**3GPP TSG-RAN WG2#129 R2-2XXXXXX**

**Athens, Greece, 17 – 21 February 2025**

**Agenda item:** 8.1.2.3

**Source:** Ericsson

**Title:** Summary of LCM Procedure for Positioning Case1 (Ericsson)

**Document for:**  Discussion, Agreement

# Introduction

This document is the report of the following email discussion:

* [POST128][026][AIML] LCM Procedure for Positioning Case1 (Ericsson)

 Intended outcome:

• Discuss the FFS from the existing RAN2 Agreements

* Attempt to resolve the FFS which does not need RAN1 input
* Identify questions to ask to RAN1 for resolving FFS waiting on RAN1 progress

• Collect general guidelines on the criteria for deciding whether to enhance legacy method(s) or introduce new method

 Deadline: Phase 1: January 17th, 2025

The agreements for Positioning Case1 has been listed below, and the FFS are highlighted.

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| **RAN2#128****Agreements** 1 For POS Case 1, RAN2 confirm that the existing unsolicited UE capability report mechanism in LPP can support UE to report the applicable functionality in both “proactive” and “reactive” as a baseline.- Proactive case: When the applicability change, UE can send an unsolicited LPP ProvideCapabilities message to LMF .- Reactive case: If the applicability changes based on the configuration in LPP ProvideAssistanceData message in step 3, UE can send an unsolicited LPP ProvideCapabilities message to LMF. Configuration details are FFS 2 As a baseline, If the AIML based positioning method becomes non-applicable when LMF requests UE location estimation, UE cannot perform the AIML based positioning, and reply with LPP Providelocationinformation message with error cause. FFS if other fallback options are considered**RAN2#127bis****Agreements:**1: The following procedures for LCM for UE sided model for AI positioning case 1 is the baseline:Step 1: LMF may request the UE to report the supported functionalities at the UE side by *LPP request capabilities* message.Step 2: UE sends *LPP provide capabilities* message to LMF with the supported functionalities at the UE side.Step 3: LMF sends the *LPP provide assistance data* message (which may contain network side additional condition).Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message.Step 5: The LMF requests the inferred location information using the *LPP request location information* message.Step 6: UE reports the inferred location using *LPP provide location information* message.2: Whether the inference configuration is provided in step 3 or/and step 5 is FFS (to be revised based on RAN1 progress).3: Whether network side additional condition is needed and what it contains is FFS (to be revised based on RAN1 progress).4: FFS whether LMF controls the UE sending unsolicited LPP provide capabilities (i.e. whether step4 is sent reactively or proactively). FFS the signalling details. 5: RAN2 will decide whether AI positioning will be a new method after further details from RAN1 are received. **RAN2#126****Agreements:**1 The LPP Capability Transfer procedures (RequestCapabilities/ProvideCapabilities messages) are used to indicate supported AI/ML positioning capabilities. FFS how to handle dynamic capabilities, depending on further RAN1 progress and understanding of the functionality. 2 wait for RAN1 for associate ID discussion3 At least for Case 1, existing LPP procedures related to Location Information Transfer (RequestLocationInformation/ ProvideLocationInformation messages) are used for providing the results of the UE sided model inference operation. FFS further details on signaling enhancements |

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# Discussion

## General guidelines/factors influencing the decision on AI/ML positioning as a new method or an existing method.

Below we try to collect company’s opinion on what should be the main basis for deciding whether to select a new method or update the existing legacy method. Example: If (most)/same assistance data from legacy positioning method is applicable to AI/ML based technique then reuse the existing one, else use a new method.

This would serve as a basis for RAN2 to swiftly decide when more information is received from RAN1.

Companies are invited to provide their opinion on the principles that govern the selection of new method or update of existing method.

**Question** 1**: What is the criteria for deciding if AI/ML positioning should be introduced as a new method or introduced as an enhancement to an existing method?**

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| **Company** | **Guidelines/factors** |
| Xiaomi | We think the legacy positioning methods are defined according to different the PRS measurement, for example, DL-RSTD for the DL-TDOA, UE Rx-Tx time difference and gNB Rx-Tx time difference for the multi-RTT and DL-PRS-RSRP for the DL-AoD.Therefore, if the new PRS measurements are needed for the AI based positioning, the AI positioning should be introduced as a new method. |
| Apple | We understand there are two criteria:1. Whether any new measurement, as Xiaomi mentioned
2. Whether any new assistance data

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| Fraunhofer | We think the following should be the criteria for determining if this is a new method or not1. Extensibility in future – whether future AI/ML enhancements can be accommodated in a clean manner.
2. Are the assumptions/constraints in existing method applicable to the new method as well?
 |
| vivo | To introduce AI/ML in NR positioning architecture, the forward compatibility should be taken into account.On the one hand, there can be possibility that R19 UE only supports AI-based positioning but not the legacy positioning method. Once AI is introduced under the legacy one, from R19 UE point of view, some mandatory features (e.g., *NR-DL-TDOA-MeasurementCapability*) in the legacy positioning method may become unnecessary to support.On the other hand, AI/ML enhanced positioning can be extended to support UE obtaining location prediction based on the hands-down information at UE in spec. Although we study AI/ML based on current introduced positioning methods (e.g., DL-TDOA, DL-AOD etc.), UE may be allowed to execute AI/ML based on other underlying methods. In this understanding, it will save more signaling overhead to introduce an individual method which does not rely on any existing positioning method; and the specification only specifies what are required for the inputs of UE-sided model (what kind of information does UE need to obtain the input to further perform AI/ML based positioning), and what are the output (UE location prediction) that UE required to transmit toward LMF. |
| Qualcomm | Similar view as Xiaomi.The standard UE positioning methods currently supported in 3GPP are defined in clause 4.3 of TS 36.305/38.305. The methods are defined based on the required measurement type (and associated position calculation function). For example, DL-TDOA is based on RSTD measurements (and hyperbolic trilateration), DL-AoD is based on RSRP/RSRPP measurements (and beam-power matching), etc. To perform the location measurements (and possibly calculate the location) assistance data are usually needed. However, the assistance data are not necessarily unique to a positioning method. For example, DL-PRS assistance data are needed for all DL-PRS based methods (DL-TDOA, DL-AoD, multi-RTT) or TRP location information is needed for all UE-based methods, etc.Therefore, the criteria for defining a new positioning method should be based on the actual positioning measurement type (e.g., T(D)OA-based, range-based, angle-based, etc.).  |
| ZTE | Whether there is no measurement type;Whether there is independency of the new feature compared to the legacy feature. |
| Huawei, HiSilicon | Each positioning method uses distinct signals and/or additional information for UE position determination. In our understanding, the intention is to reuse the existing signals and information while potentially introducing some new information on top and relying on AIML predictions in addition to measurements. In that case, we should try to enhance existing methods unless critical issues with this approach are identified. |

Further, companies are invited to express whether their initial preference is to update a legacy method or to define a new method.

**Question** 2**: What is the (initial) preferred view; update of legacy or introduce new method?**

**Option A: Enhancement of legacy**

**Option B: Introduce new method.**

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| **Company** | **A/B** | **Remark (Optional)** |
| Xiaomi | B | Considering the new PRS measurement is needed for the AI positioning, we prefer to introduce a new method. |
| Apple | B  | According to RAN1#119 agreement, new assistance data different from legacy UE-based DL-TDOA may be introduced. Furthermore, considering forward compatibility, we tend to think a new positioning method is cleaner way.AgreementFor AI/ML based positioning Case 1, all assistance information from legacy UE-based DL-TDOA, other than info #7, can be provided from LMF to UE. For info #7, RAN1 study, if necessary, choose one alternative from the following:* Alternative 1. Info #7 is provided implicitly via associated ID.
	+ Associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 2. Info #7 can be provided either implicitly or explicitly by LMF. Note: no UE capability is introduced on whether info #7 is provided implicitly or explicitly, and the UE can request info #7 to be provided explicitly or implicitly.
	+ If provided implicitly, associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 3. Info #7 is **not** be provided from LMF to UE.
	+ If info #7 is not provided, UE may assume info #7 is consistent between training and inference.
* Alternative 4. Info #7 is provided explicitly from LMF to UE.
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| Fraunhofer | B | A new method provides possibility to introduce AI/ML specific enhancements in later releases, which may not be necessary for existing methods.In LPP, we already differentiate between DL-TDOA, DL-AoD and Multi-RTT even though the AD regarding the DL-PRS is provided in only one of the methods. |
| vivo | B | Based on the forward compatible design criterion, we prefer to introduce AI/ML based positioning as an individual method. |
| Qualcomm | B | For Case 1, the UE reports the determined ("inferred") UE location coordinates. The AI/ML model and model input is implementation dependent. The model input may be timing, power, and/or phase information of a channel impulse response, possibly together with other UE obtained and/or UE internal information, etc. It may not be possible/desired to define Case 1 as e.g., T(D)OA based method or angle-based method, etc.For Case 2a (and likely also Case 2b) on the other hand (although, 2nd priority), RAN1 already agreed that (at least) DL-RSTD and UE Rx-Tx Time Difference measurements can be reported (together with other (existing) attributes such as LOS/NLOS indicator). This seems to imply that Case 2a (and Case 2b) can be considered as an AI/ML enhanced DL-TDOA and/or Multi-RTT method. Therefore, the decision may have to be made on Case-by-Case basis. Considering Case 1 has priority, the above implies that Case 1 may have to be a separate/new method. |
| ZTE | B | Using AI to generate measurements/location is a totally new UE behavior which does not have any explicit relationship with existing RSTD/RSRP/RSRP/Rx Tx time difference measurement. From signaling perspective, having a separate AI positioning method is better for forward compatibility since case 2a/2b will be specified eventually, which will introduce new measurement report quantity for AI. |
| Huawei, HiSilicon | A | In RAN1 119 meeting, it was agreed to introduce assistant information:*For AI/ML based positioning Case 1, all assistance information from legacy UE-based DL-TDOA, other than info #7, can be provided from LMF to UE. For info #7, RAN1 study, if necessary, choose one alternative from the following:*It can be seen that RAN1 assumes that legacy UE-based DL-TDOA is re-used, and all assistance information from that can be provided. So it is more reasonable to enhance legacy positioning methods to support AI-based positioning, instead of defining a new one and copying all the information there. |

## FFS which does not need RAN1 input

### Signaling enhancement for UE reporting location using AI/ML

In RAN2#126, below was agreed

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| At least for Case 1, existing LPP procedures related to Location Information Transfer (RequestLocationInformation/ ProvideLocationInformation messages) are used for providing the results of the UE sided model inference operation. FFS further details on signaling enhancements |

For Case 1, UE only reports location result to LMF without measurements. If taken as a new method, then there is default signaling for RequestLocationInformation/ ProvideLocationInformation messages as part of the procedure of new method, while when taken as legacy method then indication of AI/ML should be added in RequestLocationInformation/ ProvideLocationInformation messages.

**Question** 3**: Regarding LPP procedures related to Location Information Transfer, do companies agree with the following?**

* **If a new method is introduced, no additional signaling enhancements are needed, i.e., there is a default procedure to request and provide location;**
* **If the legacy method is reused, an AI/ML indication should be added in the request/provide location information.**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Agree with comment  | If the legacy method is reused, an AI/ML indication in the LPP request location information is enough, in other words, there is no need to add an AI/ML indication in the LPP provide location information. |
| Apple | Agree 1st bullet, 2nd bullet is postponed to stage 3 discussion | We agree 1st bullet. 2nd bullet is detailed stage 3 signaling design, which is not essential. We are not sure why rushing to make this agreement at this stage.  |
| Fraunhofer | Agree | The existing LPP mechanisms are to be reused, with AI/ML specific IEs that are signalled. We further understand that the call-flow diagrams are added in Stage 2 descriptions for AI/ML based positioning.  |
| vivo | Agree, with comment on second bullet | Agree with an indication is added for reusing the legacy ones. Such indication should be able to indicate whether the method is for AI/ML only or for both AI and non-AI. |
| Qualcomm | Partly disagree, with comments | No matter whether a new location method is introduced, or AI/ML positioning is defined as an enhancement of existing methods, the requested location method is always determined by an LMF (see TS 23.273). This means that the LPP Request Location Information message (*RequestLocationInformation-r9-IEs*) must include an entry for the "AI/ML Positioning Method", if AI/ML positioning is defined as a new method.If AI/ML positioning is an enhancement of an existing method (e.g., DL-TDOA, multi-RTT, etc.), an indication of whether "AI/ML enhanced measurements" or "legacy measurements" are desired is needed. This could be implemented simply as an additional set of *locationInformationTypes* (e.g., "AI/ML enhanced required", "AI/ML enhanced desired, but non-AI/ML allowed", etc.). |
| ZTE | Agree with 1st bullet | Agree with apple on the stage-3 indication |
| Huawei, HiSiliccon | Agree, but | If the legacy method is reused, the motivation of introducing a new flag should be discussed, e.g. it may be related to monitoring, and RAN1 inputs are needed. |

### Fallback Configuration

In RAN2#128, it was agreed:

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| If the AIML based positioning method becomes non-applicable when LMF requests UE location estimation, UE cannot perform the AIML based positioning, and reply with LPP ProvideLocationInformation message with error cause. FFS if other fallback options are considered:  |

When LMF requests UE location estimation, if for any reason UE cannot perform the AIML based positioning, the question that arises is that whether there should be a fallback option apart from the error reporting (e.g.: fallback to legacy method).

**Question** 4**: Regarding fallback option, companies are requested to provide their view on whether they agree/disagree to have any other fallback configurations?**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Agree | For the periodic reporting, the requested functionality may not be available due to the time gap between the LPP request location information message and the LPP provide location information message, so the fallback configuration is necessary and the fallback configuration could reduce the positioning latency. Moreover, if the legacy positioning method is reused for the AI/ML positioning, the existing signaling could support the fallback configuration. |
| Apple | Disagree  | We think it is sufficient to rely on agreed UE reporting error code: 1. With UE reporting error code, LMF can already take corresponding reaction (e.g. configure non-AI/ML positioning) as legacy. Thus, fallback configuration is an optimization.
2. If NW provides fallback configuration, it implies that NW needs to simultaneously provide at least two sets of radio resource and assistance data normal operation and fallback operation (e.g. non-AI positioning and AI based positioning). It is radio resource consuming for NW and a new requirement for UE, but its benefit is not clear (maybe just saving latency of one LPP message?). Rel-19 AI/ML positioning doesn’t requirement for latency reduction. So, we are not convinced its necessity.
3. On the issue of time gap raised by Xiaomi, we think that is the reason why we introduce applicable functionality reporting.
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| Fraunhofer | Agree | While the fallback option may be triggered by the UE by providing appropriate error code, based on model monitoring on the UE-side., in some scenarios, configuration of fallback mechanism from the LMF may be useful to avoid latency between the time the UE detected that AI/ML model is not performing to the time a new method is configured to the UE.  |
| vivo | Disagree | The current LPP supports LMF to request several positioning methods concurrently, which realize backup options to obtain location information by LMF implementation to request AI/ML positioning method with other legacy NR positioning methods in the meantime. No signaling enhancement is needed to support potentila “fallback” scheme. |
| Qualcomm | Disagree | We think there is nothing new to solve in this regard. Any LMF location request with a (LMF selected) positioning method can fail. E.g., GNSS location may not be possible in a given environment, etc. It is then up to an LMF to decide what to do, e.g., based on client request type. LMF may instigate another location attempt with different method(s), may fall-back to (E)CID, etc.  |
| ZTE | Agree | All legacy positioning functionality (DL-TDOA, DL-AOD, M-RTT) have same level of processing capability. We see AI functionality is an upgraded version which takes more power consumption/more computation resource to achieve, and the AI applicable functionality may change faster than legacy UE processing capability. However there is a fixed QoS (including latency) from LCS client. LCS client does not care whether the UE is using AI or not, it just cares that UE should response the required estimated location on time. So facing this upgraded AI positioning which may fail or unsatisfied more easily, if LMF decides to activate it, LMF should allocate the fallback option in advance, to ensure that UE has something meaningful to report, rather than ‘UE reporting Error+LMF’s another scheduling’.To Apple’s second argument:Currently the assistance data for non-AI and assistance data for AI are almost the same (the minor difference depends on RAN1’s further discussion). LMF does not need to provide it twice.  |
| Huawei, HiSiliccon | Comments. | RAN2 agreed that when the applicability changes, UE sends an unsolicited LPP ProvideCapabilities message to LMF. Based on this the UE should be reconfigured and LMF will normally not ask the UE for a location until this reconfiguration is done. With that in mind, the issue seems a corner case, so replying with an error cause seems sufficient. Furthermore, we should follow the principles agreed for BM use case as a baseline and for BM we agreed:* When a functionality becomes non-applicable the UE doesn’t autonomously deactivate. NW is expected to deactivate active functionality when it receives report from UE that it is non-applicable.

Similarly, for positioning, the functionality management should be under NW control, so if the NW has received the error cause from the UE, it is up to NW decision, e.g. the NW can decide to disable AI/ML based positioning and instruct the UE to use legacy positioning method.We understand that "any other fallback configurations" may refer to UE autonomous fallback mechanism, and the motivation and benefit should be discussed first, considering the above understanding. |

If yes, companies are invited to provide view on when the fallback should be (pre)configured (e.g., in which step fallback config is configured (step 1 to 6 of agreements) or if it is configured only after getting a failure message from the UE).

**Question** 5**: Regarding fallback option, when should the fallback be configured?**

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| **Company** | **Remark (when is fallback configured)** |
| Xiaomi | We think the fallback can be configured in step 5.  |
| Apple | If fallback is supported (although we are negative), we think it should be configured in step 3, which provides UE sufficient time to prepare the fallback operation. If it is provided in step 5, why not just rely on LMF reconfiguration?  |
| Fraunhofer | Configuration after a failure message induces unnecessary latency. The fallback can be configured in step 3, since the LMF has been informed on the UE capability already at step 2. |
| vivo | In **step 5**. Since we support AI/ML as an individual positioning method and fallback by NW implementation, LMF can request the “fallback” positioning method(s) together with the AI-enhanced one for both location predication and estimation in the meantime. |
| Qualcomm | As comment in our response to Question 4, we cannot see why "AI/ML positioning" requires any special/new treatment regarding "fallback".  |
| ZTE | Step 5. Step 3 is to provide assistance data configuration, not to provide NW’s request/command/indication. |
| Huawei, HiSilicon | As a baseline, the NW can reconfigure the UE after an updated LPP ProvideCapabilities message or a failure message is received. This is aligned with the principle of BM case where the functionality management is under NW control. |

Further companies are invited to provide their view on what should be the fallback configuration? Should it be a particular positioning method or any legacy positioning method or simply an abort of procedure?

**Question** 6**: Regarding fallback option, what should the fallback configuration be?**

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| **Company** | **Remark (what should be the fallback configuration)** |
| Xiaomi | We think the DL-TDOA and DL-AoD can be considered for the fallback configuration.For example, LMF configures the UE to use DL-TDoA or DL-AoD related PRS measurement to acquire its location.  |
| Apple | If fallback is supported (although we are negative), we prefer to make it simple, i.e. an abort of procedure. |
| Fraunhofer | Falllback need to be configured to switch to a legacy method if AI/ML method fails.In addition, as RAN1 has not yet defined the meaning of functionalities in AI/ML positioning, we cannot exclude at this point that more than one applicable functionality are defined for Case 1 (UE-based positioning). Thus, the fallback strategy in this case, could be switching to a different AI/ML functionality within Case 1.  |
| vivo | Since fallback can be supported by NW implementation, the fallback configuration can be any legacy positioning method requested together with the AI based positioning method. |
| Qualcomm | See our response to Question 5. If a specific location request cannot be fulfilled, the UE reports an applicable error cause.If a LMF allows/requests multiple positioning methods, the request is normally a request for "hybrid positioning". |
| ZTE | If AI positioning method falls back to legacy positioning method, agree with Xiaomi that UE based DL-TDOA/DL-AoD can be the fallback option. |
| Huawei, HiSilicon | There is no need for any UE autonomous fallback configuration. It can be left to the NW to decide which positioning configurations (legacy or AI) to use after the UE indicated applicability change or an error cause, similar to what we agreed for BM case. |

Similar to fallback, the UE may also switch from using non-AI/ML to AI/ML, e.g., UE is inapplicable for AI/ML Positioning when LMF sends RequestLocationInformation msg and later UE becomes applicable for AI/ML Positioning to be used. This would be applicable mainly for periodic positioning if there are several localizations needed over a period of time, and AI/ML Positioning is more favorable in the scenario, e.g., in NLoS condition. That is when the UE can perform both AI/ML and non-AI/ML, but initially UE reported that the applicability condition is not met but later it identifies the applicability conditions are met. Hence, should there be a switching option from non-AI/ML to AI/ML?

**Question** 7**: Do companies view a need of switching options that is to change from non-AI/ML to AI/ML, similar to fallback?**

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| **Company** | **Remark (Preference on Switching Configuration from non-AI/ML to AI/ML)** |
| Xiaomi | We don’t support that UE switches the positioning method autonomously with the functionality applicability change since the positioning method should be controlled by the LMF, and he LMF could switch the positioning method to AI/ML positioning method according to the functionality reporting from UE. |
| Apple | Not support. We can rely on LMF reconfiguration, instead of introducing more UE complexity for unclear benefit.  |
| Fraunhofer | Support. The LMF shall configure the switching between functionalities or between AI/ML or non-AI/ML methods. It may enable the UE to switch from non-AI/ML to AI/ML based on the conditions configured to the UE.  |
| vivo | So far, no discussion/decision is made on switching from non-AI to AI. We think, the AI/ML positioning should be employed by UE under LMF control. See that obtaining positioning information can be a short-time process, it may not be necessary for LMF to configure an AI backup for non-AI under some certain conditions. Besides, as mentioned above, LMF can request both AI and non-AI positioning method concurrently to achieve potential “switch” scheme. |
| Qualcomm | See our response to Question 4. The above description seems to imply that the UE can select a positioning method, which is currently not the case. For the periodic reporting example, the UE is required to send a report when reporting interval expires, even when no measurements or location estimate is available, but UE cannot autonomously select a different method (see e.g., 37.355).  |
| ZTE | No. If a UE supports both AI and legacy positioning, AI will be an upgraded version compared to legacy positioning. So there is no reason to fall back from non-AI to AI. |
| Huawei, HiSilicon | In our opinion, the switch between non-AI/ML and AI/ML can be done in the same signaling procedure under the command of the NW (i.e. no UE autonomous switching), and the difference is just about configurations. For example:- from AI/ML to non-AI/ML, the NW disables AI/ML and enables a non-AI/ML- from non-AI/ML to AI/ML, the NW disable non-AI/ML and enables an AI/MLOnce we can define configurations for AI/ML in signalling, the above procedure should be supported naturally. |

### Error Causes

*NR-AI-ML-TargetDeviceErrorCauses*

The IE *NR-AI-ML-TargetDeviceErrorCauses* is used by the target device to provide NR AI/ML positioning error reasons to the location server.

-- ASN1START

NR-AI-ML-TargetDeviceErrorCauses-r19 ::= SEQUENCE {

 cause-r19 ENUMERATED { assistanceDataInconsistentBetweenTrainingAndInference,

 thereWereNotEnoughSignalsReceivedForUeBasedAI-ML,

 resourceOrProcessingCapacityIssueForAIML,

 battery-low,

 ...

 },

 ...

}

-- ASN1STOP

**Question** 8**: For Case 1 error causes, do companies agree with the above error causes? Please add if anything is missing.**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi |  | For the periodic reporting, the requested functionality may not be available due to the time gap between the LPP request location information message and the LPP provide location information message, so we suggest to add to cause *functionalityNotAvailable*.  |
| Apple | Postpone to stage 3 discussion  | We are not why rushing to have detailed stage 3 signaling design, even before RAN1 design is not clear (e.g. what does “assistanceDataInconsistentBetweenTrainingAndInference” mean before RAN1 don’t conclude on assistance data design).  |
| Fraunhofer |  | For the periodic reporting, the AI/ML model could be underperforming, as detected by monitoring session. So, we suggest to add to cause *performanceMonitoringEvent* |
| vivo | See comment | With regard to IE: Whether there is additional or new IE *NR-AI-ML-TargetDeviceErrorCauses* depends on whether AI/ML is introduced as a new positioning method. If AI/ML is enhanced on the legacy positioning method, the AI specific error causes are added based on the legacy error causes per positioning method.With regard to field contents:1. *assistanceDataInconsistentBetweenTrainingAndInference*

The error cause is provided via *LPP Provide Location Information* after the applicable functionality reporting, where the applicability is decided based on the consistency between training and inference. Thus there is no need to consider this is a kind of cause for Target Device location error.1. *battery-low*

There is no discussion on UE battery to cause location error. Moreover, the legacy location error does not include the case that UE indicates the network that it is in low battery state and cannot perform the location estimation. If UE is short of power, it may try best effort to finish the current procedure.1. To capture the agreement, “*As a baseline, If the AIML based positioning method becomes non-applicable when LMF requests UE location estimation, UE cannot perform the AIML based positioning, and reply with LPP Providelocationinformation message with error cause*”, the first and foremost error should be *FunctionalityNotApplicable*.
2. Inspired by the legacy target device location error causes, the listed ones below can be also considered as candidate applied for AI positioning.

NR-AI-ML-TargetDeviceErrorCauses-r19 ::= SEQUENCE { cause-r19 ENUMERATED { *undefined,* assistance-data-missing, attemptedButUnableToMeasureEnoughSignals, locationCalculationAssistanceDataMissing, FunctionalityNotApplicable, … }, … } |
| Qualcomm | Partly agree | Dependent on the resolution of Question 2, additional error causes could be added to the existing error causes. However, they should provide some useful meaning/assistance to an LMF. E.g., it is unclear what a LMF should do with resourceOrProcessingCapacityIssue or battery-low, which both seem not specific to AI/ML positioning. |
| ZTE |  | Agree with VIVO on *FunctionalityNotApplicable*.When the procedure/positioning method is triggered for UE training, UE can report ‘there is not enough training data to train an AI model’. |
| Huawei, HiSilicon | Disagree | It is about stage-3 details, and motivations should be discussed first.We understand that for now for AIML-based positioning, the only use case for the error cause is for "functionality non-applicable", and whether the cause of non-applicability is needed in the capability report can be discussed later, i.e. after we make the decision on this point for BM use case. |

### Inference configuration

In RAN2#127bis, there is an FFS along the agreements

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| 2: Whether the inference configuration is provided in step 3 or/and step 5 is FFS (to be revised based on RAN1 progress). |

In Step 3, the assistance data is sent from LMF to UE, and at this stage LMF has no information about whether UE meets applicability condition for using AI/ML model or not. In this regard, the PRS configuration in Step 3 is assistance which may be used for inference, but it is up to the UE to decide suitable PRS config that is applicable for inference. LMF on the other hand only requests whether UE should perform AI/ML inference or not in Step 5 after receiving the applicability condition from the UE in Step 4 and thus the request location information (Step 5) is used for inference configurations.

**Question** 9**: Do companies agree that Step 5 is the step where an inference configuration is provided?**

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| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Agree |  |
| Apple | Agree |  |
| Fraunhofer | Agree |  |
| vivo | See comment | We consider the primary issue for RAN2 is to figure out **what is inference configuration in POS case 1**, which should be a question to ask RAN1 in Section 3.3. Q9 can only be answered with the clear content of inference configuration. |
| Qualcomm | Disagree | Step 5 is the LPP request location information, which includes an indication of location information type, QoS, etc. together with selected positioning method and method specific information types requested (e.g., requested measurement types, requested TEGs, Rx hopping, etc.). "Inference configuration" seems more related to Assistance Data and should be part of Step 3. |
| ZTE | Agree | It is not clear what is inside the inference configuration. if the inference configuration is the request/command that LMF requests UE to perform inference, step 5 is ok |
| Huawei, HiSilicon | Agree | It makes sense. |

### On LMF control for Unsolicited Applicability Reporting

|  |
| --- |
| RAN1 128 Agreement1 For POS Case 1, RAN2 confirm that the existing unsolicited UE capability report mechanism in LPP can support UE to report the applicable functionality in both “proactive” and “reactive” as a baseline.- Proactive case: When the applicability change, UE can send an unsolicited LPP ProvideCapabilities message to LMF .- Reactive case: If the applicability changes based on the configuration in LPP ProvideAssistanceData message in step 3, UE can send an unsolicited LPP ProvideCapabilities message to LMF. Configuration details are FFS  |

It has been agreed that existing unsolicited UE capability report mechanism in LPP can support UE to report the applicable functionality in both “proactive” and “reactive” as a baseline. However, a question that remains (FFS) is whether there is a need for LMF to control on sending these unsolicited messages.

We need to note here that there are two attributes:

1. Capability: AI/ML Functionality for Positioning
2. Applicable functionality.

The applicability reporting is considered a dynamic attribute which is associated with AI/ML Positioning functionality. In legacy, this dynamic capability can be considered similar to remoteUE-Indication (e.g. as mentioned in discussion paper [R2-2410475]). This has been used for the case where UE reports its coverage state. That is if the UE is out of coverage and connected via a relay UE. This is needed for the LMF to select the right positioning method. This attribute is controlled by LMF.

***remoteUE-IndicationReq***

This field, if present, indicates that the target device is requested to indicate if it operates as a L2 U2N Remote UE.

For AI/ML case, it should be up to LMF to decide whether to configure AI/ML based inference or use legacy mechanism for obtaining the UE location. Hence, LMF would require assistance information from UE if the reported capability on AI/ML functionality for positioning meets UE side and NW side additional conditions to decide if LMF should pursue AI/ML or non-AI/ML (legacy technique) and in such case, it should be up to LMF to configure the needed relevant assistance information from UE. That is, whether step 4 is needed or not should be configured by LMF. There can be cases where LMF may have already decided not to pursue AI/ML based method, (example QoS of another UE in the same cell portion using AI/ML was not met).

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| --- |
|  Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message. 4: FFS whether LMF controls the UE sending unsolicited LPP provide capabilities (i.e. whether step4 is sent reactively or proactively). FFS the signalling details.  |

**Question** 10**: Do companies agree with above that LMF should provide configuration that would allow the UE to send unsolicited LPP to provide capabilities similar to remoteUE-Indication (e.g: aiml-ApplicabilityReq in RequestCapability)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Remark** |
| Xiaomi | Disagree | We think, anyway, this is a UE capability and there is no harm in reporting it to the LMF without LMF control.Moreover, if the LMF wants to use the AI/ML positioning method, it can use it directly according to the functionality applicability reporting. Otherwise, the LMF should request the UE to report the applicable functionality and then indicates the UE to use the AI/ML positioning method, which will lead to additional positioning latency.” |
| Apple | Disagree | As legacy LPP, the NW control is implicitly enforced in a LPP positioning session. Legacy LPP unsolicited information transfer procedure doesn’t need LMF control whether the UE can report.On the exceptional case of L2 U2N relay quoted by moderator, we think it is different from AI/ML based positioning. According to Rel-18 discussion the reason to introduce “***remoteUE-IndicationReq”*** is due to some special technique issue of L2 U2N relay rather than due to dynamic capability. For example: 1. Serving cell timing is not known by remote UE

Some positioning methods requires serving cell timing by target UE. The Relay UE knows the SFN timeline of its serving cell, but the Remote UE only sees the DFN timeline provided by the Relay UE.1. L1/L2 Uu signaling can’t be used by remote UE

There are some MAC-CE/DCI specified for positioning (e.g. AP/SP SRS activation/deactivation, Measurement Gap activation/deactivation). They can’t be used for the Remote UE because there is no L2 forwarding on L1/L2 siganling specified.Thus, the IE for remote UE status reporting is due to L2 relay special issue and system may not work if no such indication reported to LMF. However, for AI/ML based positioning, the applicable functionality reporting in step 4 falls into the legacy LPP unsolicited information transfer procedure. We fail to see any serious technique issue without explicit LMF configuration in AI based positioning. Thus, we think it is only an optimization, and prefer to keep the legacy LPP procedure.  |
| Fraunhofer | Needs clarification | Our understanding is that the capability of UE to perform AI/ML based positioning can change based on the environment it is in. The UE can be aided with information from the network, enabling the UE to determine whether the AI/ML model it contains is applicable to the area or not. This information could lead the UE to determine whether or not the model it contains is applicable or not. Therefore, we see a value in providing information to the UE to enable the UE to determine whether it still has capability to perform AI/ML based positioning in the area. In our view, the proactive reporting of change in capabilities of the UE shall be supported, and this shall be optional (since the capabilities reported during Step 2 may not have changed). This enables the LMF to configure a suitable fallback approach if one of the AI/ML functionalities (or models) are not applicable in the area.  |
| vivo | Disagree | As agreed in RAN2#128 meeting, it is clear how reactive case is performed: “*Reactive case: If the applicability changes based on the configuration in LPP ProvideAssistanceData message in step 3, UE can send an unsolicited LPP ProvideCapabilities message to LMF.*” Based on NW provision of NW-side additional condition, UE can provide its applicability based on the current situation, which is supported by the current LPP Provided Capability message. **If any further indication is provided from LMF via LPP Request capability** (**Step1**, like *aiml-ApplicabilityReq*) **to enable applicable functionality reporting (Step 3)**, in the normal positioning logistic, **UE should respond** to *aiml-ApplicabilityReq* **in Step2 rather than Step3.** This is not aligned with the current positioning design. |
| Qualcomm | Disagree | Since not needed. Since a UE does generally not know the LMF capabilities, such a "control" is needed when a UE cannot infer the LMF capabilities from other messages (e.g., LPP Provide Assistance Data message). E.g., a UE should not send updated capabilities related remote status if the LMF does not support the corresponding functionality. The same applies to AI/ML positioning functionality. It would be useless/overhead if a UE reports its "applicable AI/ML functionality" when a LMF is not AI/ML positioning capable. However, for the actual "positioning capabilities" (in this case, the "supported/applicable AI/ML functionality"), the UE would always know the LMF support, either from Step 1 or Step 3 or Step 5 (at the latest). This is different from e.g., remote status indication, or LPP segmentation capabilities. I.e., the LPP Request Capabilities at Step 1 indicates which positioning capabilities are requested (e.g., DL-TDOA, etc.) and therefore, the UE knows which positioning functionality is supported by an LMF and would provide corresponding updated capabilities (if needed) e.g., at Step 4. For example, a UE would not report its changed Bluetooth positioning capabilities (e.g., at Step 4) if a UE has not received a request for Bluetooth Capabilities before (e.g., at Step 1). If Step 1 did not happen (e.g., since the LMF received the positioning capabilities from the AMF), a UE would know the LMF supported functionality from Step 3 or Step 5.  |
| ZTE | Disagree | UE’s dynamically changed AI capability should be dynamically sent to LMF, since LMF does not know when/how such capability changes, LMF cannot control.Also if AI is a new method, when LMF sends AI-RequestCapabilities, it means LMF wants to activate AI method. So at this case why LMF will need to prevent UE from sending dynamic AI capability in step 4? |
| Huawei, HiSilicon | For applicability report, agree to discuss the necessity of NW configuration | As rapporteur indicated above, the LPP message can be used for either capability or applicability reporting.For capability reporting, "unsolicited messages" is purely up to UE, and there is no need to have network control. For example, in legacy, it may happen that the UE supports positioning method 1, but the NW does not support it, and such UE reporting behaviour has been allowed based on current specs.For applicability reporting, we understand that if step 4 is out of network control, the UE may unnecessarily report its applicable functionalities (also in case they change). Similar to BM case where where the network configures whether the UE should report its applicable functionality, we suggest to discuss the necessity of NW configuration whether to allow step 4 or not. |

## Questions to ask to RAN1 for resolving FFS waiting on RAN1 progress

### Applicable functionality reporting

Do companies agree that RAN2 can provide below Agreements sequence flow (steps) and ask RAN1what would be the message content of step 4 (UE side additional condition).

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| **Agreements:**1: The following procedures for LCM for UE sided model for AI positioning case 1 is the baseline:Step 1: LMF may request the UE to report the supported functionalities at the UE side by *LPP request capabilities* message.Step 2: UE sends *LPP provide capabilities* message to LMF with the supported functionalities at the UE side.Step 3: LMF sends the *LPP provide assistance data* message (which may contain network side additional condition).Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message.Step 5: The LMF requests the inferred location information using the *LPP request location information* message.Step 6: UE reports the inferred location using *LPP provide location information* message.2: Whether the inference configuration is provided in step 3 or/and step 5 is FFS (to be revised based on RAN1 progress).3: Whether network side additional condition is needed and what it contains is FFS (to be revised based on RAN1 progress).4: FFS whether LMF controls the UE sending unsolicited LPP provide capabilities (i.e. whether step4 is sent reactively or proactively). FFS the signalling details. 5: RAN2 will decide whether AI positioning will be a new method after further details from RAN1 are received.  |

RAN2 would like to ask RAN1 if RAN1 has any opinion on whether there are any specific UE signaling as part of the applicable functionality report.

Step 4: UE reports the applicable functionality to the LMF by the *LPP provide capabilities* message.

**Question** 11**: Do companies agree to pose a question to RAN1 asking “RAN2 would like to ask RAN1 if there are any specific parameters as part of the applicable functionality report from the UE”?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Remark** |
| Xiaomi | No | We think this is not necessary since we understand that RAN1 will work on FG for AI/ML positioning in the later meeting.  |
| Apple | No | RAN1 is already quite busy. We don’t think it is important question to bother RAN1.  |
| Fraunhofer | Maybe | RAN1 will potentiality not understand what applicability functionality is, this needs to be clarified as part of LS before a question about specific parameter is posed.  |
| vivo | Yes with some update | Since the applicable functionality is reported on the basis of supported functionality, and RAN2 has no common understanding over supported/applicable functionality. Therefore, before enquiring RAN1 about the applicable functionality, the supported one should also be asked (See our reply in Section 3.3.4). And the question can be simplified as: “**RAN2 would like to ask RAN1 What is the content and granularity of applicable functionality ~~if there are any specific parameters as part of the applicable functionality report from the UE~~?**”As to the UE side additional condition mentioned by the Rapp, we think it is internally known by UE and no need to be transferred in step 4. |
| Qualcomm | No | Not needed at this stage, since this seems usual Stage 3 work to implement RAN1 capabilities/FGs. |
| ZTE | No | This should be RAN1’s UE feature discussion. We just implement them all in the ProvideCapabilities message. |
| Huawei, HiSilicon | No | We share similar views as Xiaomi. For now, it does not seem to be much need to ask RAN1 about it, and we can wait a bit for RAN1 progress. |

### Consistency between training and inference

To ensure consistency between training and inference, UE should receive assistance with NW side additional condition. According to the RAN1 progress listed so far, all assistance information from legacy UE-based DL-TDOA, other than info #7 have been agreed.

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| RAN1 AgreementFor AI/ML based positioning Case 1, all assistance information from legacy UE-based DL-TDOA, other than info #7, can be provided from LMF to UE. For info #7, RAN1 study, if necessary, choose one alternative from the following:* Alternative 1. Info #7 is provided implicitly via associated ID.
	+ Associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 2. Info #7 can be provided either implicitly or explicitly by LMF. Note: no UE capability is introduced on whether info #7 is provided implicitly or explicitly, and the UE can request info #7 to be provided explicitly or implicitly.
	+ If provided implicitly, associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 3. Info #7 is **not** be provided from LMF to UE.
	+ If info #7 is not provided, UE may assume info #7 is consistent between training and inference.
* Alternative 4. Info #7 is provided explicitly from LMF to UE.

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| 7 | 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) |

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Several approaches to ensure consistency on the table:

* NW allocates associated ID
* UE’s on-demand request on NW side additional conditions

**Question** 12**: For Case 1, do companies agree to ask to RAN1 “what will be the approach to ensure the consistency”?**

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| **Company** | **Yes(ask question)/No (let RAN1 conclude)** | **Remark** |
| Xiaomi | No | Wait for the progress from RAN1.  |
| Apple | No | As quoted by moderator, RAN1 is discussing this issue. We see no reason to send LS to push RAN1 at this stage.  |
| Fraunhofer | No | Same view as above |
| vivo | No | RAN1 is discussing the format of NW sided additional condition. RAN2 can just wait for the further outcome and adopt in turn. Or as a compromise, RAN2 may ask RAN1 about “the detailed content of NW side additional condition” and let them feedback. |
| Qualcomm | No | Not needed at this stage, since this seems usual Stage 3 work to implement RAN1 parameter list. |
| ZTE | Yes | This has been a discussion that hangs in the air for several meetings. Suggest to ask RAN1 to accelerate their discussion |
| Huawei, HiSilicon | No | Wait for RAN1 progress. |

**Question** 13**: Do companies see any other question that may be raised for NW side additional condition?**

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| **Company** | **Yes/No** | **Remark (Pls provide the question to be asked)** |
| vivo | Yes | In addition to the content of NW-side additional condition, we think the optionality of that is important as well. Besides, according to the current procedure of NW-side additional condition provision, as proactive way, we see some values that, in the inference phase, UE can require certain types of NW-side additional condition (in the form of LPP Request Location Information) in order to obtain the appropriate ones consistent to the ones in the training phase. For example, if UE-sided model is trained in some certain cells, it can indicate NW about the cell list. In this way, NW can know the specific NW configuration and allocate assistance data for inference accordingly.The two questions we want to put forward are as follows:**1.“Whether NW-side additional condition is mandatory or optional?”****2. “Whether NW-side additional condition can be provided by NW in a reactive way (i.e., UE to on-demand request for assistance data for specific cell(s))?”** |
| ZTE | Yes | Agree with vivo that UE should be able to request specific NW-side assistance data to ensure training-inference consistency.Agree with vivo’s second question and modification:**Whether NW-side additional condition can be provided by NW in a reactive way (i.e., UE to on-demand request for some specific assistance data or NW-side additional conditions of specific cell(s) or TRP(s) which has impact on the consistency between training and inference)?** |
|  |  |  |

### UE side additional condition

* Should a question be raised to RAN1, if there is any specific need for UE to report UE side additional condition? If question needs to be asked to RAN1, pls provide what it should be?
* Or if RAN2 understands that this is already covered by UE reporting applicable functionality.

**Question** 14 **Companies are requested to select one or multiple of the Options:**

**Option A: Need to send as LS to RAN1 for UE side additional condition**

**Option B\_ No need to send an LS to RAN1 for UE side additional condition**

**Option C: UE side additional condition is covered by 3.3.1 Applicable Functionality Reporting; and an LS can be sent depending upon 3.3.1 discussion.**

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| **Company** | **Option A/B/C** | **Remark (Pls provide the question to be asked)** |
| Xiaomi | Option C | In our understanding, there is no need to specify the UE side additional condition and UE only needs to the report the applicable functionality according to the network side additional condition, AI model and UE side additional condition.  |
| Apple | Option C with change or Option B | We have same view as Xiaomi that UE-side additional condition is already covered by UE reporting applicable functionality, and there is no need to specify the UE side additional condition. But as we comment on Section 3.3.1, we see no reason to send LS to RAN1 for these non-essential issues. Thus, we suggest below change on Option C:**Option C: UE side additional condition is covered by 3.3.1 Applicable Functionality Reporting~~; and an LS can be sent depending upon 3.3.1 discussion.~~** |
| vivo | Option B | From RAN2 perspective, the agreed LCM procedure is endorsed under the principle that, there is no need for UE exposing its additional condition to NW for UE-sided model. On top of that, there is no discussion or agreement from RAN1 referring such terminology in WI. |
| Qualcomm | B | Similar view as others above. In any case, this is not needed at this stage, since this seems usual Stage 3 work to implement RAN1 parameter list. |
| ZTE | B/C | Agree with Xiaomi, Apple and vivo. This UE side additional exposing should be mainly applied in usecase 2b where model is at LMF side |
| Huawei, HiSilicon | B | For UE side additional condition, as we discussed in BM case, UE does not need to report it to NW, and instead it is expressed via applicability of functionality. We would like to apply the same principle here.If companies are interested in it, we can discuss the motivation, the need and the possible solutions. |

### Other questions to ask RAN1

Companies are invited to input if there are other questions that should ask RAN1.

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| **Company** | **Remark (Pls provide the question to be asked)** |
| vivo | As mentioned in **Q11**, other than the applicable functionality, the supported functionality in **Step 2** has no common understanding from RAN2 perspective. In this sense, we would like to pose RAN1 the following question:“**What is the granularity of supported functionality? For example, is it on the use case level (e.g., use case 1)? or others?**” |
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# Conclusion

The discussion above can be summarized in the form of the following proposals:

[TBF]

# Annex RAN1 agreements

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| **RAN1#116**AgreementFor Rel-19 AI/ML based positioning, the measurements for determining model input are based on the DL PRS and UL SRS defined in TS38.211.* Note: The use of SRS for MIMO resource is transparent to UE.

Agreement* For AI/ML based positioning case 3b, at least the following types of time domain channel measurements are supported for reporting:
1. timing information;
2. paired timing information and power information.

Agreement* For AI/ML based positioning case 2b, at least the following types of time domain channel measurements are supported for UE reporting to LMF:
1. timing information;
2. paired timing information and power information.

AgreementIn Rel-19 AI/ML based positioning, regarding the time domain channel measurements, RAN1 investigate the following alternatives:* + - * Alternative (a). Sample-based measurements, where the timing information is an integer multiple of sampling periods.
			* Alternative (b). Path-based measurements, where the timing information is according to the detected path timing and may not be an integer multiple of sampling periods.

The issues to be studied include, but not limited to, the following:* + - * Tradeoff of positioning accuracy and signaling overhead
			* Impact and necessary details of gNB/UE implementation to obtain the channel measurement values.
			* Whether the same Alternative(s) applies to all cases or not
			* Applicability and necessity of specifying the Alternative(s) to different cases
			* Note: different sub-cases may have different issues.

Note: In addition to timing information, the components for the channel measurement for model input may also include power and potentially phase. To provide the type of the channel measurement in their investigation.AgreementFor AI/ML assisted positioning Case 3a, at least LOS/NLOS indicator and/or timing information are supported for reporting. * If LOS/NLOS indicator is reported, the indicator can be reported as soft indicator or hard indicator as defined in 38.214.
* If timing information is reported, the timing information at least can be reported via UL RTOA or gNB Rx-Tx time difference as defined in 38.215.
* Note: details of the report are pending further discussion.

AgreementFor AI/ML assisted positioning Case 2a, at least LOS/NLOS indicator and/or timing information are supported for reporting. * If LOS/NLOS indicator is reported, the indicator can be reported as soft indicator or hard indicator as defined in 38.214.
* If timing information is reported, the timing information at least can be reported via DL RSTD or UE Rx-Tx time difference as defined in 38.215.
* Note: details of the report are pending further discussion.

AgreementFor LMF-side model, RAN1 studies whether/what assistance information and/or measurement report may be sent from UE/PRU, and/or gNB to LMF to assist at least for the performance monitoring.* RAN1 understands that it is out of RAN1 scope to define monitoring metric calculation and related model management decisions for LMF-side model.

AgreementFor AI/ML based positioning Case 3b, for gNB channel measurements reported to LMF, the timing information is represented relative to a reference time. * FFS: Whether any specification impact of the reference time used to represent the timing information. Details of the reference time

AgreementFor AI/ML based positioning for all use cases, RAN1 investigate the necessity and feasibility of using phase information (in addition to timing information and power information) for determining model input. The issues to study include:* Tradeoff of positioning accuracy and signaling overhead
* The impact of transmitter and receiver implementation
* Specification impact
* Other aspects are not precluded

Note: the phase information may be used in different ways, e.g., one phase value for the first path or first sample only; triplet of {timing information, power information, phase information} for CIR, etc.**RAN1#116bis**AgreementFor AI/ML based positioning Case 3b, for gNB channel measurements reported to LMF, the timing information is represented relative to the existing UL RTOA reference time T0+tSRS as defined in TS 38.215. FFS: whether it is applicable when Case 3b is used to support multi-RTT Conclusion* It is out of RAN1 scope to decide whether/how synthetic data (i.e., not direct physical data) and related entities are used in AI/ML based positioning. In RAN1 discussion, data (e.g., measurement data, label data) refer to physical data, not synthetic data.

Working AssumptionFor training data generation of AI/ML based positioning Case 1, the measurement and its related data (e.g., timestamp) are generated by PRU and/or Non-PRU UE.AgreementFor training data generation of AI/ML based positioning Case 3a and 3b, the measurement and its related data (e.g., timestamp) are generated by TRP/gNB.AgreementFor training data collection of AI/ML based positioning, the collected data sample can include the following components:Part A:* channel measurement
* quality indicator of channel measurement
* time stamp of channel measurement

Part B:* ground truth label (or its approximation)
* quality indicator of label
* time stamp of label

Note: “Part A” and “Part B” terminologies are only for RAN1 discussion purpose, and may not be used in specification. Note: contents in Part A and Part B may or may not be generated by different entities.Note: Part A and/or Part B, and their contents may or may not apply for each caseFFS: detailed definition of channel measurementWorking AssumptionFor training data generation of AI/ML based positioning Case 2a and 2b, the channel measurement and its related data (e.g., time stamp) are generated by PRU and/or non-PRU UE.Working AssumptionFor training data generation of AI/ML based positioning Case 1, the label and its related data (e.g., time stamp) can be generated by: * PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of the label and its related data is out of RAN1 scope.Working AssumptionFor training data generation of AI/ML based positioning Case 2a, the label and its related data (e.g., time stamp) can be generated by: * PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of the label and its related data is out of RAN1 scope.Working AssumptionFor training data generation of AI/ML based positioning Case 2b, the label and its related data (e.g., time stamp) can be generated by: * PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of label and its related data is out of RAN1 scope.Working AssumptionFor training data generation of AI/ML based positioning Case 3b, the label and its related data (e.g., time stamp) can be generated by:* PRU
* FFS: Non-PRU UE with estimated location
* LMF

Note: transfer of label and its related data is out of RAN1 scope.AgreementFor training data generation of AI/ML based positioning Case 3a, the label and its related data (e.g., time stamp) can be generated by at least:* LMF

Note: transfer of label and its related data is out of RAN1 scope. Note: whether other network entities can generate label for Case 3a is out of RAN1 scope. AgreementFor AI/ML positioning Case 3a, for model performance monitoring metric calculation in label-based model monitoring, study the feasibility of the following options. To provide information on how to generate information on ground truth label for each option.* Option A. NG-RAN node performs monitoring metric calculation for its own model.
* Option B. LMF performs monitoring metric calculation for the model located at the NG-RAN node.

Note: Final selection of Option A and Option B is out of RAN1 scope, but RAN1 can make recommendation about the option(s), and potential support of Option A and/or Option B is pending RAN3 confirmation.Note: Exact method to perform the monitoring metric calculation is up to implementationAgreementFor model performance monitoring of AI/ML positioning Case 1, for model performance monitoring metric calculation in label-based model monitoring, study the feasibility, benefits, and potential specification impact of the following options with regard to how to generate information on ground truth label: * Option A. The target UE side performs monitoring metric calculation.
	+ Option A-1. At least information on ground truth label of the target UE is generated by LMF and provided to the target UE.
		- In one example, target UE and/or gNB sends measurement (e.g., legacy measurement) to LMF so that LMF can derive the information on ground truth label.
	+ Option A-2. At least position calculation assistance data (e.g., existing information for UE-based positioning method) is provided from LMF to the target UE.
	+ Option A-3. Reuse Rel-18 assistance data transfer framework from LMF to the target UE, where the PRU measurement (e.g., legacy measurement) and the corresponding PRU location are sent via LMF to the target UE.
	+ Option A-4. PRU measurement (and the corresponding PRU location if not already known at the UE-side) are sent from PRU to the target UE side ~~(e.g., target UE, OTT server)~~.
		- Note: Option A-4 can be realized by implementation in a manner transparent to specification if the PRU sends information to the target UE side in a proprietary method.
* Option B. The LMF performs monitoring metric calculation.
	+ Option B-1. at least inference result (i.e., the model output corresponding to target UE’s channel measurement) of the target UE is sent by the target UE to LMF.
	+ Option B-2. PRU’s channel measurement is sent via LMF to the target UE, and the inference result (i.e., the model output corresponding to PRU’s channel measurement) is sent by the target UE to LMF.

Note: exact method to perform the monitoring metric calculation is up to implementation. Note: Other options are not precluded.**RAN1#117** Working AssumptionFor training data generation of AI/ML based positioning Case 3b, the label and its related data (e.g., time stamp) can be generated by:* PRU
* Non-PRU UE with estimated location
* LMF

Note: transfer of label and its related data is out of RAN1 scope.Note: It is assumed that user data privacy of non-PRU UE is preserved.Note: Previous related working assumption made in RAN1#116bis for training data generation of AI/ML based positioning Case 3b will not need to be confirmed.AgreementSample-based measurement is defined as:* The measurement is composed of Nt' samples of the estimated channel response in time domain. The timing information for the Nt' samples are reported with a timing granularity T, where T=2kxTc. k represents the timing reporting granularity factor. Tc is the basic time unit for NR.
	+ The corresponding measurement (e.g., power if reported) corresponds to the measurement for the reported Nt' samples.
* Nt' and k can be signalled
	+ FFS: the value range of Nt'; the value range of integer k for the timing granularity T.
* The timing information is defined relative to a reference time

Further discussion is expected on the determination of Nt' and k (including signaling) , and a rule to be introduced for selecting Nt' samples.Note: It doesn’t imply the definition of Sample-based measurement will be captured into the spec.AgreementPath-based measurement refers to the measurement in the existing specifications (up to Rel-18) including measurement reporting, with potential enhancements on the number of reported paths (if needed).**Agreement**For training data collection of AI/ML based positioning, if a training data sample contains both Part A and Part B, RAN1 assumes that Part A and Part B in one training data sample are: * for a same UE (PRU or Non-PRU UE), and
* for a same location associated with Part B.

Note: the association can be discussedAgreementDraft LS R1-2405577 is endorsed in principle by adding the latest agreements made in this meeting and adding “agreements” to “Note: the working assumptions above are based on RAN1 understanding for RAN work item (NR\_AIML\_air).”AgreementFinal LS R1-2405578 is endorsed.**RAN1#118**AgreementFor AI/ML positioning Case 3a, for performance monitoring metric calculation in label-based monitoring, from RAN1 perspective, Option A and Option B are feasible,* Option A. NG-RAN node performs monitoring metric calculation for its own model.
* Option B. LMF performs monitoring metric calculation for the model located at the NG-RAN node.

Note: Final selection of Option A and Option B is out of RAN1 scope. Potential support of Option A and/or Option B is pending RAN3 confirmation. Note: Exact method to perform monitoring metric calculation is up to implementation.Note: For Option A, RAN1 assumes that user data privacy needs to be preserved.ConclusionFor model performance monitoring of AI/ML positioning Case 1, for model performance monitoring metric calculation in label-based model monitoring,* Option A-4 can be realized by implementation in a manner transparent to specification specification if the PRU sends information to the target UE side in a proprietary method. No further discussion on Option A-4.

AgreementFor training data collection of AI/ML based positioning case 3b, for time stamp of channel measurement, * For channel measurement generated by TRP/gNB, existing IE “Time Stamp” in TS 38.455 can be reused from RAN1 perspective
* Note: Purpose, such as above “training data collection", will not necessarily be specified in RAN 1 specifications

AgreementFor training data collection of Case 1 and 2a, in terms of DL PRS configuration for collecting training data, RAN1 study the following options on assistance data, using legacy mechanisms as a starting point:Option A. (UE initiated) UE makes a request to LMF on the preferred DL PRS configuration for training data collection, e.g., on-demand PRS. LMF makes the decision on determining the DL PRS configuration for training data collection and provides the assistance data to the UE. Option B. (LMF initiated) LMF determines the DL PRS configuration for training data collection and provides the assistance data to the UE.Note: the UE can be a PRU and/or a Non-PRU UE.Note: as in existing specification, the DL PRS configurations in the assistance data from LMF to UE are based on DL PRS configuration coordinated between LMF and gNB.AgreementFor the definition of sample-based measurement, select Nt’ samples out of a list of Nt consecutive samples* The Nt samples have timing granularity T.
* FFS: the starting time of the list of Nt samples
* FFS: the value range of Nt

For the sample-based measurement (if accepted in Rel-19), * For measurement by TRP/gNB, the Nt’ selected samples are expected to be those with the highest power.
* Note: Choice of the maximum value of Nt, Nt’ should take into account the need to preserve proprietary implementation.

AgreementFor AI/ML positioning Case 2b and 3b, regarding the power information for determining the model input,* For downlink power measurement, use DL PRS-RSRPP defined in TS 38.215 as a starting point.
	+ For measurement report of DL PRS-RSRPP, use the existing measurement report mapping table for PRS-RSRPP in 38.133 as a starting point.
* For uplink power measurement, use UL SRS-RSRPP defined in TS 38.215 as a starting point.
	+ For measurement report of UL SRS-RSRPP, use the existing measurement report mapping table for SRS-RSRPP in 38.133 as a starting point.

ConclusionFrom RAN1 perspective, for Case 3a measurements, * The existing procedures can be reused in terms of SRS configuration.
	+ Note: parameter values for SRS configuration can be further discussed
* These measurements can be used for multiple aspects related to case 3a, e.g. training data collection, monitoring, or inference procedures.
* Note: Purpose, such as the training data collection, monitoring, or inference procedures mentioned above, will not necessarily be specified in RAN 1 specifications

AgreementFor Rel-19 AI/ML based positioning Case 3b, regarding sample-based measurement (if supported), from RAN1 perspective, * LMF can signal parameter values of Nt, Nt', k to gNB via NRPPa.

**RAN1#118bis**AgreementFor training data collection of AI/ML based positioning, the quality indicator of timing information in Part A when reported is:* When applicable, the existing IE for timing quality, i.e., NR-TimingQuality in 37.355 and IE “Timing Measurement Quality” in 38.455;
	+ FFS: details on how to associate quality indicator to timing information

ConclusionFor training data collection of Case 1, in terms of DL PRS configuration for collecting training data, both options are feasible by using legacy mechanisms:Option A. (UE initiated) UE makes a request to LMF on the preferred DL PRS configuration for training data collection, e.g., on-demand PRS. LMF makes the decision on determining the DL PRS configuration for training data collection and provides the assistance data to the UE. Option B. (LMF initiated) LMF determines the DL PRS configuration for training data collection and provides the assistance data to the UE.Note: the UE can be a PRU and/or a Non-PRU UE.Note: as in existing specification, the DL PRS configurations in the assistance data from LMF to UE are based on DL PRS configuration coordinated between LMF and gNB.AgreementFrom RAN1 perspective, for model inference of AI/ML positioning Case 3b, at least the following are mandatorily or optionally supported in a measurement report from gNB to LMF:* (Mandatory) Channel measurement;
* (Optional) Quality of the channel measurement;
	+ FFS: details of the quality
* (Mandatory) Time stamp of the channel measurement.

AgreementFrom RAN1 perspective, when timing information is reported for Rel-19 AI/ML positioning Case 3a, at least the following are mandatorily or optionally supported in a measurement report from gNB to LMF:* (Mandatory) timing information;
* (Optional) Quality of the timing information;
	+ Existing IE “Timing Measurement Quality” can be reused.
* (Mandatory) Time stamp.

FFS: LOS/NLOS indicator.Note: The final decision of “mandatory” or “optional” presence of each field is up to RAN3.AgreementFor AI/ML positioning Case 1, regarding the assistance data provided from LMF to UE, for ensuring consistency between training and inference, * for each of the existing assistance data IE of UE-based DL-TDOA and/or UE-based DL-AoD, study whether it should be: (a) explicitly indicated, (b) implicitly indicated and/or (c) other;
* Companies can provide inputs on further enhancements of existing assistance data, including new information
* Note: this does not mean that training and inference phases are mentioned in assistance data.

Table. Existing assistance data (supported up to Rel-18) that may be transferred from LMF to UE in UE-based DL-TDOA [1] or UE-based DL-AoD [2], as applicable.

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Information** | **UE-based DL-TdoA** | **UE-based DL-AoD** |
| 1 | Physical cell IDs (PCIs), global cell IDs (GCIs), ARFCN, and PRS IDs of candidate NR TRPs for measurement |  |  |
| 2 | Timing relative to the serving (reference) TRP of candidate NR TRPs |  |  |
| 3 | DL-PRS configuration of candidate NR TRPs |  |  |
| 4 | Indication of which DL-PRS Resource Sets across DL-PRS positioning frequency layers are linked for DL-PRS bandwidth aggregation |  |  |
| 5 | SSB information of the TRPs (the time/frequency occupancy of SSBs) |  |  |
| 6 | Spatial direction information (e.g. azimuth, elevation etc.) of the DL-PRS Resources of the TRPs served by the gNB |  |  |
| 7 | 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) |  |  |
| 8 | Fine Timing relative to the serving (reference) TRP of candidate NR TRPs |  |  |
| 9 | PRS-only TP indication |  |  |
| 10 | The association information of DL-PRS resources with TRP Tx TEG ID |  |  |
| 11 | LOS/NLOS indicators |  |  |
| 12 | On-Demand DL-PRS-Configurations, possibly together with information on which configurations are available for DL-PRS bandwidth aggregation |  |  |
| 13 | Validity Area of the Assistance Data |  |  |
| 14 | PRU measurements together with the location information of the PRU |  |  |
| 15 | Data facilitating the integrity results determination of the calculated location |  |  |
| 16 | TRP beam/antenna information (including azimuth angle, zenith angle and relative power between PRS resources per angle per TRP) |  |  |
| 17 | Expected Angle Assistance information |  |  |
| 18 | PRS priority list |  |  |

[1] Table 8.12.2.1.0-1 in 38.305, Use equipment (UE) positioning in NG-RAN (Release 18), v18.3.0[2] Table 8.11.2.1.0-1 in 38.305, Use equipment (UE) positioning in NG-RAN (Release 18), v18.3.0**RAN1#119**AgreementFor the definition of sample-based measurement, for gNB/TRP measurement of an estimated channel response between a pair of UE and TRP, the starting time of the list of Nt consecutive samples is determined as follows.* + starting time = first detected path rounded down with timing granularity T.

Note: UE-side measurement is a separate discussionAgreementFor model performance monitoring of AI/ML positioning Case 1, support at least: * Option A. The target UE side performs monitoring metric calculation.
	+ The target UE may signal the monitoring outcome to the LMF.
	+ FFS: content of monitoring outcome
* FFS: Option B

AgreementFor Rel-19 AI/ML based positioning, for Case 3b, in addition to path-based measurement that is referring to the measurement in the existing specifications (up to Rel-18), additionally support the following enhancement to the measurement, * The measurement is composed of Nt' values of the estimated channel response in time domain. The Nt’ values are selected from a list of Nt consecutive channel response values, which have timing granularity T.
* The timing information for the Nt' values are reported with a timing granularity T, where T=2kxTc. k represents the timing reporting granularity factor. Tc is the basic time unit for NR.
	+ The associated measurement (e.g., power if reported) corresponds to the measurement for the reported Nt' values.
* The timing information is defined relative to a reference time, same as the path-based measurement.
* The Nt’ selected time domain channel measurement values are expected to be those with the highest power.
* The starting time of the list of Nt consecutive values is determined as: starting time = first detected path rounded down with timing granularity T.
* LMF can signal parameter values of Nt, Nt', k to gNB via NRPPa. Candidate set values:
	+ Nt'<=24. FFS: Nt' values.
	+ Nt = {32, 64, 128}
	+ FFS: k
	+ The gNB/TRP may use different Nt', Nt and/or k values other than the signalled parameter for measurement reporting. In this case, it’s up to LMF implementation to process the reported measurement
* FFS: whether transmit offset from gNB to LMF

Note: measurement by UE is a separate discussion.Note: the purpose of the time domain channel measurements, such as for Rel-19 AI/ML based positioning, is not specified AgreementFor AI/ML based positioning Case 1, all assistance information from legacy UE-based DL-TDOA, other than info #7, can be provided from LMF to UE. For info #7, RAN1 study, if necessary, choose one alternative from the following:* Alternative 1. Info #7 is provided implicitly via associated ID.
	+ Associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 2. Info #7 can be provided either implicitly or explicitly by LMF. Note: no UE capability is introduced on whether info #7 is provided implicitly or explicitly, and the UE can request info #7 to be provided explicitly or implicitly.
	+ If provided implicitly, associated ID is signaled by LMF to indicate whether info #7 is consistent between training and inference.
* Alternative 3. Info #7 is **not** be provided from LMF to UE.
	+ If info #7 is not provided, UE may assume info #7 is consistent between training and inference.
* Alternative 4. Info #7 is provided explicitly from LMF to UE.

|  |  |
| --- | --- |
| 7 | 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) |

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