**3GPP TSG RAN Meeting #102 RP-23xxxx**

**Edinburgh, Scotland, December 11th-15th, 2023** (revision of RP-232670)

**Source: Intel Corporation, CATT, Ericsson**

**Title: Revised WID on Expanded and Improved NR Positioning**

**Document for: Approval**

**Agenda Item: 9.3.1.9**

3GPP™ Work Item Description

Information on Work Items can be found at <http://www.3gpp.org/Work-Items>
See also the [3GPP Working Procedures](http://www.3gpp.org/specifications-groups/working-procedures), article 39 and the TSG Working Methods in [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm)

Title: Expanded and Improved NR Positioning

Acronym: NR\_pos\_enh2

Unique identifier: 981038

NOTE: For new WIs/SIs leave the Unique identifier empty and make a proposal for an Acronym.

 For a revised WI/SI: Take Unique identifier and acronym as shown in 3GPP workplan.

 If this is a RAN WID including Core and Perf. part, then Title, Acronym and Unique identifier refer to the feature WI.

 Please tick (X) the applicable box(es) in the table below:

 Either:

|  |  |
| --- | --- |
| **This WID includes a Core part** | **X** |
| **This WID includes a Performance part** | **X** |

 or:

|  |  |
| --- | --- |
| **This WID includes a Testing part** |  |
| **and it addresses the following 3GPP work area:** | **Radio Access** |  |
| **Core Network** |  |
| **Services** |  |

Potential target Release: *Rel-18*

NOTE: In case of contradiction with the target dates of clause 5, clause 5 determines the target release.

# 1 Impacts

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Affects:** | UICC apps | ME | AN | CN | Others (specify) |
| **Yes** |  | X | X | X |  |
| **No** | X |  |  |  |  |
| **Don't know** |  |  |  |  |  |

# 2 Classification of the Work Item and linked work items

### 2.1 Primary classification

This work item is a …

|  |  |
| --- | --- |
| X | Feature |
|  | Building Block |
|  | *Work Task* |
|  | Study Item |

NOTE: Normally, Core/Perf./Testing parts in RAN WIDs are Building Blocks. Only if they are under an SA or CT umbrella, they are defined as work tasks. If you are in doubt, please contact MCC.

### 2.2 Parent Work Item

For a brand-new topic, use “N/A” in the table below. Otherwise indicate the parent Work Item.

|  |
| --- |
| Parent Work / Study Items  |
| Acronym | Working Group | Unique ID | Title (as in 3GPP Work Plan) |
|  |  |  |  |

NOTE: RAN agreed some time ago, that it describes the feature WI + Core/Perf. part WI or Testing part WI in one WID. Therefore the table above should include the feature WI data (In case the feature covers Core and Perf. part, please list under Working Group the leading WG of the Core part).

### 2.3 Other related Work Items and dependencies

|  |
| --- |
| Other related Work/Study Items (if any) |
| **Acronym** | Unique ID | Title | Nature of relationship |
| FS\_NR\_pos\_enh2 | 940081 | Study on expanded and improved NR positioning | Preceding Study Item (Rel-18) |
| NR\_pos | 830077 | NR Positioning Support | Preceding Work Item (Rel-16) |
| FS\_NR\_pos\_enh | 860034 | Study on NR Positioning Enhancements  | Preceding Study Item (Rel-17) |
| NR\_pos\_enh | 900160 | NR Positioning Enhancements | Preceding Work Item (Rel-17) |
| FS\_NR\_pos\_cov | 880075 | Study on scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases | Preceding Study Item (Rel-17) |
| NR\_SL\_enh | 860042 | NR sidelink enhancement | Work item for NR sidelink communication enhancements (Rel-17) |
| 5G\_V2X\_NRSL | 830078 | 5G V2X with NR sidelink | Work item introducing NR sidelink communication (Rel-16) |

NOTE: Also related or dependent WIs/SIs in other TSGs shall be indicated here.

# 3 Justification

In Release 17, 3GPP RAN conducted studies on "NR Positioning Enhancements" and "Scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases".

The study on "Scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases" focused on V2X and public safety use cases with the outcome being captured in TR38.845. Additionally, SA1 has developed requirements in TS22.261 for "Ranging based services” and has developed positioning accuracy requirements in TS22.104 for IIoT use cases in out-of-coverage scenarios.

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 during Rel-17 work was on GNSS integrity, and for Rel-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.

Regarding higher accuracy, two additional techniques have been considered in Rel-18: one is to take 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 contiguous 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 accuracy but is limited to outdoor applications.

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 extremely 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, 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 Rel-17 NR positioning has introduced support for positioning in RRC\_INACTIVE state, whether the current system allows LPHAP requirements to be met was not evaluated during Rel-17.

Release-17 has specified support for RedCap UEs with reduced bandwidth support and reduced complexity including a 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.

Towards determination of the scenarios and requirements, bandwidth requirements, and solutions for support of sidelink ranging/positioning, enabling improved integrity, accuracy, and power efficiency for NR positioning solutions, and evaluation of positioning performance for RedCap UEs, a Rel-18 Study Item on “Study on Expanded and Improved NR Positioning” has been carried out by 3GPP. The outcome of the study are documented in 3GPP TR 38.859.

Based on the study, various features and enhancements have been recommended for normative work for support of sidelink ranging/positioning, support of integrity for RAT-dependent positioning methods, enhancements to enable LPHAP use-cases defined in TS 22.104, and support of positioning for RedCap UEs with acceptable positioning accuracy considering requirements for IIoT, commercial, Public Safety and V2X use-cases.

Based on the study, PRS/SRS bandwidth aggregation for intra-band contiguous carriers is concluded as feasible for single chain Tx/Rx architectures at both the UE and gNB. Another technique is the NR carrier phase positioning, which 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. Based on the study, it is concluded that it is feasible to use existing DL PRS and SRS signals to obtain the carrier phase measurements for achieving a horizontal accuracy of up to a few centimetres at least at 50% under certain conditions.

# 4 Objective

### 4.1 Objective of Core part WI

The objective of this work item is to specify solutions to introduce sidelink ranging/positioning, to introduce integrity for RAT-dependent positioning methods, to enable LPHAP use-case 6 defined in TS 22.104, to improve positioning accuracy, and to introduce support of positioning for RedCap UEs.

The specific objectives of this work item are:

* Specify solutions for support of sidelink positioning (including ranging) in NR systems, including the following [RAN1, RAN2, RAN3, RAN4]:
	+ Specify SL PRS for support of sidelink positioning such that the SL PRS uses a comb-based (full RE mapping pattern is not precluded) frequency domain structure and a pseudorandom-based sequence where the existing sequence of DL-PRS is used as a starting point [RAN1].
		- Specify support for SL PRS bandwidths of up to 100 MHz in FR1 spectrum.
		- NOTE: SL PRS transmission in FR2 is not precluded but no FR2 specific aspects will be specified.
	+ Specify measurements to support RTT-type solutions using SL, SL-AoA, and SL-TDOA [RAN1, RAN2].
	+ Specify support of resource allocation for SL PRS:
		- Including resource allocation Scheme 1 and Scheme 2, where Scheme 1 corresponds to a network-centric SL PRS resource allocation and Scheme 2 corresponds to UE autonomous SL PRS resource allocation [RAN1].
			* For resource allocation mechanism for SL PRS in Scheme 2:
				+ Study and specify support of sensing-based resource allocation, and/or a random resource selection [RAN1].
				+ Study and specify solutions for congestion control for SL PRS and/or inter-UE coordination for SL-PRS [RAN1].
		- Support resource allocation for shared resource pool with Rel-16/17/18 sidelink communication and dedicated resource pool for SL PRS [RAN1].
			* NOTE: For SL positioning resource (pre-)configuration in a shared resource pool with Rel-16/17/18 sidelink communication, backward compatibility with legacy Rel-16/17 UEs should be ensured.
	+ Specify procedures for transmit power control for SL PRS transmissions at least based on open loop power control (OLPC) [RAN1].
	+ Specify signalling and associated UE behavior for support of unicast, groupcast (not including many to one) and broadcast of SL PRS transmissions [RAN1, RAN2].
	+ Specify unicast session-based signalling and procedures to facilitate support of SL positioning for single target UE (it is not precluded to apply the procedures to multiple target UEs but no signaling optimizations will be considered for this case) [RAN2, RAN3]:
		- Specify the protocol and procedures for SL positioning between UEs (Protocol for Sidelink positioning procedures (SLPP)).
		- Specify the protocol and procedures for SL positioning between UEs and a single LMF for in coverage scenario only, including joint PC5-Uu scenarios.
			* NOTE: Assumes all involved UEs are served by same LMF.
		- For SL-TDOA, RAN2 will not work on procedures for synchronization of the anchor UEs. RAN2 can discuss and implement agreed RAN1 parameters related to synchronization.
	+ Specify signalling to NG-RAN for sidelink positioning and ranging service authorizations as needed. [RAN3, RAN2]
	+ Specify corresponding new core requirements, as well as identifying and specify the impact on the existing RAN4 specification, including RRM measurements and procedures [RAN4].
* Specify the error modelling parameters, signalling, and procedures to support UE-based and LMF-based integrity of RAT-dependent positioning methods [RAN2, RAN3].
* Specify enhancements for enabling LPHAP use-case 6 as defined in TS 22.104 including:
	+ Extending eDRX cycle beyond 10.24s in RRC\_INACTIVE state towards meeting the battery life requirement for LPHAP [RAN2, RAN3, RAN4]
		- Positioning-specific enhancement for eDRX cycle beyond 10.24s to be defined as part of Rel-18 WI on expanded and improved NR positioning.
			* NOTE: Work on this objective should be coordinated with that in Rel-18 WI on eRedCap. Towards this, the feature of extending eDRX cycle beyond 10.24s should be defined as part of Rel-18 WI on eRedCap.
		- NOTE: Inputs from RAN1 as necessary may be facilitated via LSs
	+ For UL and DL+UL positioning for UEs in RRC\_INACTIVE state, specify SRS configuration enhancements based on SRS positioning validity area to avoid frequent RRC connection for SRS (re)configuration [RAN2, RAN1, RAN3].
		- SRS for positioning configurations in multiple cells [RAN2, RAN1].
			* Note: Details including issues such as interference, timing advance, spatial relation information, pathloss reference and common SRS parameters across multiple cells can be further discussed during normative work.
		- Pre-configuration of one or multiple SRS for positioning configurations [RAN2, RAN3].
		- SRS for positioning activation/request procedure(s) [RAN2, RAN1].
	+ Specify solutions for DL PRS measurements for a UE in RRC\_IDLE state and reporting of the measurements in RRC\_CONNECTED state [RAN2].
	+ Specify solutions for alignment between (e)DRX in RRC\_INACTIVE and PRS configurations [RAN2].
	+ Specify corresponding new core requirements, as well as identifying and specifying the impact on the existing RAN4 specification, including RRM measurements and procedures [RAN4].
* Specify support of positioning for UEs with Reduced Capabilities (RedCap UEs)
	+ Specify support of Frequency Hopping (FH) beyond maximum RedCap UE bandwidth for reception of DL PRS and transmission of UL SRS for positioning [RAN1, RAN2].
		- NOTE: The complexity of the corresponding capabilities for RedCap UEs should be addressed for the introduction of appropriate capabilities for RedCap UEs.
	+ Specify RRM requirements for positioning including RRM measurements and procedures for RedCap UEs for both with and without frequency hopping [RAN4].
* Specify bandwidth aggregation for positioning measurements across up to three intra-band contiguous carriers [RAN1, RAN2, RAN4].
	+ Specify signalling and procedures to support aggregation of PRS/SRS (respectively) resources across PFLs/carriers (respectively) for positioning measurements under the assumption that the signals over aggregated resources are transmitted and received (respectively) using a single RF chain (same antenna) [RAN1, RAN2].
		- NOTE: The support of bandwidth aggregation for positioning measurements applies only to timing related measurements (e.g., RSTD, RTOA, and UE/gNB Rx-Tx time difference).
	+ Specify RRM requirements with measurement gaps in connected mode, and in inactive mode, including PRS measurement period/reporting [RAN4].
* Specify physical layer measurements and signalling to support NR DL and UL carrier phase positioning for UE-based, UE-assisted, and NG-RAN node assisted positioning [RAN1, RAN2, RAN3, RAN4].
	+ Existing DL PRS and UL SRS for positioning are used for NR carrier phase measurements.
	+ Specify measurements that are limited to a single carrier/PFL.
	+ Specify corresponding new core requirements, as well as identifying and specifying the impact on the existing RAN4 specification, including RRM measurements with measurement gaps in connected and inactive mode (including PRS measurement period/reporting) and procedures [RAN4].
* Define extensions of signalling, protocol, and procedure for NR positioning enhancement, as needed for the above objectives [RAN3].

### 4.2 Objective of Performance part WI

NOTE: Leave empty if the WI proposal does not contain a RAN performance part.

* Define corresponding performance requirements and test cases for expanded and improved NR positioning [RAN4]

### 4.3 RAN time budget request (not applicable to RAN5 WIs/SIs)

NOTE: For all new RAN related WIs/SIs which are not led by RAN WG5 the WI/SI rapporteur has to fill out the attached Excel table to request time budgets for corresponding RAN WG meetings.
The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI.
One time unit (TU) corresponds to ~ 2 hours in the meeting.
If no TU is needed, then leave the field empty otherwise enter a number >0 in the field.

 For revisions of already approved WI/SI descriptions: Please remove the Excel table from the WID/SID's zip file. The time budgets are already recorded. If you want to modify them, then this has to be done via the status report and not via a revised WID/SID.

 If this WID is covering Core and Performance part, then please fill out one line for each part in the attached Excel table.

**additional comments to the time budget request in the attached Excel table:**

# 5 Expected Output and Time scale

|  |
| --- |
| **New specifications** |
| Type  | TS/TR number | Title | For info at TSG#  | For approval at TSG# | Remarks |
| *TS* | *38.355* | *NR; Sidelink Positioning Protocol (SLPP); Protocol Specification* | *101* | *102* | *Core part, RAN2-led**Editor: Yi Guo (**yi.guo@intel.com**)* |

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
By default a new specs can only be new for one of both parts.

|  |
| --- |
| **Impacted existing TS/TR** |
| TS/TR No. | Description of change  | Target completion plenary# | Remarks |
| *38.201* | *NR; Physical layer; General description* | *101* | *Core part* |
| *38.202* | *NR; Services provided by the physical layer* | *101* | *Core part* |
| *38.211* | *NR positioning enhancements* | *101* | *Core part* |
| *38.212* | *NR positioning enhancements* | *101* | *Core part* |
| *38.213* | *NR positioning enhancements* | *101* | *Core part* |
| *38.214* | *NR positioning enhancements* | *101* | *Core part* |
| *38.215* | *NR positioning enhancements* | *101* | *Core part* |
| *38.305* | *NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN* | *103* | *Core part* |
| *37.355* | *Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)* | *102* | *Core part* |
| *37.340* | *Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Multi-connectivity; Stage 2* | *102* | *Core part* |
| *38.331* | *NR; Radio Resource Control (RRC); Protocol specification* | *102* | *Core part* |
| *38.321* | *NR;**Medium Access Control (MAC) protocol specification* | *102* | *Core part* |
| *38.306* | *NR; User Equipment (UE) radio access capabilities* | *102* | *Core part* |
| *38.300* | *NR; NR and NG-RAN Overall Description; Stage 2* | *102* | *Core part* |
| *38.304* | *NR; User Equipment (UE) procedures in Idle mode and RRC Inactive state* | *102* | *Core part* |
| *38.323* | *NR; Packet Data Convergence Protocol (PDCP) specification* | *102* | *Core part* |
| *38.401* | *NG-RAN; Architecture description* | *103* | *Core part* |
| *38.413* | *NG-RAN; NG Application Protocol (NGAP)* | *103* | *Core part* |
| *38.423* | *NG-RAN; Xn application protocol (XnAP)* | *103* | *Core part* |
| *38.455* | *NG-RAN; NR Positioning Protocol A (NRPPa)* | *103* | *Core part* |
| *38.470* | *NG-RAN; F1 general aspects and principles* | *103* | *Core part* |
| *38.473* | *NG-RAN; F1 application protocol (F1AP)* | *103* | *Core part* |
| *38.133* | *NR; Requirements for support of radio resource management -Core* | *102* | *Core part* |
| *38.133* | *NR; Requirements for support of radio resource management -Performance* | *104* | *Performance part and test cases* |

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
If an existing spec is affected by both (Core part and Perf. part), then it has to be listed twice with appropriate approval dates.

# 6 Work item Rapporteur(s)

*Chatterjee, Debdeep, Intel Corporation, debdeep.chatterjee@intel.com (RAN1, RAN4)*

*Jianxiang, Li, CATT,* *lijianxiang@catt.cn**(RAN2, RAN3)*

*Munier, Florent, Ericsson, florent.munier@ericsson.com (RedCap)*

NOTE: The first listed Rapporteur has the overall responsibility for this WI (incl all secondary tasks).

# 7 Work item leadership

*Primary: RAN1*

*Secondary: RAN2, RAN3, RAN4*

# 8 Aspects that involve other WGs

NOTE: For RAN WIs: Section 8 applies only to WGs outside of TSG RAN because all RAN WG aspects have to be covered in section 4.

RAN working groups will take into account the work from other working group SA/CT which involves the same or related objectives.

# 9 Supporting Individual Members

|  |
| --- |
| Supporting IM name |
| AT&T |
| Bosch |
| CATT |
| CEWiT |
| CMCC |
| Ericsson |
| FirstNet |
| Fraunhofer HHI |
| Fraunhofer IIS |
| Futurewei |
| HiSilicon |
| Huawei |
| Intel Corporation |
| InterDigital |
| KT Corp. |
| Lenovo |
| LG Electronics |
| MediaTek Inc. |
| Motorola Mobility |
| NEC |
| Nokia |
| Nokia Shanghai Bell |
| OPPO |
| Polaris Wireless |
| Qualcomm |
| Reliance Jio |
| Samsung |
| Sanechips |
| Sharp Corp. |
| SONY |
| Telefónica |
| TOYOTA Info Technology Center |
| Vivo |
| Vodafone |
| Xiaomi |
| ZTE |