**--------------------------------------- Start of template for collection of NR positioning results --------------------------------**

# 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

### 8.1.1 Positioning accuracy analysis

#### 8.1.1.1 Results from source [X]

Accuracy and latency analysis provided by Source X

##### 8.1.1.1.1 Description of evaluation scenarios

Brief description of evaluation scenarios and key evaluation parameters

It is recommended to put the following information into the table for each evaluated case

* Case ID: Case counter, starts from 1
* Scenario: InF-SH, InF-DH, ….
* Frequency Band: FR1 or FR2
* Positioning Technique: - e.g. name of R.16 positioning technique (R.16 DL-TDOA, R.16 UL-TDOA, R.16 Multi-RTT, R.16 DL-AOD, R.16 UL-AOA or their combination, etc.)

Evaluation assumptions for system level analysis are provided in Table 8.1.1.1.1-1.

Table 8.1.1.1.1-1: Rel.16 NR positioning - evaluation scenarios and parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | [Case ID], [Scenario], [Frequency Band], [Technique] | [Case ID], [Scenario], [Frequency Band], [Technique] | [Case ID], [Scenario], [Frequency Band], [Technique] |
| Channel model (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 Tx/Rx  Calibration Error |  |  |  |
| Beam-related assumption (beam sweeping / alignment assumptions at the tx and rx sides) |  |  |  |
| Precoding assumptions (codebook, nrof antenna elements used, etc) |  |  |  |
| Additional notes, if any |  |  |  |

##### 8.1.1.1.2 Positioning accuracy evaluation results

Table 8.1.1.1.2-1 provides summary of NR positioning evaluations results for horizontal location error.

Table 8.1.1.1.2-1: Rel.16 NR positioning - horizontal location error results from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 50% | 67% | 80% | 90% |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |

Table 8.1.1.1.2-2 provides summary of NR positioning evaluations results for vertical location error.

Table 8.1.1.1.2-2: Rel.16 NR positioning - altitude location error results from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 50% | 67% | 80% | 90% |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |

Companies are welcome to provide results in the form of CDF curves in figure format.

It is recommended to use common figure scale X- axis [0 : 0.2 : 3]m or less and Y-axis [0 : 0.1 : 1], where it is appropriate

It is recommended to mark legends by tags used for evaluation assumptions: [Case ID], [Scenario], [Frequency Band], [Technique]

##### 8.1.1.1.3 Observations on Rel-16 NR positioning accuracy

Table 8.1.1.1.3-1 captures observations based on NR positioning evaluations results for horizontal location error.

Table 8.1.1.1.3-1: Rel.16 NR positioning – horizontal accuracy performance summary [X]

|  |  |  |  |
| --- | --- | --- | --- |
| Simulation case  (Horizontal Error) | Commercial horizontal accuracy requirements [1]m @[90]% are met - Yes/No.  If no, provide performance gaps @[90]% | IIoT horizontal accuracy requirements of [0.2]m @[90]%are met - Yes/No. If no, provide performance gaps @[90]% | IIoT horizontal accuracy requirements of [0.5]m @[90]%are met -Yes/No.  If no, provide performance gaps @[90]% |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |

Table 8.1.1.1.3-2 captures observations based on NR positioning evaluations results for vertical location error.

Table 8.1.1.1.3-2: Rel.16 NR positioning – vertical accuracy performance summary [X]

|  |  |  |  |
| --- | --- | --- | --- |
| Simulation case  (Vertical Error) | Commercial vertical accuracy requirements [3]m @[90]% are met - Yes/No.  If no, provide performance gaps @[90]% | IIoT vertical accuracy requirements of [0.2]m @[90]% are met - Yes/No. If no, provide performance gaps @[90]% | IIoT vertical accuracy requirements of [1]m at @[90]% are met - Yes/No.  If no, provide performance gaps @[90]% |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |

### 8.1.2 Physical layer latency analysis for Rel-16

#### 8.1.2.1 Results from source [X]

Latency analysis provided by Source X

##### 8.1.2.1.1 Description of evaluation scenarios

Brief description of evaluation scenarios and key evaluation parameters.

##### 8.1.2.1.2 Latency analysis for Rel.16 solutions

At least the following information is provided for positioning physical layer latency analysis:

* Source initiating request for positioning measurements/location for a given UE (UE, Network))
* Destination awaiting for positioning measurements/location for a given UE (UE, Network)
* Start and end triggers/events for physical layer latency evaluation
* Initial and final RRC States of positioned UE (RRC IDLE, INACTIVE, CONNECTED) at the start and end time for the physical layer latency evaluation
* Positioning
  + technique (enumeration): (1) DL-TDOA , (2) DL AOD, (3) UL-TDOA, (4) UL-AOA, (5) Multi-RTT, (6) E-CID
  + type: DL, UL, DL+UL
  + mode: UE-based, UE-assisted
* Latency component w/ value range and description, including information on any parallel (simultaneous) components
* Total latency value

Latency components are recommended to be captured in table and ordered consequently in time starting from the earliest oneLatency analysis for the Rel.16 NR positioning is provided in Table 8.1.2.1.2-1.

Table 8.1.2.1.2-1: Rel.16 NR positioning latency [X]

|  |  |  |
| --- | --- | --- |
| [Case ID], [Scenario], [Frequency Band], [Technique]  Source [UE, NW]/Destination [UE, NW]  Positioning technique [DL-TDOA, E-CID, …], type [DL, UL, DL+UL], mode [UE-A, UE-B],  Initial and Final RRC States [IDLE, INACTIVE, CONNECTED] | | |
| Latency Components | Value Range, ms | Description of Latency Component |
| Start trigger |  |  |
| Name of component 1 |  |  |
| Name of component 2 |  |  |
|  |  |  |
| Name of last component |  |  |
| End trigger |  |  |
| Total values |  |  |

##### 8.1.2.1.3 Observations on Rel-16 NR positioning latency

Summary of latency performance analysis is provided in Table 8.1.2.1.3-1.

Table 8.1.2.1.3-1: NR positioning enhancements – latency performance summary [X]

|  |  |
| --- | --- |
| Description  Evaluation Case | L1 Latency, ms |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |

## 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).

### 8.2.1 Positioning accuracy analysis for NR positioning enhancements

#### 8.2.1.1 Results from source [X]

##### 8.2.1.1.1 Description of evaluation scenarios

Brief description of evaluation scenarios and key evaluation parameters.

It is recommended to put the following information into the table

* Case ID: Case counter, Case ID should increment from previous section
* Scenario: InF-SH, InF-DH,…
* Frequency Band: FR1, FR2
* Positioning Technique: - e.g. R.17 enhanced positioning technique (naming up to companies)

Evaluation assumptions for system level analysis of NR positioning accuracy enhancements are provided in Table 8.2.1.1.1-1.

Table 8.2.1.1.1-1: NR positioning enhancements - evaluation scenarios and parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | [Case ID], [Scenario], [Frequency Band], [Technique] | [Case ID], [Scenario], [Frequency Band], [Technique] | [Case ID], [Scenario], [Frequency Band], [Technique] |
| Channel model (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 Tx/Rx  Calibration Error |  |  |  |
| Beam-related assumption (beam sweeping / alignment assumptions at the tx and rx sides) |  |  |  |
| Precoding assumptions (codebook, nrof antenna elements used, etc) |  |  |  |
| Evaluated Enhancement  for Rel.17 |  |  |  |
| Additional notes, if any |  |  |  |

##### 8.2.1.1.2 Positioning accuracy evaluation results for NR positioning enhancements

Evaluation results of horizontal location error for NR positioning enhancements are provided in Table 8.2.1.1.2-1:

Table 8.2.1.1.2-1: NR positioning enhancements - horizontal location error results from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 50% | 67% | 80% | 90% |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |

Evaluation results of vertical location error for NR positioning enhancements are provided in Table 8.2.1.1.2-2:

Table 8.2.1.1.2-2: NR positioning enhancements - altitude location error results from [X]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | 50% | 67% | 80% | 90% |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] | Convex UEs |  |  |  |  |
| (Optional) All UEs |  |  |  |  |

Companies are welcome to provide results in the form of CDF curves in figure format.

It is recommended to use common figure scale X- axis [0 : 0.2 : 3]m or less and Y-axis [0 : 0.1 : 1], where it is appropriate

It is recommended to mark legends by tags used for evaluation assumptions: [Case ID], [Scenario], [Frequency Band], [Technique]

##### 8.2.1.1.3 Observations on NR positioning enhancements

Table 8.2.1.1.3-1 captures observations based on evaluations results of NR positioning enhancements for horizontal location error.

Table 8.2.1.1.3-1: NR positioning enhancements – horizontal accuracy performance summary [X]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Simulation case  (Horizontal Error) | Gain vs Rel.16 solution, @[90]%, [m] | Commercial horizontal accuracy requirements [1]m @[90]% are met - Yes/No.  If no, provide performance gaps | IIoT horizontal accuracy requirements of [0.2]m @[90]%are met - Yes/No. If no, provide performance gaps | IIoT horizontal accuracy requirements of [0.5]m @[90]%are met -Yes/No.  If no, provide performance gaps |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |  |

Table 8.2.1.1.3-2 captures observations based on evaluations results of NR positioning enhancements for vertical location error.

Table 8.2.1.1.3-2: NR positioning enhancements – vertical accuracy performance summary [X]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Simulation case  (Vertical Error) | Gain vs Rel16 solution @[90]%, [m] | Commercial vertical accuracy requirements [3]m @[90]% are met - Yes/No.  If no, provide performance gaps @[90]% | IIoT vertical accuracy requirements of [0.2]m @[90]% are met - Yes/No. If no, provide performance gaps @[90]% | IIoT vertical accuracy requirements of [1]m at @[90]% are met - Yes/No.  If no, provide performance gaps @[90]% |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |  |  |

### 8.2.2 Physical layer latency analysis for NR positioning enhancements

#### 8.2.2.1 Results from source [X]

##### 8.2.2.1.1 Description of evaluation scenarios

Brief description of evaluation scenarios and key evaluation parameters.

##### 8.2.2.1.2 Latency analysis of NR positioning enhancements

Companies are invited to briefly describe enhancement comparing to R.16

At least the following information is provided for positioning physical layer latency analysis:

* Source initiating request for positioning measurements/location for a given UE (UE, Network)
* Destination awaiting for positioning measurements/location for a given UE (UE, Network)
* Start and end triggers/events for physical layer latency evaluation
* Initial and final RRC States of positioned UE (RRC IDLE, INACTIVE, CONNECTED) at the start and end time for the physical layer latency evaluation
* Positioning technique and enhancements
* Latency component w/ value range and description, including information on any parallel (simultaneous) components
* Total latency value

Latency components are ordered consequently in time starting from the earliest one

Summary of latency performance analysis for NR positioning enhancements is provided in Table 8.2.2.1.2-1.

Table 8.2.2.1.2-1: NR positioning enhancements – latency analysis [X]

|  |  |  |
| --- | --- | --- |
| [Case ID], [Scenario], [Frequency Band], [Technique]  Source [UE, NW] / Destination [UE, NW]  Positioning technique [DL-TDOA, E-CID, …], type [DL, UL, DL+UL], mode [UE-A, UE-B],  Initial and Final RRC States [IDLE, INACTIVE, CONNECTED] | | |
| Latency Component | Value Range, ms | Description of Latency Component |
| Start trigger |  |  |
| Name of component 1 |  |  |
| Name of component 2 |  |  |
|  |  |  |
| Name of last component |  |  |
| End trigger |  |  |
| Total values |  |  |

##### 8.2.2.1.3 Observations on NR positioning latency enhancements

Observations on NR positioning latency enhancements are provided in Table 8.2.2.1.3-1.

Table 8.2.2.1.3-1: NR positioning enhancements - physical layer latency performance summary [X]

|  |  |  |
| --- | --- | --- |
| Description  Evaluation Case | L1 Latency,ms | Gain over R16, ms |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |
| [Case ID], [Scenario], [Frequency Band], [Technique] |  |  |

## 8.3 Efficiency analysis for NR positioning enhancements

### 8.3.1 Network efficiency analysis for NR positioning enhancements

#### 8.3.1.1 Results from source [X]

##### 8.3.1.1.1 Description of evaluation scenarios

Brief description of evaluation scenarios and key parameters of evaluation. section

##### 8.3.1.1.2 Network efficiency analysis of NR positioning enhancements

Companies are invited to briefly describe enhancement comparing to R.16.

Companies are invited to describe the methodology/model of network efficiency analysis.

##### 8.3.3.1.3 Observations on network efficiency of NR positioning enhancements

Companies are invited to present the observations/results based on their evaluation/analysis of network efficiency for NR positioning enhancements.

### 8.3.2 UE efficiency analysis for NR positioning enhancements

#### 8.3.2.1 Results from source [X]

##### 8.3.2.1.1 Description of evaluation scenarios

Brief description of evaluation scenarios and key parameters of evaluation. section

##### 8.3.2.1.2 UE efficiency analysis of NR positioning enhancements

Companies are invited to briefly describe enhancement comparing to R.16.

Companies are invited to describe the methodology/model of UE efficiency analysis.

##### 8.3.2.1.3 Observations on UE efficiency of NR positioning enhancements

Companies are invited to present the observations/results based on their evaluation/analysis of UE efficiency for NR positioning enhancements.

**--------------------------------------- End of template for collection of NR positioning results ---------------------------------**