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| Technical Report |
| 3rd Generation Partnership Project;  Technical Specification Group Radio Access Network;  Study on NR Positioning Enhancements;  (Release 17) |
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For definitive guidance on drafting 3GPP TSs and TRs, see [3GPP TS 21.801](http://www.3gpp.org/DynaReport/21801.htm) supplemented by the 3GPP web page <http://www.3gpp.org/specifications-groups/delegates-corner/writing-a-new-spec>.

Ensure all blue guidance text is removed before submitting the TS/TR to the TSG for approval.

# 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 NR positioning enhancements" [2]. 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 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] RP-193237: "new SID on NR Positioning Enhancements".

[3] 3GPP TR 38.855: "Study on NR Positioning (Release 16)".

…

[x] <doctype> <#>[ ([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

# 3 Definitions of terms, symbols and abbreviations

This clause and its three subclauses are mandatory. The contents shall be shown as "void" if the TS/TR does not define any terms, symbols, or abbreviations.

## 3.1 Terms

For the purposes of the present document, the terms 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].

**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> <Explanation>

## 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].

<ABBREVIATION> <Expansion>

# 4 General description of NR positioning

*(General description of NR positioning up to release 16 & NR positioning enhancements in rel17)*

# 5 Target requirements for NR positioning enhancements in Rel-17

## 5.1 Target requirements

## 5.2 Performance evaluation metrics

(Includes horizontal accuracy vertical accuracy and other metrics)

For evaluating performance of NR positioning technologies, the following metrics apply. The following percentiles of positioning error are analyzed: 50%, 67%, 80%, 90%.

### 5.2.1 Horizontal accuracy

### 5.2.2 Vertical accuracy

### 5.2.3 Other metrics

#### 5.2.3.1 Latency

Latency includes higher layer and physical layer latency.

The physical layer latency start- and end-time are defined for each positioning method in table 5.2.3.1-1

Table 5.2.3.1-1: Definition of physical layer latency start- and end-time

| Method | Start | End |
| --- | --- | --- |
| UE assisted DL-only & DL-ECID & Multi-RTT | Transmission of the PDSCH from the gNB carrying the LPP Request Location Information message | Successful decoding of the PUSCH carrying the LPP Provide Location Information message |
| UL-only method & UL ECID & Multi-RTT | Reception by the gNB of the NRPPa measurement request message | The transmission by the gNB of the NRPPa measurement response message |
| UE-based |  | Successful decoding of the PUSCH at gNB carrying the LPP Provide Location Information message if applicable, otherwise Calculation of Location Estimate at the UE |

#### 5.2.3.2 Network efficiency

PRS/SRS resource utilization is the metric used to evaluate network efficiency.

#### 5.2.3.3 Device efficiency

#### 5.2.3.4 UE power consumption

The UE power consumption models developed in TR38.840 can be considered as the starting point for defining the UE power consumption model for the evaluation for NR positioning.

# 6 Additional scenarios and channel models for NR positioning enhancements

*From justification, for the evaluation of solutions, the Rel-16 scenarios and channel models in TR 38.855 are reused where applicable, and additional scenarios for IIoT use cases should be defined.*

*from objective 1a. Includes definition of additional scenarios (e.g. (I)IoT) based on TR 38.901 to evaluate the performance for the use cases e.g. (I)IoT)*

The scenario parameters common to all the scenarios in the study are detailed in table 6-1. In the evaluation of all scenarios, the absolute-time-of arrival model defined in TR 38.901 is considered, without modification. Additionally, blockage model is not considered. For evaluations including UE mobility, the spatial consistency procedure defined in TR 38.901 is taken into consideration.

The evaluation methodology does not define any baseline reference signals. Configurations of DL PRS and UL SRS supported by Rel-16 specifications are used for evaluation of the achievable performance based on Rel-16 positioning technologies.

Table 6-1: Common scenario parameters applicable for all scenarios

|  |  |  |
| --- | --- | --- |
|  | FR1 Specific Values | FR2 Specific Values |
| Carrier frequency, GHz | 3.5GHz | 28GHz |
| Bandwidth, MHz | 100MHz | 400MHz |
| Subcarrier spacing, kHz | 30kHz for 100MHz | 120kHz |
| gNB model parameters |  |  |
| gNB noise figure, dB | 5dB | 7dB |
| UE model parameters |  |  |
| UE noise figure, dB | 9dB – Note 1 | 13dB – Note 1 |
| UE max. TX power, dBm | 23dBm – Note 1 | 23dBm – Note 1  EIRP should not exceed 43 dBm. |
| UE antenna configuration | Panel model 1 – Note 1  Mg = 1, Ng = 1, P = 2, dH = 0.5λ, (M, N, P, Mg, Ng) = (1, 2, 2, 1, 1) | Baseline:  Multi-panel Configuration 1 and Panel Configuration a – Note 1  - Multi-panel Configuration 1: (Mg, Ng) = (1, 2); Θmg,ng=90°; Ω0,1=Ω0,0+180°; (dg,H, dg,V)=(0,0)  - Panel Configuration a:  - Each antenna array has shape dH=dV=0.5λ  - Config a: (M, N, P) = (2, 4, 2),  - the polarization angles are 0° and 90°  - The antenna elements of the same polarization of the same panel is virtualized into one TXRU  Optional:  4-panels UE:  - The antenna elements of the same polarization of the same panel is virtualized into one TXRU |
| UE antenna radiation pattern | Omni, 0dBi | Antenna model according to Table 6.1.1-2 in TR 38.855 |
| 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 companies * Note: RX and TX timing errors are generated per panel independently   Apply 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. | |
| Note 1: According to 3GPP TR 38.802  Note 2: According to 3GPP TR 38.901 | | |

## 6.1 IIoT use cases

For evaluating baseline performance, the following scenarios (with various options/configurations) are defined for RAT-dependent positioning techniques for the NR positioning enhancements study

- Scenario 1. InF-SH for FR1 and FR2

- Scenario 2. InF-DH for FR1 and FR2

Parameters specific to scenario 1and 2 are detailed in table 6.1-1

Table 6.1-1: Parameters common to InF scenarios

|  | | FR1 Specific Values | | FR2 Specific Values |
| --- | --- | --- | --- | --- |
| Channel model | | InF-SH, InF-DH | | InF-SH, InF-DH |
| Layout | Hall size | InF-SH:  (baseline) 300x150 m  (optional) 120x60 m  InF-DH:  (baseline) 120x60 m  (optional) 300x150 m | | |
| BS locations | 18 BSs on a square lattice with spacing D, located D/2 from the walls.  - for the small hall (L=120m x W=60m): D=20m  - for the big hall (L=300m x W=150m): D=50m | | |
| Room height | 10m | | |
| Total gNB TX power, dBm | | 24dBm | 24dBm  EIRP should not exceed 58 dBm | |
| gNB antenna configuration | | (M, N, P, Mg, Ng) = (4, 4, 2, 1, 1), dH=dV=0.5λ – Note 1 | (M, N, P, Mg, Ng) = (4, 8, 2, 1, 1), dH=dV=0.5λ – Note 1  One TXRU per polarization per panel is assumed | |
| gNB antenna radiation pattern | | Single sector – Note 1 | 3-sector antenna configuration – Note 1 | |
| Peneteration loss | | 0dB | | |
| Number of floors | | 1 | | |
| UE horizontal drop procedure | | Uniformly distributed over the horizontal evaluation area for obtaining the CDF values for positioning accuracy, The evaluation area should be  - (baseline) at least the convex hull of the horizontal BS deployment.  - (optional) It can also be the whole hall area if the CDF values for positioning accuracy is obtained from whole hall area. | | |
| UE antenna height | | Baseline: 1.5m  (Optional): uniformly distributed within [0.5, X2]m, where X2 = 2m for scenario 1(Inf-SH) and X2= for scenario 2 (InF-DH) | | |
| UE mobility | | 3km/h  (Optional): FFS | | |
| Min gNB-UE distance (2D), m | | 0m | | |
| gNB antenna height | | Baseline: 8m  (Optional): two fixed heights, either {4, 8} m, or {max(4,), 8}. | | |
| Clutter parameters: {density , height ,size } | | Low clutter density:  {20%, 2m, 10m}  High clutter density:  - Baseline): {40%, 2m, 2m} for fixed UE antenna height and gNB antenna height  - (Optional): {40%, 3m, 5m}  - (Optional): {60%, 6m, 2m} | | |
| Note 1: According to Table A.2.1-7 in 3GPP TR 38.802 | | | | |

## 6.2 General commercial use cases

For general commercial use cases, Rel-16 scenarios and channel models in TR 38.855 are reused. For the absolute time of arrival modelling in IOO, UMa, Umi, companies may provide the details of their model, if any.

# 7 Studied NR positioning enhancements

*(from objective 1c. Includes positioning techniques, DL/UL positioning reference signals, signalling and procedures for improved accuracy, reduced latency, network efficiency, and device efficiency for both RAN1 and RAN2.  
Enhancements to Rel-16 positioning techniques, if they meet the requirements, will be prioritized, and new techniques will not be considered in this case. )*

# 8 Performance evaluations for R17 performance targets

## 8.1 Performance analysis of Rel-16 positioning solutions

*Including accuracy and latency (objective 1b) performance, compared to rel17 performance targets*

## 8.2 Performance of studied NR positioning enhancements

*Including performance of positioning techniques, DL/UL positioning reference signals, signalling and procedures for improved accuracy, reduced latency, network efficiency, and device efficiency ((objective 1c).*

## 8.3 Efficiency analysis for NR positioning enhancements

## 8.4 Summary of performance evaluations

# 9 Positioning integrity and reliability

*From objective 2: Includes solutions necessary to support integrity and reliability of assistance data and position information:*

# 10 Identified NR impacts in Rel-17

# 11 Conclusions

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2020-05 | RAN1#101-e | R1-2004948 |  |  |  | Baseline TR skeleton. | 0.0.1 |
| 2020-10 | RAN1#103-e | R1-2008762 |  |  |  | Update of TR based on RAN1#101-e and RAN1#102-e agreements. | 0.1 |