3GPP TSG-RAN WG2 Meeting #121bis-e***R2-23xxxxx***

Online, April 17 – 26, 2023

**Agenda item:** 7.24.2

**Source:** Qualcomm Incorporated

**Title:** Summary of [AT121bis-e][414][POS] Local Cartesian Coordinates

**Document for:**  Discussion

# 1. Introduction

This document summarizes the following e-mail discussion:

* [AT121bis-e][414][POS] Local cartesian coordinates (Qualcomm)

 Scope: Discuss the proposals/TP in R2-2303698 and attempt to converge to an agreeable CR.

 Intended outcome: Report and agreeable CR

 Deadline: Friday 2023-04-21 1000 UTC

# 2. Background

Support for local cartesian coordinates in LPP has been proposed in [1], [2].

Local cartesian coordinates were first introduced by RAN3 and then completed in SA/CT. The motivation for supporting local coordinates in NRPPa (e.g., without geodetic reference point) is for scenarios where the operator is not able to survey global coordinates with great accuracy – e.g. inside a factory, shopping mall, airport etc. as described in [3]:

 "In some indoor scenarios, it might be difficult to obtain the accurate GPS coordinates of the TRPs, as the GPS signals could be blocked by the building walls, which requires additional and unnecessary work load of calibrating indoor location. Thus, the RAN node may not be able to provide the accurate or effective global coordinates to the LMF, which can lead to large error for the UE positioning."

Local coordinates are specified in NRPPa [4], TS 23.032 [5], TS 23.273 [6] and TS 29.572 [7].

The geographic coordinates of a TRP antenna reference point (ARP) in NRPPa can be provided to an LMF as geodetic coordinates (latitude/longitude/altitude) or relative Cartesian coordinates (x/y/z). For example, the IE *Geographical Coordinates* is defined in 9.2.46 of NRPPa [4] as follows:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| IE/Group Name | Presence | Range | IE Type and Reference | Semantics Description | Criticality | Assigned Criticality |
| CHOICE *TRP Position Definition Type* | M |  |  |  | - |  |
| >*Direct* |  |  |  |  |  |  |
| >>CHOICE *Accuracy* | M |  |  |  |  |  |
| >>>*normal accuracy* |  |  |  |  |  |  |
| >>>>TRP Position | M |  | NG-RAN Access Point Position9.2.10 | The configured estimated geographical position of the antenna of the cell/TRP. |  |  |
| >>>*high accuracy* |  |  |  |  |  |  |
| >>>>TRP High Accuracy Access Position | M |  | NG-RAN High Accuracy Access Point Position9.2.49 | The configured estimated geographical high accuracy position of the antenna of the cell/TRP. |  |  |
| >*Referenced* |  |  |  |  |  |  |
| >>Reference Point | M |  | 9.2.51 | The reference point is used to derive the TRP position |  |  |
| >>CHOICE *Type* | M |  |  |  |  |  |
| >>>*Geodetic* |  |  |  |  |  |  |
| >>>>TRP Position Relative Geodetic | M |  | Relative Geodetic Location9.2.48 | The configured estimated relative geodetic coordinate of the antenna of the cell/TRP |  |  |
| >>>*Cartesian* |  |  |  |  |  |  |
| >>>>TRP Position Relative Cartesian | M |  | Relative Cartesian Location9.2.50 | The configured estimated relative Cartesian coordinate of the antenna of the cell/TRP |  |  |
| DL-PRS Resource Coordinates | O |  | 9.2.47 | DL-PRS Resource Coordinates relative to the TRP coordinate | - |  |
| ARP Location Information | O |  | 9.2.76 |  | Yes | ignore |

Local coordinates were introduced in TS 23.032 [5] as follows:

**- Coordinate ID:** an identifier for a reference point that defines the origin of a particular local Cartesian System.

**- Local Co-ordinates:** co-ordinates relative to a local Cartesian System whose origin is expressed by a reference point.

- **Clause 5.8:** Local 2D point with uncertainty ellipse.

- **Clause 5.9:** Local 3D point with uncertainty ellipsoid.

- The encoding of the above GAD shapes is defined in clause 6.1.6.2.38 and 6.1.6.2.39 in TS 29.572 [7].

The proposed draft CR in the Annex of [1][2] follows the definitions and encodings above accordingly. The LPP structure for the IE *NR-TRP-LocationInfo* is similar to that of NRPPa. A *ReferencePoint* IE defines the reference for the IE *RelativeLocation.* However, LPP supports the *RelativeLocation* currently in geodetic coordinates only.

Therefore, in certain deployments (e.g., inside a factory, shopping mall, airport etc.) an LMF may have the TRP/ARP coordinates available only in local Cartesian coordinates. In such deployments, the LPP assistance data IE *NR-TRP-LocationInfo* can not be provided to the UE, and consequently, UE-based DL-AoD and DL-TDOA can not be supported (note, a LMF can not convert the TRP/ARP local Cartesian coordinates into global geodetic coordinates if the origin has no global reference point).

A series of LSs [8],[9],[10] has been exchanged between RAN3, RAN2, and SA2, as described in [2]. In particular, RAN2 asked SA2 the following question in [9]:

 "RAN2 would like to understand whether SA2 expects there may be potential LPP impacts such as providing the local co-ordinates from the UE."

SA2 provided the following response in [8]:

 "Which of the UE positioning methods defined in LPP may support local coordinates is not specified in 23.273 and is seen as outside the SA2 ToR."

The discussion in [1],[2] resulted in the following Observations and Proposals:

|  |
| --- |
| **Observation 1:** Local coordinates are mainly intended for scenarios where the operator is not able to survey global coordinates with great accuracy – e.g. inside a factory, shopping mall, airport etc.**Observation 2:** A LMF may have the geographical coordinates of a TRP and any associated ARPs only in local Cartesian coordinates (x/y/z) available (e.g., via NRPPa).**Observation 3:** A LMF can not obtain the geodetic TRP coordinates (lat/long/alt) from local Cartesian coordinates if the reference point for the local coordinates has no globally known location (i.e., identified via Coordinate ID only).**Observation 4:** Which of the UE positioning methods defined in LPP may support local coordinates is not specified in 23.273 and is seen as outside the SA2 ToR.**Observation 5:** UE-based DL-TDOA or DL-AoD positioning would not be possible, if the LMF has the TRP coordinates in a local coordinate system only available.**Proposal 1:** Support local Cartesian coordinates for DL-TDOA and DL-AoD positioning in LPP. |

Accordingly, [1],[2] proposes to align LPP with NRPPa/23.273/23.032 and introduces local Cartesian coordinates as follows:

- The assistance data IE *NR-TRP-LocationInfo* allows providing the ARPs via a new IE *RelativeCartesianLocation-r18*.

- The IE *RelativeCartesianLocation-r18* is defined analogous to IE *RelativeLocation* (same value/distance ranges) and in agreement with TS 23.032/TS 29.572.

- For the IE *ReferencePoint*, a new CHOICE *localOrigin-v18xy* is introduced analogous to NRPPa with a *CoordinateID-r18* defined in TS 23.032/TS 29.572.

- To report the UE location, the two additional GAD shapes *Local2dPointWithUncertaintyEllipse* and *Local3dPointWithUncertaintyEllipsoid* are introduced.

- Capabilities are added for DL-AoD and DL-TDOA (analogous to GNSS).

# 3. Discussion

**Question 1:** Do you agree that UE-based DL-AoD and DL-TDOA can currently not be supported if an LMF has the TRP/ARP location coordinates available in local Cartesian coordinates only?

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Ericsson | No | We believe current functionality can work. TRP can be provisioned with both local and global coordinates even though that is choice in NRPPa spec, and this mapping is known to LMF by OAM. CHOICE means one can choose one or the other, and one can do so dynamically and regardless of what one did in previous procedure instances.Hence, if LCS client is in UE which requires coordinate in local coordinate, then it can be provided/translated by LMF.As per TS 23.273For location request indicates a value added LCS Client type, the LMF may determine the UE location in local coordinates or geographical co-ordinates or both.Also, it appears from TS 23.273; it is mandated; *the access network shall support determination of location estimates in geographical co-ordinates*.4.3.1       Access NetworkThe Access Network is involved in the handling of various positioning procedures including positioning of a target UE, provision of location related information not associated with a particular target UE and transfer of positioning messages between an AMF or LMF and a target UE. The Access Network shall support determination of location estimates in geographical co-ordinates as defined in TS 23.032 [8]. |
| OPPO | no | According to the TS 38.455 section 9.2.76, the ARP position is defined as a relative position to the TRP (reference point) , possibly in the cartesian coordinates way. And the position of TRP (in 9.2.46) could be defined in two ways: a position in the global coordinates or a relative cartesian coordinates to a reference point of which the position could be expressed in terms of a coordinate ID or a global coordinate (9.2.51). Note that the position of the coordinate ID in the global coordinate system could be obtained by looking for the mapping info stored in the OAM. As a result, It seems that no reason could be found why the LMF could not obtain the global position info of the ARP to be transmitted towards the UE for UE-based DL-AoD and DL-TDOA positioning. But we are open to further discussion if we are wrong.   |
| Qualcomm (proponent) | Yes | If an LMF has the TRP/ARP location coordinates available in local Cartesian coordinates only, UE-based mode of DL-AoD and DL-TDOA can obviously not be supported.To Ericsson/OPPO: Local coordinates are mainly intended for scenarios where the operator is not able to survey global coordinates of the TRPs. Obviously, if the TRP coordinates are always available in global coordinates, there is no need for introducing local coordinates (independent of this proposal). [OPPO]: our understanding is that using local coordinates does not necessarily means that the global coordinates of the TRPs/ARPs are not known. Actually, according to the TS 38.455, the global position of them could be derived even though the local coordinates are used.To Ericsson: It seems Ericsson misinterprets UE-based mode. This is unrelated to where the LCS client resides (which is anyhow unrelated to RAN2 specifications). UE-based mode is also used when the LCS client resides in the network. (E.g., UE-based GNSS is widely used for emergency calls, where the client is obviously in the network.)  |
| MediaTek | Yes | The comments from Ericsson and OPPO seem not to speak to the question as asked. If the LMF has the TRP/ARP location in local coordinates only, it seems obvious that UE-based DL-AoD/DL-TDOA cannot work. [OPPO]: Our point is that the LMF could always know the TRP/ARP location in global coordinate system. For example, if the TRP position is defined as a relative position to a reference point, then according to the TS 38.455 9.2.51, the reference point global position is surely known as a coordinate ID (global position could be traced from the OAM) or defined in the global coordinate system (9.2.10 or 9.2.49 in TS 38.455). In addition,the relative position from the TRP to the reference point is expressed as [east distance, north distance, hight distance], which is also in global coordinate system, according to the TS 38.455 9.2.50 |
| Xiaomi | No | We think the key point is whether the LMF can obtain the global coordinates from the local coordinates. According to the TS 38.455, Relative Cartesian Location is a location relative to some known reference location in a relative Cartesian coordinate system and the reference point is defined as below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| IE/Group Name | Presence | Range | IE Type and Reference | Semantics Description |
| CHOICE *ReferencePoint* | M |  |  | Reference point to which relative location information is related to  |
| >Coordinate ID |  |  |  |  |
| >>Coordinate ID | M |  | INTEGER(0.. 29-1,..) | Referential ID mapped via OAM |
| >Reference Point Coordinates |   |   |   |   |
| >>Reference Point Position | M |   | NG-RAN Access Point Position9.2.10 |   |
| >Reference Point Coordinates High Accuracy |   |   |  |   |
| >>Reference Point High Accuracy Access Position  | M |   | NG-RAN High Accuracy Access Point Position9.2.49 |   |

The reference point can be presented by global coordinates, thus the LMF can convert the TRP/ARP local Cartesian coordinates into global geodetic coordinate and the LPP enhancement is not needed. |
| Qualcomm-2 |  | If a Reference Point has known global coordinates, coordinate systems can be converted (if the translation and rotation of the two systems is also known)).However, as mentioned, the motivation for local coordinates was for scenarios where the global coordinates can not be obtained. Hence, the CHOICE in e.g., NRPPa:

|  |
| --- |
| CHOICE *ReferencePoint* |
| >Coordinate ID |
| >>Coordinate ID |
| >Reference Point Coordinates |

This is also reflected in TS 23.032:**Local Co-ordinates:** co-ordinates relative to a local Cartesian System whose origin is expressed by a reference point. The origin may have known WGS84 coordinates. Local Co-ordinates are only applicable in 5GS.This is in agreement with e.g., OPPO that "using local coordinates does not necessarily mean that the global coordinates of the TRPs/ARPs are not known." However, the question is what happens if global coordinates are not known:Do you agree that UE-based DL-AoD and DL-TDOA can currently not be supported if an LMF has the TRP/ARP location coordinates available in local Cartesian coordinates only.It seems companies think this would not be a valid scenario/deployment? But if the reference point always has a known global location, what would then be the motivation for introducing local coordinates with just an Identifier and without any coordinates? Clearly, the reference point may have global coordinates, but not necessarily. Regarding this comment from OPPO:In addition,the relative position from the TRP to the reference point is expressed as [east distance, north distance, hight distance], which is also in global coordinate system, according to the TS 38.455 9.2.50East-North-UP are not global coordinates, these are the directions of the x-y-z axis. |
| vivo | No | According to TS 23.273, it is the LMF that controls if local coordinates shall be determined and delivered to LCS Client/AF via GMLC.That is, for UE-based positioning, the assistance data and result can always be global coordinate. If the LMF has the TRP/ARP location coordinates available in local Cartesian coordinates only, the LMF may convert it to a virtual global coordinate first, e.g., set the location of reference point as ‘both degrees of Latitude and Longitude equal 0’. The target UE may perform UE-based positioning based on the virtual global coordinate and provide the result to LMF. The LMF can convert the virtual global coordinate to local coordinate.With the above solution, no stage 3 impact is needed. |
| Intel | Yes | Agree with QC, “If an LMF has the TRP/ARP location coordinates available in local Cartesian coordinates only, UE-based mode of DL-AoD and DL-TDOA can obviously not be supported.”. However seems companies who do not agree this because they believe LMF should always be able to obtain the global cooridination.  |
| ZTE | Maybe | We are not sure if ReferencePoint is chosen to be ‘Coordinate ID’, whether it means the LMF can not acquire a global coordinate of the reference point (then the LMF can not get the global coordinate of TRPs, accordingly). If this is valid we think the provision of TRP local coordinates to UE is needed. |
| Samsung | Yes | First, the scenario where the LMF has the TRP/ARP location coordinates only in local Cartesian seems valid.Second, in the scenario above, we agree that UE-based DL-Aod/DL-TDOA can not be supported with the current LPP spec. Even though it is understood that the solution from vivo might work, we prefer to explicitly support it by LPP enhancement rather than just leave this issue to LMF implementation.  |
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**Question 2:** Do you agree to add support for local Cartesian coordinates also to LPP?

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Ericsson | No  | Besides above, we believe the indoor local coordinate computation would require also the map of indoor building, to accurately map where the UE is in. Hence, having the coordinate would not be adequate anyways. How to provision the map to UE is a question and that should be addressed by a separate WI perhaps. |
| OPPO | No | See our answer to Q1, seems unnecessary  |
| Qualcomm(proponent) | Yes | Otherwise, UE-based TDOA/DL-AoD may not be possible.To Ericsson: "Indoor local coordinate computation" does not require a map. It seems Ericsson misinterprets UE-based mode of a positioning method (see also our comments for Q1). |
| MediaTek | Yes | We view this as alignment work. The existence of local coordinates in NRPPa means that the LMF may be using local coordinates for the TRP/ARP location; in this case, the assistance data should reflect the local coordinates as analysed in the paper. |
| Xiaomi | No |  |
| vivo | No |  |
| Intel | Yes | We share the same view with MediaTek, it is to align with RAN3.  |
| ZTE  |  | See Q1, if this is valid we think the provision of TRP local coordinates to UE is needed. |
| Samsung | Yes | Agree with MediaTek and Intel. |
|  |  |  |
|  |  |  |

**Question 3:** If your response to Question 2 was at least partly positive, do you have any comments on the draft LPP CR attached to [2]? Note, the draft CR is also available in the same folder as this discussion document (File Name: R2-23xxxxx\_(Draft LPP CR on local coordinates)\_v00.docx).

|  |  |
| --- | --- |
| Company | Comments |
| MediaTek | The field name “cartesian-coordinates-units-r18” is not in line with the coding guidelines (should be “cartesianCoordinatesUnits”). |
| Samsung | In ReferencePoint IE, we would like to propose to make *localOrigin-v18xy* directly point *coordinateID-r18* for simplicity as below.ReferencePoint-r16 ::= SEQUENCE { referencePointGeographicLocation-r16 CHOICE { location3D-r16 EllipsoidPointWithAltitudeAndUncertaintyEllipsoid, ha-location3D-r16 HighAccuracyEllipsoidPointWithAltitudeAndUncertaintyEllipsoid-r15, ..., localOrigin-v18xy CoordinateID-r18 }, ...} |
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# References

[1] R2-2300532, "Support of Local Cartesian Coordinates in LPP", Qualcomm Incorporated, RAN2#121.

[2] [R2-2303698](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_121bis-e/Docs/R2-2303698.zip), "Support of Local Cartesian Coordinates in LPP", Qualcomm Incorporated, RAN2#121bis-e.

[3] R3-203602, "(TP for BL CR for TS 38.455/TS 38.473): TRP Geographical Coordinates", Huawei, Deutsche Telekom, LGU+, BT, Orange.

[4] 3GPP TS 38.455: "NR Positioning Protocol A (NRPPa)".

[5] 3GPP TS 23.032: "Universal Geographical Area Description (GAD)".

[6] 3GPP TS 23.273: "Location Services (LCS); Stage 2".

[7] 3GPP TS 29.572: "Location Management Services; Stage 3".

[8] [R2-2204441](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2204441.zip), "Response LS on determination of location estimates in local co-ordinates", SA2.

[9] [R2-2108957](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_115-e/LSout/R2-2108957.zip), "Reply LS on determination of location estimates in local co-ordinates", RAN2.

[10] [R2-2109339](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs/R2-2109339.zip), "Reply LS on determination of location estimates in local co-ordinates", RAN3.