**3GPP TSG-RAN2 Meeting #117-e *Draft R2-2203605***

**Online, 21 Feb- 3 March, 2022**

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| *CR-Form-v12.2* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **38.305** | **CR** | **CRNum** | **rev** | **-** | **Current version:** | **16.7.0** |  |
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| *For* [***HELP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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| ***Title:*** | Running 38.305 CR for Positioning WI on RAT dependent positioning methods | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Intel Corporation | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_pos\_enh-Core | | | | |  | ***Date:*** | | | 2022-02-14 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | B |  | | | | | ***Release:*** | | | Rel-17 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-15 (Release 15) Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | To capture positioning related agreements into TS38.305. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | **RAN2#117**  1 Remove section 8.13.2.4 and 8.13.2.5 (the information between UE and gNB for TEG) .  2 to revise the stage-2 “Sequence of Procedure for UL-TDOA positioning” in TS 38.305 to include RRC message exchange to convey the UE Tx TEG association information to the gNB.  3revise the stage-2 7.x.1 as “- On-Demand PRS transmission procedure allows the LMF to control whether PRS is transmitted or not and to change the characteristics of an ongoing PRS transmission. The on-demand PRS transmission procedure can be initiated either by the UE or LMF.”  4revise the stage-2 7.x.2 as “-put step1 in the box of UE Initiated On-Demand PRS. ”  5 revise the stage-2 7.x.2 as “-put The LPP Request Assistance Data message for On-Demand PRS may also be sent in an MO-LR location service request message. As a Note”  5revise the stage-2 7.x.2 as “-step 2b, - Add “In case of LMF-initiated On-Demand PRS” at the beginning of stage 2b, and remove “available PRS configuration.”  6revise the stage-2 7.x.2 as “-step 3, -Change “or change to PRS transmission characteristics” to “or change to the transmission characteristics of an ongoing PRS transmission”  7 revise the stage-2 7.x.2 as “-put step 7, as a Note”  8 revise the stage-2 7.x.2 as “-remove posSI”  9capture MG and PPW in section 7.y, 7.z. Add step 3 for PPW and use solid line, remove first sentence from step 3 of 7.y.2, editorial changes in 7.z.1.  10 Update storing UE capability as The LMF may interact with the AMF to provide (updated) UE Positioning Capability to AMF and to receive stored UE Positioning Capability from AMF as described in TS 23.273 [35]  11 Capture positioning in RRC\_INACTIVE in section 7.w  **RAN2#116bis:**  Updated based on TS38.305 v16.7.0 (no realy change)  On-Demand PRS  Section 7.x.1   * Editorial change, removed “the”;   Section 7.x.2:  -Removed “Editor's Note: FFS if the UE can send the MO-LR to request On-Demand PRS.” Since it has been agreed in last meeting;  - Removed “Editor's Note: FFS on the content of On-Demand PRS request.” Since it will not impact stage 2;  **Postmeeting-629:**  1 Include a "Scheduled Location Time" with measurement time information in LPP CommonIEsRequestLocationInformation, defining the desired time when the location measurements or location estimate is to be obtained/valid. [7.3.2, 7.3.3, 7.3.4]  2 Proposal 3a (modified): Pre-configured DL-PRS assistance data can be associated with a "validity area" at least in LPP. [3.1, 8.10.3, 8.11.3, 8.12.3]  3 The pre-configured Measurement Gap .[6.2.4, 7.4.1]  4 The pre-configured PRS Processing Window .[3.1, 6.2.4, 7.4.1]  5 If the LMF indicates predefined configurations, the UE can request them via LPP RequestAssistanceData.[7.x]  6 Merged R2-2201870 (Added EN FFS which RRC message(s) are used.for RxTEG)  **RAN2#116**, capture following :  **Latency reduction:**  Scheduled location time, storing capability in AMF is captured in section 5.4.4, 7.3.2, 7.3.3 and 7.3.4;  **Positioning in RRC\_INACTVE:**  **On-Demand PRS transmission:**  Captured in section 7.x;  **PRU:**  Captured in section 3.2 and 5.4.x; | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Rel-17 Positioning is not supported in 38.305. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 3.1, 3.2, 5.4.4, 5.4.x, 6.2.2, 6.2.4, 7.x, 7.3.2, 7.3.3, 7.3.4, 7.4.1, 8.10.2.2, 8.11.2.1, 8.11.2.2, 8.12.2.1, 8.12.2.2, 8.12.3.1, 8.13.2, 8.13.3.4 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS/TR 38.331 CR TBD  TS/TR 37.355 CR TBD | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | | Revision of R2-2202490 based on At117-e604  Same as R2-2201815 ([Post116bis-e][629][POS] 38.305 RAT-dependent positioning running CR (Intel))  Revision of R2-2111374 | | | | | | | | |

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in 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 TR 21.905 [1].

As used in this document, the suffixes "-based" and "-assisted" refer respectively to the node that is responsible for making the positioning calculation (and which may also provide measurements) and a node that provides measurements (but which does not make the positioning calculation). Thus, an operation in which measurements are provided by the UE to the LMF to be used in the computation of a position estimate is described as "UE-assisted" (and could also be called "LMF-based"), while one in which the UE computes its own position is described as "UE-based".

**Transmission Point (TP)**: A set of geographically co-located transmit antennas (e.g. antenna array (with one or more antenna elements)) for one cell, part of one cell or one DL-PRS-only TP. Transmission Points can include base station (ng-eNB or gNB) antennas, remote radio heads, a remote antenna of a base station, an antenna of a DL-PRS-only TP, etc. One cell can include one or multiple transmission points. For a homogeneous deployment, each transmission point may correspond to one cell.

**Reception Point (RP)**: A set of geographically co-located receive antennas (e.g. antenna array (with one or more antenna elements)) for one cell, part of one cell or one UL-SRS-only RP. Reception Points can include base station (ng-eNB or gNB) antennas, remote radio heads, a remote antenna of a base station, an antenna of a UL-SRS-only RP, etc. One cell can include one or multiple reception points. For a homogeneous deployment, each reception point may correspond to one cell.

**PRS-only TP**: A TP which only transmits PRS, DL-PRS signals and is not associated with a cell.

**SRS-only RP**: An RP which only receives UL-SRS signals and is not associated with a cell.

**Transmission-Reception Point (TRP)**: A set of geographically co-located antennas (e.g. antenna array (with one or more antenna elements)) supporting TP and/or RP functionality.

**Pre-configured assistance data**: Refers to the DL-PRS assistance data (with associated validity criteria) that can be provided to the UE (before or during an ongoing LPP positioning session), to be then utilized for potential positioning measurements at a future time (e.g. for deferred MT-LR). Pre-configured DL-PRS assistance data may consist of multiple instances, where each instance is applicable to a different area within the network.

**PRS Processing Window (PPW):** The PRS Processing Window is configured by the network to a UE for NR DL-PRS measurements without measurement gap.

**UE Rx Timing Error Group (UE Rx TEG)**: A UE Rx TEG is associated with one or more DL timing measurements, which have the Rx timing error difference within a certain margin.

**UE RxTx Timing Error Group (UE RxTx TEG):** A UE RxTx TEGis associated with one or more UE Rx-Tx time difference measurements, which have the ‘Rx timing errors+Tx timing errors’ difference within a certain margin.

**UE Tx Timing Error Group (UE Tx TEG)**: A UE Tx TEGis associated with the transmissions of one or more UL SRS resources for the positioning purpose, which have the Tx timing error difference within a certain margin.

**TRP Rx Timing Error Group (TRP Rx TEG):** A TRP Rx TEG is associated with one or more UL timing measurements, which have the Rx timing error difference within a certain margin.

**TRP RxTx Timing Error Group (TRP RxTx TEG):** A TRP RxTx TEGis associated with one or more gNB Rx-Tx time difference measurements, which have the ‘Rx timing errors+Tx timing errors’ difference within a certain margin.

**TRP Tx Timing Error Group (TRP Tx TEG):** A TRP Tx TEG is associated with the transmissions of one or more DL PRS resources, which have the Tx timing error difference within a certain margin.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 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 TR 21.905 [1].

5GC 5G Core Network

5GS 5G System

A-AoA Azimuth-Angle of Arrival

ADR Accumulated Delta Range

AoA Angle of Arrival

AP Access Point

ARP Antenna Reference Point

BDS BeiDou Navigation Satellite System

BSSID Basic Service Set Identifier

CID Cell-ID (positioning method)

CLAS Centimetre Level Augmentation Service

DL-AoD Downlink Angle-of-Departure

DL-PRS Downlink Positioning Reference Signal

DL-TDOA Downlink Time Difference Of Arrival

E-SMLC Enhanced Serving Mobile Location Centre

E-CID Enhanced Cell-ID (positioning method)

ECEF Earth-Centered, Earth-Fixed

ECI Earth-Centered-Inertial

EGNOS European Geostationary Navigation Overlay Service

E-UTRAN Evolved Universal Terrestrial Radio Access Network

FDMA Frequency Division Multiple Access

FKP Flächenkorrekturparameter (Engl: Area Correction Parameters)

GAGAN GPS Aided Geo Augmented Navigation

GLONASS GLObal'naya NAvigatsionnaya Sputnikovaya Sistema (Engl.: Global Navigation Satellite System)

GMLC Gateway Mobile Location Centre

GNSS Global Navigation Satellite System

GPS Global Positioning System

GRS80 Geodetic Reference System 1980

HESSID Homogeneous Extended Service Set Identifier

LCS LoCation Services

LMF Location Management Function

LPP LTE Positioning Protocol

MAC Master Auxiliary Concept

MBS Metropolitan Beacon System

MO-LR Mobile Originated Location Request

MT-LR Mobile Terminated Location Request

Multi-RTT Multi-Round Trip Time

NG-C NG Control plane

NG-AP NG Application Protocol

NI-LR Network Induced Location Request

N-RTK Network – Real-Time Kinematic

NRPPa NR Positioning Protocol A

OTDOA Observed Time Difference Of Arrival

PDU Protocol Data Unit

posSI Positioning System Information

posSIB Positioning SIB

PPP Precise Point Positioning

PPP-RTK Precise Point Positioning – Real-Time Kinematic

PRS Positioning Reference Signal (for E-UTRA)

PRU Positioning Reference Unit

QZSS Quasi-Zenith Satellite System

RP Reception Point

RRM Radio Resource Management

RSRP Reference Signal Received Power

RSRQ Reference Signal Received Quality

RSSI Received Signal Strength Indicator

RSTD Reference Signal Time Difference

RTK Real-Time Kinematic

SBAS Space Based Augmentation System

SET SUPL Enabled Terminal

SIB System Information Block

SLP SUPL Location Platform

SP Semi-Persistent

SRS Sounding Reference Signal

SSID Service Set Identifier

SSR State Space Representation

STEC Slant TEC

SUPL Secure User Plane Location

TADV Timing Advance

TBS Terrestrial Beacon System

TEC Total Electron Content

TEG Timing Error Group

TP Transmission Point

TRP Transmission-Reception Point

UE User Equipment

UL-AoA Uplink Angle of Arrival

UL-RTOA Uplink Relative Time of Arrival

UL-SRS Uplink Sounding Reference Signal

UL-TDOA Uplink Time Difference of Arrival

URA User Range Accuracy

WAAS Wide Area Augmentation System

WGS-84 World Geodetic System 1984

WLAN Wireless Local Area Network

Z-AoA Zenith Angles of Arrival

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## 5.2 UE Positioning Operations

To support positioning of a target UE and delivery of location assistance data to a UE with NG-RAN access in 5GS, location related functions are distributed as shown in the architecture in Figure 5.1-1 and as clarified in greater detail in TS 23.501 [2] and TS 23.273 [35]. The overall sequence of events applicable to the UE, NG-RAN and LMF for any location service is shown in Figure 5.2-1.

Note that when the AMF receives a Location Service Request in case of the UE is in CM-IDLE state, the AMF performs a network triggered service request as defined in TS 23.502 [26] and TS 23.273 [35] in order to establish a signalling connection with the UE and assign a specific serving gNB or ng-eNB. The UE is assumed to be in connected mode before the beginning of the flow shown in the Figure 5.2-1; that is, any signalling that might be required to bring the UE to connected mode prior to step 1a is not shown. The signalling connection may, however, be later released (e.g. by the NG-RAN node as a result of signalling and data inactivity) while positioning is still ongoing.



Figure 5.2-1: Location Service Support by NG-RAN

1a. Either: some entity in the 5GC (e.g. GMLC) requests some location service (e.g. positioning) for a target UE to the serving AMF.

1b. Or: the serving AMF for a target UE determines the need for some location service (e.g. to locate the UE for an emergency call).

1c. Or: the UE requests some location service (e.g. positioning or delivery of assistance data) to the serving AMF at the NAS level.

2. The AMF transfers the location service request to an LMF.

3a. The LMF instigates location procedures with the serving and possibly neighbouring ng-eNB or gNB in the NG-RAN – e.g. to obtain positioning measurements or assistance data.

3b. In addition to step 3a or instead of step 3a, the LMF instigates location procedures with the UE – e.g. to obtain a location estimate or positioning measurements or to transfer location assistance data to the UE.

4. The LMF provides a location service response to the AMF and includes any needed results – e.g. success or failure indication and, if requested and obtained, a location estimate for the UE.

5a. If step 1a was performed, the AMF returns a location service response to the 5GC entity in step 1a and includes any needed results – e.g. a location estimate for the UE.

5b. If step 1b occurred, the AMF uses the location service response received in step 4 to assist the service that triggered this in step 1b (e.g. may provide a location estimate associated with an emergency call to a GMLC).

5c. If step 1c was performed, the AMF returns a location service response to the UE and includes any needed results – e.g. a location estimate for the UE.

Location procedures applicable to NG-RAN occur in steps 3a and 3b in Figure 5.2-1 and are defined in greater detail in this specification. Other steps in Figure 5.2-1 are applicable only to the 5GC and are described in greater detail and in TS 23.502 [26] and TS 23.273 [35].

Steps 3a and 3b can involve the use of different position methods to obtain location related measurements for a target UE and from these compute a location estimate and possibly additional information like velocity. Positioning methods supported in this release are summarized in clause 4.3 and described in detail in clause 8.

The case that the NG-RAN node functions as an LCS client is not supported in this version of the specification.

## 5.3 NG-RAN Positioning Operations

### 5.3.1 General NG-RAN Positioning Operations

Separately from location service support for particular UEs, an LMF may interact with elements in the NG-RAN in order to obtain measurement information to help assist one or more position methods for all UEs. An LMF may also interact with NG-RAN node to provide assistance data information for broadcasting.

### 5.3.2 OTDOA Positioning Support

An LMF can interact with any ng-eNB reachable from any of the AMFs with signalling access to the LMF in order to obtain location related information to support the OTDOA for E-UTRA positioning method, including PRS-based TBS for E-UTRA. The information can include timing information for the TP in relation to either absolute GNSS time or timing of other TPs and information about the supported cells and TPs including PRS schedule.

Signalling access between the LMF and ng-eNB may be via any AMF with signalling access to both the LMF and ng‑eNB.

An LMF can also interact with any gNB reachable from any of the AMFs with signalling access to the LMF in order to obtain NR cell timing information to support the OTDOA for E-UTRA positioning method, in case the UE is served by a NR cell.

### 5.3.3 Assistance Information Broadcast Support

An LMF can interact with any NG-RAN node reachable from any of the AMFs with signalling access to the LMF in order to provide assistance data information for broadcasting. The information can include positioning System Information Blocks (posSIBs) together with assistance information meta data, broadcast cells and broadcast periodicity.

Signalling access between the LMF and NG-RAN node is via any AMF with signalling access to both the LMF and NG-RAN node.

### 5.3.4 NR RAT-Dependent Positioning Support

An LMF can interact with any gNB reachable from any of the AMFs with signalling access to the LMF in order to obtain location related information to support the NR RAT-Dependent positioning methods. The information can include timing information for the TRP in relation to either absolute GNSS time or timing of other TRPs and information about the supported cells and TRPs including PRS schedule.

When an LMF determines a positioning method for a UE, which requires gNB measurements, the LMF can interact with the gNB to support the positioning method. The LMF can request the gNB for SRS configuration for the UE and the gNB can respond with the SRS configuration to the LMF. The gNB can provide an updated SRS configuration to the LMF when the SRS configuration changes. If semi-persistent or aperiodic SRS is configured to the UE, the LMF may activate/deactivate the SRS. When the SRS is transmitted by the UE, the LMF can request multiple TRPs to perform uplink measurements and report the results.

Signalling access between the LMF and gNB for non-UE associated NRPPa procedure in Clause 7.2.1 may be via any AMF with signalling access to both the LMF and gNB. Signalling access between the LMF and gNB for UE associated NRPPa procedure in Clause 7.2.1 is via the serving AMF, as in TS 23.273 [35].

## 5.4 Functional Description of Elements Related to UE Positioning in NG-RAN

### 5.4.1 User Equipment (UE)

The UE may make measurements of downlink signals from NG-RAN and other sources such as E-UTRAN, different GNSS and TBS systems, WLAN access points, Bluetooth beacons, UE barometric pressure and motion sensors. The measurements to be made will be determined by the chosen positioning method.

The UE may also contain LCS applications, or access an LCS application either through communication with a network accessed by the UE or through another application residing in the UE. This LCS application may include the needed measurement and calculation functions to determine the UE's position with or without network assistance. This is outside of the scope of this specification.

The UE may also, for example, contain an independent positioning function (e.g., GPS) and thus be able to report its position, independent of the NG-RAN transmissions. The UE with an independent positioning function may also make use of assistance information obtained from the network.

### 5.4.2 gNB

The gNB is a network element of NG-RAN that may provide measurement information for a target UE and communicates this information to an LMF.

To support NR RAT-Dependent positioning, the gNB may make measurements of radio signals for a target UE, and provide measurement results for position estimation. A gNB may serve several TRPs, including for example remote radio heads, and UL-SRS only RPs and DL-PRS-only TPs.

A gNB may broadcast assistance data information, received from an LMF, in positioning System Information messages.

### 5.4.3 ng-eNB

The ng-eNB is a network element of NG-RAN that may provide measurement results for position estimation and makes measurements of radio signals for a target UE and communicates these measurements to an LMF.

The ng-eNB makes its measurements in response to requests from the LMF (on demand or periodically).

An ng-eNB may serve several TPs, including for example remote radio heads and PRS-only TPs for PRS-based TBS positioning for E-UTRA.

An ng-eNB may broadcast assistance data information, received from an LMF, in positioning System Information messages.

### 5.4.4 Location Management Function (LMF)

The LMF manages the support of different location services for target UEs, including positioning of UEs and delivery of assistance data to UEs. The LMF may interact with the serving gNB or serving ng-eNB for a target UE in order to obtain position measurements for the UE, including uplink measurements made by an NG-RAN and downlink measurements made by the UE that were provided to an NG-RAN as part of other functions such as for support of handover.

The LMF may interact with a target UE in order to deliver assistance data if requested for a particular location service, or to obtain a location estimate if that was requested.

The LMF may interact with multiple NG-RAN nodes to provide assistance data information for broadcasting. The assistance data information for broadcast may optionally be segmented and/or ciphered by the LMF. The LMF may also interact with AMFs to provide ciphering key data information to the AMF as described in greater detail in TS 23.273 [35].

For positioning of a target UE, the LMF decides on the position methods to be used, based on factors that may include the LCS Client type, the required QoS, UE positioning capabilities, gNB positioning capabilities and ng-eNB positioning capabilities. The LMF then invokes these positioning methods in the UE, serving gNB and/or serving ng‑eNB. The positioning methods may yield a location estimate for UE-based position methods and/or positioning measurements for UE-assisted and network-based position methods. The LMF may combine all the received results and determine a single location estimate for the target UE (hybrid positioning). Additional information like accuracy of the location estimate and velocity may also be determined.

The LMF may interact with the AMF to provide (updated) UE Positioning Capability to AMF and to receive stored UE Positioning Capability from AMF as described in TS 23.273 [35].

### 5.4.x Positioning Reference Unit (PRU)

A Positioning Reference Unit (PRU) at a known location can perform positioning measurements (e.g., RSTD, RSRP, UE Rx-Tx Time Difference measurements, etc.) and report these measurements to a location server. In addition, the PRU can transmit SRS to enable TRPs to measure and report UL positioning measurements (e.g., RTOA, UL-AoA, gNB Rx-Tx Time Difference, etc.) from PRUs at a known location. The PRU measurements can be compared by a location server with the measurements expected at the known PRU location to determine correction terms for other nearby target devices. The DL- and/or UL location measurements for other target devices can then be corrected based on the previously determined correction terms.

From a location server perspective, the PRU functionality is realized by a UE with known location.

Editor's Note: FFS: The exact positioning functionalities supported, and the assistance data/location information transfers supported by PRU.

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## 6.1 Network interfaces supporting positioning operations

### 6.1.1 General LCS control plane architecture

The general LCS control plane architecture in the 5GS applicable to a target UE with NG-RAN access is defined in TS 23.501 [2] and TS 23.273 [35].

### 6.1.2 NR-Uu interface

The NR-Uu interface, connecting the UE to the gNB over the air, is used as one of several transport links for the NR positioning protocol(s) for a target UE with NR access to NG-RAN.

### 6.1.3 LTE-Uu interface

The LTE-Uu interface, connecting the UE to the ng-eNB over the air, is used as one of several transport links for the LTE positioning protocol(s) for a target UE with LTE access to NG-RAN.

### 6.1.4 NG-C interface

The NG-C interface between the gNB and the AMF and between the ng-eNB and the AMF is transparent to all UE-positioning-related procedures. It is involved in these procedures only as a transport link for the NR positioning protocol(s).

For gNB related positioning procedures, the NG-C interface transparently transports both positioning requests from the LMF to the gNB and positioning results from the gNB to the LMF.

For ng-eNB related positioning procedures, the NG-C interface transparently transports both positioning requests from the LMF to the ng-eNB and positioning results from the ng-eNB to the LMF.

For delivery of broadcast assistance data information, the NG-C interface transparently transports both the assistance data information from the LMF to the NG-RAN node for broadcasting and the feedback information on assistance information broadcasting from the NG-RAN node to the LMF. The NG-C interface is also used by an AMF to transparently transport ciphering keys via NG-RAN node to UEs using a NAS message. The ciphering keys are used to decipher broadcast assistance data information, if the broadcast assistance data information is ciphered.

### 6.1.5 NL1 interface

The NL1 interface, between the LMF and the AMF, is transparent to all UE related, gNB related and ng-eNB related positioning procedures. It is used only as a transport link for the LTE Positioning Protocols LPP and NR Positioning Protocol A NRPPa.

### 6.1.6 F1 interface

In case of split gNB architecture, the F1 interface is used to support the exchange of positioning information between the gNB-DU and the gNB-CU; it is also used transparently as a transport link for the LPP.

## 6.2 UE-terminated protocols

### 6.2.1 LTE Positioning Protocol (LPP)

The LTE Positioning Protocol (LPP) is terminated between a target device (the UE in the control-plane case or SET in the user-plane case) and a positioning server (the LMF in the control-plane case or SLP in the user-plane case). It may use either the control- or user-plane protocols as underlying transport. In this specification, only control plane use of LPP is defined. User plane support of LPP is defined in [15] and [16].

LPP messages are carried as transparent PDUs across intermediate network interfaces using the appropriate protocols (e.g., NGAP over the NG-C interface, NAS/RRC over the LTE-Uu and NR-Uu interfaces). The LPP protocol is intended to enable positioning for NR and LTE using a multiplicity of different position methods, while isolating the details of any particular positioning method and the specifics of the underlying transport from one another.

The protocol operates on a transaction basis between a target device and a server, with each transaction taking place as an independent procedure. More than one such procedure may be in progress at any given moment. An LPP procedure may involve a request/response pairing of messages or one or more "unsolicited" messages. Each procedure has a single objective (e.g., transfer of assistance data, exchange of LPP related capabilities, or positioning of a target device according to some QoS and use of one or more positioning methods). Multiple procedures, in series and/or in parallel, can be used to achieve more complex objectives (e.g., positioning of a target device in association with transfer of assistance data and exchange of LPP related capabilities). Multiple procedures also enable more than one positioning attempt to be ongoing at the same time (e.g., to obtain a coarse location estimate with low delay while a more accurate location estimate is being obtained with higher delay).

An LPP session is defined between a positioning server and the target device, the details of its relation with transactions are described in clause 4.1.2 of TS 36.355 [19].

For the 3GPP 5GS Control Plane solution defined in TS 23.501 [2], TS 23.502 [26] and TS 23.273 [35], the UE is the target device and the LMF is the server. For SUPL 2.0 support, the SUPL Enabled Terminal (SET) is the target device and the SUPL Location Platform (SLP) is the server. The operations controlled through LPP are described further in clause 7.1.

LPP defined data structures for assistance data information are reused for supporting RRC broadcast of assistance data information which are embedded in positioning SIBs. This enables broadcast assistance data using the same data structures which are used for point to point location.

### 6.2.2 Radio Resource Control (RRC) for NR

The RRC protocol for NR is terminated between the gNB and the UE. It provides transport for LPP messages over the NR-Uu interface.

In addition to providing transport for LPP messages over the NR-Uu interface, it supports transfer of measurements that may be used for positioning purposes through the existing measurement systems specified in TS 38.331 [14].

The RRC protocol for NR also supports broadcasting of assistance data via positioning System Information messages.

The RRC protocol for NR is also used to configure UEs with a sounding reference signal (SRS) to support NG-RAN measurements for NR positioning, provide pre-configured measurement gap configuration (s) and pre-configured PRS processing window for DL PRS measurement and report the UE TxTEG (Tx Timing Error Group) for UL-TDOA.

The RRC protocol for NR is also used to configure UEs with a sounding reference signal (SRS) for SRS transmission in RRC\_INACTIVE to support NG-RAN measurements for NR positioning.

### 6.2.3 Radio Resource Control (RRC) for LTE

The RRC protocol for LTE is terminated between the ng-eNB and the UE. In addition to providing transport for LPP messages over the LTE-Uu interface, it supports transfer of measurements that may be used for positioning purposes through the existing measurement systems specified in TS 36.331 [13].

The RRC protocol for LTE also supports broadcasting of assistance data via positioning System Information messages.

### 6.2.4 Medium Access Control (MAC) for NR

The MAC protocol for NR supports activation and deactivation of configured semi-persistent SRS resource sets as specified in TS 38.321 [39] to support NG-RAN measurements for NR positioning.

The MAC protocol for NR also supports request of positioning measurement gap activation and deactivation from a UE, and activation and deactivation of pre-configured measurement gap from the NG-RAN as specified in TS 38.321 [39].

The MAC protocol for NR can also be used to activate and deactivate of PRS Processing Window as specified in TS 38.321 [39].

## 6.3 NG-RAN Node terminated protocols

### 6.3.1 NR Positioning Protocol A (NRPPa)

The NR Positioning Protocol A (NRPPa) carries information between the NG-RAN Node and the LMF. It is used to support the following positioning functions:

- E-CID for E-UTRA where measurements are transferred from the ng-eNB to the LMF.

- Data collection from ng-eNB's and gNB's for support of OTDOA positioning for E-UTRA.

- Cell-ID and Cell Portion ID retrieval from gNB's for support of NR Cell ID positioning method.

- Exchange of information between LMF and NG-RAN node for the purpose of assistance data broadcasting.

- NR E-CID where measurements are transferred from the gNB to the LMF.

- NR Multi-RTT where measurements are transferred from the gNB to the LMF.

- NR UL-AoA where measurements are transferred from the gNB to the LMF.

- NR UL-TDOA where measurements are transferred from the gNB to the LMF.

- Data collection from gNBs for support of DL-TDOA, DL-AoD, Multi-RTT, UL-TDOA, UL-AoA.

The NRPPa protocol is transparent to the AMF. The AMF routes the NRPPa PDUs transparently based on a Routing ID corresponding to the involved LMF over NG-C interface without knowledge of the involved NRPPa transaction. It carries the NRPPa PDUs over NG-C interface either in UE associated mode or non-UE associated mode.

In case of a split gNB architecture, the NRPPa protocol is terminated at the gNB-CU.

### 6.3.2 NG Application Protocol (NGAP)

The NGAP protocol, terminated between the AMF and the NG-RAN Node, is used as transport for LPP and NRPPa messages over the NG-C interface. The NGAP protocol is also used to instigate and terminate NG-RAN Node related positioning procedures.

## 6.4 Signalling between an LMF and UE

### 6.4.1 Protocol Layering

Figure 6.4.1-1 shows the protocol layering used to support transfer of LPP messages between an LMF and UE. The LPP PDU is carried in NAS PDU between the AMF and the UE.



Figure 6.4.1-1: Protocol Layering for LMF to UE Signalling

### 6.4.2 LPP PDU Transfer

Figure 6.4.2-1 shows the transfer of an LPP PDU between an LMF and UE, in the network- and UE-triggered cases. These two cases may occur separately or as parts of a single more complex operation.



Figure 6.4.2-1: LPP PDU transfer between LMF and UE (network- and UE-triggered cases)

1. Steps 1 to 4 may occur before, after, or at the same time as steps 5 to 8. Steps 1 to 4 and steps 5 to 8 may also be repeated. Steps 1 to 4 are triggered when the LMF needs to send an LPP message to the UE as part of some LPP positioning activity. The LMF then invokes the Namf\_Communication \_N1N2MessageTransfer service operation towards the AMF to request the transfer of a LPP PDU to the UE. The service operation includes the LPP PDU together with the LCS Correlation ID in the N1 Message Container as defined in TS 29.518 [28].

2. If the UE is in CM-IDLE state (e.g. if the NG connection was previously released due to data and signalling inactivity), the AMF initiates a network triggered service request as defined in TS 23.502 [26] in order to establish a signalling connection with the UE and assign a serving NG-RAN node.

3. The AMF includes the LPP PDU in the payload container of a DL NAS Transport message, and a Routing Identifier identifying the LMF in the Additional Information of the DL NAS Transport message defined in TS 24.501 [29]. The AMF then sends the DL NAS Transport message to the serving NG-RAN Node in an NGAP Downlink NAS Transport message defined in TS 38.413 [30]. The AMF need not retain state information for this transfer; it can treat any response in step 7 as a separate non-associated transfer.

4. The NG-RAN Node forwards the DL NAS Transport message to the UE in an RRC DL Information Transfer message.

5. Steps 5 to 8 are triggered when the UE needs to send an LPP PDU to the LMF as part of some LPP positioning activity. If the UE is in CM-IDLE state, the UE instigates a UE triggered service request as defined in TS 23.502 [26] in order to establish a signalling connection with the AMF and assign a serving NG-RAN node.

6. The UE includes the LPP PDU in the payload container of an UL NAS Transport message, and the Routing Identifier, which has been received in step 4, in the Additional Information of the UL NAS Transport message defined in TS 24.501 [29]. The UE then sends the UL NAS Transport message to the serving NG-RAN node in an RRC UL Information Transfer message.

7. The NG-RAN node forwards the UL NAS Transport Message to the AMF in an NGAP Uplink NAS Transport message.

8. The AMF invokes the Namf\_Communication\_N1MessageNotify service operation towards the LMF indicated by the Routing Identifier received in step 7. The service operation includes the LPP PDU received in step 7 together with the LCS Correlation ID in the N1 Message Container as defined in TS 29.518 [28].

## 6.5 Signalling between an LMF and NG-RAN node

### 6.5.1 Protocol Layering

Figure 6.5.1-1 shows the protocol layering used to support transfer of NRPPa PDUs between an LMF and NG-RAN Node.

The NRPPa protocol is transparent to the AMF. The AMF routes the NRPPa PDUs transparently based on a Routing ID which corresponds to the involved LMF node over the NG interface without knowledge of the involved NRPPa transaction. It carries the NRPPa PDUs over NG interface either in UE associated mode or non-UE associated mode.



Figure 6.5.1-1: Protocol Layering for LMF to NG-RAN Signalling

### 6.5.2 NRPPa PDU Transfer for UE Positioning

Figure 6.5.2-1 shows NRPPa PDU transfer between an LMF and NG-RAN Node to support positioning of a particular UE.



Figure 6.5.2-1: NRPPa PDU Transfer between an LMF and NG-RAN node for UE Positioning

1. Steps 1 to 3 are triggered when the LMF needs to send an NRPPa message to the serving NG-RAN Node for a target UE as part of a NRPPa positioning activity. The LMF then invokes the Namf\_Communication\_N1N2MessageTransfer service operation towards the AMF to request the transfer of a NRPPa PDU to the serving NG-RAN Node for the UE. The service operation includes the NRPPa PDU together with the LCS Correlation ID in the N2 Message Container as defined in TS 29.518 [28].

2. If the UE is in CM-IDLE state (e.g. if the NG connection was previously released due to data and signalling inactivity), the AMF performs a network triggered service request as defined in TS 23.502 [26] in order to establish a signalling connection with the UE and assign a serving NG-RAN Node.

3. The AMF forwards the NRPPa PDU to the serving NG-RAN Node in an NGAP Downlink UE Associated NRPPa Transport message over the NG signalling connection corresponding to the UE and includes the Routing ID related to the LMF. The AMF need not retain state information for this transfer – e.g. can treat any response in step 4 as a separate non-associated transfer.

4. Steps 4 and 5 are triggered when a serving NG-RAN Node needs to send an NRPPa message to the LMF for a target UE as part of an NRPPa positioning activity. The NG-RAN Node then sends an NRPPa PDU to the AMF in an NGAP Uplink UE Associated NRPPa Transport message and includes the Routing ID received in step 3.

5. The AMF invokes the Namf\_Communication\_N2InfoNotify service operation towards the LMF indicated by the Routing ID received in step 4. The service operation includes the NRPPa PDU received in step 4 together with the LCS Correlation ID in the N2 Info Container as defined in TS 29.518 [28]. Steps 1 to 5 may be repeated.

### 6.5.3 NRPPa PDU Transfer for Positioning Support

Figure 6.5.3-1 shows NRPPa PDU transfer between an LMF and NG-RAN Node when related to gathering data from the NG-RAN Node for positioning support for all UEs.



Figure 6.5.3-1: NRPPa PDU Transfer between an LMF and NG-RAN for obtaining NG-RAN Data

0. An ng-eNB in the NG-RAN may communicate with several TPs (including PRS-only TPs in case of PRS-based TBS is supported) to configure TPs, obtain TP configuration information, etc.

A gNB in the NG-RAN may communicate with several TRPs (including PRS-only TPs) to configure TRPs, obtain TRP configuration information, etc.

NOTE: NG-RAN–TP/TPR signalling and configuration is outside the scope of this specification.

1. Steps 1 and 2 are triggered when the LMF needs to send an NRPPa message to an NG-RAN Node to obtain data related to the NG-RAN Node, and possibly associated TPs. The LMF invokes the Namf\_Communication\_NonUeN2MessageTransfer service operation towards the AMF to request the transfer of a NRPPa PDU to a NG-RAN node (gNB or ng-eNB) in the NG-RAN. The service operation includes the target NG-RAN node identity and the NRPPa PDU in the N2 Information Container as defined in TS 29.518 [28].

2. The AMF forwards the NRPPa PDU to the identified NG-RAN Node in an NGAP Downlink Non UE Associated NRPPa Transport message and includes a Routing ID identifying the LMF. The AMF need not retain state information for this transfer – e.g. can treat any response in step 3 as a separate non-associated transfer.

3. Steps 3 and 4 are triggered when an NG-RAN Node needs to send an NRPPa PDU to an LMF containing data applicable to the NG-RAN Node, and possibly associated TPs. The NG-RAN Node then sends an NRPPa PDU to the AMF in an NGAP Uplink Non UE Associated NRPPa Transport message and includes the Routing ID received in step 2.

4. The AMF invokes the Namf\_Communication\_NonUeN2InfoNotify service operation towards the LMF indicated by the Routing Identifier received in step 3. The service operation includes the NRPPa PDU received in step 3 in the N2 Info Container as defined in TS 29.518 [28]. Steps 1 to 4 may be repeated.

### 6.5.4 NRPPa PDU Transfer for Assistance Information Broadcast

Figure 6.5.4-1 shows NRPPa PDU transfer between an LMF and NG-RAN node to support broadcast of assistance data.



Figure 6.5.4-1: NRPPa PDU Transfer between an LMF and NG-RAN Node for providing assistance information for broadcasting.

1. Step 1 is triggered when the LMF needs to send new or updated assistance information to an NG-RAN node for broadcasting in positioning system information messages. The LMF invokes the Namf\_Communication\_NonUeN2MessageTransfer service operation towards the AMF to request the transfer of a NRPPa PDU to a NG-RAN node (gNB or ng-eNB) in the NG-RAN. The service operation includes the target NG-RAN node identity and the NRPPa PDU in the N2 Information Container as defined in TS 29.518 [28].

2. The AMF forwards the NRPPa PDU to the identified NG-RAN node in an NGAP Downlink Non UE Associated NRPPa Transport message and includes the Routing ID identifying the LMF. The AMF need not retain state information for this transfer.

Figure 6.5.4-2 shows NRPPa PDU transfer between an NG-RAN node and LMF for providing feedback to the LMF on assistance data broadcasting.



Figure 6.5.4-2: NRPPa PDU Transfer between an NG-RAN node and LMF for providing feedback on assistance data broadcasting.

1. Step 1 is triggered when an NG-RAN node needs to send an NRPPa PDU to an LMF for providing feedback on assistance data broadcasting. Step 1 may only be triggered if the procedure in Figure 6.5.4-1 has already been performed. The NG-RAN node sends an NRPPa PDU to the AMF in an NGAP Uplink Non UE Associated NRPPa Transport message. The NG-RAN node includes the previously received Routing ID related to the LMF (Figure 6.5.4-1).

2. The AMF invokes the Namf\_Communication\_NonUeN2InfoNotify service operation towards the LMF indicated by the Routing identifier received at step 1. The service operation includes the NRPPa PDU received in step 1 in the N2 Info Container as defined in TS 29.518 [28].

## 6.6 Void

# 7 General NG-RAN UE Positioning procedures

## 7.1 General LPP procedures for UE Positioning

### 7.1.1 LPP procedures

Positioning procedures in the NG-RAN are modelled as transactions of the LPP protocol using the procedures defined in this specification. A procedure consists of a single operation of one of the following types:

- Exchange of positioning capabilities;

- Transfer of assistance data;

- Transfer of location information (positioning measurements and/or position estimate);

- Error handling;

- Abort.

Parallel transactions are permitted (i.e. a new LPP transaction may be initiated, while another one is outstanding).

As described in clause 6.2.1, the protocol operates between a "target" and a "server". In the control-plane context, these entities are the UE and LMF respectively; in the SUPL context they are the SET and the SLP. A procedure may be initiated by either the target or the server.

### 7.1.2 Positioning procedures

#### 7.1.2.1 Capability transfer

The capability transfer procedure between a "target" and a "server" is specified in clause 7.1.2.1 of TS 36.305 [25].

#### 7.1.2.2 Assistance data transfer

The assistance data transfer procedure between a "target" and a "server" is specified in clause 7.1.2.2 of TS 36.305 [25].

#### 7.1.2.3 Location information transfer

The location information transfer procedure between a "target" and a "server" is specified in clause 7.1.2.3 of TS 36.305 [25].

#### 7.1.2.4 Multiple transactions

Multiple LPP transactions may be in progress simultaneously as specified in clause 7.1.2.4 of TS 36.305 [25].

#### 7.1.2.5 Sequence of procedures

LPP procedures are not required to occur in any fixed order, in order to provide greater flexibility in positioning. Thus, a UE may request assistance data at any time in order to comply with a previous request for location measurements from the LMF; an LMF may instigate more than one request for location information (e.g., measurements or a location estimate) in case location results from a previous request were not adequate for the requested QoS; and the target device may transfer capability information to the server at any time if not already performed.

Despite the flexibility allowed by LPP, it is expected that procedures will normally occur in the following order:

1. Capability Transfer;

2. Assistance Data Transfer;

3. Location Information Transfer (measurements and/or location estimate).

Specific examples for each positioning method are shown in clause 8.

#### 7.1.2.6 Error handling

The error handling procedure is specified in clause 7.1.2.6 of TS 36.305 [25].

#### 7.1.2.7 Abort

The abort procedure is specified in clause 7.1.2.7 of TS 36.305 [25].

### 7.1.3 UE positioning measurements in RRC\_IDLE state for NB-IoT

NB-IoT UEs may perform measurements for some positioning methods only when in RRC\_IDLE state.

Figure 7.1.3-1 shows the general positioning procedure where the UE performs positioning measurements in RRC\_IDLE state.



Figure 7.1.3-1: UE positioning measurements in RRC\_IDLE state.

1. The LMF is aware of the UE access type and/or coverage level if applicable from the Location Service Request message received from the AMF. The LMF may send a LPP Request Capabilities message to the UE to obtain the UE positioning method capabilities from the UE, as described in clause 7.1.2.1.

2. The UE sends its positioning method capabilities to the LMF in a LPP Provide Capabilities message, including an indication of position methods for which the UE needs to make measurements in RRC\_IDLE state.

3. The LMF may determine the assistance data required for the selected position method or methods, and sends them in one or more LPP Provide Assistance data messages to the UE, as described in clause 7.1.2.2. If an LPP acknowledgement was requested, the UE sends an LPP acknowledgment for each received LPP Provide Assistance data message to the LMF.

4. If the UE capabilities from step 2 indicate that RRC\_IDLE state is required for positioning measurements, the LMF may allow additional response time to the UE to obtain the location measurements, and sends one or more LPP Request Location Information messages to the UE requesting positioning measurements or a location estimate, and including the required response time, as described in clause 7.1.2.3. For E-CID positioning method, when NRSRP/NRSRQ measurements are requested the UE is requested to provide NRSRP/NRSRQ measurements for intra-frequency neighbour cells and for inter-frequency neighbour cells. The UE may use inter-frequency information in system information of the serving cell specified in TS 36.331 [13] to decide on which inter-frequency cells to measure.

5. The UE sends an LPP acknowledgement for each received LPP Request Location Information message to the LMF, if an LPP acknowledgement was requested at step 4 but does not perform the requested measurements.

6. The UE may finish any other activities in progress (e.g., SMS or data transfer), and waits until the network releases or suspends the connection (after a certain period of inactivity). The UE will then receive an RRC connection release or suspend from the ng-eNB due to the expiration of the inactivity timer.

7. When the UE has entered RRC\_IDLE state, the UE performs the measurements requested in step 4.

8. Before the location measurements are to be sent to the LMF, the UE instigates a UE-triggered service request or, when User Plane CIoT 5GC optimization applies, the Connection Resume procedure as defined in TS 23.501 [2], if the UE is not using Control Plane CIoT 5GC Optimisation, in order to establish a signalling connection with the AMF. If the UE is using Control Plane CIoT 5GC Optimisation, procedures for Mobile Originated Data Transport in Control Plane CIoT 5GC optimisation as defined in TS 23.501 [2] are performed by the UE to establish a signalling connection with the AMF.

9. When the LPP response time received in step 4 expires (or when location measurements are available before expiry), the UE sends one or more LPP Provide Location Information messages containing the requested location measurements or location estimate obtained in step 7 to the LMF.

## 7.2 General NRPPa Procedures for UE Positioning

### 7.2.1 NRPPa procedures

Positioning and data acquisition transactions between a LMF and NG-RAN node are modelled by using procedures of the NRPPa protocol. There are two types of NRPPa procedures:

- UE associated procedure, i.e. transfer of information for a particular UE, including the procedures supporting the Positioning Information Transfer and E-CID Location Information Transfer functions;

- Non UE associated procedure, i.e. transfer of information applicable to the NG-RAN node and associated TRP, including the procedures supporting the OTDOA Information Transfer, Assistance Information Transfer, TRP Information Transfer, and Measurement Information Transfer functions.

Parallel transactions between the same LMF and NG-RAN node are supported; i.e. a pair of LMF and NG-RAN node may have more than one instance of an NRPPa procedure in execution at the same time.

For possible extensibility, the protocol is considered to operate between a generic "access node" (e.g. gNB, ng-eNB) and a "server" (e.g. LMF). An NRPPa transaction is only initiated by the server.



Figure 7.2.1-1: A single NRPPa transaction

Figure 7.2.1-1 shows a single NRPPa transaction. The transaction is terminated in step 2 in procedures including OTDOA Information Exchange and TRP Information Exchange. For procedures such as Positioning Information Exchange, Measurement and E-CID Measurement Initiation, additional responses may be allowed (e.g. sending of updated information periodically and/or whenever there is some significant change). In this case, the transaction may be ended after some additional responses. In the NRPPa protocol, the described transaction may be realized by the execution of one procedure defined as a request and a response, followed by one or several procedures initiated by the NG-RAN node (each procedure defined as a single message) to realize the additional responses. The Correlation ID, as specified in TS 29.572 [33], included by the LMF when it invokes the Namf\_Communication\_N1N2MessageTransfer AMF service operation to transfer the NRPPa PDU may be used by the LMF to identify the target UE positioning session.

### 7.2.2 NRPPa transaction types

#### 7.2.2.1 Location information transfer

The term "location information" in this clause refers to the information used in, or used for assisting in, computing position (e.g., cell information, SRS configurations, radio measurements or positioning measurements). It is delivered in response to a request.



Figure 7.2.2‑1: Location information transfer

1. The server sends a request for location related information to the NG-RAN node, and indicates the type of location information needed. The request may refer to a particular UE.

2. In response to step 1, the NG-RAN Node transfers location related information to the server. The location related information transferred should match the location related information requested in step 1.

3. If requested in step 1, the NG-RAN node may transfer additional location related information to the server in one or more additional NRPPa messages.

## 7.3 Service Layer Support using combined LPP and NRPPa Procedures

### 7.3.1 General

As described in TS 23.502 [26] and TS 23.273 [35], UE-positioning-related services can be instigated from the 5GC for an NI-LR or MT‑LR location service, or from the UE in case of an MO-LR location service. The complete sequence of operations in the 5GC is defined in TS 23.502 [26] and TS 23.273 [35]. This clause defines the overall sequences of operations that occur in the LMF, NG-RAN and UE as a result of the 5GC operations.

### 7.3.2 NI-LR and MT-LR Service Support

Figure 7.3.2-1 shows the sequence of operations for an NI-LR or MT-LR location service, starting at the point where the AMF initiates the service in the LMF.



Figure 7.3.2-1: UE Positioning Operations to support an MT-LR or NI-LR

1. The AMF sends a location request to the LMF for a target UE and may include associated QoS, the scheduled location time and the UE LPP positioning capabilities when available, as described in TS 23.273 [35].

2. The LMF may obtain location related information from the UE and/or from the serving NG-RAN Node. In the former case, the LMF instigates one or more LPP procedures to transfer UE positioning capabilities, provide assistance data to the UE and/or obtain location information from the UE. The UE may also instigate one or more LPP procedures after the first LPP message is received from the LMF (e.g., to request assistance data from the LMF). If a scheduled location time is provided in step 1, the LMF may schedule location measurements by the UE to occur at or near to the scheduled location time. The LPP procedures to transfer UE LPP positioning capabilities may be skipped if the LMF already obtained the UE positioning capabilities from the AMF in step 1.

3. If the LMF needs location related information for the UE from the NG-RAN, the LMF instigates one or more NRPPa procedures. Step 3 is not necessarily serialised with step 2; if the LMF and NG-RAN Node have the information to determine what procedures need to take place for the location service, step 3 could precede or overlap with step 2. If scheduled location time is provided in step 1, the LMF may schedule location measurements by the NG-RAN to occur at or near to the scheduled location time.

4. The LMF returns a location response to the AMF with any location estimate obtained as a result of steps 2 and 3. The LMF may also return the LPP UE capabilities as described in TS 23.273 [35].

NOTE: The LMF may send a location request to the UE at step 2 containing the scheduled location time sometime before the scheduled location time to allow the UE to enter CM Connected state shortly before the scheduled location time.

### 7.3.3 MO-LR Service Support

Figure 7.3.3-1 shows the sequence of operations for an MO-LR service, starting at the point where an LCS Client in the UE or the user has requested some location service (e.g., retrieval of the UE's location or transfer of the UE's location to a third party).



Figure 7.3.3-1: UE Positioning Operations to support an MO-LR

1. The UE sends an MO-LR location service request message included in a UL NAS TRANSPORT message as specified in TS 24.501 [29] to the AMF. The MO-LR location service request message may carry an LPP PDU to instigate one or more LPP procedures to transfer capabilities, request assistance data, and/or transfer location information and the scheduled location time , as described in TS 23.273 [35].

2. The AMF invokes the Nlmf Determine Location Request service operation towards the LMF as specified in TS 29.572 [33] and includes any LPP PDU, the scheduled location time received in step 1 and the UE LPP positioning capabilities when available.

3. The LMF may obtain location related information from the UE and/or from the serving NG-RAN node. In the former case or if an immediate response is needed to any LPP procedure instigated by the UE in step 1 (e.g., a request for assistance data), the LMF instigates one or more LPP procedures to transfer UE positioning capabilities, provide assistance data to the UE and/or obtain location information from the UE. The UE may also instigate further LPP procedures after the first LPP message is received from the LMF (e.g., to request assistance data or to request further assistance data). If a scheduled location time is provided in step 2, the LMF may schedule location measurements by the UE to occur at or near to the scheduled location time. The LPP procedures to transfer UE positioning capabilities may be skipped if the LMF already obtained the UE positioning capabilities from the AMF in step 2.

4. If the LMF needs location related information for the UE from the NG-RAN, the LMF instigates one or more NRPPa procedures. Step 4 may also precede step 3 or occur in parallel with it. If scheduled location time is provided in step 1, the LMF may schedule location measurements by the NG-RAN to occur at or near to the scheduled location time.

5. The LMF invokes the Nlmf Determine Location Response service operation towards the AMF as specified in TS 29.572 [33] which includes any location estimate obtained as a result of steps 3 and 4. The LMF may also return the LPP UE capabilities as described in TS 23.273 [35].

6. If the UE requested location transfer to a third party the AMF transfers the location received from the LMF in step 5 to the third party as defined in TS 23.273 [35].

7. The AMF sends an MO-LR location service response message included in a DL NAS TRANSPORT message as specified in TS 24.501 [29].

### 7.3.4 Deferred MT-LR Event Reporting Support

Figure 7.3.4-1 shows the sequence of operations for an Deferred MT-LR Event Reporting starting at the point where the UE reports an event to the LMF.



Figure 7.3.4-1: UE Positioning Operations to support a Deferred MT-LR

1. The UE sends a supplementary services event report message to the LMF as described in TS 24.571 [41] which is transferred via the serving AMF and is delivered to the LMF using an Namf\_Communication\_N1MessageNotify service operation. The event report may indicate the type of event being reported and may include an embedded positioning message which includes any location measurements or location estimate.

2. If LMF determines no positioning procedure is needed, steps 3 and 4 are skipped.

3. The LMF may utilize any location information received in step 1. The LMF may also retrieve location related information from the UE and/or from the serving NG-RAN Node. In the former case, the LMF instigates one or more LPP procedures to provide assistance data to the UE and/or obtain location information from the UE. The UE may also instigate one or more LPP procedures after the first LPP message is received from the LMF (e.g., to request assistance data from the LMF).

4. If the LMF needs location related information for the UE from the NG-RAN, the LMF instigates one or more NRPPa procedures. Step 3 is not necessarily serialised with step 2; if the LMF and NG-RAN Node have the information to determine what procedures need to take place for the location service, step 3 could precede or overlap with step 2.

5. The LMF invokes an Nlmf\_Location\_EventNotify service operation towards the GMLC with an indication of the type of event being reported and any location estimate obtained as a result of steps 2 and 3.

## 7.4 General RRC procedures for UE Positioning

### 7.4.1 NR RRC Procedures

NR RRC supports the following positioning related procedures:

- Location Measurement Indication;

- RRC message for UE TxTEG.

Editor's Note: FFS on RRC name and procedure for UE TxTEG;..

#### 7.4.1.1 Location Measurement Indication

The location measurement indication procedure is used by the UE to request measurement gaps for OTDOA RSTD measurements, for subframe and slot timing detection for inter-RAT E-UTRA RSTD measurements, or for NR DL-PRS measurements.



Figure 7.4.1.1-1: Location measurement indication procedure

**Precondition:** The UE served by a gNB has received a LPP message from an LMF requesting inter-RAT RSTD measurements for OTDOA positioning or NR DL-PRS measurements.

1. If the UE requires measurement gaps for performing the requested location measurements while measurement gaps are either not configured or not sufficient, or if the UE needs gaps to acquire the subframe and slot timing of the target E-UTRA system before requesting measurement gaps for the inter-RAT RSTD measurements (see TS 38.133 [32], the UE sends an RRC Location Measurement Indication message to the serving gNB. The message indicates that the UE is going to start location measurements, or that the UE is going to acquire subframe and slot timing of the target E-UTRA system, and includes information required for the gNB to configure the appropriate measurement gaps. When the gNB has configured the required measurement gaps the UE performs the location measurements or timing acquisition procedures.

2. When the UE has completed the location procedures which required measurement gaps, the UE sends another RRC Location Measurement Indication message to the serving gNB. The message indicates that the UE has completed the location measurements or timing acquisition procedures.

#### 7.4.1.z RRC for UE TxTEG

RRC procedures are used to request UE and report Tx ‘timing error group’ (UE TxTEG) for UL-TDOA.



Figure 7.4.1.z-1: RRC procedure for UE TxTEG

**Precondition:** The serving gNB of a UE has received a NRPPa message from an LMF requesting the TxTEG of the UE for NR UL-TDOA positioning.

1. The serving gNB may send a RRC message to the UE, requesting the UE to provide the association information of UL SRS resources for positioning with Tx TEGs to the serving gNB if the UE supports UE Tx TEG reporting. Based on the request from the LMF, the RRC message from the serving gNB to the UE indicates the UE should provide either a single report or a periodic report of UE TxTEG association to the serving gNB.
2. When the UE receives the request via RRC message, UE will report the UE TxTEG information, including all the changes of the UE TxTEG during the report period if the UE is required to report UE Tx TEG periodically. UE will report all the UE TxTEG at the time when the RRC message is received if the UE is only required to report the one-shot UE TxTEG information.

Editor's Note: FFS on RRC name and procedure for UE TxTEG;..

### 7.4.2 LTE RRC Procedures

LTE RRC supports the following positioning related procedures:

- Inter-frequency RSTD measurement indication.

#### 7.4.2.1 Inter-frequency RSTD measurement indication

The Inter-frequency RSTD measurement indication procedure is used by the UE to request measurement gaps for OTDOA RSTD measurements.



Figure 7.4.2.1-1: Inter-frequency RSTD measurement indication procedure

**Precondition:** The UE served by an ng-eNB has received a LPP message from an LMF requesting inter‑frequency RSTD measurements for OTDOA positioning.

1. If the UE requires measurement gaps for performing the requested inter‑frequency RSTD measurements for OTDOA positioning while measurement gaps are either not configured or not sufficient, the UE sends an RRC Inter-frequency RSTD Measurement Indication message to the serving ng-eNB. The message indicates that the UE is going to start inter-frequency RSTD measurements and includes information required for the ng-eNB to configure the appropriate measurement gaps. When the ng-eNB has configured the required measurement gaps the UE performs the inter-frequency RSTD measurements.

2. When the UE has completed the inter-frequency RSTD measurements which required measurement gaps, the UE sends another RRC Inter-frequency RSTD Measurement Indication message to the serving ng-eNB. The message indicates that the UE has completed the inter-frequency RSTD measurements.

## 7.x Procedures for On-Demand PRS transmission

### 7.x.1 General

On-Demand PRS transmission procedure allows the LMF to control whether PRS is transmitted or not and to change the characteristics of an ongoing PRS transmission. The on-demand PRS transmission procedure can be initiated either by the UE or LMF.

### 7.x.2 On-Demand PRS transmission procedures

Figure 7.x.2-1 shows the general positioning procedure for On-Demand PRS transmission.



Figure 7.x.2-1: Procedures for On-Demand PRS request.

0. The LMF may receive information on the possible On-Demand PRS configurations that the gNB can support during the TRP Information Exchange procedure.

1. In case of UE-initiated On-Demand PRS, the LMF may configure the UE with pre-defined PRS configurations via LPP Provide Assistance Data message or via posSI.

2a. In case of UE-initiated On-Demand PRS, the UE sends an On-Demand PRS request to the LMF via LPP Request Assistance Data message. The On-Demand PRS request can be the request for a defined PRS configuration with PRS configuration ID or explicit parameter for PRS configuration and may be a request for PRS transmission or change to the PRS transmission characteristics for positioning measurements.

NOTE 1: The LPP Request Assistance Data message for On-Demand PRS may also be sent in an MO-LR location service request message.

2b. In case of LMF-initiated On-Demand PRS, the LMF and the UE may exchange LPP messages e.g., to obtain UE measurements or the DL-PRS positioning capabilities of the UE, etc).

3. The LMF determines the need for PRS transmission or change to the transmission characteristics of an ongoing PRS transmission.

4. The LMF requests the serving and non-serving gNBs/TRPs for new PRS transmission or PRS transmission with changes to the PRS configuration via NRPPa PRS CONFIGURATION REQUEST message.

5. The gNBs/TRPs provide the PRS transmission update in the NRPPa PRS CONFIGURATION RESPONSE message accordingly .

6. LMF provides the updated PRS configuration used for PRS transmission via LPP Provide Assistance Data message to the UE.

NOTE 2: If the LPP Request Assistance Data for On-Demand DL-PRS at Step 2a was sent in an MO-LR location service request message, the LMF provides a MO-LR response as described in clause 7.3.3.

NOTE 3: It is up to Network (LMF) implementation on the steps to follow (accept/reject/ignore) on receiving UE-initiated On-Demand PRS request.

NOTE 4: It is up to Network (TRP) implementation on the steps to follow (accept/reject/ignore) on receiving LMF-initiated On-Demand PRS requests.

Editor's Note: Depending upon RAN3 input, the above description may need to be updated especially for NRPPa procedure, e.g. the name of the message, exchange between RAN and LMF on allowed PRS configuration, etc.

## 7.y Procedures for Pre-configured Measurement Gap

### 7.y.1 General

The pre-configured measurement gap procedure is used by the network to provide measurement gap for NR DL-PRS measurements. The gNB may activate/deactivate the pre-configurated measurement gap upon receiving the request from a UE or LMF.

### 7.y.2 Pre-configured Measurement Gap procedures

Figure 7.y.2-1 shows the general positioning procedure for Pre-configured Measurement Gap.



Figure 7.y.2-1: Pre-configured measurement gap configuration procedure

1. Based on the assistance information from the LMF and the UE capability, the serving gNB provides pre-configured measurement gap configuration(s) with associated ID(s) to the UE by sending RRC Reconfiguration message specified in TS 38.331 [14];

2. The UE sends RRC Reconfiguration complete message to the gNB to confirm the reception of pre-configured measurement gap configuration;

3. If the UE requires measurement gaps for performing the requested location measurements, the UE sends UL MAC CE Activation/Deactivation Request to the gNB and indicates the requested measurement gap configuration based on the ID configured in step 1;

4. Based on the quest from the UE in step 3a or the request from the LMF in step 3b, the gNB may send DL MAC CE Activation/Deactivation command containing an ID to activate the associated measurement gap;

Editor's Note: FFS on details of MAC CE, NRPPa, RRC;.

## 7.z Procedures for Pre-configured PRS processing window

### 7.z.1 General

The pre-configured PRS processing window procedure is used by the network to provide PRS processing window for NR DL-PRS measurements to the UE without measurement gap. The gNB may activate the pre-configurated PRS processing window upon receiving the request from LMF.

### 7.z.2 Pre-configured PRS processing window procedures

Figure 7.z.2-1 shows the general positioning procedure for Pre-configured PRS processing window.



Figure 7.z.2-1: Pre-configured PRS processing window configuration procedure

1. Based on the assistance information from the LMF and the UE capability, the serving gNB provides pre-configured PRS processing window configuration(s) with associated ID(s) to the UE by sending RRC Reconfiguration message specified in TS 38.331 [14];

2. The UE sends RRC Reconfiguration complete message to the gNB to confirm the reception of pre-configured PRS processing window configuration;

3. The LMF requests the gNB to (de)activate the preconfigured PRS processing window;

4. Based on the request from the LMF in step 3, the gNB sends DL MAC CE Activation/Deactivation command containing an ID to activate the associated PRS processing window;

Editor's Note: FFS on details of MAC CE, NRPPa, RRC;.

## 7.w Positioning in RRC\_INACTIVE

Positioning may be performed when a UE is in RRC\_INACTIVE. Any uplink LCS or LPP message can be transported in RRC\_INACTIVE. If the UE initiated data transmission using UL SDT, the network can send DL LCS, LPP and RRC message (e.g. to configure SRS for UL positioning, if it is supported) to the UE.

/\*\*\*Skip unrelated parts\*\*\*/

## 8.10 Multi-RTT positioning

### 8.10.1 General

In the Multi-RTT positioning method, the UE position is estimated based on measurements performed at both, UE and TRPs. The measurements performed at the UE and TRPs are UE/gNB Rx-Tx time difference measurements (and optionally DL-PRS-RSRP and UL-SRS-RSRP) of DL-PRS and UL-SRS, which are used by an LMF to determine the RTTs.

The UE may require measurement gaps to perform the Multi-RTT measurements from NR TRPs. The UE may request measurement gaps from a gNB using the procedure described in clause 7.4.1.1.

### 8.10.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE/gNB.

#### 8.10.2.1 Information that may be transferred from the LMF to UE

The information that may be transferred from the LMF to the UE are listed in Table 8.10.2.1-1.

Table 8.10.2.1-1: Assistance data that may be transferred from LMF to the UE

|  |
| --- |
| Information |
| Physical cell IDs (PCIs), global cell IDs (GCIs), and PRS IDs, ARFCNs of candidate NR TRPs for measurement |
| Timing relative to the serving (reference) TRP of candidate NR TRPs |
| DL-PRS configuration of candidate NR TRPs |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| PRS-only TP indication |
| On-Demand DL-PRS-Configurations |

#### 8.10.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from UE to the LMF is listed in Table 8.10.2.2-1. The individual UE measurements are defined in TS 38.215 [37].

Table 8.10.2.2-1: Measurement results that may be transferred from UE to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and PRS ID, ARFCN, PRS resource ID, PRS resource set ID for each measurement |
| DL-PRS-RSRP measurement |
| UE Rx-Tx time difference measurement |
| Time stamp of the measurement |
| Quality for each measurement |
| TA offset used by UE |
| UE Rx TEG IDs, UE Tx TEG IDs, and UE RxTx TEG IDs associated with UE Rx-Tx time difference measurements |
| LOS/NLOS information for UE measurements |
| First path RSRP |

#### 8.10.2.3 Information that may be transferred from the gNB to LMF

The assistance data that may be transferred from gNB to the LMF is listed in Table 8.10.2.3-1.

Table 8.10.2.3-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, ARFCN and TRP IDs of the TRPs served by the gNB |
| Timing information of TRPs served by the gNB |
| DL-PRS configuration of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates information of the DL-PRS Resources of the TRPs served by the gNB |

The configuration data for a target UE that may be transferred from the serving gNB to the LMF is listed in Table 8.10.2.3-2.

Table 8.10.2.3-2: UL information/UE configuration data that may be transferred from serving gNB to the LMF

|  |
| --- |
| UE configuration data |
| UE SRS configuration |
| SFN initialization time for the SRS configuration |

The measurement results that may be signalled from gNBs to the LMF is listed in Table 8.10.2.3-3.

Table 8.10.2.3-3: Measurement results that may be transferred from gNBs to the LMF

|  |
| --- |
| Measurement results |
| NCGI and TRP ID of the measurement |
| gNB Rx-Tx time difference measurement |
| UL-SRS-RSRP |
| UL Angle of Arrival (azimuth and elevation) |
| Time stamp of the measurement |
| Quality for each measurement |
| Beam Information of the measurement |

#### 8.10.2.4 Information that may be transferred from the LMF to gNBs

The requested UL-SRS transmission characteristics information that may be signalled from the LMF to the gNB is listed in Table 8.10.2.4-1.

Table 8.10.2.4-1: Requested UL-SRS transmission characteristics information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| Number Of Transmissions/duration for which the UL-SRS is requested |
| Bandwidth |
| Resource type (periodic, semi-persistent, aperiodic) |
| Number of requested SRS resource sets and SRS resources per set |
| Pathloss reference:  - PCI, SSB Index  - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID |
| Spatial relation info  - PCI, SSB Index  - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID  - NZP CSI-RS Resource ID  - SRS Resource ID  - Positioning SRS Resource ID |
| Periodicity of the SRS for each SRS resource set |
| SSB Information |
| Carrier frequency of SRS transmission bandwidth |

The TRP measurement request information that may be signalled from the LMF to the gNBs is listed in Table 8.10.2.4-2.

Table 8.10.2.4-2: TRP Measurement request information that may be transferred from LMF to gNBs.

|  |
| --- |
| Information |
| TRP ID, and NCGI of the TRP to receive UL-SRS |
| UE-SRS configuration |
| UL timing information together with timing uncertainty, for reception of SRS by candidate TRPs |
| Report characteristics for the measurements |
| Measurement Quantities |
| Measurement periodicity |
| Measurement beam information request |

The Positioning Activation/Deactivation request information that may be signalled from the LMF to the gNB is listed in Table 8.10.2.4-3.

Table 8.10.2.4-3: Requested positioning activation/deactivation information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| SP UL-SRS:  - Activation or Deactivation request  - Positioning SRS Resource Set ID which is to be activated/deactivated  - Spatial relation for Resource IDi  - Activation Time |
| Aperiodic UL-SRS  - Aperiodic SRS Resource Trigger List  - Activation Time |
| UL-SRS:  - Release all |

### 8.10.3 Multi-RTT Positioning Procedures

The procedures described in this clause support Multi-RTT positioning measurements obtained by the UE and TRPs/gNB.

#### 8.10.3.1 Procedures between LMF and UE

##### 8.10.3.1.1 Capability Transfer Procedure

The Capability Transfer procedure for Multi-RTT positioning is described in clause 7.1.2.1.

##### 8.10.3.1.2 Assistance Data Transfer Procedure

###### 8.10.3.1.2.1 Assistance Data Transfer between LMF and UE

The purpose of this procedure is to enable the LMF to provide assistance data to the UE (e.g., as part of a positioning procedure) and the UE to request assistance data from the LMF (e.g., as part of a positioning procedure). The LMF may provide the DL-PRS assistance data (with associated validity criteria) to the UE (before or during an ongoing LPP positioning session), to be utilized for potential positioning measurements at a future time.

8.10.3.1.2.1.1 LMF initiated Assistance Data Delivery

Figure 8.10.3.1.2.1.1-1 shows the Assistance Data Delivery operations for the Multi-RTT positioning method when the procedure is initiated by the LMF.



Figure 8.10.3.1.2.1.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that assistance data needs to be provided to the UE (e.g., as part of a positioning procedure) and sends an LPP Provide Assistance Data message to the UE. This message may include any of the Multi-RTT positioning assistance data defined in Table 8.10.2.1-1.

8.10.3.1.2.1.2 UE initiated Assistance Data Transfer

Figure 8.10.3.1.2.1.2-1 shows the Assistance Data Transfer operations for the Multi-RTT positioning method when the procedure is initiated by the UE.



Figure 8.10.3.1.2.1.2-1: UE-initiated Assistance Data Transfer Procedure

(1) The UE determines that certain Multi-RTT positioning assistance data are desired (e.g., as part of a positioning procedure when the LMF provided assistance data are not sufficient for the UE to fulfil the request) and sends an LPP Request Assistance Data message to the LMF. This request includes an indication of which specific Multi-RTT assistance data are requested. Additional information concerning the UE's approximate location and serving and neighbour cells may also be provided in the Request Assistance Data message and/or in an accompanying Provide Location Information message to help the LMF provide appropriate assistance data. This additional data may include the UE's last known location if available, the cell IDs of the UE serving NG-RAN node and possibly neighbour NG-RAN nodes, as well as NR E-CID measurements.

(2) The LMF provides the requested assistance in an LPP Provide Assistance Data message, if available at the LMF. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data.

##### 8.10.3.1.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

###### 8.10.3.1.3.1 LMF-initiated Location Information Transfer Procedure

Figure 8.10.3.1.3.1-1 shows the Location Information Transfer operations for the Multi-RTT positioning method when the procedure is initiated by the LMF.



Figure 8.10.3.1.3.1-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends an LPP Request Location Information message to the UE. This request includes indication of Multi-RTT measurements requested, including any needed measurement configuration information, and required response time.

(2) The UE obtains Multi-RTT measurements as requested in step 1. The UE then sends an LPP Provide Location Information message to the LMF, before the Response Time provided in step (1) elapsed, and includes the obtained Multi-RTT measurements. If the UE is unable to perform the requested measurements, or the Response Time elapsed before any of the requested measurements were obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

###### 8.10.3.1.3.2 UE-initiated Location Information Delivery procedure

Figure 8.10.3.1.3.2-1 shows the Location Information Delivery procedure operations for the Multi-RTT positioning method when the procedure is initiated by the UE.



Figure 8.10.3.1.3.2-1: UE-initiated Location Information Delivery Procedure.

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE Multi-RTT measurements already available at the UE.

#### 8.10.3.2 Procedures between LMF and gNB

##### 8.10.3.2.1 Assistance Data Delivery between LMF and gNB

The purpose of these procedures is to enable the gNB to provide assistance data described in Table 8.10.2.3-1 to the LMF, for subsequent delivery to the UE using the procedures of clause 8.10.3.1.2.1 or for use in the calculation of positioning estimates at the LMF or enable the LMF to request UL-SRS configuration information from the serving gNB of a target UE.

Figure 8.10.3.2.1-1 shows the TRP Information Exchange operation from the gNB to the LMF for the Multi-RTT positioning method.



Figure 8.10.3.2.1-1: LMF-initiated TRP Information Exchange Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

Figure 8.10.3.2.1-2 shows the UL information Delivery operation from the serving gNB to the LMF.



Figure 8.10.3.2.1-2: LMF-initiated UL Information Request Procedure

(1) The LMF sends a NRPPa message POSITIONING INFORMATION REQUEST to the serving gNB of the target UE to request UE SRS configuration information. If the message includes the Requested UL-SRS Transmission Characteristics as listed in Table 8.10.2.4-1, the gNB should take this information into account when configuring UL-SRS transmissions for the UE.

(2) The serving gNB determines the UE SRS configuration to be allocated for the UE and sends NRPPa message POSITIONING INFORMATION RESPONSE to the LMF that includes the UE SRS configuration defined in Table 8.10.2.3-2. If the serving gNB is not able to provide the requested information, it returns a failure message indicating the cause of the failure.

(3) If a change has occurred in the UE SRS configuration during the UE SRS time duration requested at step 1, the gNB sends a POSITIONING INFORMATION UPDATE message to the LMF. This message contains, in the case of a change in UE SRS configuration parameters, the UE SRS configuration information for all cells with UE SRS configured, or an indication that the UE SRS configuration has been released in the UE.

##### 8.10.3.2.2 Location Information Transfer/Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from a gNB for position calculation of the UE and also provide necessary assistance data to the gNB.

Figure 8.10.3.2.2-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.10.3.2.2-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends a NRPPa message to the selected gNB to request Multi-RTT measurement information. The message includes any information required for the gNB to perform the measurements as defined in Table 8.10.2.4-2.

(2) If the report characteristics in step 1 is set to "on demand", the gNB obtains the requested Multi-RTT measurements and returns them in a Measurement Response message to the LMF. The Measurement Response message includes the obtained Multi-RTT measurements as defined in Table 8.10.2.3-3.

If the report characteristics in step 1 is set to "periodic", the gNB replies with a Measurement Response message without including any measurements in the message. The gNB then periodically initiates the Measurement Report procedure in step 3 for the Multi-RTT measurements, with the requested reporting periodicity.  
  
If the gNB is not able to accept the Measurement Request message in step 1, the gNB returns a failure message indicating the cause of the failure.

(3) The gNB periodically provides the Multi-RTT measurements as defined in Table 8.10.2.3-3. to the LMF if that was requested at step 1.

(4) At any time after step 2, the LMF may send a Measurement Update message to the gNB providing updated information required for the gNB to perform the Multi-RTT measurements as defined in Table 8.10.2.4-2. Upon receiving the message, the gNB overwrites the previously received measurement configuration information.

(5) If the previously requested Multi-RTT measurements can no longer be reported, the gNB notifies the LMF by sending a Measurement Failure Indication message.

(6) When the LMF wants to abort an ongoing Multi-RTT measurement it sends a Measurement Abort message to the gNB.

##### 8.10.3.2.3 Positioning Activation/Deactivation Procedure

The purpose of this procedure is to enable the LMF to request activation and deactivation of UL-SRS transmission of the target UE.

Figure 8.10.3.2.3-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.10.3.2.3-1: Positioning Activation/Deactivation Procedure.

(1) The LMF sends the NRPPa Positioning Activation Request message to the serving gNB of the target UE to request UL-SRS activation for the target UE. For a semi-persistent UL-SRS, the message includes an indication of an UL-SRS resource set to be activated and may include information that indicates the spatial relation for the semi-persistent UL-SRS resource to be activated, as listed in Table 8.10.2.4-3. For an aperiodic UL-SRS, the message may include aperiodic SRS Resource trigger list to indicate the UL-SRS resource to be activated.

(2) For semi-persistent UL-SRS, the serving gNB may then activate the configured semi-persistent UL-SRS resource sets by sending the SP Positioning SRS Activation/Deactivation MAC CE command as specified in TS 38.321 [39]. For aperiodic UL-SRS, the serving gNB may then activate the configured aperiodic UL-SRS resource sets by sending the DCI as specified in TS 38.212 [40].  
If the UL-SRS has been successfully activated as requested in step 1, the gNB sends the NRPPa Positioning Activation Response message to the LMF. The serving gNB may include a system frame number and a slot number in the NRPPa Positioning Activation Response message to the LMF. If the serving gNB is not able to fulfil the request from step 1, it returns the Positioning Activation Failure message indicating the cause of the failure.

(3) If a previously activated UL-SRS should be deactivated, or the UL-SRS transmission should be released, the LMF sends the NRPPa Positioning Deactivation message to the serving gNB of the target device to request deactivation of UL-SRS resource sets, or release all the UL-SRS resources. This message includes an indication of the UL-SRS resource set to be deactivated, or an indication of releasing all UL-SRS resources.

### 8.10.4 Sequence of Procedure for Multi-RTT positioning

Figure 8.10.4-1 shows the messaging between the LMF, the gNBs and the UE to perform LMF-initiated Location Information Transfer Procedure for Multi-RTT.



Figure 8.10.4-1: Multi-RTT positioning procedure

0. The LMF may use the procedure in Figure 8.10.3.2.1-1 to obtain the TRP information required for Multi-RTT positioning.

1. The LMF may request the positioning capabilities of the target device using the LPP Capability Transfer procedure described in clause 8.10.3.1.1.

2. The LMF sends a NRPPa POSITIONING INFORMATION REQUEST message to the serving gNB to request UL information for the target device as described in Figure 8.10.3.2.1-2.

3. The serving gNB determines the resources available for UL-SRS and configures the target device with the UL-SRS resource sets at step 3a.

4. The serving gNB provides the UL-SRS configuration information to the LMF in a NRPPa POSITIONING INFORMATION RESPONSE message.

NOTE: It is up to implementation on whether SRS configuration is provided earlier than DL-PRS configuration.

5. In the case of semi-persistent or aperiodic SRS, the LMF may request activation of UE SRS transmission by sending a NRPPa Positioning Activation Request message to the serving gNB of the target device as described in clause 8.10.3.2.3. The gNB then activates the UE SRS transmission and sends a NRPPa Positioning Activation Response message. The target device begins the UL-SRS transmission according to the time domain behavior of UL-SRS resource configuration.

6. The LMF provides the UL information to the selected gNBs in a NRPPa MEASUREMENT REQUEST message as described in clause 8.10.3.2.2. The message includes all information required to enable the gNBs/TRPs to perform the UL measurements.

7. The LMF sends a LPP Provide Assistance Data message to the target device as described in clause 8.10.3.1.2.1. The message includes any required assistance data for the target device to perform the necessary DL-PRS measurements.

8. The LMF sends a LPP Request Location Information message to request Multi-RTT measurements.

9a: The target device performs the DL-PRS measurements from all gNBs provided in the assistance data at step 7.

9b: Each gNB configured at step 6 measures the UE SRS transmissions from the target device.

10. The target device reports the DL-PRS measurements for Multi-RTT to the LMF in a LPP Provide Location Information message.

11. Each gNB reports the UE SRS measurements to the LMF in a NRPPa Measurement Response message as described in clause 8.10.3.2.2.

12. The LMF sends a NRPPa POSITIONING DEACTIVATION message to the serving gNB as described in clause 8.10.3.2.3.

13. The LMF determines the RTTs from the UE and gNB Rx-Tx time difference measurements for each gNB for which corresponding UL and DL measurements were provided at steps 10 and 11 and calculates the position of the target device.

## 8.11 DL-AoD positioning

### 8.11.1 General

In the DL-AoD positioning method, the UE position is estimated based on DL-PRS-RSRP measurements taken at the UE of downlink radio signals from multiple NR TRPs, along with knowledge of the spatial information of the downlink radio signals and geographical coordinates of the TRPs.

The UE while connected to a gNB may require measurement gaps to perform the DL-AoD measurements from NR TRPs. The UE may request measurement gaps from a gNB using the procedure described in clause 7.4.1.1.

The specific positioning techniques used to estimate the UE's location from this information are beyond the scope of this specification.

### 8.11.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE/gNB.

#### 8.11.2.1 Information that may be transferred from the LMF to UE

The information that may be transferred from the LMF to the UE are listed in table 8.11.2.1-1.

Table 8.11.2.1-1: Assistance data that may be transferred from LMF to the UE

|  |  |  |
| --- | --- | --- |
| Information | UE-assisted | UE-based |
| Physical cell IDs (PCIs), global cell IDs (GCIs), ARFCN, and PRS IDs of candidate NR TRPs for measurement | Yes | Yes |
| Timing relative to the serving (reference) TRP of candidate NR TRPs | Yes | Yes |
| DL-PRS configuration of candidate NR TRPs | Yes | Yes |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) | Yes | Yes |
| Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB | No | Yes |
| Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) | No | Yes |
| PRS-only TP indication | Yes | Yes |
| TRP beam/antenna information(include azimuth angle, zenith angle and relative power between PRS resources per angle per TRP) | No | Yes |
| LOS/NLOS indicators | No | Yes |
| On-Demand DL-PRS-Configurations | Yes | Yes |
| Spatial direction information | Yes | No |
| Expected Angle Assistance information | Yes | Yes |
| PRS priority list | Yes | Yes |

#### 8.11.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from UE to the LMF is listed in Table 8.11.2.2-1. The individual UE measurements are defined in TS 38.215 [37].

Table 8.11.2.2-1: Measurement results that may be transferred from UE to the LMF

|  |  |  |
| --- | --- | --- |
| Information | UE‑assisted | UE‑based |
| Latitude/Longitude/Altitude, together with uncertainty shape | No | Yes |
| PCI, GCI, ARFCN, PRS resource ID, PRS resource set ID and PRS ID for each measurement | Yes | No |
| DL-PRS-RSRP measurement | Yes | No |
| Time stamp of the measurements | Yes | No |
| Time stamp of location estimate | No | Yes |
| DL-PRS receive beam index | Yes | No |
| The first path DL-PRS-RSRP measurement result | Yes | No |
| LOS/NLOS information for UE measurements | Yes | No |

#### 8.11.2.3 Information that may be transferred from the gNB to LMF

The assistance data that may be transferred from gNB to the LMF is listed in Table 8.11.2.3-1.

Table 8.11.2.3-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, ARFCN, and TRP IDs of the TRPs served by the gNB |
| Timing information of TRPs served by the gNB |
| DL-PRS configuration of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates information of the DL-PRS Resources of the TRPs served by the gNB |

### 8.11.3 DL-AoD Positioning Procedures

The procedures described in this clause support UE-assisted and UE-based DL-AOD.

#### 8.11.3.1 Procedures between LMF and UE

##### 8.11.3.1.1 Capability Transfer Procedure

The Capability Transfer procedure for DL-AoD positioning is described in clause 7.1.2.1.

##### 8.11.3.1.2 Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to provide assistance data to the UE (e.g., as part of a positioning procedure) and the UE to request assistance data from the LMF (e.g., as part of a positioning procedure). The LMF may provide the DL-PRS assistance data (with associated validity criteria) to the UE (before or during an ongoing LPP positioning session), to be utilized for potential positioning measurements at a future time.

###### 8.11.3.1.2.1 LMF initiated Assistance Data Delivery

Figure 8.11.3.1.2.1-1 shows the Assistance Data Delivery operations for the DL-AoD positioning method when the procedure is initiated by the LMF.



Figure 8.11.3.1.2.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that assistance data needs to be provided to the UE (e.g., as part of a positioning procedure) and sends an LPP Provide Assistance Data message to the UE. This message may include any of the DL-AoD positioning assistance data defined in Table 8.11.2.1-1.

###### 8.11.3.1.2.2 UE initiated Assistance Data Transfer

Figure 8.11.3.1.2.2-1 shows the Assistance Data Transfer operations for the DL-AoD positioning method when the procedure is initiated by the UE.



Figure 8.11.3.1.2.2-1: UE-initiated Assistance Data Transfer Procedure

(1) The UE determines that certain DL-AoD positioning assistance data are desired (e.g., as part of a positioning procedure when the LMF provided assistance data are not sufficient for the UE to fulfil the request) and sends an LPP Request Assistance Data message to the LMF. This request includes an indication of which specific DL-AoD assistance data are requested. Additional information concerning the UE's approximate location and serving and neighbour cells may also be provided in the Request Assistance Data message and/or in an accompanying Provide Location Information message to help the LMF provide appropriate assistance data. This additional data may include the UE's last known location if available, the cell IDs of the UE serving NG-RAN node and possibly neighbour NG-RAN nodes, as well as NR E-CID measurements.

(2) The LMF provides the requested assistance in an LPP Provide Assistance Data message, if available at the LMF. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data.

#### 8.11.3.1.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request location estimate from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

###### 8.11.3.1.3.1 LMF-initiated Location Information Transfer Procedure

Figure 8.11.3.1.3.1-1 shows the Location Information Transfer operations for the DL-AoD positioning method when the procedure is initiated by the LMF.



Figure 8.11.3.1.3.1-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends an LPP Request Location Information message to the UE. This request includes indication of DL-AoD measurements requested, including any needed measurement configuration information, and required response time.

(2) The UE obtains DL-AoD measurements as requested in step 1. The UE then sends an LPP Provide Location Information message to the LMF, before the Response Time provided in step (1) elapsed, and includes the obtained DL-PRS-RSRP measurements. If the UE is unable to perform the requested measurements, or the Response Time elapsed before any of the requested measurements were obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

###### 8.11.3.1.3.2 UE-initiated Location Information Delivery procedure

Figure 8.11.3.1.3.2-1 shows the Location Information Delivery procedure operations for the DL-AoD positioning method when the procedure is initiated by the UE.



Figure 8.11.3.1.3.2-1: UE-initiated Location Information Delivery Procedure.

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE DL-AoD measurements already available at the UE.

#### 8.11.3.2 Procedures between LMF and gNB

##### 8.11.3.2.1 Assistance Data Delivery procedure

The purpose of this procedure is to enable the gNB to provide assistance data described in Table 8.11.2.3-1 to the LMF, for subsequent delivery to the UE using the procedures of clause 8.11.3.1.2 or for use in the calculation of positioning estimates at the LMF.

###### 8.11.3.2.1.1 LMF-initiated assistance data delivery to the LMF

Figure 8.11.3.2.1.1-1 shows the TRP Information Exchange operation from the gNB to the LMF for the DL-AoD positioning method.



Figure 8.11.3.2.1.1-1: LMF-initiated TRP Information Exchange Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

## 8.12 DL-TDOA positioning

### 8.12.1 General

In the DL-TDOA positioning method, the UE position is estimated based on DL RSTD (and optionally DL-PRS-RSRP) measurements taken at the UE of downlink radio signals from multiple NR TRPs, along with knowledge of the geographical coordinates of the TRPs and their relative downlink timing.

The UE while connected to a gNB may require measurement gaps to perform the DL-TDOA measurements from NR TRPs. The UE may request measurement gaps from a gNB using the procedure described in clause 7.4.1.1.

The specific positioning techniques used to estimate the UE's location from this information are beyond the scope of this specification.

### 8.12.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and UE/gNB.

#### 8.12.2.1 Information that may be transferred from the LMF to UE

The information that may be transferred from the LMF to the UE are listed in table 8.12.2.1-1.

Table 8.12.2.1-1: Assistance data that may be transferred from LMF to the UE

|  |  |  |
| --- | --- | --- |
| Information | UE‑assisted | UE‑based |
| Physical cell IDs (PCIs), global cell IDs (GCIs), ARFCN, and PRS IDs of candidate NR TRPs for measurement | Yes | Yes |
| Timing relative to the serving (reference) TRP of candidate NR TRPs | Yes | Yes |
| DL-PRS configuration of candidate NR TRPs | Yes | Yes |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) | Yes | Yes |
| Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB | No | Yes |
| Geographical coordinates of the TRPs served by the gNB (include a transmission reference location for each DL-PRS Resource ID, reference location for the transmitting antenna of the reference TRP, relative locations for transmitting antennas of other TRPs) | No | Yes |
| Fine Timing relative to the serving (reference) TRP of candidate NR TRPs | No | Yes |
| PRS-only TP indication | Yes | Yes |
| The association information of DL-PRS resources with TRP Tx TEG ID | No | Yes |
| LOS/NLOS indicators | No | Yes |
| On-Demand DL-PRS-Configurations | Yes | Yes |

#### 8.12.2.2 Information that may be transferred from the UE to LMF

The information that may be signalled from UE to the LMF is listed in Table 8.12.2.2-1. The individual UE measurements are defined in TS 38.215 [37].

Table 8.12.2.2-1: Measurement results that may be transferred from UE to the LMF

|  |  |  |
| --- | --- | --- |
| Information | UE‑assisted | UE‑based |
| Latitude/Longitude/Altitude, together with uncertainty shape | No | Yes |
| PCI, GCI, ARFCN, PRS resource ID, PRS resource set ID and PRS ID for each measurement | Yes | No |
| DL RSTD measurement | Yes | No |
| DL-PRS-RSRP measurement | Yes | No |
| Time stamp of the measurements | Yes | No |
| Time stamp of location estimate | No | Yes |
| Quality for each measurement | Yes | No |
| UE Rx TEG IDs for DL RSTD measurements | Yes | No |
| LOS/NLOS information for UE measurements | Yes | No |

#### 8.12.2.3 Information that may be transferred from the gNB to LMF

The assistance data that may be transferred from gNB to the LMF is listed in Table 8.12.2.3-1.

Table 8.12.2.3-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, ARFCN, and TRP IDs of the TRPs served by the gNB |
| Timing information of TRPs served by the gNB |
| DL-PRS configuration of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Spatial direction information of the DL-PRS Resources of the TRPs served by the gNB |
| Geographical coordinates information of the DL-PRS Resources of the TRPs served by the gNB |

### 8.12.3 DL-TDOA Positioning Procedures

The procedures described in this clause support UE-assisted and UE-based DL-TDOA.

#### 8.12.3.1 Procedures between LMF and UE

##### 8.12.3.1.1 Capability Transfer Procedure

The Capability Transfer procedure for DL-TDOA positioning is described in clause 7.1.2.1.

##### 8.12.3.1.2 Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to provide assistance data to the UE (e.g., as part of a positioning procedure) and the UE to request assistance data from the LMF (e.g., as part of a positioning procedure). The LMF may provide the DL-PRS assistance data (with associated validity criteria) to the UE (before or during an ongoing LPP positioning session), to be utilized for potential positioning measurements at a future time.

###### 8.12.3.1.2.1 LMF initiated Assistance Data Delivery

Figure 8.12.3.1.2.1-1 shows the Assistance Data Delivery operations for the DL-TDOA positioning method when the procedure is initiated by the LMF.



Figure 8.12.3.1.2.1-1: LMF-initiated Assistance Data Delivery Procedure

(1) The LMF determines that assistance data needs to be provided to the UE (e.g., as part of a positioning procedure) and sends an LPP Provide Assistance Data message to the UE. This message may include any of the DL-TDOA positioning assistance data defined in Table 8.12.2.1-1.

###### 8.12.3.1.2.2 UE initiated Assistance Data Transfer

Figure 8.12.3.1.2.2-1 shows the Assistance Data Transfer operations for the DL-TDOA positioning method when the procedure is initiated by the UE.



Figure 8.12.3.1.2.2-1: UE-initiated Assistance Data Transfer Procedure

(1) The UE determines that certain DL-TDOA positioning assistance data are desired (e.g., as part of a positioning procedure when the LMF provided assistance data are not sufficient for the UE to fulfil the request) and sends an LPP Request Assistance Data message to the LMF. This request includes an indication of which specific DL-TDOA assistance data are requested. Additional information concerning the UE's approximate location and serving and neighbour cells may also be provided in the Request Assistance Data message and/or in an accompanying Provide Location Information message to help the LMF provide appropriate assistance data. This additional data may include the UE's last known location if available, the cell IDs of the UE serving NG-RAN node and possibly neighbour NG-RAN nodes, as well as NR E-CID measurements.

(2) The LMF provides the requested assistance in an LPP Provide Assistance Data message, if available at the LMF. If any of the UE requested assistance data in step (1) are not provided in step 2, the UE shall assume that the requested assistance data are not supported, or currently not available at the LMF. If none of the UE requested assistance data in step (1) can be provided by the LMF, return any information that can be provided in an LPP message of type Provide Assistance Data which includes a cause indication for the not provided assistance data.

##### 8.12.3.1.3 Location Information Transfer Procedure

The purpose of this procedure is to enable the LMF to request location estimate from the UE, or to enable the UE to provide location measurements to the LMF for position calculation.

###### 8.12.3.1.3.1 LMF-initiated Location Information Transfer Procedure

Figure 8.12.3.1.3.1-1 shows the Location Information Transfer operations for the DL-TDOA positioning method when the procedure is initiated by the LMF.



Figure 8.12.3.1.3.1-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends an LPP Request Location Information message to the UE. This request includes indication of DL-TDOA measurements requested, including any needed measurement configuration information, and required response time.

(2) The UE obtains DL-TDOA measurements as requested in step 1. The UE then sends an LPP Provide Location Information message to the LMF, before the Response Time provided in step (1) elapsed, and includes the obtained DL RSTD measurements and, optionally, the DL-PRS-RSRP measurements. If the UE is unable to perform the requested measurements, or the Response Time elapsed before any of the requested measurements were obtained, the UE returns any information that can be provided in an LPP message of type Provide Location Information which includes a cause indication for the not provided location information.

###### 8.12.3.1.3.2 UE-initiated Location Information Delivery procedure

Figure 8.12.3.1.3.2-1 shows the Location Information Delivery procedure operations for the DL-TDOA positioning method when the procedure is initiated by the UE.



Figure 8.12.3.1.3.2-1: UE-initiated Location Information Delivery Procedure.

(1) The UE sends an LPP Provide Location Information message to the LMF. The Provide Location Information message may include any UE DL-TDOA measurements and, optionally, the DL-PRS-RSRP measurements already available at the UE.

#### 8.12.3.2 Procedures between LMF and gNB

##### 8.12.3.2.1 Assistance Data Delivery procedure

The purpose of this procedure is to enable the gNB to provide assistance data to the LMF, for subsequent delivery to the UE using the procedures of clause 8.12.3.1.2 or for use in the calculation of positioning estimates at the LMF.

###### 8.12.3.2.1.1 LMF-initiated assistance data delivery to the LMF

Figure 8.12.3.2.1.1-1 shows the TRP Information Exchange operation from the gNB to the LMF for the DL-TDOA positioning method.



Figure 8.12.3.2.1.1-1: LMF-initiated TRP Information Exchange Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

## 8.13 UL-TDOA positioning

### 8.13.1 General

In the UL-TDOA positioning method, the UE position is estimated based on UL-RTOA (and optionally UL-SRS-RSRP) measurements taken at different TRPs of uplink radio signals from UE, along with other configuration information.

The specifics of any UL-TDOA positioning methods or techniques used to estimate the UE's location from these measurements are beyond the scope of this specification.

In order to obtain uplink measurements, the TRPs need to know the characteristics of the SRS signal transmitted by the UE for the time period required to perform uplink measurement. These characteristics should be static over the periodic transmission of SRS during the uplink measurements. Hence, the LMF will indicate to the serving gNB the need to direct the UE to transmit SRS signals for uplink positioning. It is up to the serving gNB to make the final decision on resources to be assigned and to communicate this SRS configuration information back to the LMF so that LMF can forward the SRS configuration to the TRPs. The gNB may decide (e.g., in case no resources are available) to configure no resources for the UE and report the empty resource configuration to the LMF.

### 8.13.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and gNB/TRPs.

#### 8.13.2.0 Assistance Data that may be transferred from the gNB to the LMF

The assistance data that may be transferred from the gNB to the LMF is listed in Table 8.13.2.0-1.

Table 8.13.2.0-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP IDs of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Geographical coordinates information of the DL-PRS Resources of the TRPs served by the gNB |

#### 8.13.2.1 Configuration Data that may be transferred from the gNB to the LMF

The configuration data for a target UE that may be transferred from the serving gNB to the LMF is listed in Table 8.13.2.1-1.

Table 8.13.2.1-1: UE configuration data that may be transferred from serving gNB to the LMF

|  |
| --- |
| UE configuration data |
| UE SRS configuration |
| Timing information of the TRP, which configured the UE SRS transmission |

#### 8.13.2.2 Location Information that may be transferred from the gNBs to LMF

The information that may be transferred from gNBs to the LMF include measurement results listed in Table 8.13.2.2-1. The individual measurements are defined in TS 38.215 [37].

Table 8.13.2.2-1: Measurement results that may be transferred from gNBs to the LMF

|  |
| --- |
| Measurement results |
| NCGI and TRP ID of the measurement |
| UL-RTOA |
| UL-SRS-RSRP |
| Time stamp of the measurement |
| Quality for each measurement |
| Beam Information for each measurement |

#### 8.13.2.3 Information that may be transferred from the LMF to gNBs

The requested UL-SRS transmission characteristics information that may be signalled from the LMF to the gNB is listed in Table 8.13.2.3-1.

Table 8.13.2.3-1: Requested UL-SRS transmission characteristics information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| Number Of Transmissions/duration for which the UL-SRS is requested |
| Bandwidth |
| Resource type (periodic, semi-persistent, aperiodic) |
| Pathloss reference:  - PCI, SSB Index, SSB configuration (time/frequency occupancy of SSBs)  - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID |
| Spatial relation info  - PCI, SSB Index, SSB configuration (time/frequency occupancy of SSBs)  - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID  - NZP CSI-RS Resource ID  - SRS Resource ID  - Positioning SRS Resource ID |
| SSB Information |
| Periodicity of the SRS for each SRS resource set |
| Carrier frequency of SRS transmission bandwidth |

The TRP measurement request information that may be signalled from the LMF to the gNB is listed in table 8.13.2.3-2.

Table 8.13.2.3-2: TRP Measurement request information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| TRP ID, cell ID of the TRP to receive UL-SRS |
| UE-SRS configuration |
| UL timing information together with timing uncertainty, for reception of SRS by candidate TRPs |
| Report characteristics for the measurements |
| Measurement Quantities |
| Measurement periodicity |
| Measurement beam information request |

The Positioning Activation/Deactivation request information that may be signalled from the LMF to the gNB is listed in Table 8.13.2.3-3.

Table 8.13.2.3-3: Requested positioning activation/deactivation information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| SP UL-SRS:  - Activation or Deactivation request  - Positioning SRS Resource Set ID which is to be activated/deactivated  - Spatial relation for Resource IDi  - Activation Time |
| Aperiodic UL-SRS:  - Aperiodic SRS Resource Trigger List  - Activation time |
| UL-SRS:  - Release all |







### 8.13.3 UL-TDOA Positioning Procedures

The procedures described in this clause support UL-TDOA positioning measurements obtained by the gNB and provided to the LMF using NRPPa.

#### 8.13.3.1 Capability Transfer Procedure

The Capability Transfer procedure for UL-TDOA positioning is described in clause 7.1.2.1.

#### 8.13.3.2 Assistance Data Transfer Procedure

##### 8.13.3.2.1 Assistance Data Delivery between LMF and gNB

The purpose of these procedures is to enable the gNB to provide assistance data described in Table 8.13.2.0-1 to the LMF, for subsequent delivery to the gNB using the procedures of clause 8.13.3.3 or for use in the calculation of positioning estimates at the LMF or enable the LMF to request UL-SRS configuration information from the serving gNB of a target UE.

Figure 8.13.3.2.1-1 shows the UL information Delivery operation from the serving gNB to the LMF.



Figure 8.13.3.2.1-1: LMF-initiated UL Information Request Procedure

(1) The LMF sends a NRPPa message POSITIONING INFORMATION REQUEST to the serving gNB of the target UE to request UE SRS configuration information. If the message includes the Requested UL-SRS Transmission Characteristics as listed in Table 8.13.2.3-1, the gNB should take this information into account when configuring UL-SRS transmissions for the UE.

(2) The serving gNB determines the UE SRS configuration to be allocated for the UE and sends NRPPa message POSITIONING INFORMATION RESPONSE to the LMF that includes the UE SRS configuration defined in Table 8.13.2.1-1. If the serving gNB is not able to provide the requested information, it returns a failure message indicating the cause of the failure.

(3) If a change has occurred in the UE SRS configuration during the UE SRS time duration requested at step 1, the gNB sends a POSITIONING INFORMATION UPDATE message to the LMF. This message contains, in the case of a change in UE SRS configuration parameters, the UE SRS configuration information for all cells with UE SRS configured, or an indication that the UE SRS configuration has been released in the UE.

Figure 8.13.3.2.1-2 shows the TRP Information Exchange operation from the gNB to the LMF for the UL-TDOA positioning method.



Figure 8.13.3.2.1-2: LMF-initiated TRP Information Exchange Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

#### 8.13.3.3 Location Information Transfer/Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from a gNB for position calculation of the UE and also provide necessary assistance data to the gNB.

Figure 8.13.3.3-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.13.3.3-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends a NRPPa message to the selected gNB to request UL-TDOA measurement information. The message includes any information required for the gNB to perform the measurements as defined in Table 8.13.2.3-2.

(2) If the report characteristics in step 1 is set to "on demand", the gNB obtains the requested UL-TDOA measurements and returns them in a Measurement Response message to the LMF. The Measurement Response message includes the obtained UL-TDOA measurements as defined in Table 8.13.2.2-1.

If the report characteristics in step 1 is set to "periodic", the gNB replies with a Measurement Response message without including any measurements in the message. The gNB then periodically initiates the Measurement Report procedure in step 3 for the UL-TDOA measurements, with the requested reporting periodicity.  
  
If the gNB is not able to accept the Measurement Request message in step 1, the gNB returns a failure message indicating the cause of the failure.

(3) The gNB periodically provides the UL-TDOA measurements as defined in Table 8.13.2.2-1 to the LMF if that was requested at step 1.

(4) At any time after step 2, the LMF may send a Measurement Update message to the gNB providing updated information required for the gNB to perform the UL-TDOA measurements as defined in Table 8.13.2.3-2. Upon receiving the message, the gNB overwrites the previously received measurement configuration information.

(5) If the previously requested UL-TDOA measurements can no longer be reported, the gNB notifies the LMF by sending a Measurement Failure Indication message.

(6) When the LMF wants to abort an ongoing UL-TDOA measurement it sends a Measurement Abort message to the gNB.

#### 8.13.3.3a Positioning Activation/Deactivation Procedure

The purpose of this procedure is to enable the LMF to request activation and deactivation of UL-SRS transmission of the target UE.

Figure 8.13.3.3a-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.13.3.3a-1: Positioning Activation/Deactivation Procedure.

(1) The LMF sends the NRPPa Positioning Activation Request message to the serving gNB of the target UE to request UL-SRS activation for the target UE. For a semi-persistent UL-SRS, the message includes an indication of an UL-SRS resource set to be activated and may include information that indicates the spatial relation for the semi-persistent UL-SRS resource to be activated, as listed in Table 8.13.2.3-3. For an aperiodic UL-SRS, the message may include aperiodic SRS Resource trigger list to indicate the UL-SRS resource to be activated.

(2) For semi-persistent UL-SRS, the serving gNB may then activate the configured semi-persistent UL-SRS resource sets by sending the SP Positioning SRS Activation/Deactivation MAC CE command as specified in TS 38.321 [39]. For aperiodic UL-SRS, the serving gNB may then activate the configured aperiodic UL-SRS resource sets by sending the DCI as specified in TS 38.212 [40].  
If the UL-SRS has been successfully activated as requested in step 1, the gNB sends the NRPPa Positioning Activation Response message to the LMF. If the serving gNB is not able to fulfil the request from step 1, it returns the Positioning Activation Failure message indicating the cause of the failure. The serving gNB may include a system frame number and a slot number in the NRPPa Positioning Activation Response message to the LMF.

(3) If a previously activated UL-SRS should be deactivated, or the UL-SRS transmission should be released, the LMF sends the NRPPa Positioning Deactivation message to the serving gNB of the target device to request deactivation of UL-SRS resource sets, or release all the UL-SRS resources. This message includes an indication of the UL-SRS resource set to be deactivated, or an indication of releasing all UL-SRS resources.

#### 8.13.3.4 Sequence of Procedure for UL-TDOA positioning

Figure 8.13.3.4-1 shows the messaging between the LMF, the gNBs and the UE to perform UL-TDOA procedure.



Figure 8.13.3.4-1: UL-TDOA positioning procedure

0. The LMF may use the procedure in Figure 8.13.3.2.1-2 to obtain the TRP information required for UL-TDOA positioning.

1. The LMF may request the positioning capabilities of the target device using the LPP Capability Transfer procedure as described in clause 8.13.3.1.

2. The LMF sends a NRPPa POSITIONING INFORMATION REQUEST message to the serving gNB to request UL-SRS configuration information for the target device as described in Figure 8.13.3.2.1-1.

3. The serving gNB determines the resources available for UL-SRS and configures the target device with the UL-SRS resource sets at step 3a. The gNB may request the UE TxTEG association information in step 3b, the target device reports it (and upon the change in the association).

4. The serving gNB provides the UL information to the LMF in a NRPPa POSITIONING INFORMATION RESPONSE message.

5. In the case of semi-persistent or aperiodic SRS, the LMF may request activation of UE SRS transmission by sending the NRPPa Positioning Activation Request message to the serving gNB of the target device as described in clause 8.13.3.3a. The gNB then activates the UL-SRS transmission and sends the NRPPa Positioning Activation Response message. The target device begins the UL-SRS transmission according to the time domain behavior of UL-SRS resource configuration.

6. The LMF provides the UL-SRS configuration to the selected gNBs in a NRPPa MEASUREMENT REQUEST message as described in clause 8.13.3.3. The message includes all information required to enable the gNBs/TRPs to perform the UL measurements.

7. Each gNB configured at step 6 measures the UL-SRS transmissions from the target device.

8. Each gNB reports the UL-SRS measurements to the LMF in a NRPPa Measurement Response message as described in clause 8.13.3.3.

9. The LMF sends a NRPPa POSITIONING DEACTIVATION message to the serving gNB as described in clause 8.13.3.3a.

## 8.14 UL-AoA positioning

### 8.14.1 General

In the UL-AoA positioning method, the UE position is estimated based on UL-AoA (and optionally UL-SRS-RSRP) of uplink radio signals taken at different TRPs, along with other configuration information.

The specific of any UL-AoA positioning methods or techniques used to estimate the UE's location from these measurements are beyond the scope of this specification.

In order to obtain uplink measurements, the TRPs need to know the characteristics of the SRS signal transmitted by the UE for the time period required to calculate uplink measurement. These characteristics should be static over the periodic transmission of SRS during the uplink measurements. Hence, the LMF will indicate to the serving gNB the need to direct the UE to transmit SRS signals for uplink positioning. It is up to the gNB to make the final decision on resources to be assigned and to communicate this configuration information back to the LMF so that LMF can configure the TRPs. The gNB may decide (e.g., in case no resources are available) to configure no resources for the UE and fail the corresponding NRPPa procedure.

### 8.14.2 Information to be transferred between NG-RAN/5GC Elements

This clause defines the information that may be transferred between LMF and gNB/TRPs.

#### 8.14.2.0 Assistance Data that may be transferred from the gNB to the LMF

The assistance data that may be transferred from the gNB to the LMF is listed in Table 8.14.2.0-1.

Table 8.14.2.0-1: Assistance data that may be transferred from gNB to the LMF

|  |
| --- |
| Information |
| PCI, GCI, and TRP IDs of the TRPs served by the gNB |
| SSB information of the TRPs (the time/frequency occupancy of SSBs) |
| Geographical coordinates information of the DL-PRS Resources of the TRPs served by the gNB |

#### 8.14.2.1 Configuration Data that may be transferred from the gNB to the LMF

The configuration data for a target UE that may be transferred from the serving gNB to the LMF is listed in Table 8.14.2.1-1.

Table 8.14.2.1-1: UE configuration data that may be transferred from serving gNB to the LMF

|  |
| --- |
| UE configuration data |
| UE SRS configuration |
| Timing information of the TRP, which configured the UE SRS transmission |

#### 8.14.2.2 Location Information that may be transferred from the gNBs to LMF

The information that may be transferred from gNBs to the LMF include measurement results are listed in Table 8.14.2.2-1. The individual measurements are defined in TS 38.215 [37].

Table 8.14.2.2-1: Measurement results that may be transferred from gNBs to the LMF

|  |
| --- |
| Measurement results |
| NCGI and TRP ID of the measurement |
| UL Angle of Arrival (azimuth and elevation) |
| UL-SRS-RSRP |
| Time stamp of the measurement |
| Quality for each measurement |
| Beam information for each measurement |

#### 8.14.2.3 Information that may be transferred from the LMF to gNB

The requested UL-SRS transmission characteristics information that may be signalled from the LMF to the gNB is listed in Table 8.14.2.3-1.

Table 8.14.2.3-1: Requested UL-SRS transmission characteristics information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| Number Of Transmissions/duration for which the UL-SRS is requested |
| Bandwidth |
| Resource type (periodic, semi-persistent, aperiodic) |
| Number of requested SRS resource sets and SRS resources per set |
| Pathloss reference:  - PCI, SSB Index, SSB configuration (time/frequency occupancy of SSBs)  - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID |
| Spatial relation info  - PCI, SSB Index, SSB configuration (time/frequency occupancy of SSBs)  - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID  - NZP CSI-RS Resource ID  - SRS Resource ID  - Positioning SRS Resource ID |
| SSB Information |
| Periodicity of the SRS for each SRS resource set |
| Carrier frequency of SRS transmission bandwidth |

The TRP measurement request information that may be signalled from the LMF to the gNB is listed in table 8.14.2.3-2.

Table 8.14.2.3-2: TRP Measurement request information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| TRP ID, cell ID of the TRP to receive UL-SRS |
| UE-SRS configuration |
| UL timing information together with timing uncertainty, for reception of SRS by candidate TRPs |
| Report characteristics for the measurements |
| Measurement Quantities |
| Measurement periodicity |
| Measurement beam information request |

The Positioning Activation/Deactivation request information that may be signalled from the LMF to the gNB is listed in Table 8.14.2.3-3.

Table 8.14.2.3-3: Requested positioning activation/deactivation information that may be transferred from LMF to gNB.

|  |
| --- |
| Information |
| SP UL-SRS:  - Activation or Deactivation request  - Positioning SRS Resource Set ID which is to be activated/deactivated  - Spatial relation for Resource IDi  - Activation Time |
| Aperiodic UL-SRS:  - Aperiodic SRS Resource Trigger list  - Activation time |
| UL-SRS:  - Release all |

### 8.14.3 UL-AoA Positioning Procedures

The procedures described in this clause support UL-AoA positioning measurements obtained by the gNB and provided to the LMF using NRPPa.

#### 8.14.3.1 Capability Transfer Procedure

The Capability Transfer procedure for UL-AoA positioning is described in clause 7.1.2.1.

#### 8.14.3.2 Assistance Data Transfer Procedure

##### 8.14.3.2.1 Assistance Data Delivery between LMF and gNB

The purpose of these procedures is to enable the gNB to provide assistance data described in Table 8.14.2.0-1 to the LMF, for subsequent delivery to the gNB using the procedures of clause 8.14.3.3 or for use in the calculation of positioning estimates at the LMF or enable the LMF to request UL-SRS configuration information from the serving gNB of a target UE.

Figure 8.14.3.2.1-1 shows the UL information Delivery operation from the serving gNB to the LMF.



Figure 8.14.3.2.1-1: LMF-initiated UL Information Request Procedure

(1) The LMF sends a NRPPa message POSITIONING INFORMATION REQUEST to the serving gNB of the target UE to request UE SRS configuration information. If the message includes the Requested UL-SRS Transmission Characteristics as listed in Table 8.14.2.3-1, the gNB should take this information into account when configuring UL-SRS transmissions for the UE.

(2) The serving gNB determines the UE SRS configuration to be allocated for the UE and sends NRPPa message POSITIONING INFORMATION RESPONSE to the LMF that includes the UE SRS configuration defined in Table 8.14.2.1-1. If the serving gNB is not able to provide the requested information, it returns a failure message indicating the cause of the failure.

(3) If a change has occurred in the UE SRS configuration during the UE SRS time duration requested at step 1, the gNB sends a POSITIONING INFORMATION UPDATE message to the LMF. This message contains, in the case of a change in UE SRS configuration parameters, the UE SRS configuration information for all cells with UE SRS configured, or an indication that the UE SRS configuration has been released in the UE.

Figure 8.14.3.2.1-2 shows the TRP Information Exchange operation from the gNB to the LMF for the UL-AoA positioning method.



Figure 8.14.3.2.1-2: LMF-initiated TRP Information Exchange Procedure

(1) The LMF determines that certain TRP configuration information is desired (e.g., as part of a periodic update or as triggered by OAM) and sends an NRPPa TRP INFORMATION REQUEST message to the gNB. This request includes an indication of which specific TRP configuration information is requested.

(2) The gNB provides the requested TRP information in an NRPPa TRP INFORMATION RESPONSE message, if available at the gNB. If the gNB is not able to provide any information, it returns an TRP INFORMATION FAILURE message indicating the cause of the failure.

#### 8.14.3.3 Location Information Transfer/Assistance Data Transfer Procedure

The purpose of this procedure is to enable the LMF to request position measurements from a gNB for position calculation of the UE and also provide necessary assistance data to the gNB.

Figure 8.14.3.3-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.14.3.3-1: LMF-initiated Location Information Transfer Procedure

(1) The LMF sends a NRPPa message to the selected gNB to request UL-AoA measurement information. The message includes any information required for the gNB to perform the measurements as defined in Table 8.14.2.3-2.

(2) If the report characteristics in step 1 is set to "on demand", the gNB obtains the requested UL-AoA measurements and returns them in a Measurement Response message to the LMF. The Measurement Response message includes the obtained UL-AoA measurements as defined in Table 8.14.2.2-1.

If the report characteristics in step 1 is set to "periodic", the gNB replies with a Measurement Response message without including any measurements in the message. The gNB then periodically initiates the Measurement Report procedure in step 3 for the UL-AoA measurements, with the requested reporting periodicity.  
  
If the gNB is not able to accept the Measurement Request message in step 1, the gNB returns a failure message indicating the cause of the failure.

(3) The gNB periodically provides the UL-AoA measurements as defined in Table 8.14.2.2-1 to the LMF if that was requested at step 1.

(4) At any time after step 2, the LMF may send a Measurement Update message to the gNB providing updated information required for the gNB to perform the UL-AoA measurements as defined in Table 8.14.2.3-2. Upon receiving the message, the gNB overwrites the previously received measurement configuration information.

(5) If the previously requested UL-AoA measurements can no longer be reported, the gNB notifies the LMF by sending a Measurement Failure Indication message.

(6) When the LMF wants to abort an ongoing UL-AoA measurement it sends a Measurement Abort message to the gNB.

#### 8.14.3.3a Positioning Activation/Deactivation Procedure

The purpose of this procedure is to enable the LMF to request activation and deactivation of UL-SRS transmission of the target UE.

Figure 8.14.3.3a-1 shows the messaging between the LMF and the gNB to perform this procedure.



Figure 8.14.3.3a-1: Positioning Activation/Deactivation Procedure.

(1) The LMF sends the NRPPa Positioning Activation Request message to the serving gNB of the target UE to request UL-SRS activation for the target UE. For a semi-persistent UL-SRS, the message includes an indication of an UL-SRS resource set to be activated and may include information that indicates the spatial relation for the semi-persistent UL-SRS resource to be activated, as listed in Table 8.14.2.3-3. For an aperiodic UL-SRS, the message may include aperiodic SRS Resource trigger list to indicate the UL-SRS resource to be activated.

(2) For semi-persistent UL-SRS, the serving gNB may then activate the configured semi-persistent UL-SRS resource sets by sending the SP Positioning SRS Activation/Deactivation MAC CE command as specified in TS 38.321 [39]. For aperiodic UL-SRS, the serving gNB may then activate the configured aperiodic UL-SRS resource sets by sending the DCI as specified in TS 38.212 [40].  
If the UL-SRS has been successfully activated as requested in step 1, the gNB sends the NRPPa Positioning Activation Response message to the LMF. If the serving gNB is not able to fulfil the request from step 1, it returns the Positioning Activation Failure message indicating the cause of the failure. The serving gNB includes a system frame number and a slot number in the NRPPa Positioning Activation Response message to the LMF.

(3) If a previously activated UL-SRS should be deactivated, or the UL-SRS transmission should be released, the LMF sends the NRPPa Positioning Deactivation message to the serving gNB of the target device to request deactivation of UL-SRS resource sets, or release all the UL-SRS resources. This message includes an indication of the UL-SRS resource set to be deactivated, or an indication of releasing all UL-SRS resources.

#### 8.14.3.4 Sequence of Procedure for UL-AoA positioning

Figure 8.14.3.4-1 shows the messaging between the LMF, the gNBs and the UE to perform UL-AoA procedure.



Figure 8.14.3.4-1: UL-AoA positioning procedure

0. The LMF may use the procedure in Figure 8.14.3.2.1-2 to obtain the TRP information required for UL-AoA positioning.

1. The LMF may request the positioning capabilities of the target device using the LPP Capability Transfer procedure as described in clause 8.14.3.1.

2. The LMF sends a NRPPa POSITIONING INFORMATION REQUEST message to the serving gNB to request UL-SRS configuration information for the target device as described in Figure 8.14.3.2.1-1.

3. The serving gNB determines the resources available for UL-SRS and configures the target device with the UL-SRS resource sets at step 3a.

4. The serving gNB provides the UL-SRS configuration information to the LMF in a NRPPa POSITIONING INFORMATION RESPONSE message.

5. In the case of semi-persistent or aperiodic SRS, the LMF may request activation of UE SRS transmission by sending the NRPPa Positioning Activation Request message to the serving gNB of the target device as described in clause 8.14.3.3a. The gNB then activates the UL-SRS transmission and sends the NRPPa Positioning Activation Response message. The target device begins the UL-SRS transmission according to the time domain behavior of UL-SRS resource configuration.

6. The LMF provides the UL-SRS configuration to the selected gNBs in a NRPPa MEASUREMENT REQUEST message as described in clause 8.14.3.3. The message includes all information required to enable the gNBs/TRPs to perform the UL measurements.

7. Each gNB configured at step 6 measures the UL-SRS transmissions from the target device.

8. Each gNB reports the UL-SRS measurements to the LMF in a NRPPa Measurement Response message as described in clause 8.14.3.3.

9. The LMF sends a NRPPa POSITIONING DEACTIVATION message to the serving gNB as described in clause 8.14.3.3a.

# Annex-Agreements on RAT dependent positioning methods

## Latency reduction

### 3GPP TSG-RAN WG2 Meeting #114-e R2-21xxxxx Online, 19-27 May 2021

Agreements:

Support pre-configuration of assistance data to the UE at least in an LPP session. Details of how to enable this are FFS (e.g. what additional functionality beyond deferred location procedure might be needed).

The LPP Request Location Information message can serve as an indication to the UE to utilize the pre-configured AD. FFS additional conditions/validity criteria for using the pre-configured AD.

### 3GPP TSG-RAN WG2 Meeting #115 electronic R2-2108835

Agreement:

Proposal 3: Regarding the validity conditions/criteria associated with pre-configured assistance data, consider at least the following options:

 Option A: Based on a validity area (e.g. a list of cells)

 Option B: Based on a (configured) validity timer or a numerical limit on number of times it is utilized

 Option C: Based on explicit modification or release from the LMF/NG-RAN

 Option D: Based on the UE’s current location and/or the time

Agreement:

Proposal 6 (modified): In response to the question asked by SA2 regarding UE positioning capability, ~~it is proposed to~~ capture that the positioning related UE capabilities can be variable.

NOTE: P6 was edited after agreement for clarity (deletion marked with strikeout). Checked in email discussion [AT115-e][600].

### 3GPP TSG-RAN WG2 Meeting #116 electronic

Agreements:

Proposal 1: Assistance data can be (pre-)configured independently of any given LPP positioning session and thus can be reused across multiple positioning sessions.

Proposal 2: It is suggested to agree that in order to reduce positioning latency associated with signaling of assistance data (via both broadcast or dedicated signaling), pre-configured assistance data can be considered valid for usage across multiple LPP positioning sessions.

FFS spec impact from these proposals.

Agreement:

Pre-configured assistance data (distinct from “pre-defined configuration” as discussed for on-demand PRS) refers to the DL-PRS assistance data (with associated validity criteria) that can be provided to the UE (before or during an ongoing LPP positioning session), to be then utilized for potential positioning measurements at a future time (e.g. for deferred MT-LR). FFS whether to capture this in a spec.

Agreement:

Proposal 8 (modified): Down-prioritize dynamic triggering of a preconfigured SRS at UE in connected mode by gNB for transmitting SRS based on measurement report provided by UE in Rel-17.

### 3GPP TSG-RAN WG2 Meeting #116bis electronic

Agreements:

Proposal 1a (modified): Include a "Scheduled Location Time" with measurement time information in LPP CommonIEsRequestLocationInformation, defining the desired time when the location measurements or location estimate is to be obtained/valid. FFS if the information is an absolute time or a window.

Proposal 1d: Include the capability to support scheduled location in each method-ProvideCapabilities message, where 'method' can be any of the LPP positioning methods. The capability should indicate the time base(s) supported for scheduling location measurements.

Agreements:

Proposal 3a (modified): Pre-configured DL-PRS assistance data can be associated with a "validity area" at least in LPP. FFS on details and whether it would be included in RRC broadcast.

Agreements:

Proposal 5a: A new UL MAC CE for positioning measurement gap activation and deactivation request is introduced.

Proposal 5b: The new UL MAC CE for positioning measurement gap activation and deactivation request includes at least the ID of the pre-configured positioning measurement gap configuration for which the activation/deactivation is requested. Other parameter are FFS.

Proposal 5c (modified): A new DL MAC CE for positioning measurement gap activation and deactivation command is introduced for positioning latency reduction. LS to RAN1/4 indicating our conclusion, and confirming that DL MAC CE can also be used for positioning measurement gap deactivation as well as activation (to be drafted by email).

Proposal 5d: The new DL MAC CE for positioning measurement gap activation and deactivation command includes at least the ID of the pre-configured positioning measurement gap configuration which has been configured/activated by the gNB. Other parameter are FFS.

Proposal 5e: The Scheduling Request should be triggered when there is no PUSCH and UL MAC CE for positioning measurement gap activation/deactivation request is triggered.

Agreements:

Proposal 4: The pre-configured Measurement Gap Configurations for Positioning are provided via RRCReconfiguration message. The pre-configured Measurement Gap Configurations for Positioning are included in IE MeasGapConfig.

Proposal 5: The content of the pre-configured Measurement Gap Configurations for Positioning includes at least the existing measurement gap parameters together with an ID identifying each Measurement Gap Configuration for Positioning.

Proposal 6: The existing RRC LocationMeasurementIndication procedure to request the positioning measurement gaps can still be used by a UE, even when pre-configured measurement gaps are provided to the UE.

Agreements:

Proposal 7: The PRS processing window configuration is provided via RRCReconfiguration message. Whether PRS processing window configuration is provided per BWP or not is up to RAN1 to decide.

Proposal 8: A new DL MAC CE for PRS Processing Window activation and deactivation command is introduced.

Proposal 9: The new DL MAC CE for PRS Processing Window activation and deactivation command includes at least the ID of the pre-configured PRS Processing Window configuration, at least in the case when multiple PRS Processing Windows can be configured.

Proposal 10: The UE behaviour related to the PRS Processing Window feature is captured in the MAC specification.

Agreement:

Proposal 3: Pre-configured DL-PRS assistance data can consist of multiple instances, where each instance is applicable to a different area within the network. FFS on additional specification impacts and whether this can already be supported with the agreement made that pre-configured DL-PRS assistance data can be associated with a "validity area". Single instance of AD is not excluded; FFS if there would be signalling for multiple area IDs in the same instance. Signalling details can be discussed in the LPP running CR discussion.

Agreements:

- On the concurrent measurement gap, RAN2 wait for further input from RAN1/RAN4.

- On the Network-Controlled Small Gap, RAN2 wait for further input from RAN1/RAN4.

- An LMF needs to provide "assistance information" to a gNB to support measurement gap (pre-)configuration.

- The information that needs to be transferred between LMF and gNB to support the positioning measurement gap (pre-)configuration can be decided by RAN3.

- Whether UL MAC CE can also be used for PRS processing window activation/deactivation should be decided by RAN1.

- The information that needs to be transferred between LMF and gNB to support the PRS Processing Windows configuration can be decided by RAN3.

## RRC\_INACTIVE

### 3GPP TSG-RAN WG2 Meeting #113b-e R2-21xxxxx Online, 12-20 April 2021

Agreements:

WA: Any uplink LCS or LPP message can be transported in RRC\_INACTIVE from RAN2 perspective, subject to the data volume supported by AS layers. I.e. RAN2 do not specify a restriction on message type.

FFS if LPP needs to select transport, i.e. if the message is just submitted to lower layers which decide how to deliver it (SDT, change state, etc.).

FFS if RRC state is exposed to LPP.

### 3GPP TSG-RAN WG2 Meeting #114-e R2-21xxxxx Online, 19-27 May 2021

Agreements:

Any uplink LCS or LPP message can be transported in RRC\_INACTIVE from RAN2 perspective.

Follow Rel-17 SDT framework for INACTIVE UL and DL positioning:

 If the UE initiated data transmission using UL SDT, the network can send DL LCS, LPP message and RRC message (e.g. to configure SRS (TBD on what message is used), if UL positioning supported) to the UE.

 Otherwise, if UE did not initiate UL SDT, rely on legacy operation, i.e. the network shall transition the UE to RRC\_CONNECTED, e.g. based on RAN paging.

Agreements:

Exposure of the RRC state of the UE to the LPP layer of the UE for RRC\_INACTIVE UL and DL positioning will not be specified. This does not exclude cross-layer behaviour in implementations.

The RRC state of the UE is not exposed to the LMF for INACTIVE UL and DL positioning.

### 3GPP TSG-RAN WG2 Meeting #115 electronic R2-2108835

Agreements:

LPP PDU and LCS message transfer:

Proposal 1: The LPP PDU Transfer Procedure in Annex A is used as baseline for further work.

NOTE 1: Some details may depend on further progress of the SDT work item.

NOTE 2: Whether such a procedure needs to be captured in Stage 2 specification or not can be decided later when the procedure has been fully developed/agreed. That is, the procedure can be considered as "running baseline".

Proposal 2: The LCS Message Transfer Procedure in Annex B is used as baseline for further work.

NOTE 1: Some details may depend on further progress of the SDT work item.

NOTE 2: Whether such a procedure needs to be captured in Stage 2 specification or not can be decided later when the procedure has been fully developed/agreed. That is, the procedure can be considered as "running baseline".

Proposal 3: UL LPP message segmentation can also be used by the UE in RRC\_INACTIVE state; i.e., a LPP message body can be sent in several shorter LPP messages instead of one long LPP message by using the SDT "Subsequent Data Transmission" phase. FFS spec impact.

DL and RAT-independent positioning:

Proposal 4: The Deferred 5GC-MT-LR Procedure with SDT for DL-only and RAT-independent positioning in Annex C is used as baseline for further work.

NOTE 1: Some details may depend on further progress of SDT work item.

NOTE 2: Whether such a procedure needs to be captured in Stage 2 specification or not can be decided later when the procedure has been fully developed/agreed. That is, the procedure can be considered as "running baseline".

NOTE 3: Once the procedure is stable from RAN2 perspective, send an LS to SA2 including the baseline procedure.

Agreement:

(High priority)Proposal 1: Support all the RAT independent positioning methods in RRC\_INACTIVE state.

Agreement:

gNB can configure the UE with periodic SRS (assuming periodic SRS is supported in RRC\_INACTIVE) by RRCRelease with suspendConfig at least when periodic event is configured for deferred MT-LR. Other cases can be further discussed.

### 3GPP TSG-RAN WG2 Meeting #116 electronic

Agreement:

Proposal 1 (modified): The PRS configuration from LMF to UE is independent of the RRC state. That is, no impact on PRS configuration for RRC\_INACTIVE (13/15) from RAN2 perspective.

Agreement:

Proposal 4 (modified): For positioning in RRC\_INACTIVE state, the positioning assistance data can be delivered to UE through the following ways:

- positioning system information, i.e. posSIB;(12/13)

- pre-configure assistance data when UE in RRC\_CONNECTED state;(11/13)

- send to UE in RRC\_INACTIVE during ongoing SDT procedure. (9/13)

Agreement:

Proposal 6: SRS for positioning in RRC\_INACTIVE state can be configured through the following ways:

- RRCRelease with SuspendConfig (13/13)

- SDT DL RRC message, i.e. Msg B / Msg 4 of RA-SDT (9/13)

- WA: pre-configure positioning SRS in RRC\_CONNECTED (9/13)

FFS detailed signalling for these approaches.

Proposal 8: Support SP SRSp for positioning in RRC\_INACTIVE state. (12/13)

Proposal 9: SP Positioning SRS Activation/Deactivation MAC CE is reused for triggering SRSp transmission in RRC\_INACTIVE. (12/12)

Proposal 10: AP SRSp is not supported for positioning in RRC\_INACTIVE state. (11/13)

### 3GPP TSG-RAN WG2 Meeting #116bis electronic

Agreements:

Proposal 1 (modified) To support UL positioning in RRC\_INACTIVE, reuse SDT TA timer mechanism (with a separate timer with similar function) for TA validation.

Proposal 2 To support UL positioning in RRC\_INACTIVE, reuse RSRP change based solution for TA validation

Proposal 3 The SRSp configuration is considered as invalid if TA is not valid.

Proposal 4 When cell reselection is performed and UE initiates RRC resume procedure to the cell which is different from the cell in which the SRSp is configured, the TA timer configuration for SRS should be released.

Proposal 5 (modified) The SRSp configuration is released when the UE sends RRCResumeRequest to a cell other than the cell where it is released to RRC\_INACTIVE state.

Proposal 6 BWP info together with the SRS-PosResourceSet IE is included in RRCRelease message for SRS configuration in RRC\_INACTIVE.

Proposal 7 RAN2 confirms RAN1 agreement that UE may be configured to transmit UL SRS for Positioning where the following parameters are additionally configured for the transmission of the SRS for Positioning during the RRC\_INACTIVE state: frequency location and bandwidth, SCS, CP length.

Proposal 8 Add the restriction on AP SRS in the field description of resourceType “The aperiodic is not applicable for the UE in RRC\_INACTIVE.”.

FFS if the TA timer configuration is invalidated upon any cell reselection.

Agreement:

RAN2 will not make additional effort to make the gNB aware of when to transit the UE to RRC\_INACTIVE (left to gNB implementation and RAN3 solution).

Agreements:

Proposal 3 The agreement with WA: pre-configure positioning SRS in RRC\_CONNECTED is removed.

Proposal 12 (modified) No indication is added in Rel-17 from NW to UE for the continuity of UL SRS Tx when transiting from one mode to other.

## On demand PRS

### 3GPP TSG-RAN WG2 Meeting #113b-e R2-21xxxxx Online, 12-20 April 2021

Agreements:

UE-initiated on-demand PRS request is enabled by enhancing LPP RequestAssistanceData. FFS how much control the network has over the UE request.

The UE-initiated mechanism is enabled by the UE request triggering a request from the LMF, and the C.

Put the stage 2 description for UE-initiated and LMF-initiated PRS request under the same framework.

### 3GPP TSG-RAN WG2 Meeting #115 electronic R2-2108835

Agreements:

Before providing available DL-PRS configuration to the UE, the LMF may obtain configuration information on what DL-PRS can be supported from one or more TRPs via NRPPa.

Capture the steps provided above as a baseline, along with a note indicating it remains FFS if the UE can send the MO-LR to request on-demand PRS.

FFS if we indicate to SA2 that MO-LR can be used to trigger on-demand PRS procedure.

It is up to Network (LMF) implementation on the steps to follow (accept/reject/ignore) on receiving request from UE for changing the DL-PRS configurations.

### 3GPP TSG-RAN WG2 Meeting #116 electronic

Agreements:

Proposal 1: RAN2 to agree to support the UE originated request of on-demand PRS via MO-LR for autonomous self location. (11/14)

Proposal 3: RAN2 to agree that UE can send an MO-LR Request message included in an UL NAS TRANSPORT message to the serving AMF including an LPP Request Assistance Data message which is used for on-demand DL-PRS transmission, and the MOLR-Type of this MO-LR Request message is “assistanceData”. (12/14)

Proposal 4: RAN2 to agree the following general stage 2 procedure as baseline for UE initiated on-demand PRS via MO-LR. (13/14) [Figure 2 of R2-2109483, with the associated list of steps as given in section 5 of R2-2109483.] To be discussed in development of the running stage 2 CR (post-meeting) how much of this detail we need to capture in 38.305.

Agreements:

Proposal 1.1: The UE may initiate an on-demand PRS request per positioning method including DL-TDoA, DL-AoD and Multi-RTT, via the existing LPP RequestAssistanceData message.

Proposal 1.2: There is no need for introducing a new LPP message to carry the on-demand PRS request.

### 3GPP TSG-RAN WG2 Meeting #116bis electronic

Agreements:

If the LMF indicates predefined configurations, the UE can request them via LPP RequestAssistanceData.

Agreement:

LPP signalling supports index-based and explicit request of DL-PRS parameters from the UE. The UE is not required to implement requesting explicit parameters and the LMF is not required to grant them if the UE does request.

## PRU

### 3GPP TSG-RAN WG2 Meeting #115 electronic R2-2108835

Agreements:

Proposal 1 (modified): For purposes of RAN2 discussion, the PRU functionality as described in the RAN1 LS can be considered as UE with known location (to some degree of accuracy) at least (16/17).

PRU modelled as a gNB can be discussed in RAN3 (no RAN2 action).

Agreement:

RAN2 confirm that the PRU considered as a UE supports the normal LPP procedures for assistance data transfer and location information transfer.

### 3GPP TSG-RAN WG2 Meeting #116 electronic

Agreement:

Proposal 5: Regarding the handling of the PRU topic, agree the following way forward:

(1) Send an LS to SA2 asking SA2 whether the MT-LR or MO-LR location procedures as currently specified in TS 23.273 can be used to enable an LMF obtaining location measurements from PRUs (via LPP) and to trigger SRS transmission of PRUs (via NRPPa), or whether an LMF needs to be enabled to instigate location procedures for a PRU (e.g., LPP, NRPPa procedures) without receiving a location request for the PRU from an AMF (i.e., in the absence of an MT-LR or MO-LR for the PRU), and if so, whether support can be provided as part of Release 17.

(2) Send an LS to RAN1 asking RAN1 whether the LMF determined "correction information" obtained from PRU measurements need to be provided to target UEs for UE-based mode of operation, and if so, ask RAN1 to provide further details on the specific "correction information" which need to be provided to target UEs. In addition, ask RAN1 to provide further details on the "PRU antenna orientation information" which should be provided to an LMF.

LS to be progressed by email (extension of [AT116-e][615], to approve by email by EOM).

Agreements:

Proposal 3: RAN2 confirm that the PRU considered as a UE supports the normal LPP procedures for PRU capability transfer.

Proposal 1 (modified): RAN2 confirms that a PRU can support at least the following functionality (as described in the RAN1 LS), dependent on PRU capability:

- Provide the positioning measurements (e.g., RSTD, RSRP, Rx-Tx time differences) to an LMF.

- Transmit the UL SRS signals for positioning.

- FFS known location information and antenna orientation information

### 3GPP TSG-RAN WG2 Meeting #116bis electronic

Agreement:

RAN2 will not discuss PRUs further without further guidance from RAN1 (LS or feature list).

## Accuracy enhancements

### 3GPP TSG-RAN WG2 Meeting #116bis electronic

Agreements:

Proposal 2.1-1: enhance LPP assistance data signalling to allow UE to request and LMF to provide TRP beam/antenna information.

Proposal 2.1-2: enhance LPP assistance data signalling to allow LMF to provide the association information of DL PRS resources with TRP Tx TEG ID.

Proposal 2.1-6: enhance LPP assistance data signalling to allow UE to request and LMF to provide the expected angle value and uncertainty.

Proposal 2.2-1: introduce in LPP RequestLocationInformation: request for UE Rx TEG ID, maximum number of Rx TEGs for the same PRS resource, request for UE Tx TEG ID, maximum number of RxTx TEGs for the same PRS resource, request for UE RxTx TEGD ID.

Proposal 2.2-2: introduce in LPP ProvideLocationInformation: UE Rx TEG IDs, UE Tx TEG IDs, and UE RxTx TEG IDs.

Proposal 2.2-3: introduce in LPP ProvideLocationInformation: multiple UE Rx-Tx time difference measurements (for N different UE Rx TEGs), and multiple UE Rx-Tx time difference measurements (for N different UE RxTx TEGs with the same UE Tx TEG).

Proposal 2.2-5: introduce support for an LMF to request and UE to report first path PRS RSRP for DL-AoD.

Proposal 2.2-6: introduce support for extended additional paths beyond 2.

Proposal 2.2-7: introduce support a LoS/NLoS indication per RSTD, RSRP and UE RxTx measurements.

Agreements:

Proposal 2.1-3: to include the association information of DL PRS resources with TRP Tx TEG ID in posSIB.

Proposal 2.1-4: include in the LPP assistance data the information about subset of PRS resources for the purpose of prioritization of DL-AOD reporting.

Proposal 2.1-5: include in the LPP assistance data the the boresight direction information.

For UL-TDOA, RRC signalling is used to convey the information about signalling for association of UL SRS resources with UE Tx TEGs ID to the gNB. For multi-RTT, LPP is used. FFS which RRC message(s) are used.