3 in TS 38.101-1 [2] for the uplink bandwidth in which case the allocation according to Table 7.3.1-2 in TS 36.101 [4] or Table 7.3.2-3 in TS 38.101-1 [2] applies

10.2.2.2 Maximum input level

No need to define additional requirements for con-current inter-band V2X operation since NR UE shall meet the requirements per each carrier while all downlink carriers are active.

10.2.2.3 The other Rx requirements

The other Rx requirements for inter-band con-current V2X UE can be reused. The legacy other RX requirement will be applied on each CC of NR licensed bands.

- ACS: Keep the same requirements per CC

- In band Blocking: Keep the same requirements per CC. For the inter-band con-current V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.
- Out-of-Band Blocking: Keep the same requirements per CC. For the inter-band con-current V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.
- Narrow Band Blocking: NR NBB requirements only applied on CC of NR licensed bands.
- Spurious response: Keep the same requirements per CC. For the inter-band con-current V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.
- Wideband inter-modulation: Keep the same requirements per CC. For the inter-band con-current V2X UE, $P_{Interferer}$ power is increased by $\Delta R_{IB,c}$ in the requirement.

10.3 NR V2X SL operation in 5.9GHz or other potential ITS spectrum and NR Uu operation in licensed bands for FR2

10.4 NR V2X SL operation and NR Uu operation both in licensed bands for FR2

11 Conclusion and recommendations

According to the coexistence simulation results at both licensed band and ITS spectrum in section 5.4, RAN4 made consensus for the NR V2X deployment scenarios in section 4.3.1.

Based on the NR V2X operating scenarios, RAN4 studied and specified the NR V2X UE RF requirements to support the following scenarios to comply the regional regulatory requirements in FR1.

- Specify operating NR V2X bands and system parameters (Section 7)
- Specify RF core requirements in the ITS spectrum (Section 8 and 9)
    - Specify additional-SEM requirements to comply regional regulation
    - Specify the restricted max. power to protect CEN DSRC tolling system
- Specify RF core requirements for NR SL (at n47) and LTE SL (at B47) as TDM for Tx transmission and simultaneous receptions (Section 8 and 9)
- Specify RF core requirements for licensed bands (Section 8 and 9)
- Specify RF core requirements for inter-band con-current operation (Section 10)

Above RF core requirements for NR V2X operating scenarios in TR38.886, RAN4 will specify NR V2X UE RF core requirements in TS38.101-1 and TS38.101-3 for NR V2X operation in FR1.

Annex A

Link level simulation mapping model for NR V2X

The detail link level simulation parameters are shown in Table A-1. The reference for SNR-TO-BLER mapping model for NR V2V system is shown in following Table A- 2 according to the operating frequency bands respectively.

Table A-1 Detail link-level simulation parameters for NR V2X

parameter	Assumption
Bandwidth	40MHz
Carrier frequency	2 GHz/ 3.5GHz/ 5.9GHz
numerology	15 kHz
Number of antenna	1T2R
channel	Urban-LOS
Modulation	QPSK
Coding	LDPC
TB size	1100 Bytes
Number of Occupied PRB	70
DMRS configuration	Rel-15 PDSCH DMRS Configuration type 2
DMRS symbol index	1, 8 for 30 km/h 1,4,8,12 for 120 km/h
Symbols number in a slot	14(including one symbol AGC symbol and 1 symbol gap)
Relative speed	30km/h and 120km/h
Retransmission	Off[2]
The maximum transmission number	1
synchronization	No timing error
Note 1: These all link level assumptions are only intended for evaluation of SNR-TO-BLER in RAN4 coexistence study. Note 2: Retransmission option of 1,2 or 3 is .not precluded based on contributions from other companies.	

Table A- 2 Reference table of Link level BLER vs. SNR for NR V2X

SNR(dB)	Centre frequency 2GHz		Centre frequency 3.5GHz		Centre frequency 5.9GHz	
	Relative Speed 30Km/h	Relative Speed 120Km/h	Relative Speed 30Km/h	Relative Speed 120Km/h	Relative Speed 30Km/h	Relative Speed 120Km/h
-10	1	1	1	1	1	1
-9	1	1	1	1	1	1
-8	1	1	1	1	1	1
-7	0.9997	1	0.9998	0.9999	1	1
-6	0.9978	0.9993	0.9988	0.9996	0.9992	0.9997
-5	0.9915	0.9944	0.9917	0.996	0.9934	0.9991
-4	0.9697	0.9769	0.9736	0.9845	0.9756	0.9926
-3	0.9244	0.9385	0.9322	0.9535	0.9331	0.9738
-2	0.8436	0.8688	0.8509	0.8901	0.8575	0.9265
-1	0.7319	0.7666	0.7404	0.7992	0.7524	0.8415
0	0.6007	0.6448	0.6081	0.6718	0.6317	0.7205
1	0.4691	0.5075	0.4764	0.5329	0.4948	0.5757
2	0.3455	0.3802	0.3612	0.3953	0.3691	0.429
3	0.2454	0.272	0.2562	0.2783	0.2614	0.3018
4	0.1671	0.1907	0.1737	0.1859	0.1762	0.1959
5	0.1034	0.1218	0.11	0.1122	0.1105	0.1192
6	0.0611	0.0736	0.0699	0.0663	0.0712	0.0664
7	0.0337	0.0409	0.0391	0.0381	0.0412	0.0331
8	0.0175	0.0198	0.0213	0.0192	0.0222	0.0157
9	0.009	0.0092	0.0111	0.0085	0.0109	0.007
10	0.0039	0.004	0.0055	0.0032	0.0048	0.0026
11	0.0014	0.0015	0.0025	0.001	0.002	0
12	0	0	0	0	0	0

Annex B:
Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2019-04	RAN4 #90BIS	R4-1905096				TR38.886 v0.0.1: TR skeleton for NR V2X service with SL operation	0.0.1
2019-05	RAN4 #91	R4-1906061				TR38.886 v0.1.0: TR update for NR V2X service with SL operation	0.1.0
						Approved TP lists in RAN4 #91 meeting - R4-1906851 TP on In-device Coexistence Scenarios - R4-1907607 TP on Editorial Corrections to TR38.886 -	
2019-08	RAN4 #92	R4-1908696				TR38.886 v0.2.0: TR update for NR V2X service with SL operation	0.2.0
						Approved TP lists in RAN4 #92 meeting - R4-1908378 TP for band and bandwidth for NR V2X - R4-1910393 TP for band and bandwidth for NR V2X - R4-1910400 TP on adjacent channel co-existence scenarios and parameters for NR V2X service on FR1 - R4-1908351 TP on Adjacent Channel Coexistence - R4-1908973 TP on PRR performance metrics for NR V2X coexistence simulation	
2019-10	RAN4 #92BIS	R4-1911451				TR38.886 v0.3.0: TR update for NR V2X service with SL operation	0.3.0
						Approved TP lists in RAN4 #92BIS meeting - R4-1912307, "TP on In-device Coexistence," - R4-1912887, "TP on General Tx/Rx requirements for NR V2X UE," - R4-1913062, "TP on the operating scenarios for NR V2X Service," - R4-1913065, "[V2X] TP on sub-clause title for NR V2X," - R4-1913066, "TP to TR 38.886 for coexistence simulation results," - R4-1913069, "[V2X] TP on link level simulation mapping for NR V2X,"	
2019-11	RAN4 #93	R4-1913967				TR38.886 v0.4.0: TR update for NR V2X service with SL operation	0.4.0
						Approved TP lists in RAN4 #93 meeting - R4-1916147 TP on channel raster for NR V2X UE - R4-1916148 TP on modification on co-existence conclusion for NR V2X service - R4-1915984 [V2X] TP to add some abbreviations - R4-1914494 [V2X] TP to clean up NR V2X coexistence simulation assumption - R4-1916163 TP to TR for UE to UE Coexistence study of NR V2X at 5.9GHz - R4-1915988 TP for RF requirements for NR V2X - R4-1916143 TP on NR V2X UE RF requirements for supporting 30MHz CBW and 256QAM at n47 - R4-1916144 TP on general Tx/Rx requirements for NR V2X UE at licensed bands - R4-1913953 TP on RF core requirements for con-current operation of NR V2X UE - R4-1916145 [V2X] TP on MPR simulation assumption for NR V2X in band n47	
2020-02		R4-2001214				TR38.886 v0.5.0: TR update for NR V2X service with SL operation	0.5.0

	RAN4 #94-e					Approved TPs and draft CRs list in RAN4 #94-e meeting - R4-2001215 Summary on E-mail discussion for NR V2X - R4-2001221 TP on conclusion of NR V2X WI - R4-2002795 TP on channel arrangement for NR V2X - R4-2002788 draftCR for TS 38.101-1 Con-current operation for NR-V2X - R4-2002789 draftCR for TS 38.101-3 Con-current operation for NR-V2X - R4-2002785 TP on additional On/OFF Switching Time Mask for TDM operation between LTE SL and NR SL at n47 - R4-2002763 Draft CR on NR V2X UE Transmitter requirements for single carrier - R4-2002761 TP on revised MPR simulation assumptions and update NR requirements to cover open issue - R4-2002783 A-MPR simulation assumptions and initial results for NR V2X at n47 - R4-2002786 Draft CR on additional On/OFF Switching Time Mask for TDM operation between LTE SL and NR SL at n47 - R4-2002792 draftCR for TS 38.101-1 UL MIMO for NR-V2X - R4-2002796 CR for TS38.101-1, Introduce Rx requirements for NR V2X - R4-2002797 CR for TS38.101-3, Introduce Rx requirements for NR V2X concurrent operation	
2020-04	RAN4 #94-e-BIS	R4-2005739				TR38.886 v0.6.0: TR update for NR V2X service with SL operation to reflect the approved TPs in #94-e and #94-e-BIS meeting Approved TPS and Draft CRs list in RAN4 #94-e-BIS meeting - R4-2005226 TP on remaining issues for NR V2X UE - R4-2005632 TP on REFSENS requirements - R4-2005636 TP on IndeviceCoexistence - R4-2005639 TP on channel bandwidths for NR V2X licensed band n38 - R4-2005645 Draft CR for TS 38.101-3 Introduction of NR V2X cross RAT requirements - R4-2005228 Updated CR on introducing RF requirements for 5G V2X service in TS38.101-1 in rel-16 - R4-2005633 Draft CR for TS38.101-1, Introduce Rx requirements for NR V2X single carrier	0.6.0
2020-05	RAN4 #95-e	R4-2006745				TR38.886 v1.0.0: TR update for NR V2X service with SL operation to reflect the approved TPs in RAN4 #95-3 meeting Approved TPs and Draft CRs listed in RAN4 #95-e meeting - R4-2008456 CR on NR V2X UE RF requirements for single carrier in TS38.101-1 - R4-2009149 TP on remaining issues for NR V2X UE - R4-2008445 TX diversity for NR-V2X - R4-2009163 DraftCR to specify MPR\AMPR requirements for PC3 NR V2X in band n47 - R4-2008444 DraftCR to specify configured transmitted power for NR V2X in band n47 - R4-2008449 TP on remaining issues on Rx RF requirements for NR V2X - R4-2009168 WF on remaining issues for TS38.101-1 and TS38.101-3 for NR V2X WI	1.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2020-06	RAN#88					Approved by plenary – Rel-16 spec under change control	16.0.0
2020-09	RAN#89	RP-201492	0003	1	F	CR for TR38.886: Correction on TR38.886 for V2X UE Tx and Rx requirements	16.1.0
2020-12	RAN#90	RP-202443	0001	1	F	CR to TR 38.831 on beam correspondence corrections	16.2.0
2020-12	RAN#90	RP-202443	0002	1	F	CR to TR 38.831 to include DL CA agreement	16.2.0
2020-12	RAN#90		0004	1	F	Correction on update 5G V2X UE RF requirements in TR38.886	16.2.0
2020-12	RAN#90		0005	1	F	CR for 38.886, Time mask for TDM between NR V2X and LTE V2X in ITS band	16.2.0