**3GPP TSG RAN meeting #89e RP-201780**

**Electronic Meeting, September 14-18, 2020**

## Status Report to TSG

**Agenda item:** 9.7.3

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **WI / SI Name** | NR Positioning Enhancements | | | | |
| included in this status report | Study Item:  Yes | Core part:  No | Performance part:  No | | Testing part:  No |
| **Acronym** | FS\_NR\_Pos\_Enh | | | | |
| **Unique ID** | 860034 | | | | |
| **TSG Tdoc of latest approved WI/SI description (if any)** | RP-200928 | | | | |
| **Target Completion Date**  **(indicate if changed)** | Study Item:  12/2020 | Core part:  NA | Performance part:  NA | Testing part:  NA | |
| **Overall Completion level** | Study Item:  50% | Core part:  NA | Performance Part:  NA | Testing part:  NA | |

Note: Overall completion level percentage numbers should use one of the colors below:

* xx%: Normal progress, no RAN plenary action needed
* xx%: Progress behind schedule, may need RAN plenary intervention. If so, SR should clearly define requested action
* xx%: Progress critically behind, RAN plenary shall intervene. SR should define requested action

**Source:**

|  |  |  |
| --- | --- | --- |
| **Leading WG** | | RAN1 |
| **Rapporteur** | **Name** | Ren DA |
| **Company** | CATT |
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| **Rapporteur** | **Name** | Yi GUO |
| **Company** | Intel Corporation |
| **Email** | yi.guo@intel.com |

## 1 Work plan related evaluation

|  |  |
| --- | --- |
| **Do you want to modify the time budget for this WI/SI compared to what was endorsed at the last RAN meeting?** | No |

*If you answered No: Then please remove the Excel file from the zip file of this status report.*

*If you answered Yes: Then please fill out the attached Excel template to request a modification of the time budgets for your WI /SI. The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI. The basis are the endorsed time budgets of the last RAN meeting. Please highlight all changes of the values.  
 One time unit (TU) corresponds to ~ 2 hours in the meeting.  
 If this status report covers a WI with Core and Performance part, then please have one line for each in the attached Excel table.  
 Note: If no Excel table is attached, then this means no time budget change.*

**Additional explanations/motivations for the time budget changes in the attached Excel table:**

## 2. Detailed progress in RAN WGs since last TSG meeting (for all involved WGs)

NOTE: Agreements and Open issues impacted cross-TSG aspects shall be explicitly highlighted

## 2.1 RAN1

#### 2.1.1 Agreements

Agreements (RAN1#101-e)

Agreement:

* InF-SH and InF-DH models in TR 38.901 are adopted as the baseline scenarios for defining the channel models, parameters and modelling techniques for performance evaluations in the Rel. 17 positioning enhancements at least for IIoT use cases
* Note: Modifications to parameters in the InF-DH models will be discussed separately.
* Note: Target performance and performance gap identification will be discussed separately.
* Note: Individual companies may consider additional InF models in TR 38.901 as complementary evaluation scenarios in their simulation investigation and the evaluation results can be considered to be captured in the TR 38.857.
* Note: Target positioning requirements may not necessarily be reached for all scenarios.

Agreement (Proposal 4.1-1, Revision #2, in Section 4.1 of R1-2004868):

* Adopt the parameters defined in Table below as the baseline parameters for all scenarios in the evaluation of the positioning performance in Rel-17.
* Note: Individual companies may consider additional parameter values or different parameter settings in their simulation investigation
* Note: Optional scenarios and assumptions will be discussed separately and can be included

**Table: 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: FFS |
| 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) | |
| Note 1: According to 3GPP TR 38.802  Note 2: According to 3GPP TR 38.901 | | |

Agreement:

Optional: The following UE antenna configuration can be considered

* 4 UE panels:
  + The antenna elements of the same polarization of the same panel is virtualized into one TXRU
* FFS: Other details

Agreement:

Absolute-time-of arrival model defined in TR 38.901 without modification is considered in the evaluation of all scenarios.

Agreement:

Blockage model is not considered in the evaluation of all scenarios

Agreement: (Proposal 5.1-4, Revision 3, in Section 5.1 of R1-2004961)

* Adopt the parameters defined in the Table below as the baseline parameters for all InF scenarios in the evaluation of positioning performance in Rel-17.
* Note: Individual companies may consider additional parameter values or different parameter settings in their simulation investigation

Table: Parameters common to InF scenario(s)

|  | | 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 at least the convex hull of the horizontal BS deployment. 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): FFS | | |
| UE mobility | | 3km/h  (Optional): FFS | | |
| Min gNB-UE distance (2D), m | | 0m | | |
| gNB antenna height | | Baseline: 8m  (Optional): FFS | | |
| Clutter parameters: {density , height ,size } | | Low clutter density:  {20%, 2m, 10m}  High clutter density:  See Proposal 5.1-7 | | |
| Note 1: According to Table A.2.1-7 in 3GPP TR 38.802 | | | | |

Agreement:

Optional: For evaluating vertical positioning performance, UE antenna height can be uniformly distributed within [0.5, X2]m, where X2 = 2m for InF-SH and X2= for InF-DH defined in TR 38.901.



Agreement:

Clutter parameters {density , height ,size } for high clutter density are set as follows:



* (Baseline): {40%, 2m, 2m} for fixed UE antenna height and gNB antenna height
* (Optional): {40%, 3m, 5m}
* (Optional): {60%, 6m, 2m}

Agreement:

It will be left to companies to define the configurations for DL PRS and UL SRS for the evaluation of positioning performance.

* Note: 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.

Agreement:

CDFs of positioning errors are used as performance metrics in NR positioning evaluation with at least the following percentiles 50%, 67%, 80%, 90%.

* Note: In addition to overall positioning accuracy performance, companies are encouraged to report the estimation accuracy of UE/gNB measurements (e.g., RSTD) for performance comparison.

Agreement:

For TR 38.857, the template used in TR 38.855 for the inclusion of simulation results is reused. In addition, the following parameters should be provided for each scenario together with the simulation results.

|  |  |
| --- | --- |
| **Parameter** | **[Source 1, scenario, FRx]** |
| Channel model (baseline, otherwise state any modifications) |  |
| Reference Signal Physical Structure and Resource Allocation (RE pattern) |  |
| Reference signal (type of sequence, number of ports, …) |  |
| Number of sites |  |
| Number of symbols used per slot per positioning estimate |  |
| Number of slots 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 |  |
| 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 |  |

Agreement:

CDF values for positioning accuracy for IIoT scenarios are derived based on:

* Case 1 (Required): The UEs inside the convex hull of the horizontal BS deployment area.
* Case 2 (Optional): All the UEs

Agreement:

Optional: For evaluating vertical positioning performance, gNB antenna height can also be set to two fixed heights, which is either {4, 8} m, or {max(4,), 8}.



Agreement:

Network efficiency and UE efficiency can be evaluated at least in an analytical manner.

* FFS: the definition of efficiency metric (e.g., the positioning performance (accuracy, latency) vs. PRS/SRS resource utilization etc.)
* Note: It will be up to each company on whether to use other methods (e.g., numerical simulation) for the evaluation.

Agreement:

* In Rel-17 target positioning requirements for **commercial use cases** are defined as follows:
  + Horizontal position accuracy (< 1 m) for [90%] of UEs
  + Vertical position accuracy (< [2 or 3] m) for [90%] of UEs
  + End-to-end latency for position estimation of UE (< [100 ms])
  + FFS: Physical layer latency for position estimation of UE (< [10 ms])
* In Rel-17 target positioning requirements for **IIoT use cases** are defined as follows:
  + Horizontal position accuracy (< X m) for [90%] of UEs
    - X = [0.2 or 0.5] m
  + Vertical position accuracy (< Y m) for [90%] of UEs
    - Y = [0.2 or 1] m
  + End-to-end latency for position estimation of UE (< [10ms, 20ms, or 100ms])
  + FFS: Physical layer latency for position estimation of UE (< [10ms])
* Note: Target positioning requirements may not necessarily be reached for all scenarios

Agreement:

Optional: UE mobility can be considered in evaluation with the consideration of the spatial consistency procedure defined in TR 38.901.

* FFS: the details of the mobility models

Agreement:

* UE power consumption for NR positioning can be optionally evaluated in the SI.
* Note: It is up to each company on how to evaluate the power consumption for positioning. 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

Agreement:

The TR skeleton in R1-2004948 is endorsed.

Agreement:

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

* FFS: X, Y

        Note: RX and TX timing errors are generated per panel independently

        FFS: how the Rx and Tx timing errors are applied

Agreement:

* In Rel-17 SI, for the evaluation of positioning enhancements for commercial use cases, no baseline scenario is defined. UMi, UMa and IOO scenario(s) defined in TR 38.855 can be considered as optional scenarios without modifications to existing configuration parameters.
* FFS: absolute time of arrival model for UMi, UMa and IOO scenarios

Agreement:

Physical layer latency can be evaluated through analysis and, optionally, numerical evaluation.

Agreement:

Higher layer positioning latency can be evaluated in this SI.

* FFS: how to evaluate higher-layer positioning latency
* FFS: which higher-layers should be included in the evaluation

Agreements (RAN1#102-e)

Agreement:

Physical Layer Latency Start and End times are defined as follows:

|  |  |  |
| --- | --- | --- |
| **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 | Transmission of the PDSCH from the gNB carrying the LPP Request Location Information if applicable, otherwise,   * Alt. 1: transmission of the PUSCH carrying the MG Request from the UE. * Alt. 2: Transmission of the PDSCH from the gNB carrying the LPP message containing the assistance data * Alt. 3: Start of the Reception of DL PRS   Note: Suggest to downselect this at the next meeting.  Note: The high layers latency components may be subject to adjustment for different alternatives. | Successful decoding of the PUSCH at gNB carrying the LPP Provide Location Information message if applicable, otherwise Calculation of Location Estimate at the UE |

Conclusion:

RAN1 will not define additional optional values for UE and gNB antenna heights for evaluations.

Conclusion:

RAN1 will not define additional details for the optional UE antenna configuration of 4 UE panels for evaluations.

Conclusion:

For power consumption evaluation, it is up to each company to detail their methodology (including power model) for evaluation.

Agreement:

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.

Conclusion:

For UE mobility, the details of the optional mobility model are left to companies.

Agreement:

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

* FFS: what is included in resource utilization, e.g. PRS/SRS/MG configurations, beam sweeping assumptions

Agreement:

For the absolute time of arrival modelling in IOO, UMa, Umi, companies may provide the details of their model, if any

Agreement:

Text proposal for LS to RAN WG2 and CC SA WG2 and RAN WG3 for analysis of latency of NR positioning protocols defined in Rel.16:

RAN1 evaluates physical layer latency and its potential reduction for NR Rel-17 positioning solutions. In order to evaluate End-To-End latency of NR positioning solutions the input from RAN2 is needed on latency components of NR/NG-RAN/5GC higher layer positioning protocols. RAN1 respectfully asks if RAN2 can provide a list of latency components with corresponding range of values for the existing and any potential enhanced NR positioning solutions, keeping in mind the End-To-End latency described as desired in the study item description (RP-200928)

Final LS approved in [R1-2007264](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_102\Docs\R1-2007264.zip)

Agreement:

Physical layer latency for DL only, UL only, DL+UL positioning solutions for UE-based and UE-assisted approaches are separately studied

Agreement:

Capture the following in TR as an observation:

* Performance analysis of baseline I-IoT InF scenarios shows that InF-SH scenario is characterized by high probability of LOS links. In InF-DH the probability of LOS links is reduced substantially while probability of NLOS links is increased accordingly.

Conclusion:

* Evaluations show that high probability of NLOS links and propagation delay offset imposed by NLOS links may cause performance degradation of positioning accuracy, that was especially observed in InF-DH scenario
* Initial evaluations have also shown that under certain ideal assumptions (e.g., synchronization error, Rx/Tx calibration error) the effective LOS/NLOS classification/detection, outlier determination/rejection techniques may be beneficial to improve NR positioning accuracy
* Note: Additional evaluations need to be performed before deciding whether and how to capture the above in the TR

Conclusion:

* It is observed that calibration errors of UE/gNB Tx/Rx timing may negatively impact accuracy of timing-based methods of Rel.16 positioning solutions when precise UE positioning is targeted.
* Note: Additional evaluations need to be performed before deciding whether and how to capture the above in the TR

Conclusion:

* Evaluations show that network synchronization errors may cause accuracy degradation of the DL-TDOA or UL-TDOA Rel-16 positioning solutions
* Note: Additional evaluations need to be performed before deciding whether and how to capture the above in the TR

Agreement:

* FFS whether Rel.16 granularity of timing measurement reports is enough to avoid degradation in I-IoT scenarios and meet positioning requirements

Agreement:

* 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
    - For Rel.16 solutions, it is based on specification for each solution
  + Initial and final RRC State 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 one:

|  |  |  |
| --- | --- | --- |
| **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** | **Description of Latency Component** |
| Start trigger |  |  |
| Name of component 1 |  |  |
| Name of component 2 |  |  |
|  |  |  |
| Name of last component |  |  |
| End trigger |  |  |
| Total values |  |  |

Agreement:

Partial staggering and non-staggering RE mapping of SRS for positioning with different combinations of comb-factors and symbol lengths will be investigated in Rel-17.

* The methods/signalling for addressing potential time-domain aliasing due to the partial/non-staggering RE mapping will be included in the study

Agreement:

* Semi-persistent and a-periodic transmission and reception of DL PRS will be investigated in Rel-17.
  + FFS: the details on when and how to enable semi-persistent and a-periodic DL PRS
  + FFS: to be supported for which positioning methods, e.g.,
    - UE-assisted and/or UE-based positioning
    - DL positioning and/or Multi-RTT
* On-demand transmission and reception of DL PRS will be investigated in Rel-17.
  + FFS: the details on when and how to enable on-demand DL PRS
  + FFS: to be supported for which positioning methods, e.g.,
    - UE-assisted and/or UE-based positioning
    - DL positioning and/or Multi-RTT
* Notes:
  + Semi-persistent means MAC-CE triggered
  + Aperiodic would correspond to DCI-triggered
  + On-demand corresponds to the UE-initiated or network-initiated request of PRS and/or SRS. So, it is NOT the same as whether PRS is DCI-triggered or MAC-CE triggered. It is about UE or LMF request/suggesting/recommending specific PRS pattern, ON/OFF, periodicity, BW, etc.

Agreement:

* Multipath mitigation techniques will be investigated in this SI for improving positioning accuracy, which may include, but not limited to the following:
  + The applicable scenarios and performance benefits of multipath mitigation techniques
  + The methods/measurement/signaling for the LOS/NLOS detection and identification
  + The measurements for supporting the multipath mitigation/utilization
  + The procedure and signaling for supporting the multipath mitigation/utilization
  + Implementation-based solutions (e.g., outlier rejection) without the need of any additional specified method/measurements/procedures/signaling.
* Note: The above study applies to DL only, UL only, DL+UL positioning solutions for UE-based and UE-assisted positioning.

Agreement:

* NR positioning for UEs in RRC\_IDLE state and UEs in RRC\_INACTIVE state will be investigated in Rel-17, including the benefits on latency, network/UE efficiency and UE power consumption
* FFS: which positioning methods to be supported, e.g., DL positioning, UL positioning, DL+UL positioning and/or Multi-RTT
* FFS: the details of how to enable the UE positioning in RRC\_IDLE state and RRC\_INACTIVE state
  + Reference signals (e.g., based on DL PRS signals, UL SRS signals, both of them, etc.)
  + Signaling and procedures (e.g., based on PRACH procedure, paging triggered UL SRS transmission, etc.)

Agreement:

* For reducing NR positioning latency, more efficient signaling & procedures will be investigated to enable a device to request and report positioning information, which may include, but not limited to, the following aspects:
  + DL PRS/UL SRS configuration, activation or triggering.
  + The request for positioning information (the assistance data, etc.).
  + The report of positioning information (the measurement report, etc.).
* Note: It is not within RAN1 scope to analyze positioning architecture enhancements to enable such more efficient signaling & procedures.
* Note: RAN1 does not make any assumptions on whether the LCS architecture specified in TS 23.273 is enhanced or not.

Agreement:

* Aggregating multiple DL positioning frequency layers of the same or different bands for improving positioning performance for both intra-band and inter-band scenarios will be investigated in Rel-17, which may take into account at least the following
* The scenarios and performance benefits of aggregating multiple DL positioning frequency layers
* The impact of channel spacing, timing offset, phase offset, frequency error, and power imbalance among CCs to the positioning performance for intra-band contiguous/ non-contiguous and inter-band scenarios
* UE complexity considerations
* Note: What is captured in the TR will be discussed separately.

Agreement:

Simultaneous transmission by the UE and reception by the gNB of the SRS for positioning across multiple CCs and multiple slots can be investigated in Rel-17, which may consider

* The scenarios and performance benefits of the enhancement
* The impact of channel spacing, TA and timing offset, phase offset, frequency error, and power imbalance across slots or CCs to the positioning performance for intra-band contiguous/ non-contiguous and inter-band scenarios

Agreement:

The scenario, benefits, and methods for improving the accuracy of the UL AoA and DL-AoD methods for both UE-based and network-based (including UE-assisted) positioning can be investigated in Rel-17.

Agreement:

The scenario, benefits, methods and signaling for improving positioning accuracy in the presence of the UE Rx/Tx transmission delays, and/or and gNB Rx/Tx transmission delays, will be investigated for UE-based and network-based (including UE-assisted) positioning in Rel-17.

#### 2.1.2 Remaining Open issues

RAN1#101-e is the first RAN1 meeting of this SI. According to the meeting arrangement, RAN1 started working on the following objectives in SID:

* Defining the additional scenarios (e.g. (I)IoT) based on TR 38.901 to evaluate the performance for the use cases (e.g. (I)IoT). [RAN1]
* Evaluate the achievable positioning accuracy and latency with the Rel-16 positioning solutions in (I)IoT scenarios and identify any performance gaps. [RAN1]

In RAN1#101-e, RAN1 has defined the additional scenarios and completed the baseline simulation assumptions and some optional simulation assumptions for the additional scenarios.

In RAN1#102-e, RAN1 has continued working on above 1st objective and completed it.

In addition, RAN1 has continued working on above 2nd objective in RAN1#102-e. The evaluation is expected to be completed in RAN1#103-e.

Furthermore, RAN1 has started discussing of the following objective in RAN1#102-e. RAN1’s work is expected to be completed in RAN1#103-e.

* Identify and evaluate positioning techniques, DL/UL positioning reference signals, signalling and procedures for improved accuracy, reduced latency, network efficiency, and device efficiency.  
  Enhancements to Rel-16 positioning techniques, if they meet the requirements, will be prioritized, and new techniques will not be considered in this case. [RAN1, RAN2]

## 2.2 RAN2

#### 2.2.1 Agreements

Agreements (RAN2#111-e)

**Enhancements for commercial use cases:**

Agreement:

RAN2 to study positioning in idle/inactive mode, on-demand PRS and latency analysis in the study phase.

Note: RAN2 will continue the discussion on E2E latency based on email discussion;

**Integrity-KPIs and use cases:**

Agreement:

Agreements:

* Start from the definitions of the four candidate KPIs. Additional definitions can be added when needed.

Agreements:

1. Agree to adopt the Target Integrity Risk (TIR), Alert Limit (AL) and Time-to-Alert TTA) as the Integrity KPIs.

2. Agree to the following definitions of the KPIs:

Target Integrity Risk (TIR)

The probability that the positioning error exceeds the Alert Limit (AL) without warning the user within the required Time-to-Alert (TTA).

NOTE: The TIR is usually defined as a probability rate per some time unit (e.g. per hour, per second or per independent sample).

Alert Limit (AL)

The maximum allowable positioning error such that the positioning system is available for the intended application. If the positioning error is beyond the AL, operations are hazardous and the positioning system should be declared unavailable for the intended application to prevent loss of integrity.

NOTE: When the AL bounds the positioning error in the horizontal plane or on the vertical axis then it is called Horizontal Alert Limit (HAL) or Vertical Alert Limit (VAL) respectively.

Time-to-Alert (TTA)

The maximum allowable elapsed time from when the positioning error exceeds the Alert Limit (AL) until the function providing position integrity annunciates a corresponding alert.

3. Agree to include the PL integrity definition with the following baseline; FFS if updates are needed.

Protection Level:

The PL is a statistical upper-bound of the positioning error that ensures that, the probability per unit of time of the true error being greater than the AL and the PL being less than or equal to the AL, for longer than the TTA, is less than the required TIR.

NOTE: When the PL bounds the positioning error in the horizontal plane or on the vertical axis then it is called Horizontal Protection Level (HPL) or Vertical Protection Level (VPL) respectively.

4. The additional definitions are FFS on a ‘need-to-define’ basis.

5. Agree to study the Automotive, IIoT and Rail use cases as illustrative examples.

6. Agree to the Skeleton for Section 9 of TR 38.857.

Note: RAN2 will continue the discussion via email discussion to capture any additional integrity use cases and open issues on integrity, and draft a TP incorporating the existing agreements and any further progress.

**Integrity-Error sources:**

Agreement:

Proposal 2: Error source for RAT-dependent positioning methods should be studied under RAN1. Send an LS to RAN1 to trigger the study on error sources for RAT-dependent positioning methods for positioning integrity

Proposal 3: RAN2 can independently study the error sources for RAT-independent positioning methods.

Proposal 5: RAN2 confirms that 4 possible sources of feared events are applicable for RAT-independent positioning in 3GPP system.

1. Faults in the correction data e.g.

a. Incorrect computation by the provider

b. External feared event impacting the provider

2. Faults in transmitting the data to the UE, e.g.

a. Data integrity faults

3. External feared events, e.g.

a. Satellite feared events

b. Atmospheric feared events

c. Multipath

4. UE faults

#### 2.2.2 Remaining Open issues

Commercial use cases:

- Continue the study on E2E latency, positioning in idle/inactive mode and on demand PRS;

Integrity-KPIs and use cases:

- To identify any additional use cases, definitions;

Integrity-error sources:

- To identify any additional error sources for RAT independent positioning methods;

Integrity- Methodologies for network-assisted and UE-assisted integrity:

## 2.3 RAN3

#### 2.3.1 Agreements

#### 2.3.2 Remaining Open issues

## 2.4 RAN4

#### 2.4.1 Agreements

#### 2.4.2 Remaining Open issues

## 2.5 RAN5

#### 2.5.1 Agreements

#### 2.5.2 Remaining Open issues

#### 2.5.3 Remaining Open issues with cross-WG dependencies

## 2.6 RAN6

#### 2.6.1 Agreements

#### 2.6.2 Remaining Open issues

## 3. Detailed progress in SA/CT WGs since last TSG meeting (for all involved WGs)

NOTE: This section only needs to be filled in for WI/SIs where there is a corresponding relevant WI/SI in SA/CT.

## 3.1 SAx/CTs

#### 3.1.1 Agreements with cross-TSG impacts

#### 3.1.2 Remaining Open issues with cross-TSG impacts

NOTE: This section should also flag any critical dependencies that need TSG attention.

## 4. References

NOTE: This can be e.g. a list of all related Tdocs in the affected WGs since last TSG, references to LSs, produced TRs/TSs, the work/study item description or status reports of previous TSGs.

1. R1-2005095 Session notes for 8.2 (Study on NR positioning enhancements) Ad-Hoc Chair (Ericsson)
2. R1-2003638 Work plan for Study on NR Positioning Enhancements CATT, Intel, Ericsson
3. R1-2004649 TR skeleton for TR 38.857 Ericsson
4. R1-2004948 TR skeleton for TR 38.857 Ericsson
5. R1-2004701 FL Summary for NR Positioning Enhancements Moderator (CATT)
6. R1-2004868 FL Summary #2 for NR Positioning Enhancements Moderator (CATT)
7. R1-2004961 FL Summary #3 for NR Positioning Enhancements Moderator (CATT)
8. R1-2005049 FL Summary #4 for NR Positioning Enhancements Moderator (CATT)
9. R1-2005049 FL Summary #4 for NR Positioning Enhancements Moderator (CATT)
10. R1-2005102 Summary of Email Discussion [101-e-Post-NR-Pos-Enh] Moderator (CATT)
11. R1-2005188 Summary #2 of Email Discussion [101-e-Post-NR-Pos-Enh] Moderator (CATT)
12. R1-2003639 Summary of discussion on IIoT Scenarios for NR Positioning Enhancements CATT
13. R1-2003906 Additional scenarios for evaluation Samsung
14. R1-2003963 Discussions on IIoT scenarios for positioning CMCC
15. R1-2004141 Discussion on additional scenarios for evaluation LG Electronics
16. R1-2004490 Considerations on Additional Scenarios for Evaluation Qualcomm Incorporated
17. R1-2003284 IIOT Scenarios for Positioning Futurewei
18. R1-2003295 Discussion on scenarios and evaluation methodology for Rel-17 positioning Huawei, HiSilicon
19. R1-2003427 Discussion on additional scenarios for NR positioning evaluation vivo
20. R1-2003479 Additional scenarios for evaluation on positioning enhancements ZTE
21. R1-2003640 IIoT use cases and scenarios for evaluation of NR Positioning Enhancements CATT
22. R1-2003719 Additional scenarios for evaluation of NR positioning Nokia, Nokia Shanghai Bell
23. R1-2003767 I-IoT scenarios for NR positioning evaluations Intel Corporation
24. R1-2004063 Discussion on Scenarios for Evaluation OPPO
25. R1-2004190 Considerations on Scenarios for Evaluations of IIoT Positioning Sony
26. R1-2004199 View on scenarios and evaluation parameters for Rel 17 positioning enhancement CEWiT
27. R1-2004517 Additional scenarios and considerations for NR positioning Fraunhofer IIS, Fraunhofer HHI
28. R1-2004650 Additional scenarios for performance evaluations Ericsson
29. R1-2003296 Performance evaluation for Rel-17 positioning Huawei, HiSilicon
30. R1-2003428 Evaluation of achievable accuracy and latency for NR positioning enhancements vivo
31. R1-2003480 Evaluation results of additional scenarios for positioning ZTE
32. R1-2003668 Evaluation of DL-AoD technique under IIOT scenario MediaTek Inc.
33. R1-2003768 Initial analysis of NR positioning performance in I-IoT scenarios Intel Corporation
34. R1-2004064 Evaluation of NR positioning in IIOT scenario OPPO
35. R1-2004651 Evaluation of Achievable Positioning Accuracy and Latency Ericsson
36. R1-2003547 Evaluation of Rel-16 Positioning for IIOT Futurewei
37. R1-2003641 Discussion of evaluation of NR positioning performance CATT
38. R1-2003720 Views on evaluation of achievable positioning accuracy and latency Nokia, Nokia Shanghai Bell
39. R1-2003907 Evaluation of achievable positioning accuracy and latency Samsung
40. R1-2003964 Discussions on evaluation methodology of latency CMCC
41. R1-2004191 Considerations on Evaluation of Positioning Accuracy and Latency Sony
42. R1-2004491 Initial Evaluation of achievable Positioning Accuracy & Latency Qualcomm Incorporated
43. R1-2004518 Evaluation of positioning enhancements Fraunhofer IIS, Fraunhofer HHI
44. R1-2003285 IIOT Positioning techniques Consideration Futurewei
45. R1-2003297 Discussion of positioning enhancement Huawei, HiSilicon
46. R1-2003429 Discussion on potential positioning enhancements vivo
47. R1-2003481 Potential NR positioning enhancements for Rel.17 ZTE
48. R1-2003642 Discussion of NR positioning enhancements CATT
49. R1-2003669 Views on Positioning enhancement for Rel-17 MediaTek Inc.
50. R1-2003701 Potential positioning enhancements BUPT
51. R1-2003721 Initial views on potential positioning enhancements Nokia, Nokia Shanghai Bell
52. R1-2003769 Potential NR positioning enhancements Intel Corporation
53. R1-2003908 Potential positioning enhancements Samsung
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55. R1-2003977 Positioning enhancements for RRC IDLE and RRC INACTIVE state UE Beijing Xiaomi Mobile Software
56. R1-2003988 Discussion on potential positioning enhancements Spreadtrum Communications
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60. R1-2004192 Potential Techniques for Positioning Enhancements Sony
61. R1-2004420 Discussion on potential techniques for NR Positioning Enhancements NTT DOCOMO, INC.
62. R1-2004492 Initial thoughts on Potential Positioning Enhancements Qualcomm Incorporated
63. R1-2004652 Potential enhancements for NR positioning in release 17 Ericsson
64. R1-2003430 Discussion on power consumption model for NR positioning enhancements vivo
65. R1-2003643 Discussion of NLOS IIoT channel modelling for NR positioning enhancement CATT
66. R1-2003909 Uplink Transmission Based Relative Positioning Samsung
67. R1-2004066 Analysis of NR Positioning for IIOT Scenarios OPPO
68. R1-2004609 Discussion of sidelink positioning Huawei, HiSilicon
69. R1-2004653 PRS separation based on Cyclic shifts Ericsson
70. R1-2007386 Session notes for 8.5 (Study on NR Positioning Enhancements) Ad-Hoc Chair (Ericsson)
71. R1-2006913 TP for additional scenarios and channel models in TR 38.857 Ericsson
72. R1-2005251 Additional consideration on evaluation methodology Huawei, HiSilicon
73. R1-2005283 Remaining Issues on Evaluation Assumptions FUTUREWEI
74. R1-2005379 Discussion on additional scenarios for NR positioning evaluation vivo
75. R1-2005462 Evaluation assumptions for NR positioning enhancements ZTE
76. R1-2005577 Remaining Issues on Scenarios for Evaluation of NR Positioning Sony
77. R1-2005710 Remaining issues on additional scenarios for evaluation of NR Positioning Enhancements CATT
78. R1-2005877 Remaining details on additional scenarios for NR positioning evaluations Intel Corporation
79. R1-2005990 Discussion on Scenarios for Evaluation OPPO
80. R1-2006066 Additional scenarios for evaluation BUPT
81. R1-2006148 Additional scenarios for evaluation Samsung
82. R1-2006214 Remaining issues on target performance requirement of IIoT use case CMCC
83. R1-2006238 UE mobility model for evaluation InterDigital, Inc.
84. R1-2006374 Discussion on additional scenarios for evaluation for NR positioning LG Electronics
85. R1-2006427 Additional scenarios for evaluation of NR positioning Nokia, Nokia Shanghai Bell
86. R1-2006458 Additional scenarios for evaluation Fraunhofer IIS, Fraunhofer HHI
87. R1-2006808 Considerations on Additional Scenarios for Evaluation Qualcomm Incorporated
88. R1-2006914 Remaining details on additional scenarios for evaluation Ericsson
89. R1-2007103 FL summary for additional scenarios for evaluation of NR positioning enhancements Moderator (Ericsson)
90. R1-2007209 FL summary#2 for additional scenarios for evaluation of NR positioning enhancements Moderator (Ericsson)
91. R1-2007285 FL summary#3 for additional scenarios for evaluation of NR positioning enhancements Moderator (Ericsson)
92. R1-2005252 Performance evaluation for Rel-17 positioning Huawei, HiSilicon
93. R1-2005380 Evaluation of achievable positioning accuracy and latency vivo
94. R1-2005463 Evaluation results based on NR Rel-16 positioning ZTE
95. R1-2005578 Initial Views on Evaluation of Positioning Accuracy and Latency Sony
96. R1-2005711 Discussion of evaluation of NR positioning performance CATT
97. R1-2005878 NR Positioning Performance in I-IoT Scenarios Intel Corporation
98. R1-2005991 Evaluation of NR positioning in IIOT scenario OPPO
99. R1-2006067 Evaluation of achievable positioning accuracy and latency BUPT
100. R1-2006149 Evaluation of achievable positioning accuracy and latency Samsung
101. R1-2006197 Evaluation of DL-TDOA and DL-AoD techniques under IIOT scenarios MediaTek Inc.
102. R1-2006215 Discussion on achievable positioning latency CMCC
103. R1-2006239 Discussion on evaluation of latency InterDigital, Inc.
104. R1-2006323 Considerations for Positioning Latency Evaluation Lenovo, Motorola Mobility
105. R1-2006375 Discussion on evaluation of achievable positioning accuracy and latency for NR positioning LG Electronics
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109. R1-2006809 Evaluation of achievable Positioning Accuracy & Latency Qualcomm Incorporated
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113. R1-2007262 Feature lead summary #2 for email discussion [102-e-NR-Pos-Enh-Eval-Acc-Lat] Moderator (Intel Corporation)
114. R1-2007263 Draft LS on Latency of NR Positioning Protocols Intel Corporation
115. R1-2007264 LS on Latency of NR Positioning Protocols RAN1, Intel Corporation
116. R1-2007358 Feature lead summary #3 for email discussion [102-e-NR-Pos-Enh-Eval-Acc-Lat] Moderator (Intel Corporation)
117. R1-2007359 Template for collection of NR positioning evaluation results Moderator (Intel Corporation)
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119. R1-2005284 Positioning Enhancements FUTUREWEI
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127. R1-2006068 Potential positioning enhancements BUPT
128. R1-2006150 Potential positioning enhancements Samsung
129. R1-2006194 Views on positioning enhancement for Rel-17 MediaTek Inc.
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133. R1-2006324 On Potential NR Positioning Enhancements Lenovo, Motorola Mobility
134. R1-2006376 Discussion on potential enhancements for NR positioning LG Electronics
135. R1-2006429 Views on potential positioning enhancements Nokia, Nokia Shanghai Bell
136. R1-2006460 Potential positioning enhancements Fraunhofer IIS, Fraunhofer HHI
137. R1-2006522 Initial Views on Potential Positioning Enhancements Apple
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144. R1-2006972 FL Summary for Potential Positioning Enhancements Moderator (CATT)
145. R1-2007111 FL Summary#2 for Potential Positioning Enhancements Moderator (CATT)
146. R1-2007172 FL Summary#3 for Potential Positioning Enhancements Moderator (CATT)
147. R1-2007210 FL Summary#4 for Potential Positioning Enhancements Moderator (CATT)
148. R1-2007343 FL Summary#5 for Potential Positioning Enhancements Moderator (CATT)
149. R1-2005382 Discussion on power consumption model for NR positioning enhancements vivo
150. R1-2005465 Channel state estimation based on prior channel information ZTE
151. R1-2005713 Discussion of NLOS channel modelling and network time synchronization for NR positioning CATT
152. R1-2005993 Analysis of NR Positioning for IIOT Scenarios OPPO
153. R1-2006151 Uplink Transmission Based Relative Positioning Samsung
154. R1-2006241 Discussion on positioning during idle/inactive mode InterDigital, Inc.
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160. R2-2006671 Skeleton proposals for TR38.857 CATT
161. R2-2006542 Proposed table of contents - Section 9 (positioning integrity) - TR 38.857 Swift Navigation, Ericsson, Intel Corporation
162. R2-2006749 Handling on Rel-16 leftover issue in Rel-17 Intel Corporation
163. R2-2006669 Summary on Rel-17 positioning enhancement discussion in RAN1 CATT, Intel Corporation, Ericsson
164. R2-2006672 Discussion on ehancements for commercial use cases CATT
165. R2-2008261 [AT111-e][612][POS] Assumptions for analysis of commercial use cases (Ericsson) Ericsson
166. R2-2006578 Discussion on R17 positioning enhancement Huawei, HiSilicon
167. R2-2006956 Enhancements for commercial use cases Ericsson
168. R2-2006567 Discussion on potential positioning enhancement vivo
169. R2-2007049 Discussion on positioning enhancements for commercial use cases Spreadtrum Communications
170. R2-2007629 NR Positioning Enhancements Qualcomm Incorporated
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172. R2-2007587 End-to-end latency reduction for DL/UL positioning InterDigital, Inc.
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174. R2-2007159 Discussion on on-demand DL-PRS OPPO
175. R2-2007170 Discussion on PRS enhancements Beijing Xiaomi Electronics
176. R2-2007157 Positioning for UE in RRC Idle and Inactive state OPPO
177. R2-2007173 Positioning enhancements for RRC IDLE and RRC INACTIVE state UE Beijing Xiaomi Electronics
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182. R2-2006673 Discussion on integrity KPIs and use cases CATT
183. R2-2006564 Identify positioning integrity use case and KPIs vivo
184. R2-2006579 Discussion on positioning integrity KPIs and relevant use cases Huawei, HiSilicon
185. R2-2006954 Positioning integrity KPIs and support for RAT dependent use cases Ericsson
186. R2-2007050 Discussion on positioning integrity KPIs and use cases Spreadtrum Communications
187. R2-2007646 Discussion on use cases and KPIs for position integrity ESA
188. R2-2007102 Discussion on Positioning Integrity Apple
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190. R2-2007936 Discussion of the positioning integrity definition ZTE Corporation, Sanechips
191. R2-2007073 Discussion on integrity and reliability for positioning based on an IIoT use case Sumitomo Elec. Industries, Ltd
192. R2-2007187 Discussion on Integrity of positioning information Sony
193. R2-2007937 Discussion of the integrity events and integrity failure ZTE Corporation, Sanechips
194. R2-2008263 [AT111-e][613][POS] Integrity Error Sources (Huawei) Huawei, HiSilicon
195. R2-2008613 LS on the error source for RAT-dependent positioning Huawei, HiSilicon
196. R2-2006580 Discussion on positioning integrity validation and reporting Huawei, HiSilicon
197. R2-2006674 Discussion on error sources, threat models, occurrence rates and failure modes CATT
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199. R2-2006955 Factors impacting positioning integrity Ericsson
200. R2-2007647 Discussion on GNSS position integrity error sources ESA
201. R2-2007938 Discussion of the positioning error sources, threat models and failure modes ZTE Corporation, Sanechips
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204. R2-2006581 Discussion for network-assisted and UE-assisted integrity Huawei, HiSilicon
205. R2-2006957 LPP signalling for integrity support of RAT dependent positioning Ericsson
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207. R2-2007238 Reporting movement model Fraunhofer IIS, Fraunhofer HHI
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31.08.2020 minor adaptations for RAN #89e

20.04.2020 minor adaptations for RAN #88e

18.02.2020 minor adaptations for RAN #87e

14.11.2019 minor adaptations for RAN #86

18.08.2019 minor adaptations for RAN #85

12.05.2019 minor adaptations for RAN #84

27.02.2019 minor adaptations for RAN #83

21.11.2018 completion levels with colours added (for RAN #82)

v04.81 31.07.2018 simplification of template and addition of cross-TSG aspects (for RAN #81)

v04.80 21.05.2018 minor adaptations for RAN #80

v04.79 26.02.2018 minor adaptations for RAN #79

v04.78 18.11.2017 minor adaptations for RAN #78

v04.77 06.08.2017 minor adaptations for RAN #77

v04.76 15.05.2017 minor adaptations for RAN #76

v04.75 31.01.2017 minor adaptations for RAN #75

v04.74 28.10.2016 minor adaptations for RAN #74

v04.73 01.09.2016 adaptations for RAN #73 (time units in extra Excel table, RAN6 reporting included)

v04.72 26.05.2016 adaptations for RAN #72 (introduction of NR & GERAN TUs)

v04.71 10.02.2016 minor adaptations for RAN #71

v04.70 30.10.2015 minor adaptations for RAN #70

v04.69 12.08.2015 minor adaptations for RAN #69

v04.68 21.05.2015 minor adaptations for RAN #68

v04.67 01.02.2015 minor adaptations for RAN #67

v04.66 16.11.2014 minor adaptations for RAN #66

v04.65 16.08.2014 minor adaptations for RAN #65

v04.64 22.05.2014 minor adaptations for RAN #64

v04.63 24.01.2014 restructuring for RAN #63 to cover Core & Perf. in one doc file

v03.62 11.11.2013 section 1.2.3 adapted for RAN #62

v03 11.08.2013 section 1.2.3 added on time budget

v02 07.05.2010 history added, some spelling corrections

v01 13.11.2009 First version of the template