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| 3GPP TR 38.859 V0.1.0 (2022-08) |
| Technical Report |
| 3rd Generation Partnership Project;Technical Specification Group Radio Access Network;Study on Expanded and Improved NR Positioning;(Release 18) |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document captures the findings of the study item "Study on Expanded and Improved NR Positioning" [7]. The purpose of this technical report is to document the requirements, additional scenarios, evaluations and technical proposals treated during the study and provide a way forward toward normative work on expanded enhancements to NR positioning in TSG RAN WGs.

# 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 38.857: "Study on NR positioning enhancements".

[3] 3GPP TR 38.845: "Study on scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases".

[4] 3GPP TS 22.261: "Service requirements for the 5G system".

[5] 3GPP TR 22.855: "Study on ranging-based services".

[6] 3GPP TS 22.104: "Service requirements for cyber-physical control applications in vertical domains".

[7] RP-213588: “New SID on Study on expanded and improved NR positioning”.

[8] 3GPP TR 37.885: “Study on evaluation methodology of new Vehicle-to-Everything (V2X) use cases for LTE and NR”.

[9] 3GPP TR 36.885: “Study on LTE-based V2X Services”.

[10] 3GPP TR 36.843: “Study on LTE Device to Device Proximity Services”.

[11] 3GPP TR 38.901: “Study on channel model for frequencies from 0.5 to 100 GHz”.

[12] 3GPP TR 38.855: “Study on NR positioning support”.

[13] 3GPP TR 38.840: “Study on User Equipment (UE) power saving in NR”.

[14] 3GPP TR 38.802: “Study on New Radio Access Technolog - Physical Layer Aspects”.

[15] 3GPP TR 38.830: “Study on NR coverage enhancements”.

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [6] 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 [6].

Definition format (Normal)

**<defined term>:** <definition>.

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

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

Symbol format (EW)

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [6] 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 [6].

AGV Automated Guided Vehicle

BW Bandwidth

DL Downlink

GNSS Global Navigation Satellite System

IIoT Industrial Internet of Things

IoT Internet of Things

ITS Intelligent Transportation Systems

LPHAP Low Power High Accuracy Positioning

NR New Radio

PRS Positioning Reference Signal

RAN Radio Access Network

RAT Radio Access Technology

RedCap Reduced Capability

RTK Real Time Kinematic

SI Study Item

SID Study Item Description

SL Sidelink

SRS Sounding Reference Signals

TR Technical Report

TS Technical Specification

UE User Equipment

UL Uplink

V2X Vehicle to Everything

WI Work Item

# 4 General Descriptions of Expanded NR Positioning Enhancements

In Release 17, 3GPP RAN conducted studies on "NR positioning enhancements" TR 38.857 [2] and "Scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases" TR 38.845 [3].

The study on "Scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases" focussed on V2X and public safety use cases with the outcome being captured in TR 38.845 [3]. Additionally, SA1 has developed requirements in TS 22.261 [4] for "Ranging based services” TR 22.855 [5] and has developed positioning accuracy requirements in TS 22.104 [6] for IIoT use cases in out-of-coverage scenarios. There is a need for 3GPP to study and develop sidelink positioning solutions that can support the use cases, scenarios and requirements identified during these activities.

The study on "NR positioning enhancements" TR 38.857 [2] investigated higher accuracy, and lower latency location, high integrity and reliability requirements resulting from new applications and industry verticals for 5G. Some of the enhancements identified during that work have been specified during the Release 17 Work Item on "NR positioning enhancements", but there remain a number of opportunities for enhancement that have not yet been incorporated into the specifications.

Regarding higher accuracy, two promising techniques identified in earlier studies will be considered in Release 18: one is to take the advantage of the rich 5G spectrum to increase the bandwidth for the transmission and reception of the positioning reference signals based on PRS/SRS bandwidth aggregation for intra-band carriers, and the other is to use the NR carrier phase measurements. GNSS carrier phase positioning has been used very successfully for centimetre-level positioning but is limited to outdoor applications. NR carrier phase positioning has the potential for significant performance improvements for indoor and outdoor deployments in comparison with the existing NR positioning methods, as well as shorter latency and lower UE power consumption in comparison with RTK-GNSS outdoors.

Positioning integrity is a measure of the trust in the accuracy of the position-related data and the ability to provide timely warnings based on assistance data provided by the network. The focus in Release 17 work was on GNSS integrity, and for Release 18 it is natural to extend this to address other positioning techniques as well as there are relevant integrity aspects of mission critical use cases that rely on positioning estimates and the corresponding uncertainty estimate. Integrity enables applications to make the correct decisions based on the reported position, e.g., when monitoring a robotic arm to decide whether its arm movement are within allowed limits to ensure safety distances to humans and other objects.

SA1 has introduced requirements for LPHAP (Low Power High Accuracy Positioning) for industrial IoT scenarios including use cases such as massive asset tracking, AGV tracking in industrial factory and person localization in danger zones. The SA1 requirements are for high accuracy and extreme low power consumption with battery life sustainable up to one or more years. A typical scenario of interest is use case 6 as defined TS 22.104 [6], which corresponds to tracking of workpiece (in- and outdoor) in assembly area and warehouse with a target accuracy of <1m, a positioning interval of 15-30 seconds, and a battery life of 6-12 months. While Release 17 NR positioning has introduced support for positioning in RRC\_INACTIVE state, there is a need to evaluate whether the current system allows LPHAP requirements to be met.

Release 17 has specified support for RedCap UEs with reduced bandwidth support and reduced complexity including reduced number of receive chains. Such UEs could support NR positioning functionality but there is a gap in that the core and performance requirements have not been specified for the positioning related measurements performed by RedCap UEs, and no evaluation was performed to see how the reduced capabilities of RedCap UEs might impact eventual position accuracy. This gap is to be investigated by the present SI.

# 5 Sidelink Positioning

## 5.1 Sidelink Positioning Scenarios and Requirements

The following objectives were captured in SID [7] for study of sidelink positioning solutions:

Coverage scenarios to cover:

In-coverage, partial-coverage and out-of-coverage.

Requirements:

Based on requirements identified in TR 38.845 [3] and TS 22.261 [3] and TS 22.104 [5].

Use cases:

V2X (TR 38.845) [3], public safety (TR 38.845) [3], commercial (TS 22.261) [3], IIOT (TS 22.104) [5].

Spectrum:

ITS, licensed

Both PC5-only-based positioning solutions and combination of Uu- and PC5-based positioning solutions were considered for study of sidelink positioning.

For evaluations, in-coverage and out-of-coverage scenarios were prioritized. Further, for evaluation of V2X and public safety use-cases, at least in-coverage and out-of-coverage scenarios were considered, while for evaluation of IIoT and commercial use-cases, at least in-coverage scenarios were considered.

For evaluations, operation in FR1 bands and FR2 bands with channel bandwidths of up to 100 MHz and 400 MHz respectively were considered.

For evaluations of relative positioning, the horizontal plane was assumed to be parallel to the ground.

For this study, requirements on positioning accuracy are expressed as accuracy requirements in terms of percentiles of UEs for one or more of the following metrics:

* Ranging accuracy, expressed as the difference (error) between the calculated distance/direction and the actual distance/direction in relation to another node;
* Relative positioning accuracy, expressed as the difference (error) between the calculated horizontal/vertical position and the actual horizontal/vertical position relative to another node;
* Absolute positioning accuracy. expressed the difference (error) between the calculated horizontal/vertical position and the actual horizontal/vertical position.

It should be noted that exact applicability of specific requirements can be expected to vary across use-cases.

For evaluation of V2X use-cases for SL positioning, the following accuracy requirements were considered:

* V2X-Set A (similar to “Set 2” defined in TR 38.845 [3])
	+ Horizontal accuracy of 1.5 m (absolute or relative); Vertical accuracy of 3 m (absolute and relative) for 90% of UEs
* V2X-Set B (similar to “Set 3” defined in TR 38.845 [3])
	+ Horizontal accuracy of 0.5 m (absolute or relative); Vertical accuracy of 2 m (absolute and relative) for 90% of UEs

For evaluation of public safety use-cases for SL positioning solutions, the following accuracy requirements were considered:

* 1 m (absolute or relative) horizontal accuracy and 2 m (absolute or relative between 2 UEs) or 0.3 m (relative positioning change for one UE) vertical accuracy for 90% of UEs
* Relative speed: up to 30 km/hr.

For evaluation of commercial use-cases for SL positioning solutions, the following accuracy requirements were considered:

* 1 m (absolute or relative) horizontal accuracy and 2 m (absolute or relative) vertical accuracy for 90% of UEs
* Relative speed: up to 30 km/hr.

For evaluation of IIoT use-cases for SL positioning solutions, the following accuracy requirements were considered:

* For horizontal accuracy,
	+ IIoT-hor-Set A: 1 m (absolute or relative) for 90% of UEs
	+ IIoT-hor-Set B: 0.2 m (absolute or relative) for 90% of UEs
* For vertical accuracy,
	+ IIoT-ver-Set A: 1 m (absolute or relative) for 90% of UEs
	+ IIoT-ver-Set B: 0.2 m (absolute or relative) for 90% of UEs
* Relative speed: up to 30 km/hr.

For evaluated SL positioning methods, sources were expected to report:

1. whether each of the two requirements are satisfied, and
2. %-ile of UEs satisfying the target positioning accuracy for a requirement that may not be satisfied for 90% of the UEs.

For the above target requirements for evaluations, it should be noted that the target positioning requirements may not necessarily be achieved for all scenarios and deployments. Further, all positioning techniques may not achieve all positioning requirements in all scenarios.

For sidelink based ranging, for a given use-case, the value of the distance requirement for ranging distance accuracy is same as the value identified for horizontal positioning accuracy for relative positioning.

For ranging between two devices, ranging direction accuracy is defined as accuracy of angle of arrival (AoA) at a receiving node.

The following requirements on ranging direction accuracy were considered:

* RangingAngle-Set A: Y = ±15° for 90% of the UEs
* RangingAngle-Set B: Y = ±8° for 90% of the UEs

For evaluations of ranging direction accuracy, sources were expected to report:

1. whether each of the two requirements are satisfied, and
2. %-ile of UEs satisfying the target positioning accuracy for a requirement that may not be satisfied for 90% of the UEs.

For the above target requirements for evaluations, it should be noted that the target positioning requirements may not necessarily be achieved for all scenarios and deployments. Further, all positioning techniques may not achieve all positioning requirements in all scenarios.

## 5.2 Potential Solutions for Sidelink Positioning

### 5.2.1 Physical Layer aspects for SL Positioning Solutions

### 5.2.2 Potential Architecture and Signalling Procedures for Sidelink Positioning

## 5.3 Summary of Sidelink Positioning Evaluations

### 5.3.1 Evaluation of Bandwidth Requirements to meet Identified Accuracy Requirements

### 5.3.2 Evaluation of Absolute Positioning, Relative Positioning, and Ranging Methods

## 5.4 Potential specification impact for Sidelink Positioning

# 6 Positioning Enhancements for Improved Integrity, accuracy, and power efficiency

## 6.1 Integrity for RAT-Dependent Positioning Techniques

### 6.1.1 Identification of error sources

### 6.1.2 Methodologies, procedures and signalling for determination of positioning integrity

### 6.1.3 Summary of Evaluation Results for Integrity for RAT-Dependent Positioning Techniques

### 6.1.4 Potential Specification Impact for Integrity for RAT-Dependent Positioning Techniques

## 6.2 PRS / SRS Bandwidth Aggregation

### 6.2.1 Potential Solutions Based on PRS / SRS Bandwidth Aggregation

### 6.2.2 Summary of Evaluations for PRS/SRS Bandwidth Aggregation

### 6.2.3 Potential Specification Impact for PRS/SRS Bandwidth Aggregation

## 6.3 NR Carrier Phase Positioning

### 6.3.1 NR Carrier Phase Positioning Scenarios

For evaluations of NR carrier phase positioning, the following scenarios are considered:

* Baseline: InF-SH, InF-DH
* Optional: Indoor Open Office, Umi, Highway scenarios

### 6.3.2 Potential Solutions for NR Carrier Phase Positioning

### 6.3.3 Summary of Evaluations for NR Carrier Phase Positioning

### 6.3.4 Potential Specification Impact for NR Carrier Phase Positioning

## 6.4 Low Power High Accuracy Positioning

### 6.4.1 Target use cases and requirements for Low Power High Accuracy Positioning

Use case 6 defined in TS 22.104 [6] is the single representative use case for the study of LPHAP.

For LPHAP, the main objective of the evaluations from the perspective of lower layers is on UE power consumption.

At least relative power unit is adopted as the performance metric to evaluate the power consumption of the Rel-17 RRC\_INACTIVE state positioning and potential enhancements.

A reference device (e.g., a mobile phone) with reference traffic type, reference battery capability, and reference battery life is defined for the purpose of identification of the performance gap that achieved by the Rel-17 RRC\_INACTIVE state positioning baseline and the target battery life of LPHAP use case 6.

### 6.4.2 Summary of Evaluations for Low Power High Accuracy Positioning

Evaluations of baseline Rel-17 RRC\_INACTIVE state positioning with the evaluation assumptions agreed for the study show that the power consumption on deep sleep state accounts for the highest proportion in the total power.

### 6.4.3 Potential Specification Impact for Low Power High Accuracy Positioning

## 6.5 Positioning of UEs with Reduced Capabilities

For the purpose of the study of positioning performance for UEs with Reduced Capabilities (RedCap UEs), the following target performance requirements were considered:

For commercial use cases for both indoor and outdoor scenarios

* Horizontal positioning accuracy: (< 3 m) for 90% of UEs
* Vertical positioning accuracy: (< 3 m) for 90% of UEs

For IIoT use cases:

* Horizontal positioning accuracy: (< 1 m) for 90% of UEs
* Vertical positioning accuracy: (< 3 m) for 90% of UEs

For the above target requirements for evaluations, it should be noted that the target positioning requirements may not necessarily be achieved for all scenarios and deployments. Further, all positioning techniques may not achieve all positioning requirements in all scenarios.

### 6.5.1 Potential Solutions for Positioning for RedCap UEs

### 6.5.2 Summary of Evaluations for Positioning for RedCap UEs

### 6.5.3 Potential Specification Impact for Positioning for RedCap UEs

# 7 Conclusions

Annex A.1: Evaluation Methodology for Sidelink Positioning

In this subclause, the evaluation methodology and assumptions for evaluation of sidelink positioning methods are described.

Table A.1-1 lists the performance metrics for evaluation of sidelink positioning.

Table A.1-1: Performance metrics for evaluations of sidelink positioning

| Evaluation case | Metrics |
| --- | --- |
| Relative or absolute positioning | * Horizontal accuracy
* Vertical accuracy
 |
| Ranging | * Ranging distance
* Ranging angle/direction
 |
| Metrics to be reported | * The percentiles of positioning accuracy error including 50%, 67%, 80%, 90% of UEs.
* CDF of positioning accuracy error
 |
| Other metrics | Performance metrics other than positioning accuracy, such as PHY/end-to-end latency, are up to companies |

The evaluation assumptions are listed in Tables A.1-2 through A.1-6 for the assumptions relevant evaluation of all use-cases and those for each of the identified use-cases of V2X, public safety, commercial, and IIoT respectively.

Table A.1-2: Evaluation assumptions common to all evaluations of sidelink positioning

| Assumptions | Value |
| --- | --- |
| Simulation bandwidth | * FR1: 10, 20, 40 and 100 MHz
* FR2: 100, 200 and 400MHz
 |
| Reference signals for sidelink positioning | * Baseline: Existing pattern and sequence of DL-PRS or positioning SRS
* Other choices of pattern and sequence not precluded – companies to provide details.
* AGC settling time is considered.
 |
| PHY/link level abstraction | Explicit simulation of all links, individual parameters estimation is applied. Companies to provide description of applied algorithms for estimation of signal location parameters. |
| Network and anchor UE synchronization | * Baseline: Perfect synchronization between network and anchor UEs in the evaluation is assumed.
	+ Network synchronization error and timing errors defined in Table 6-1 in TR 38.857 [2] can also be optionally used for synchronization between BS and BS, between BS and anchor UEs, and between anchor UEs.
 |
| Sidelink anchor nodes  | * For evaluation of SL only positioning, anchor UEs are used to locate target UEs.
* For evaluation of Joint Uu/SL positioning, both BS and anchor UEs are used to locate target UEs.
* Baseline for absolute positioning: sidelink anchors location coordinates are perfectly known.
	+ Uncertainty in the sidelink anchors location coordinates can be considered by companies
 |
| UE-pair selection for ranging | Relative positioning or ranging is performed between two UEs within X m. Value(s) of X to be reported b companies. |
| Positioning method | To be reported by companies. |
| Additional considerations | * Companies should report whether SL-PRS and other SL signals are FDM-ed or not FDM-ed, and whether other SL signals are present
* System level simulations (rather than link level simulations) are used as the baseline tool.
* For SL positioning evaluation in highway scenario or urban grid scenarios, performance metrics can include absolute horizontal accuracy, relative horizontal accuracy, ranging with distance accuracy, and ranging with direction accuracy (optionally).
* In highway and urban grid scenarios, other UE types, e.g., pedestrian UE or VRU devices may be further considered.
 |

Table A.1-3: Evaluation assumptions for evaluations of sidelink positioning for V2X use-cases

| Assumptions | Value |
| --- | --- |
| Scenarios | V2X use-cases with highway and urban grid scenarios defined in TR 37.885 [8].* Road configuration for urban grid and highway provided in Annex A in TR 37.885 [8] is reused.
 |
|  | **Urban grid for V2X** | **Highway for V2X** |
| Carrier frequency  | Uu : 4 GHz SL: 6 GHz | Uu : 2 GHz or 4GHzSL: 6 GHz |
| Deployment layout for absolute positioning | * Alt 1 as optional: BS and UE-type RSU deployment follows TR 36.885, where wrap around method of 19\*3 hexagonal cells with 500m ISD in Figure A.1.3-3 of subclause A.1.3 in TR 36.885 [9] is used.
* Alt 2 as baseline: BSs are disabled, UE-type RSUs are uniformly located with 200m spacing on both sides of highway symmetrically.
	+ Optional: staggered/unsymmetrical UE-type RSU distribution like

Note: Alt 1 is assumed for evaluation of joint Uu/PC5 positioning, Alt 2 is assumed for evaluation of PC5-only positioning. | BS and UE-type RSU deployment follows the description in subclause A.1.3 in TR 36.885 [9].* Companies can provide results for additional BS/ UE-type RSU deployments, e.g., additional UE-type RSUs are added to UE-type RSU deployment in TR 36.885 [9]
 |
| Deployment layout for relative positioning/ranging | * BSs are disabled
* UE type RSU may be disabled (as baseline) or enabled (as optional)
	+ If enabled, UE-type RSUs are uniformly located with 200m spacing on both sides of highway symmetrically.
		- Optional: staggered/unsymmetrical UE-type RSU distribution like

 | * BSs are disabled (baseline), or enabled (optional)
	+ Companies to report their assumptions
* UE type RSU may be disabled or enabled (companies should report their assumption)
	+ If enabled, UE type RSU deployment follows the description section A.1.3 in TR 36.885 [9].
	+ If enabled, companies can provide additional RSU deployment, e.g. additional RSUs are added to RSU deployment in TR 36.885 [9].
 |
| BS Tx power  | Macro BS: 49dBm  |
| UE Tx power  | Vehicle UE or UE type RSU: 23dBm |
| BS receiver noise figure | 5dB |
| UE receiver noise figure | 9 dB |
| UE dropping | UE dropping option A defined in section 6.1.2 of TR 37.885 [8]:* UE dropping option A is used for the highway scenario:
	+ Vehicle type distribution: 100% vehicle type 2.
	+ Clustered dropping is not used.
	+ Vehicle speed is 140 km/h in all the lanes as baseline and 70 km/h in all the lanes optionally.
* UE dropping option A is used for the urban grid scenario:
	+ Vehicle type distribution: 100% vehicle type 2.
	+ Clustered dropping is not used.
	+ Vehicle speed is 60 km/h in all the lanes.

In the intersection, a UE goes straight, turns left, turns right with the probability of 0.5, 0.25, 0.25, respectively. |
| UE antenna model | Description in subclause 6.1.4 in TR 37.885 [8] is reused:* Vehicle UE option 1 is the baseline (Vehicle UE antenna is modelled in Table 6.1.4-8 and 6.1.4-9 in TR 37.885 [8])
* Vehicle UE option 2 (two panels) can be optionally selected by companies.
 |
| Channel model | Description in subclause 6.2 in TR 37.885 is reused. |

Table A.1-4: Evaluation assumptions for evaluations of sidelink positioning for public safety use-cases

| Assumptions | Value |
| --- | --- |
| Overall assumptions | Companies to provide detailed simulation assumptions including selected scenarios, channel models, center frequency, UE drop models, etc. |
| Channel model | Channel model in TR 36.843 is reused:* Reuse the parameters of “Channel models” specified in Section A.2.1.2 of TR 36.843 with following modification: Each component of channel model reuses what is specified in TR 38.901.
 |
| Anchor UE height | To be reported by companies, e.g., same as TRP height. |
| Performance metrics | At least include absolute positioning accuracy and ranging with distance accuracy.* Optional: Relative positioning accuracy or ranging with angle/direction accuracy
 |

Table A.1-5: Evaluation assumptions for evaluations of sidelink positioning for commercial use-cases

| Assumptions | Value |
| --- | --- |
| Overall assumptions | Companies to provide detailed simulation assumptions including selected scenarios, channel models, center frequency, UE drop models, etc. |
| Channel model | Channel model in TR 36.843 is reused:Reuse the parameters of “Channel models” specified in Section A.2.1.2 of TR 36.843 with following modification: Each component of channel model reuses what is specified in TR 38.901. |
| Anchor UE height | To be reported by companies, e.g., same as TRP height. |
| Performance metrics | At least include absolute positioning accuracy and ranging with distance accuracy.Optional: Relative positioning accuracy or ranging with angle/direction accuracy |

Table A.1-6: Evaluation assumptions for evaluations of sidelink positioning for IIoT use-cases

| Assumptions | Value |
| --- | --- |
| Deployment scenario and BS-to-UE channel models | InF-SH and/or InF-DH defined in TR 38.857 [2]. |
| UE-to-UE channel model | * Option 1: BS-2-UE channel model defined in TR 38.901 [11] is revised:
	+ The UE parameters in the channel model defined in 38.901 [11], e.g. UE height, antenna model, transmit power are used to replace corresponding parameters for BS.
	+ Anchor UE height to be reported by companies, e.g., anchor UE height is the same as TRP.
* Option 2: D2D channel mode from 36.843 A.2.1.2 is used.
 |
| Anchor UE dropping | Companies to report how to drop anchor UEs and how to select anchor UEs. |
| Performance metrics | At least include absolute and relative positioning accuracy |

Annex A.2: Evaluation Methodology for PRS/SRS Bandwidth Aggregation

Annex A.3: Evaluation Methodology for NR Carrier Phase Positioning

NR carrier phase positioning performance will be evaluated at least with the carrier phase measurements of a single measurement instance.

For evaluations of NR carrier phase positioning, the relevant evaluation assumptions as in TR 38.855 [12] and TR 38.857 [2] are reused, with optional modifications to the assumptions based on appropriate justification.

For evaluations of NR carrier phase positioning, the following scenarios are considered:

* Baseline: InF-SH, InF-DH
* Optional: Indoor Open Office, Umi, Highway scenarios
	+ Note 1: Other evaluation scenarios are not precluded
	+ Note 2: Existing Rel-17 DL/UL reference signals for the Uu interface are to be used for the Highway scenario.

Evaluations for FR1 bands are considered as baseline while those for FR2 bands are optional.

For modelling of error sources, the following may be considered:

* Phase noise (FR2)
* CFO/Doppler
* Oscillator-drift
* Transmitter/receiver antenna reference point location errors
* Transmitter/receiver initial phase error
* Phase center offset
* Note: Other error sources are not precluded
* Note: UE mobility can be considered in the evaluations
* Note: one or more error sources can be evaluated jointly
* Note: companies should provide the error sources model with their evaluations

The impact of multipath will be considered as part of evaluations of NR carrier phase positioning, and the methods of mitigating the impact of multipath for the carrier phase positioning will be studied, if it is considered necessary after the evaluation.

Further, the use of PRUs to facilitate NR carrier phase positioning can be evaluated.

Annex A.4: Evaluation Methodology for Low Power High Accuracy Positioning

Table A.4-1 lists the common assumptions for evaluation of LPHAP.

Table A.4-1: Evaluation assumptions common to all evaluations of LPHAP

| Assumptions | Value |
| --- | --- |
| Frequency range | FR1 baseline; FR2 optional |
| SCS | 30kHz for FR1 (baseline); 120kHz for FR2 (optional) |
| Bandwidth of the DL PRS and UL SRS for positioning | 100 MHz |
| Measurements per position fix | Single-sample measurement per position fix (baseline); 4-sample measurement per position fix (optional) |
| UE mobility | Up to 3 kmph |
| Power consumption modelling – basic considerations | * Power consumption of 5GC data traffic is not modelled and only the power consumption of the traffic type related to LPHAP positioning (e.g., obtaining/updating SRS configurations, DL PRS measurement reporting, etc.) is considered.
	+ Consideration of power consumption due to paging monitoring is not precluded for baseline evaluation.
* Up to each company to provide detailed power model and evaluation results on power consumption in FR2.
* Adopt the power consumption model, additional transition energy and total transition time of the three sleep types (deep sleep, light sleep, and micro sleep) in TR38.840 [13] as the evaluation baseline.
 |
| Periodicity of DL PRS / UL SRS for positioning | Baseline: 1 DL PRS / UL SRS for positioning occasion per N I-DRX cycle(s)* Candidate values of N to evaluate is 1 and 8 for I-DRX cycle of 1.28s.
	+ Up to companies to select one or both of the above values.
* Candidate value of N to evaluate is 1 for I-DRX cycle of 10.24s.
 |
| I-DRX configuration | Included in the baseline evaluations* I-DRX cycles: 1.28s (baseline); 10.24s (optional)
* Note: This does not preclude the case where no I-DRX cycle nor paging is considered in the evaluation of potential solutions to maximize the battery life.
 |
| e-DRX and/or paging reception | The following may be optionally considered:* e-DRX cycles to evaluate: 20.48s; 30.72s.
* For paging reception:
	+ 1 paging occasion is included in one eDRX cycle
	+ 10% paging rate
* No paging reception can be optionally evaluated.
* 1 DL PRS and/or UL SRS for positioning occasion per 1 eDRX cycle
	+ Minimizing the gap between PRS measurement, SRS transmission and/or measurement reporting with paging monitoring in time domain can be evaluated.
 |
| Performance requirements | * Horizontal positioning accuracy < 1 m for 90% of UEs
* Positioning interval / duty cycle of 15-30 s
* UE battery life of 6 months – 1 year
* Note: Setting an exact value each from the set of positioning interval / duty cycle and UE battery life in the evaluation and identification of performance gap will be discussed separately when necessary.

Note: At least when the positioning accuracy is evaluated without jointly evaluating the associated power consumption, the target horizontal positioning accuracy requirement on LPHAP of <1m is assumed to be achieved by Rel-16/17 positioning techniques with a positioning bandwidth of at least 100MHz. |

For conversion between relative power unit and device battery lifetime to identify any performance gaps, the following characterization is considered:

* Battery life is used as the metric to identify the gap

in which,

* C1 is the battery capacity of the reference device;
* T1 is the battery life of the reference device;
* P1 = 50 is the relative power unit obtained based on the reference traffic type;
* X is the percentage of the power consumed by the reference traffic type;
* C2 is the battery capacity of the LPHAP device;
* P2 is the evaluated relative power unit of the LPHAP device;
* T2\_req is the target battery life of the LPHAP device
* K is an implementation factor, K = 1 (baseline); K = 0.5, 2, 4 (optional)

Note: In the above model, the voltage is assumed to be the same for the reference device and the LPHAP device.

Note: As the reference device and LPHAP device characteristics, and therefore the parameter values of the model for determining battery life, is dependent on implementation factors, manufacturer, design options and cost options, it is up to individual company to evaluate the optional K values, and report the corresponding parameter values.

Examples of these parameters are provided as in Table A.4-2.

Table A.4-2: Example values of parameters for conversion between power consumption unit and device battery lifetime

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| C1 (mAh) | T1 (hours) | X | Reference traffic type | C2 (mAh) | T2req (months) |
| 4500 | 12 | 20 % | FTP (model 3) | 800 for Type A LPHAP device (baseline)4500 for Type B LPHAP device (optional) | 6 to 12 |

The power consumption model used for baseline evaluation of Rel-17 positioning in RRC\_INACTIVE state is as in Table A.4-3.Table A.4-3: Power consumption model for baseline evaluation of Rel-17 positioning in RRC\_INACTIVE state

|  |  |
| --- | --- |
| Power State | Relative power |
| PDCCH-only (PPDCCH) | 50Note |
| PDCCH + PDSCH (PPDCCH+PDSCH) | 120 |
| SSB proc. (PSSB) | 50 |
| UL | 250 (0 dBm)700 (23 dBm) |
| (Optional) PRACH | [210] |
| (Optional) BWP switching | [50] |
| (Optional) Intra-frequency RRM measurement (Pintra) | [60] (synchronous case, N=8, measurement only; Pintra, meas-only)[80] (combined search and measurement; Pintra, search+meas) |
| (Optional) Inter-frequency RRM measurement (Pinter) | [60] (measurement only per freq. layer; Pinter, meas-only)[150] (neighbor cell search power per freq. layer; Pinter, search-only)Micro sleep power assumed for switch in/out a freq. layer |
| Note: Power scaling to 20MHz reception bandwidth follows the rule in Section 8.1.3 of TR 38.840, i.e., max{reference power \* 0.4, 50}. |

For the purpose of LPHAP evaluation, an ultra-deep sleep state is considered with the two modelling options as in Table A.4-4.

Table A.4-4: Power consumption model for ultra-deep sleep state

|  |  |
| --- | --- |
| Parameters | Values |
| Model A: |
| Relative power unit  | 0.015 |
| Additional transition energy | [Between 2000 and 20000] |
| Total transition time | 400 ms |
| Model B: |
| Relative power unit  | 0.01 |
| Additional transition energy | 450 |
| Total transition time | 25 ms |
| FFS: restrictions in processing associated with option 2 after the UE comes out of ultra-deep sleep state |

For DL PRS-based positioning, the following reference configuration is assumed:

* Number of Positioning Frequency Layers = 1;
* Number of DL PRS resources measured per slot = 8;
* DL PRS instance of smaller than or equal to 1 slot duration.

The power consumption model for DL PRS-based positioning and UL SRS-based positioning are as in Tables A.4-4 and A.4-5 respectively.

Table A.4-5: Power consumption model for DL PRS-based positioning

|  |  |  |
| --- | --- | --- |
| **N: Number of** **TRPs for DL PRS measurement** | **Synchronous case (baseline)** | **Asynchronous case (optional)** |
| **FR1 (baseline)** | **FR2** **(optional)** | **FR1** | **FR2** |
| N=4 (baseline) | 120 | 195 | 140 | 255 |
| N=8 (optional) | 150 | 225 | 170 | 285 |

Table A.46: Power consumption model for UL SRS-based positioning

|  |  |
| --- | --- |
| **Power State** | **Relative power** |
| SRS | 210 (baseline);700 (optional) |

For DL positioning, at least the following power components and parameter values are considered for the baseline evaluation of Rel-17 RRC\_INACTIVE positioning:

* For UE-assisted DL positioning,
	+ SSB proc. with 2 ms duration and the periodicity of I-DRX cycle;
	+ Paging with 2 ms duration, the periodicity of I-DRX cycle, and group paging rate of 10%;
	+ DL PRS measurement with 0.5 ms duration;
	+ CG-SDT with 1ms duration and the periodicity of positioning interval;
	+ RRCRelsease after the CG-SDT can be optionally included with [1] ms duration;
	+ (Optional) BWP switching with [1] ms duration;
	+ (Optional) Intra-/inter-frequency RRM measurement in low SINR condition with [1] ms duration;
	+ (Optional) RA-SDT (e.g., including CORSET0 + SIB1, PRACH, RAR, Msg 3/4/5) in case of CG-SDT is unavailable.
* For UE-based DL positioning,
	+ SSB proc. with 2 ms duration and the periodicity of I-DRX cycle;
	+ Paging with 2 ms duration, the periodicity of I-DRX cycle, and group paging rate of 10%;
	+ DL PRS measurement with 0.5 ms duration;
	+ (Optional) BWP switching with [1] ms duration;
	+ (Optional) Intra-/inter-frequency RRM measurement in low SINR condition with [1] ms duration.

For UL positioning, at least the following power components and parameter values are considered for the baseline evaluation of Rel-17 RRC\_INACTIVE positioning:

* SSB proc. with 2 ms duration and the periodicity of I-DRX cycle;
* Paging with 2 ms duration, the periodicity of I-DRX cycle, and group paging rate of 10%;
* UL SRS for positioning transmission with 0.5 ms duration;
* (Optional) BWP switching with [1] ms duration;
* (Optional) Intra-/inter-frequency RRM measurement in low SINR condition with [1] ms duration.

In addition to the above, the following should be noted for DL and UL positioning in modelling the power components and timelines:

* The power component and parameter values for DL and UL positioning are respectively applicable to the DL and UL parts of UE-assisted DL+UL positioning method.
* Additional power components and different parameter values for those in brackets above can be considered in the evaluation.
* Companies are encouraged to provide the assumption on the timeline between different power consumption events in the evaluation of potential enhancements to reduce the transition times between different power states and to extend the sleeping time as much as possible.

Annex A.5: Evaluation Methodology for Positioning for RedCap UEs

In this subclause, the evaluation methodology and assumptions for evaluation of positioning performance for Reduced Capability (RedCap) NR UEs are described.

For evaluation of RedCap UE positioning performances, all RAT based positioning methods can be considered. Sources should detail the chosen method(s) when presenting performance evaluations.

Table A.5-1 lists the set of common parameters applicable for evaluation of positioning performance of RedCap UEs.

Table A.5-1: Common parameters applicable for all scenarios for Redcap UEs evaluations

| Assumptions | FR1 Specific Values | FR2 Specific Values  |
| --- | --- | --- |
| Carrier frequency, GHz  | 3.5GHz, 700MHz (optional) – Note 1 | 28GHz – Note 1 |
| Bandwidth, MHz | 20MHz baseline, 5MHz optional | 100MHz |
| Subcarrier spacing, kHz | 30KHz, 15KHz (for 700MHz carriers) | 120kHz |
| Positioning Reference Signals | DL PRS and/or UL SRS.Sources to detail the chosen configuration of reference signal(s) |
| Deployment scenarios | * Baseline: (Case 1): Umi street canyon, as described in Table 6.1-1-4 of TR 38.855
* Optional outdoor:
	+ (Case 2): UMa, as described in Table 6.1-1-6 of TR 38.855
	+ (Case 3): RMa, companies to report parameters assumed for evaluations.
* Baseline: (Case 4): InF-SH as described in Table 6.1-1 of TR 38.857
* Optional indoor: (Case 5) Indoor Open Office, as described in Table 6.1-1-3 of TR 38.855
* Optional indoor: (Case 6) InF-DH as described in Table 6.1-1 of TR 38.857
 |
| **gNB model parameters**  |  |  |
| gNB noise figure, dB | 5dB | 7dB |
| gNB antenna configuration | At 700MHz: (M,N,P,Mg,Ng) = (4,2,2,1,1), (dH, dV) = (0.5, 0.8)λ – Note 3 |
| **UE model parameters**  |  |  |
| UE noise figure, dB | 9dB – Note 1 | 13dB – Note 1 |
| UE max. TX power, dBm | 23dBm – Note 1 | 23dBm – Note 1EIRP should not exceed 43 dBm. |
| UE antenna radiation pattern  | Omni, 0dBi | Antenna model according to Table 6.1.1-2 in TR 38.855 |
| UE antenna configuration | Panel model 1 – Note 1dH = 0.5λ,for 1Rx UEs: (M, N, P, Mg, Ng) = (1, 1, 1, 1, 1)for 2Rx UEs: (M, N, P, Mg, Ng) = (1, 1, 2, 1, 1) | * (M, N, P, Mg, Ng) = (1, 2, 2, 1, 1) **as minimum antenna configuration (baseline)**
* (M, N, P, Mg, Ng) = (2, 2, 2, 1, 1) **as optional configuration.**
 |
| UE antenna radiation pattern  | Omni, 0dBi | Antenna model according to Table 6.1.1-2 in TR 38.855 |
| Number of UE branches | Baseline: 1Rx 1TxOptional: 2Rx 1 Tx | Baseline: 2Rx and 1Tx |
| PHY/link level abstraction | Explicit simulation of all links, individual parameters estimation is applied. Companies to provide description of applied algorithms for estimation of signal location parameters. |
| Network synchronization | The network synchronization error, per UE dropping, is defined as a truncated Gaussian distribution of (T1 ns) rms values between an eNB and a timing reference source which is assumed to have perfect timing, subject to a largest timing difference of T2 ns, where T2 = 2\*T1– That is, the range of timing errors is [-T2, T2]– T1: 0ns (perfectly synchronized), 50ns (Optional) |
| UE/gNB RX and TX timing error | (Optional) The UE/gNB RX and TX timing error, in FR1/FR2, can be modeled as a truncated Gaussian distribution with zero mean and standard deviation of T1 ns, with truncation of the distribution to the [-T2, T2] range, and with T2=2\*T1:- T1: X ns for gNB and Y ns for UE- X and Y are up to sources - Note: RX and TX timing errors are generated per panel independentlyApply the timing errors as follows: - For each UE drop, - For each panel (in case of multiple panels)- Draw a random sample for the Tx error according to [-2\*Y,2\*Y] and another random sample for the Rx error according to the same [-2\*Y,2\*Y] distribution. - For each gNB - For each panel (in case of multiple panels)- Draw a random sample for the Tx error according to [-2\*X,2\*X] and another random sample for the Rx error according to the same [-2\*X,2\*X] distribution. - Any additional Time varying aspects of the timing errors, if simulated, can be left up to each company to report.- For UE evaluation assumptions in FR2, it is assumed that the UE can receive or transmit at most from one panel at a time with a panel activation delay of 0ms. |
| Selection of RedCap UEs for indoor scenarios for reporting of results | * (Required): The UEs inside the convex hull of the horizontal BS deployment area.
* (Optional): All the UEs.
 |
| Note 1: According to 3GPP TR 38.802 [14]Note 2: According to 3GPP TR 38.901 [11]Note 3: According to 3GPP TR38.830 [15] |

Annex B.1: Evaluation Results for Sidelink Positioning

## B.1.X Results from source [X]

## B.1.X.1 Description of evaluation scenarios

[Brief descriptions of the evaluated scenarios]

Common assumptions applicable to all evaluated scenarios that are different from or not provided in Tables A.1-1 through A.1-6 are provided in Table B.1.X.1-1.

Table B.1.X.1-1: Common assumptions for sidelink positioning evaluations that are different from or not provided in Annex A.1 from [X]

|  |  |
| --- | --- |
| Parameter |  |
| Carrier frequency |  |
| Subcarrier spacing |  |
| Reference Signal Transmission Bandwidth |  |
| Reference Signal Physical Structure and Resource Allocation (RE pattern) |  |
| Reference signal including PRS, SRS and SL-PRS(type of sequence, number of ports, …) |  |
| Number of symbols used per occasion |  |
| number of occasions used per positioning estimate |  |
| Power-boosting level |  |
| Uplink power control (applied/not applied) |  |
| interference modelling (ideal muting, or other) |  |
| Description of Measurement Algorithm (e.g. super resolution, interference cancellation, ….) |  |
| Description of positioning technique / applied positioning algorithm (e.g. Least square, Taylor series, etc) |  |
| Synchronization assumptions |  |
| UE/gNB RX and TX timing error assumption |  |
| Precoding assumptions (codebook, nrof antenna elements used, etc) |  |
| Additional notes, if any |  |

Evaluation cases and relevant additional assumptions for highway scenarios for V2X use cases are provided in Table B.1.X.1-2. [multiple tables are OK]

Table B.1.X.1-2: Assumptions for sidelink positioning in highway scenarios for V2X use cases that are different from or not provided in Annex A.1 from [X]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Case 1 | Case 2 | … | Case n |
| UE Antenna model |  |  |  |  |
| TRP antenna model |  |  |  |  |
| BS/RSU deployment for absolute positioning |  |  |  |  |
| BS/RSU deployment for relative positioning/ranging  |  |  |  |  |
| Selected values of X (relative positioning or ranging is performed between two UEs within X m) |  |  |  |  |
| Positioning method |  |  |  |  |

Evaluation cases and relevant additional assumptions for urban grid scenarios for V2X use cases are provided in Table B.1.X.1-3. [multiple tables are OK]

Table B.1.X.1-3: Assumptions for sidelink positioning in urban grid scenarios for V2X use cases that are different from or not provided in Annex A.1 from [X]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Case 1 | Case 2 | … | Case n |
| UE Antenna model |  |  |  |  |
| TRP antenna model |  |  |  |  |
| BS/RSU deployment for absolute positioning |  |  |  |  |
| BS/RSU deployment for relative positioning/ranging  |  |  |  |  |
| Selected values of X (relative positioning or ranging is performed between two UEs within X m) |  |  |  |  |
| Positioning method |  |  |  |  |

Evaluation cases and relevant additional assumptions for IIoT use cases are provided in Table B.1.X.1-4. [multiple tables are OK]

Table B.1.X.1-4: Assumptions for sidelink positioning for IIoT use cases that are different from or not provided in Annex A.1 from [X]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Case 1 | Case 2 | … | Case n |
| UE Antenna model |  |  |  |  |
| TRP antenna model |  |  |  |  |
| BS/RSU deployment for absolute positioning |  |  |  |  |
| BS/RSU deployment for relative positioning/ranging  |  |  |  |  |
| Selected values of X (relative positioning or ranging is performed between two UEs within X m) |  |  |  |  |
| Positioning method |  |  |  |  |

Evaluation cases and relevant additional assumptions for public safety use cases are provided in Table B.1.X.1-5. [multiple tables are OK]

Table B.1.X.1-5: Assumptions for sidelink positioning for public safety use cases that are different from or not provided in Annex A.1 from [X]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Case 1 | Case 2 | … | Case n |
| Scenario |  |  |  |  |
| UE Antenna model |  |  |  |  |
| TRP antenna model |  |  |  |  |
| BS/RSU deployment for absolute positioning |  |  |  |  |
| BS/RSU deployment for relative positioning/ranging  |  |  |  |  |
| Selected values of X (relative positioning or ranging is performed between two UEs within X m) |  |  |  |  |
| Positioning method |  |  |  |  |

Evaluation cases and relevant additional assumptions for public safety use cases are provided in Table B.1.X.1-5. [multiple tables are OK]

Table B.1.X.1-6: Assumptions for sidelink positioning for commercial use cases that are different from or not provided in Annex A.1 from [X]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Case 1 | Case 2 | … | Case n |
| Scenario |  |  |  |  |
| UE Antenna model |  |  |  |  |
| TRP antenna model |  |  |  |  |
| BS/RSU deployment for absolute positioning |  |  |  |  |
| BS/RSU deployment for relative positioning/ranging  |  |  |  |  |
| Selected values of X (relative positioning or ranging is performed between two UEs within X m) |  |  |  |  |
| Positioning method |  |  |  |  |

## B.1.X.2 Positioning accuracy evaluation results for Sidelink Positioning

[Brief description of the content, without observations, e.g., which sidelink positioning scenarios are evaluated, etc.]

## B.1.X.2.1 Positioning accuracy evaluation results for Sidelink Positioning for Highway Scenarios for V2X

Table B.1.X.2.1-1 provides horizontal absolute positioning accuracy results using sidelink positioning for highway scenarios for V2X use cases.

Table B.1.X.2.1-1: Sidelink positioning - horizontal absolute accuracy for highway scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #1, BW#100M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
| e.g., Case #2, BW#40M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |

Table B.1.X.2.1-2 provides vertical absolute positioning accuracy results using sidelink positioning for highway scenarios for V2X use cases.

Table B.1.X.2.1-2: Sidelink positioning - vertical absolute accuracy for highway scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.1-3 provides horizontal relative positioning accuracy results using sidelink positioning for highway scenarios for V2X use cases.

Table B.1.X.2.1-3: Sidelink positioning - horizontal relative accuracy for highway scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.1-4 provides vertical relative positioning accuracy results using sidelink positioning for highway scenarios for V2X use cases.

Table B.1.X.2.1-4: Sidelink positioning - vertical relative accuracy for highway scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.1-5 provides ranging distance accuracy results using sidelink positioning for highway scenarios for V2X use cases.

Table B.1.X.2.1-5: Sidelink positioning - ranging distance accuracy for highway scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.1-6 provides ranging distance accuracy results using sidelink positioning for highway scenarios for V2X use cases.

Table B.1.X.2.1-6: Sidelink positioning - ranging angle accuracy for highway scenarios for V2X use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging angle accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

## B.1.X.2.2 Positioning accuracy evaluation results for Sidelink Positioning for Urban Grid Scenarios for V2X

Table B.1.X.2.2-1 provides horizontal absolute positioning accuracy results using sidelink positioning for urban grid scenarios for V2X use cases.

Table B.1.X.2.2-1: Sidelink positioning - horizontal absolute accuracy for urban grid scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #1, BW#100M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
| e.g., Case #2, BW#40M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |

Table B.1.X.2.2-2 provides vertical absolute positioning accuracy results using sidelink positioning for urban grid scenarios for V2X use cases.

Table B.1.X.2.2-2: Sidelink positioning - vertical absolute accuracy for urban grid scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.2-3 provides horizontal relative positioning accuracy results using sidelink positioning for urban grid scenarios for V2X use cases.

Table B.1.X.2.2-3: Sidelink positioning - horizontal relative accuracy for urban grid scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.2-4 provides vertical relative positioning accuracy results using sidelink positioning for urban grid scenarios for V2X use cases.

Table B.1.X.2.2-4: Sidelink positioning - vertical relative accuracy for urban grid scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.2-5 provides ranging distance accuracy results using sidelink positioning for urban grid scenarios for V2X use cases.

Table B.1.X.2.2-5: Sidelink positioning - ranging distance accuracy for urban grid scenarios for V2X use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.2-6 provides ranging distance accuracy results using sidelink positioning for urban grid scenarios for V2X use cases.

Table B.1.X.2.2-6: Sidelink positioning - ranging angle accuracy for urban grid scenarios for V2X use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging angle accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

## B.1.X.2.3 Positioning accuracy evaluation results for Sidelink Positioning for IIoT

Table B.1.X.2.3-1 provides horizontal absolute positioning accuracy results using sidelink positioning for IIoT use cases.

Table B.1.X.2.3-1: Sidelink positioning - horizontal absolute accuracy for IIoT use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #1, BW#100M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
| e.g., Case #2, BW#40M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |

Table B.1.X.2.3-2 provides vertical absolute positioning accuracy results using sidelink positioning for IIoT use cases.

Table B.1.X.2.3-2: Sidelink positioning - vertical absolute accuracy for IIoT use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.3-3 provides horizontal relative positioning accuracy results using sidelink positioning for IIoT use cases.

Table B.1.X.2.3-3: Sidelink positioning - horizontal relative accuracy for IIoT use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.3-4 provides vertical relative positioning accuracy results using sidelink positioning for IIoT use cases.

Table B.1.X.2.3-4: Sidelink positioning - vertical relative accuracy for IIoT use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.3-5 provides ranging distance accuracy results using sidelink positioning for IIoT use cases.

Table B.1.X.2.3-5: Sidelink positioning - ranging distance accuracy for IIoT use cases from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the requirement of set A | Whether meet the requirement of set B |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table B.1.X.2.3-6 provides ranging distance accuracy results using sidelink positioning for IIoT use cases.

Table B.1.X.2.3-6: Sidelink positioning - ranging angle accuracy for IIoT use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging angle accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

## B.1.X.2.4 Positioning accuracy evaluation results for Sidelink Positioning for Public Safety

Table B.1.X.2.4-1 provides horizontal absolute positioning accuracy results using sidelink positioning for public safety use cases.

Table B.1.X.2.4-1: Sidelink positioning - horizontal absolute accuracy for public safety use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #1, BW#100M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
| e.g., Case #2, BW#40M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |

Table B.1.X.2.4-2 provides vertical absolute positioning accuracy results using sidelink positioning for public safety use cases.

Table B.1.X.2.4-2: Sidelink positioning - vertical absolute accuracy for public safety use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.4-3 provides horizontal relative positioning accuracy results using sidelink positioning for public safety use cases.

Table B.1.X.2.4-3: Sidelink positioning - horizontal relative accuracy for public safety use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.4-4 provides vertical relative positioning accuracy results using sidelink positioning for public safety use cases.

Table B.1.X.2.4-4: Sidelink positioning - vertical relative accuracy for public safety use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.4-5 provides ranging distance accuracy results using sidelink positioning for public safety use cases.

Table B.1.X.2.4-5: Sidelink positioning - ranging distance accuracy for public safety use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.4-6 provides ranging distance accuracy results using sidelink positioning for public safety use cases.

Table B.1.X.2.4-6: Sidelink positioning - ranging angle accuracy for public safety use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging angle accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

## B.1.X.2.5 Positioning accuracy evaluation results for Sidelink Positioning for Commercial use cases

Table B.1.X.2.5-1 provides horizontal absolute positioning accuracy results using sidelink positioning for commercial use cases.

Table B.1.X.2.5-1: Sidelink positioning - horizontal absolute accuracy for commercial use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #1, BW#100M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
| e.g., Case #2, BW#40M, FR#1, positioning method #TDOA, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |

Table B.1.X.2.5-2 provides vertical absolute positioning accuracy results using sidelink positioning for commercial use cases.

Table B.1.X.2.5-2: Sidelink positioning - vertical absolute accuracy for commercial use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.5-3 provides horizontal relative positioning accuracy results using sidelink positioning for commercial use cases.

Table B.1.X.2.5-3: Sidelink positioning - horizontal relative accuracy for commercial use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.5-4 provides vertical relative positioning accuracy results using sidelink positioning for commercial use cases.

Table B.1.X.2.5-4: Sidelink positioning - vertical relative accuracy for commercial use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target positioning accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.5-5 provides ranging distance accuracy results using sidelink positioning for commercial use cases.

Table B.1.X.2.5-5: Sidelink positioning - ranging distance accuracy for commercial use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging distance accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Table B.1.X.2.5-6 provides ranging distance accuracy results using sidelink positioning for commercial use cases.

Table B.1.X.2.5-6: Sidelink positioning - ranging angle accuracy for commercial use cases from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case ID and brief description  | 50% | 67% | 80% | 90% | Whether meet the target requirement |
| e.g., Case #, BW#, FR#, positioning method#, |  |  |  |  | Yes?If not, %-ile of UEs satisfying the target ranging angle accuracy requirement |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Annex B.2: Evaluation Results for Integrity for RAT-Dependent Positioning Techniques

Annex B.3: Evaluation Results for PRS/SRS Bandwidth Aggregation

Annex B.4: Evaluation Results for NR Carrier Phase Positioning

## B.4.X Results from source [X]

## B.4.X.1 Description of evaluation scenarios

[Brief descriptions of the evaluated scenarios]

Evaluation scenarios, key techniques, and assumptions for performance analysis of NR carrier phase positioning are provided in Table B.4.X.1-1. [multiple tables are OK]

Table B.4.X.1-1: NR carrier phase positioning enhancements - evaluation scenarios and parameters from [X]

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **[Case ID], [Scenario]** | **[Case ID], [Scenario]** | **[Case ID], [Scenario]** |
| Scenario [TS 38.855, TS 38.857] |  |  |  |
| Single carrier frequency, or multiple carrier frequencies, GHz |  |  |  |
| Bandwidth, MHz |  |  |  |
| Subcarrier spacing, kHz |  |  |  |
| RS signal descriptions(PRS or posSRS, Number of OFDM simbles, Comb size) |  |  |  |
| NR Carrier phase positioning method (DL, UL, or DL+UL(RTT)) |  |  |  |
| R16/R17 positioning method (if it is used together with CPP) |  |  |  |
| Carrier phase estimation techniques (time-domain, freq-domain, references) |  |  |  |
| Differential positioning techniques if used (e.g., single differential, double differential, etc.)  |  |  |  |
| Integer ambiguity resolution techniques (e.g., virtual Integer ambiguity, LAMBDA, cost functions, Least squares, …) |  |  |  |
| Multipath mitigation techniques(e.g., first path detection, ...)  |  |  |  |
| Single-measurement instance CPP, or multiple measurement instances CPP |  |  |  |
| UE position calculation algorithm (e.g. Least squares, Taylor series, …) |  |  |  |
| Network synchronization assumption (e.g., 0ns, 10ns, ..) |  |  |  |
| UE/TRP Initial phase offset  |  |  |  |
| CFO/Doppler |  |  |  |
| *Oscillator-drifts* |  |  |  |
| ARP errors |  |  |  |
| Phase Center Offsets |  |  |  |
| Phase noise (FR2) |  |  |  |
| Additional notes, if any |  |  |  |

## B.4.X.2 Positioning accuracy evaluation results for NR Carrier Phase Positioning

[Brief description of the content, without observations]

Table B.4.X.2-1 provides horizontal positioning accuracy results using NR carrier phase positioning.

Table B.4.X.2-1: NR carrier phase positioning - horizontal accuracy from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **[Case ID], [Scenario]****[additional descriptions]** | **50%** | **67%** | **80%** | **90%** | **Met target requirements?** **(Yes/No)** | **Additional comments** |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

[Note: It is up to the companies whether to include additional descriptions for each case, and which information are included. For example, it may include the error sources considered in the evaluation of the case, and/or the number of carrieries, and/or DL or UL CPP, etc.]

Table B.4.X.2-2 provides horizontal positioning accuracy results using NR carrier phase positioning.

Table B.4.X.2-2: NR carrier phase positioning - vertical accuracy from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **[Case ID], [Scenario], [additional descriptions]** | **50%** | **67%** | **80%** | **90%** | **Met target requirements?** **(Yes/No)** | **Additional comments** |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

[Note: It is up to the companies whether to include additional descriptions for each case, and which information are included. For example, it may include the error sources considered in the evaluation of the case, and/or the number of carrieries, and/or DL or UL CPP, etc.]

[Note: Companies are welcome to provide results in the form of CDF figure. It is recommended to limit figure scale X- axis [0 : 0.1 : 5]m or less and Y-axis [0 : 0.1 : 1]. Legends of lines recommended to be marked by tags: [Case ID], [Scenario].]Annex B.5: Evaluation Results for Low Power High Accuracy Positioning

## B.5.X Results from source [X]

## B.5.X.1 Description of evaluation scenarios

[Brief descriptions of the evaluated scenarios]

Evaluation cases and corresponding assumptions for UE power consumption analysis are provided in Table B.5.X.1-1. [multiple tables are OK]

Table B.5.X.1-1: Low Power High Accuracy Positioning - Evaluation cases and assumptions from [X]

|  |  |  |  |
| --- | --- | --- | --- |
| Evaluation assumption | [Case ID], [Frequency Band], [Positioning method], [LPHAP device type] | [Case ID], [Frequency Band], [Positioning method], [LPHAP device type] | [Case ID], [Frequency Band], [Positioning method], [LPHAP device type] |
| Sleep state |  |  |  |
| DRX cycle |  |  |  |
| paging reception |  |  |  |
| RS periodicity |  |  |  |
| M-sample |  |  |  |
| RRM measurement |  |  |  |
| BWP switching |  |  |  |
| Measurement reporting (e.g., RA/CG-SDT, reporting interval) |  |  |  |
| Implementation factor K |  |  |  |
| Note: Companies are recommended to provide the following information for each evaluation case:* Case ID
* Positioning method: e.g., UE-assisted DL positioning, UL positioning, UE-assisted DL+UL positioning, etc.
* Frequency range: e.g., FR1
* LPHAP device type: e.g., Type A, Type B
 |

## B.5.X.2 Evaluation results for Low Power High Accuracy Positioning

[Brief description of the content, without observations]

Table B.5.X.2-1 provides detailed UE power consumption results for each evaluated case.

Table B.5.X.2-1: UE power consumption results for each evaluation case from [X]

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Evaluation case | Power states | Relative power unit | Duration (in slots) | Instances | Sum Durations (in slots) | Relative power | Power ratio |
| Case ID | e.g., Deep/light/micro sleep, SSB, paging, PRS measurement, UL, SRS, etc |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Total (every power cycle) |  |  |  |
| Slot-averaged power unit |  |
| Battery life (in month) |  |

Table B.5.X.2-2 provides summary of UE power consumption results for each evaluated case.

Table B.5.X.2-2: Summary for UE power consumption results from [X]

|  |  |  |  |
| --- | --- | --- | --- |
| Evaluation case description | Slot-averaged relative power unit (P2) | Battery life (in month) | Target requirements met? (Yes/No); If no, provide gaps |
| 6 months | 12 months |
| [Case ID], [Rel-17, or potential enhancements] |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

Annex B.6: Evaluation Results for Positioning for RedCap UEs

## B.6.X Results from source [X]

## B.6.X.1 Description of evaluation scenarios

[Brief descriptions of the evaluated scenarios]

Evaluation assumptions for system level analysis are provided in Table B.6.X.1-1 [multiple tables are OK]

Table B.6.X.1-1: NR RedCap UE positioning - evaluation scenarios and parameters from [X]

|  |  |
| --- | --- |
| Parameter | Case XYZ (channel model, FRx) |
| Scenario (baseline, otherwise state any modifications) |  |
| Carrier frequency |  |
| Subcarrier spacing |  |
| Reference Signal Transmission Bandwidth |  |
| Reference Signal Physical Structure and Resource Allocation (RE pattern) (reference to figure in contribution) |  |
| Reference signal(type of sequence, number of ports, …) |  |
| Number of sites |  |
| Number of symbols used per occasion |  |
| number of occasions used per positioning estimate |  |
| Power-boosting level |  |
| Uplink power control (applied/not applied) |  |
| interference modelling (ideal muting, or other) |  |
| Description of Measurement Algorithm (e.g., super resolution, interference cancellation, ….) |  |
| Description of positioning technique / applied positioning algorithm (e.g., Least square, Taylor series, etc) |  |
| Network synchronization assumptions |  |
| UE/gNB RX and TX timing error |  |
| Beam-related assumption (beam sweeping / alignment assumptions at the tx and rx sides) |  |
| Precoding assumptions (codebook, nrof antenna elements used, etc) |  |
| UE antenna configuration |  |
| Number of UE branches |  |
| Description of enhancement solutions, if any |  |
| gNB antenna configuration  |  |
| UE noise figure  |  |
| UE antenna height |  |
| gNB antenna height |  |
| Additional notes, if any |  |

## B.6.X.2 NR RedCap UE positioning accuracy evaluation results

[Brief description of the content, without observations]

Table B.6.X.2-1 provides summary of …

Table B.6.X.2-1: Rel.16 NR RedCap UE positioning (baseline) - horizontal location error results from [X]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cases |  | 50% | 67% | 80% | 90% | Requirements met? (Yes/No) |
| Case #, channel model, FRx, positioning method  | (Optional) All UEs |  |  |  |  |  |
| Convex UEs |  |  |  |  |  |

Figure B.6.X.2-1 provides the results of …



Figure B.6.X.2-1: results from [X]

Annex X: Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-05 | RAN1#109-e | R1-2205398 |  |  |  | Baseline TR skeleton. | 0.0.0 |
| 2022-08 | RAN1#110 | R1-22xxxxx |  |  |  | Incorporating decisions from RAN1 #109-e | 0.1.0 |