3GPP TSG-RAN WG2 Meeting #112-e***R2-20xxxxx***

Electronic, January XXXXX, 2020

**Agenda item:** 8.XX.X

**Source:** Swift Navigation

**Title:** [Post112-e][618][POS] Draft TP – Methodologies (PHASE 2)

**Document for:**  Discussion and Decision

# 1. PHASE 2 - Introduction

This document is Phase 2 of the following email discussion [1][2][3]:

[Post112-e][618][POS] Finalise integrity text proposals (Swift)

Scope: Refine the text proposals in R2-2010877/R2-2010878/R2-2010879.

Intended outcome: Agreeable TPs

Deadline: Long

It should be reviewed alongside the other email discussion documents:

* Email Guideline - [Post112-e][618][POS] Integrity TPs [3]
* [618] KPIs and Use Cases – PHASE 2 Draft TP [4]
* [618] Error Sources – PHASE 2 Draft TP [5]

# 2. PHASE 2 – Moderator Summary

A summary of key topics from Phase 1 (Appendix A) is provided below. The summary is grouped based on the common themes raised in Questions 1 to 5 rather than individual summaries of each question.

**NOTE:** An updated TP has not yet been proposed in Phase 2. The Moderator suggests to first agree to the scope of the Methodologies before attempting to converge the text. Where specific updates to the text and tables have been proposed in Phase 1, these comments are specifically addressed in the moderator summary below. This approach will also provide the flexibility for additional text proposals to be submitted in Phase 2 before updating the TP.

## 2.1 Methodologies Summary Table

There was strong consensus to include a table summarizing the UE-based and UE-assisted considerations for supporting positioning integrity in the 3GPP specifications. Table 9.4.1.3 was discussed as a suitable baseline, including the updates further proposed below.

**Proposal 1: Agree to include a table summarizing the UE-based and UE-assisted considerations for supporting positioning integrity in 3GPP.**

Swift Navigation proposed to include LMF faults in Table 9.4.1.3. Vivo and Huawei suggested methods of ‘triggering alerts’ should be studied, while Nokia, InterDigital, OPPO, ZTE proposed that triggering alerts is out of scope of the study and handled on implementation. Nokia proposed to update the definitions of network-assisted (UE-based) and UE-assisted (LMF-based) and to clarify the definition of ‘Source’. ZTE proposed to clarify the meaning of ‘LMF to the UE’. CATT and Vivo proposed that MO-LR still requires the KPIs to come from the LMF. Qualcomm and Huawei indicated the location services impact (MO-LR, MT-LR) requires further clarification in the TP.

Therefore, the following proposals are made:

**Proposal 2: Agree that triggering alerts is out of scope of the study, FFS as part of the WI.**

**Proposal 3: Agree to the proposed updates to Table 9.4.1.3 below:**

**Table 9.4.1.3: Summary of network-assisted (UE-Based) and UE-assisted (LMF-Based) considerations for supporting positioning Integrity in 3GPP.**

NOTE: the table provides a summary of considerations and the final details and specification impacts are FFS in the WI.

\*NOTE: Examples of KPIs are the TIR, AL, TTA. Examples of Integrity results are the PL, Integrity Availability and KPIs.

\*\*NOTE: From LMF to UE does not mean the integrity assistance information is generated by the LMF.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Positioning Mode** | **Location service type** | **Source (LMF or UE) of KPIs\*** | **Source (LMF or UE) of Integrity results\*** | **Integrity assistance information\*\*** | **Spec impact** |
| Network assisted (UE-based): Positioning integrity result is derived by the UE | MO-LR | Obtained via UE internal implementation; | UE internal implementation | From LMF to UE:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events | Procedure to transfer Integrity assistance information from LMF to UE |
| MT-LR | From LMF | From UE | From LMF to UE:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events | Procedure to transfer Integrity assistance information and KPIs from LMF to UE  Procedure to transfer Integrity results from UE to LMF |
| UE assisted (LMF-based): Positioning integrity result is derived by the LMF | MO-LR | From UE | From LMF | From Positioning Service Provider to LMF:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events  From UE to LMF:  - UE feared events | Procedure to transfer Integrity assistance information and KPIs from UE to LMF  Procedure to transfer Integrity results from LMF to UE |
| MT-LR | Obtained via LMF implementation | LMF internal implementation | From Positioning Service Provider to LMF:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events  From UE to LMF:  - UE feared events | Procedure to transfer Integrity assistance information from UE to LMF |

## 2.2. Signaling framework

There was very strong consensus that the LPP signaling procedures for exchanging positioning information between the LMF and the UE are within scope of the study. ZTE and Qualcomm noted that only the interface between the LMF and UE is relevant to the specifications, whereas the assistance information from an external source to the LMF is out of scope. This was further supported by the signaling requirements identified as in scope of the study from the majority of other companies. These categories are summarized by the Moderator as follows:

1. Signaling to determine the positioning integrity capability
2. Signaling to the deliver the KPIs to the UE and/or LMF
3. Signaling to deliver the integrity assistance information to the UE (UE-based only)
4. Signaling to deliver the integrity measurements from the UE to the LMF (UE-assisted only)
5. Signaling to deliver the integrity results

**Proposal 4: Agree that the LPP signaling procedures should be studied for exchanging information between the LMF and the UE to support positioning integrity determination.**

**Proposal 5: Agree that signaling of integrity assistance data from the positioning service provider (external source) to the LMF is implementation defined and therefore out of scope.**

**Proposal 6: Agree that signaling requirements (a)(b)(c)(d)(e) should be studied for exchanging positioning integrity information.**

**Question 1: Do you agree that signaling of (a)(b)(c)(d)(e) based on LPP should be considered as the baseline for the WI phase?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment** |
| Swift Navigation | Yes | Our view is the signaling requirements can be met with the existing LPP procedures:   1. Capability Transfer Procedure 2. FFS if KPIs need to be delivered, study if the QoS parameters of Location Information Transfer Procedure can be utilized 3. Assistance Data Transfer Procedure 4. & (e) Location Information Transfer Procedure   Specific new IEs to be determined during the WI phase |
| OPPO |  | For (b), we wonder if it is either to UE or to LMF, i.e., there is no case for “and”;  For (c), we wonder if we need the case for UE-assisted as well, i.e., assistance information to LMF.  For (d), we wonder if the said “integrity measurements” are for the UE feared events? If yes, the issue for (c) above is solved, otherwise, the problem remains.  For (e), it is good to clarify “to UE (UE-assisted) or to LMF (UE-based)” |
| Xiaomi | Yes | For (d), we think integrity measurements is a prat of integrity assistance information or integrity results, so the (d) can be merged to (c) or (e). For (e), the integrity results may need to be sent to network when the integrity event is detected.  So we have the following views:  (a), capability transfer procedure  (b) and (c), assistance transfer procedure  (d) and (e), location information transfer procedure |
| Huawei/HiSilicon | (b)(c)(d)(e) | For (a), it’s not clear what does the positioning integrity capability mean here. Does it mean that UE supports the integrity? If so, we don’t think it’s proper to consider “integrity” as a capability.  For (b)(c)(d)(e), we think the signalling should be discussed for MO-LR/MT-LR and LMF-based/UE-based separately. |
| Nokia | Yes | We agree with the intention of some comments above that some of the items (a)(b)(c)(d)(e) could be combined. For instance, KPIs could be treated as a part of assistance information. However, we think such details can be discussed in WI phase. At this stage, we prefer separating them to make it more clear about what sort of information will be (or can be) considered, as the SI conclusion. |
| Apple | (a)(b)(c)(e) | (a) is needed because integrity needs to be an optional UE capability  Not clear what “integrity measurements” mean, I think this is part of integrity results, so d) and e) needs to be merged in the same procedure. |
| Qualcomm |  | It seems this could be reduced to the following:  *Capability Transfer* procedures seem required to provide information to an LMF on the supported integrity assistance data and measurements by the target device.  *Assistance Data Transfer* procedures seem required to enable the target to request integrity assistance data from the server, and to enable the server to transfer integrity assistance data to the target in the absence of a request.  *Location Information Transfer* procedures seem required to provide integrity KPI's (e.g., as part of QoS) to the target, and for the target to provide any integrity result to an LMF (e.g., as part of the location estimate). |

There was a general consensus that the relationship between the location services protocols (MO-LR, MT-LR) and the LPP procedures for supporting positioning integrity requires further description in addition to the Table 9.4.1.3.

**Question 2: Please comment on the relationship between the location services protocols (MO-LR, MT-LR) and the LPP procedures for supporting UE-based and UE-assisted positioning integrity?**

|  |  |
| --- | --- |
| Company | Comments |
| OPPO | We are generally fine with the current description on the location services protocol (MO-LR, MT-LR), yet do have a question on the relationship between   * UE-based/assisted positioning calculation * UE-based/assisted integrity calculation   From our perspective, the baseline should be   * UE-based mode for both positioning and integrity calculation; * UE-assisted mode for both positioning and integrity calculation;   While the mixed mode should be of lower priority   * UE-based positioning calculation yet UE-assisted integrity calculation; * UE-assisted positioning calculation yet UE-based integrity calculation; |
| Xiaomi | For UE based MO-LR, when the system is unavailable (PL>AL), the integrity results may need to be sent to network. |
| Huawei/HiSilicon | We think the relationship between the location services protocols (MO-LR, MT-LR) and the LPP procedures mainly lies in the following two aspects:  1. Where does the source (LMF or UE) of KPIs come from.  2. Where should the integrity results should be delivered to.  Specifically,   * For MT-LR service, the integrity KPIs are delivered or indicated from the positioning service client to the AMF. In the case of UE-based positioning, LPP procedures including a) transfer KPIs from LMF to UE and b) transfer Integrity results from UE to LMF should be involved.   For MO-LR service, the KPIs can be obtained via UE internal implementation without involving any LPP signalling. In the case of LMT-based positioning, LPP procedures including a) transfer KPIs from UE to LMF and b) transfer Integrity results from LMF to UE should be involved. |
| Nokia | Depending on where the LCS client resides (UE or Network) and where the integrity result is derived (UE-based integrity or LMF-based integrity), we will have different LPP signaling procedures. We think Table 9.4.1.3 summarizes it quite well already. |
| Apple | Agree with OPPO & Nokia |
| Qualcomm | The location services protocols for MT-LR include for example privacy notification and verification signalling, which seems not impacted by the introduction of Integrity. The MO-LR signalling is used to e.g., request assistance data or location estimate from an LMF and can include several LPP PDUs. Therefore, it seems the impacts are restricted to LPP, and would not require changes to Location Services procedures and protocols.  From Table 9.4.1.3, it seems not the location services type is significant, but the location of the LCS Client (i.e., External LCS Client or UE Internal Client). It seems the Integrity KPIs are always determined by the Client (i.e., consumer of the location information), no matter whether e.g., MT-LR, MO-LR, etc.. |

## 2.3 Methodology Descriptions

Swift Navigation, ZTE and Huawei proposed to include a general methodology of positioning integrity to inform what is in scope and out of scope of the specifications.

Swift Navigation and InterDigital proposed that the overview on Detection of feared events (Sections 9.4.1.1.1 to 9.4.1.1.4) should be considered for inclusion as a background. The majority of companies proposed that the Summary in Table 9.4.1.3 is a sufficient background. ESA further proposed to remove Sections 9.4.1.1.1 to 9.4.1.1.4 and instead use Table 9.4.1.1.6 as a much simpler summary.

Nokia, OPPO and u-blox also indicated support for simplifying Section 9.4.1.1 (and its subsections) by leveraging the summary content provided in Table 9.4.1.1.6. The Moderator has also updated Table 9.4.1.1.6 to reflect the proposals in the updated Error Sources TP [5].

Swift Navigation, ESA and Huawei proposed to retain the text on positioning integrity validation in Section 9.4.1.1.5.

**Table 9.4.1.1.6: Summary of A-GNSS integrity assistance information considerations (FFS).**

NOTE: new integrity assistance information is FFS as part of the WI.

**\***NOTE: the UE or LMF are responsible for mitigating these feared events locally, outside the scope of the specifications.

|  |  |  |
| --- | --- | --- |
| **Feared Event Category** | **Feared Event** | **Examples of positioning integrity assistance information (FFS)** |
| 1. Feared events in the assistance data | Incorrect computation by positioning service provider, e.g. software bug, corrupt or lost data | Validity or quality flags for existing assistance information |
| External feared event impacting positioning service provider, e.g. station outages, or other GNSS feared event (i.e. Category 3) |
| 2. Feared events during positioning data transmission | Data integrity faults | Data corruption check, e.g. CRC |
| Data Authentication / Signature |
| 3. External feared events | Satellite feared events  e.g. bad signal-in-space or bad broadcast navigation data | Satellite health or quality flags |
| Atmospheric feared events | Ionospheric indicator |
| Tropospheric indicator |
| Local Environment feared events, e.g. Multipath, Spoofing, Interference | FFS |
| 4. UE feared events | GNSS receiver measurement error | FFS |
| Hardware faults | \* |
| Software faults | \* |
| 5. LMF feared events | Hardware faults | \* |
| Software faults | \* |

The title of Figure 9.4.1.1.6 has also been generalized for both the UE-based and UE-assisted modes and the entity name for ‘Correction Service Provider’ was updated to ‘Positioning Service Provider’.

**Figure 9.4.1.1.6: Relationship between the positioning integrity feared event categories and the 3GPP positioning architecture. Refer to [21] for a detailed description of the UE positioning architecture.**



**Question 3: Which of the following proposed items should be included in the TR as a sub-section?**

1. Summary table of UE-based and UE-assisted considerations (based on Table 9.4.1.3)
2. Validation of positioning integrity (based on 9.4.1.1.5)
3. General introduction to integrity methodologies (new text required)
4. Detection of feared events *[text]* (e.g. 9.4.1.1.1 – 9.4.1.1.4)
5. Detection of feared events *[summary table]* (e.g. 9.4.1.1.6)
6. Figure 9.4.1.1.6

|  |  |  |
| --- | --- | --- |
| Company | Sections (a)(b)(c)(d)(e)(f) | Other (please describe) |
| Swift Navigation | (a)(b)(c)(e)(f) |  |
| OPPO | A, d, e, |  |
| Xiaomi | a, c, d, e, f |  |
| Huawei/HiSilicon | (a)(b)(c)(f) |  |
| Nokia | (a)(c)(f) | Just some comments:   * We think (b)(d)(e) are implementation issues, so we do not need whole dedicated sections to describe these. If we want, some very simple paragraphs would be sufficient. * Also, we would like to confirm what (c) is really about? We suppose this is the “text” version of (a) that describes signalling exchanges for integrity derivation and reporting. If this is the case, then we agree. |
| Apple | a) c) f) |  |
| Qualcomm | a) | However, we wonder what the user case and UE requirements for UE-assisted GNSS integrity would be. E.g., can integrity be determined based on a single-shot location measurements? |

**Question 4: Do you agree with Proposals 1 to 6 for determining the scope of Methodologies for supporting positioning integrity in the 3GPP specifications? If not, please identify which specific proposal(s) you want to discuss and why.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Swift Navigation | Yes |  |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| Huawei/HiSilicon | Yes |  |
| Nokia | Yes |  |
| Apple | Yes |  |
| Qualcomm |  | For determining the "scope" the Proposals look O.K. However, some Proposals are rather specific; e.g., Proposal 3. We would have the following comments on Proposal 3:  - "Location service type" seems irrelevant for integrity. It seems the location of the LCS Client is the differentiation (i.e., External LCS Client or UE Internal Client).  - For an External Client, the integrity KPI Source seems to be an LMF according to Proposal 3. However, we wonder how an LMF would be able to determine the KPIs? It seems the KPIs would always be determined by the client (consumer of the location information); e.g., as part of the QoS?  - There should be no need for introducing a "Positioning Service Provider" for Integrity. I.e., we also do not have a "Positioning Service Provider" for basic A-GNSS assistance data, or DGNSS, RTK, etc.  - We wonder what the user case for UE-assisted GNSS Integrity would be, and what would be the UE requirements? E.g., can integrity be determined based on single-shot location measurements? However, it should be O.K. to include this in the study, but we also note that the section 9.4.1.2 in the Annex (UE-Assisted A-GNSS Integrity Methods) is currently empty. |

1. Phase 1

# 1. Introduction (PHASE 1)

This document contains the questions and baseline TP for the following email discussion [1][2][3]:

[Post112-e][618][POS] Finalise integrity text proposals (Swift)

Scope: Refine the text proposals in R2-2010877/R2-2010878/R2-2010879.

Intended outcome: Agreeable TPs

Deadline: Long

The following documents should also be reviewed as part of this email discussion:

* Email Guideline - [Post112-e][618][POS] Integrity TPs [3]
* [618] KPIs and Use Cases – PHASE 1 Draft TP [4]
* [618] Error Sources – PHASE 1 Draft TP [5]

# 2. Methodologies (PHASE 1)

Objective C of the study is to:

* **Study methodologies for network-assisted and UE-assisted integrity.**

As reflected in the latest submissions to RAN2#112-e and the comments online by **ESA,** the methodologies have received least discussion and treatment to date, and therefore require further examination. The ‘Summary of 8.11.3.3 Methodologies for network-assisted and UE-assisted integrity’ prepared by InterDigital [6] provides a comprehensive review of the methodologies topics raised in the submissions to RAN2#112-e. Many of these considerations are not yet reflected in the draft TP below [2]. Therefore, the questions below are intended to identify and prioritize the open issues for addressing Objective C.

# 2.1 Scope of Study Objective

**Question 1: What key topics should be addressed for the integrity methodologies objective?**

|  |  |
| --- | --- |
| Company | Comments |
| Swift Navigation | We think three key topics need to be addressed:  **1. High level methodology of positioning integrity, e.g.**   * Identification of feared events * Methodologies for mitigation of feared events * Analysis of impact of feared events on positioning error to derive PL * Reporting of positioning integrity (e.g. Integrity Availability, Alerts etc)   **2. Methods to mitigate the identified feared events - refer to Q3**  **3. Signaling procedures for positioning integrity, e.g.**   * UE-based and UE-assisted positioning methods * Assistance data IEs for transferring feared events * Capability Transfer * Assistance Data Transfer * Location Information Transfer * Broadcast assistance? |
| vivo | 1. We need clarify what is analysed by 3GPP and what are out of scope. 2. Give definition of how to calculate PL. 3. which component takes the responsibility to calculate, and which component provide assistant data.  |  |  |  | | --- | --- | --- | | component | functions | actions | | UE | Calculate PL | When receive assistant data,then …..  When get TIR from.. then… | | gNB | FFS |  | | LMF | Provide assistant data | Detect assistant data from…and transmit to …. |   4.Procedures ,sequence of msg delivery and signal definition. |
| Nokia | We think we should focus on the aspects with specification impacts. In particular, what new information elements we should add to LPP interface to support positioning integrity. From our perspective there are three key types of such information elements:   * Assistance data for integrity evaluation * Positioning integrity requirements (i.e. KPIs) * Integrity results reporting   How these information elements are exchanged (and/or derived, e.g. integrity results) based on 3GPP framework in both MO-LR and MT-LR cases should be highlighted. |
| InterDigital | For identifying the potential impacts to protocols (e.g. LPP, RRC) and functions/nodes (e.g. LMF, gNB, UE) within the scope of 3GPP, we think the following topics related to integrity methodologies can be addressed in the study:   * On whether UE-based (network-assisted) integrity and/or LMF-based (UE-assisted) integrity should be supported * Capability for supporting positioning integrity * Delivery of positioning integrity KPIs to UE and/or LMF * Delivery of information on external error sources to UE and/or LMF * On how/where positioning integrity is determined (i.e. based on PL calculation) * Request and delivery of positioning integrity measurement/results * Generation and delivery of alerts messages when detecting integrity events |
| OPPO | We also agree to focus on the aspects that have spec impact, e.g.,   * Signalling to deliver KPI * Signalling to deliver feared event * Signalling to deliver integrity output |
| CATT | Integrity can be supported by UE-based and UE-assisted in A-GNSS positioning method. The integrity methodologies focus on the procedures and interaction in 3GPP framework.   * KPIs within the integrity service levels (AL, IR and TTA as integrity QoS parameters) from AMF to LMF, and from LMF to UE. * Capability Transfer Procedure between UE and LMF * Assistance Data Transfer Procedure delivering error sources of feared events between UE and LMF * Location Information Transfer procedure: e.g. the integrity monitor results to LMF in UE-assisted mode and report LocationFailureCause or not monitored in UE-based mode. |
| ZTE | We share the similar views with the above companies that RAN2 should mainly consider the following topics:  • The architecture of the positioning integrity system.  • How to transmit KPI, integrity assistance data(e.g. feared event factor), integrity result and integrity event in the system.  • How to solve/relief the influence of defined feared events.  • What kinds of positioning integrity methods should be addressed(e.g. MO-LR, UE-assisted, etc). |
| Xiaomi | We should focus on the signaling procedures for integrity methodologies based on the current positioning architecture.   * Integrity capability transfer procedure * KPI and feared event transfer procedure * Integrity results delivery procedure * The definitions of integrity methodologies |
| ESA | We share the views from above in particular Nokia and InterDigitial. A number of relevant items begin to emerge. |
| u-blox | We think the 3GPP work should be focused on specification impact and agree with the views put forward by Nokia and InterDigital. |
| Qualcomm | Share similar views from e.g. Nokia, ESA, u-blox above. The focus should be on the 3GPP specification impacts only. |
| Huawei/HiSilicon | We think the following key issues should be addressed:  1) What’s content of the integrity monitor results? And how to deal with integrity results for MO-LR and MT-LR?  2) How to handle the alert? For example, for MO-LR, the alert should be given to the UE, while for MT-LR, the alert will need to be sent to the LCS client.  3) For the assistance data required for integrity, which LPP messages can be reused and what new IEs are needed?  4) Study the signaling process to support integrity for MO-LR/MT-LR UE-based and UE-assisted positioning respectively. |

**Question 2: From the existing Tdoc submissions, what content should be considered for inclusion?**

|  |  |
| --- | --- |
| Company | Comments |
| Swift Navigation | **1. High level methodology of positioning integrity:**   * Requires new introductory text to describe the generalized methodology underpinning topics (2) and (3).   **2. Methods to mitigate the identified error sources**   * We think the current text for 9.4.1.1 (and its subsections) is sufficient for UE-based. * UE-assisted is FFS. * The updated summary tables for UE-based and UE-assisted (FFS) proposed by Swift Navigation in Question 2 in the Error Sources TP [5] should also be added.   **3. Signaling procedures for positioning integrity - see InterDigital Summary (R2-2010675):**   * UE-based and UE-assisted methods [Sections 2.1, 2,2, 2,3, R2-2010675] * Assistant data IEs for transferring feared events [Section 3.3, R2-2010675] * Capability Transfer [Section 3.1, R2-2010675] * Assistance Data Transfer [Section 3.2, R2-2010675] * Location Information Transfer [Section 3.5, R2-2010675] * Integrity Results reporting [Section 3.6, R2-2010675] * Broadcast assistance [FFS] |
| vivo | Only **Table 9.4.1.3: Summary of network assisted (UE-Based) and UE-assisted (LMF-Based) considerations for determining Integrity.** |
| Nokia | The Table 9.4.1.3 in the TP below is quite nice, and should be included in the TR.  For integrity methods of feared event detection elaborated in the 9.4.1.1 in the TP below, we feel they are all pointing to a similar outcome: Assistance information needs to be defined. Therefore, rather than describing each method individually in 9.4.1.1, we prefer directly rename the section 9.4.1.1 as “**Potential Assistance information for Positioning Integrity Support**” and list the possible new assistance information that could be added, each with a short example (i.e. the related integrity method) of how this could be applied.  In some sense we agree with vivo we should only focus on Table 9.4.1.3 in the SI phase, as this captures what specification impacts we foresee in the WI phase. |
| InterDigital | We agree with Swift that from the Tdoc submissions, the content related to the following topics can be considered for inclusion:   * Overview on UE-based (network-assisted) integrity and LMF-based (UE-assisted) integrity (summarized in table 9.4.1.1.6) * Detection of feared events (the current TP can be used as baseline) * Signalling and procedures for supporting positioning integrity |
| OPPO | We agree with others that the table of 9.4.1.3 is the key part that should be included.  Otherwise, for the detection of feared events, since it would be probably out of the 3GPP scope, so is less important. Maybe one way-out is as suggested by Nokia, i.e., to simplify the content a bit. |
| CATT | We are fine with the current table 9.4.1.3. Moreover, signalling to deliver KPIs from AMF to LMF also is needed. |
| ZTE | We also share the similar view that table 9.4.1.3 should be included in the TR.  Besides, signalling and procedures for positioning integrity and feared event factors should also be considered (R2-2010475). |
| Xiaomi | We also think the 9.4.1.3 should be included in the TR. Moreover, the signaling procedures for integrity methodologies can be captured in the TR. |
| ESA | Agree with Nokia and vivo, actually we object to the entire TP except Table 9.4.1.3 and Validation of integrity. |
| u-blox | We also support Nokia’s proposal |
| Qualcomm | Similar view as ESA.  The text proposals should summarize any identified NR/specification impacts in order to derive appropriate conclusions for a potential work item phase.  It seems Table 9.4.1.3 is the main summary. However, some aspects in the Table require further clarification:  The relation between integrity and location services protocols (e.g., MO-LR, MT-LR) is rather unclear. The specification impacts seem primarily on LPP and not on location services.  The role of an "service provider" requires clarification. Typically, any "service provider" aspects are out of scope of 3GPP. From a UE point of view, the "service provider" is the network operator from which a UE obtains service (i.e., subscription). How (if at all) a network operator or deployment obtains assistance data from external sources is beyond the scope of 3GPP.  The need for new procedures (e.g., to transfer integrity assistance data from LMF to UE, or transfer integrity results from UE to LMF) is unclear. It seems existing LPP Procedures can be used (i.e., there seems no specification impacts on the procedures but on information elements carried in messages of existing LPP procedures). |
| Huawei/HiSilicon | We suggest to include:  1) System framework for positioning integrity with several function parts.  2) The assistance information required for gNB or UE for integrity measurement reporting.  3) The behavior of LMF/gNB/UE in the case of integrity failure.  4) Signaling procedures for LMF-based and UE-based positioning.  The framework and signaling procedures provide by R2-2010279 can be considered as a baseline. |

# 2.2 GNSS Positioning Integrity Methods

**Question 3. What GNSS positioning integrity methods should be addressed within the scope of the study?**

|  |  |
| --- | --- |
| Company | Comments |
| Swift Navigation | We think the updates proposed in topic (2) for Question 2 above will complete the existing text for describing methods of identifying and detecting GNSS feared events, further supplemented by the high-level introductions to be provided for topic (1). |
| vivo | UE-based, UE assistant |
| Nokia | As we commented in the previous question, we think this is more important to directly identify new assistance information that could be specified, rather than go through the integrity methods that are currently in the TP. In the end they are based on implementation, but 3GPP should focus on the assistance information that facilitate the implementation of these methods. |
| InterDigital | Given the scope defined in the SID and the positioning service types supported in Rel-16, the following GNSS positioning integrity methods can be addressed in the study:  - UE-based and MO-LR (UE initiated)  - UE-based and MT-LR (LMF initiated)  - LMF-based and MO-LR (UE initiated)  - LMF-based and MT-LR (LMF initiated) |
| OPPO | We agree the method listed in the table 9.4.1.3, i.e.,   * UE-based and UE-assisted * MO and MT |
| CATT | The current table 9.4.1.3 already has covered the methods. |
| ZTE | Same view with InterDigital. |
| Xiaomi | We think the method in the table 9.4.1.3 should be addressed. |
| ESA | Objective says “study methodologies for network-based and UE-assisted integrity”. We think the last Table in this TP takes us on the right path; |
| Qualcomm | "UE-assisted", "UE-based" etc. are positioning modes as defined in e.g., TS 23.273. The relation between "positioning modes" and "integrity methods" is unclear. It seems what is required are additional assistance data elements and "measurement" related reporting. Once this required information has been identified, the applicability to e.g., UE-assisted or UE-based mode should become obvious. |
| Huawei/HiSilicon | We suggest to study the possible error models (e.g. Gaussian Mixed Model, CDF/PDF overbounding) can be provided to measure the positioning error caused by the listed error sources. |

# 2.3 Methodologies Summary table

**Question 4. Do you agree with Table 9.4.1.3 as a summary of the methodologies?**

|  |  |
| --- | --- |
| Company | Comments |
| Swift Navigation | Yes, while noting the table does not currently include **LMF faults** for UE-assisted and is therefore subject to the outcomes from Question 1 in the Error Sources TP [5]. |
| vivo | With modification |
| Nokia | The definitions of “Network-assisted (UE-based)” and “UE-assisted (LMF-based)” are not so clear. We prefer to have clear definitions such as:   * ***Network-assisted (UE-based) integrity:*** *Positioning integrity result is derived by UE.* * ***UE-assisted (LMF-based) integrity:*** *Positioning integrity result is derived by LMF.*   Also, we should emphasize that this table mainly concerns the information exchange framework between LMF and UE, so the term “source” in the table is referring to either LMF and UE.  We are not sure “triggering alert” proposed by vivo could be seen as spec. impact or not, as it should be an implementation issue for LMF/UE to determine how to deal with the obtained integrity result. |
| InterDigital | Yes. For clarity, we agree for using the terminology proposed by Nokia for UE-based and LMF-based integrity. We also share similar concern with Nokia that the insertion of “triggering alert” under the Spec Impact column, as proposed by vivo, may not be suitable in the current stage of discussions. |
| OPPO | The table is generally good, and we are fine with further clarification on LMF-faults and definition of “Network-assisted (UE-based)” and “UE-assisted (LMF-based)”.  We are not sure about “triggering alert” either, i.e., it should be an implementation issue as commented by Nokia. |
| CATT | The understanding of MO-LR is not correct in table 9.4.1.3.  **Source of KPIs** (e.g. TIR, AL, TTA etc) still comes from LMF to UE, rather than Obtained via UE internal implementation.  Please refer to 6.2 5GC-MO-LR Procedure in TS 23.273.  Figure 6.2-1 illustrates the general network positioning requested by the UE to the serving PLMN for obtaining the location related information of itself.  1) If the UE is in CM-IDLE state, UE instigates the UE triggered Service Request as defined in clause 4.2.3.2 of TS 23.502 [19] in order to establish a signalling connection with the AMF.  2) The UE sends an MO-LR Request message included in a UL NAS TRANSPORT message. The MO-LR Request may optionally include an LPP positioning message. Different types of location services can be requested: location estimate of the UE, location estimate of the UE to be sent to an LCS client or AF, or location assistance data. If the UE is requesting its own location or that its own location be sent to an LCS client or AF, this message carries LCS requested QoS information (e.g. accuracy, response time, LCS QoS Class), the requested maximum age of location and the requested type of location (e.g. "current location", "current or last known location"). If the UE is requesting that its location be sent to an LCS client, the message shall include the identity of the LCS client or the AF, and may include the address of the GMLC through which the LCS client or AF (via NEF) should be accessed. |
| ZTE | We have the same concern with Nokia and InterDigital about the “triggering alert”. From our mind, we may add this part after sufficient discussion.  Besides, for the integrity assistance information column, we prefer to add a note shown as below:  *“ ‘****From LMF to UE****’ does not mean that the integrity assistance information is generated by LMF.”*  For example, for non-3GPP related feared events like satellite or local environment should be handled/provided by the correction service provider which is shown in figure 9.4.1.1.6. In such situation, the provider may transmit the related data to LMF and LMF may either use this data or transmit it to UE. |
| Xiaomi | We are fine with the table 9.4.1.3. |
| ESA | Yes, we do agree in principle. It needs fine-tuning but this can follow at a later stage, once we have the complete picture. |
| u-blox | We generally agree with the table but clarifications regarding UE-based and LMF-based are needed. |
| Qualcomm | As commented above, the location services impact (MO-LR, MT-LR) require further clarification.  The relation between positioning mode (UE-based or UE-assisted) and "integrity method" should also be clarified.  Since there seems no standard interface between a "Service Provider" and an LMF, any information exchange between "Service Provider" and "LMF" should be out of scope. Only the interface between UE and LMF seems relevant.  Specification impacts on procedures to transfer e.g., assistance data or integrity results between LMF and UE are unclear. It seems existing LPP procedures could be used. |
| Huawei/HiSilicon | We have several concerns about Table 9.4.1.3:  1. The description of “Integrity results” are required to help understand the table, e.g. what’s the content and what are the results used for.  2. We think the integrity results of the MT-LR case should be sent to the LCS client that invokes the positioning service, instead of “Keep inside the LMF”. |

# 2.4 Other Open Issues

**Question 5: Are there any open issues which have not been addressed by Questions 1 to 4? If so, please identify the issue(s), your reasoning and your proposed resolution.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| Huawei/HiSilicon | Yes | We think a general introduction of integrity methodologies should first be provided. Now the introduction in section 9.4.1 only includes the detection of GNSS error sources. According to the current TP, the methodology at least also includes integrity validation, etc. A comprehensive description is required. |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# 2.5 Draft Text Proposal

The baseline text from R2-2010879 [2] unless otherwise indicated by track changes or comments.

*Start of Text Proposal*

9.4 Positioning Integrity Methods

9.4.1 RAT-Independent

Detection of GNSS error sources is necessary to support positioning integrity by ensuring the TIR can be met. This section describes how the feared events occurring in different parts of the positioning system can be detected to support the implementation of UE-based and UE-assisted methodologies.

9.4.1.1 UE-Based A-GNSS Integrity Methods

9.4.1.1.1 Detection of Feared Events in the Correction Data

The 3GPP network-assistance data can be used to indicate potential faults in the correction data processing itself, as determined by the corrections service provider systems. If the GNSS correction data processing encounters an error that degrades or impacts the validity of the correction data (e.g. lost, corrupt or invalid observations, software bugs; or external feared events such as satellite failures), and the service provider is capable of monitoring and detecting these feared events, the quality of the correction data can be indicated to the UE. As noted in Table 2, there are no existing IEs corresponding to correction data quality, meaning new assistance data is needed. Signaling the Correction Data quality allows the UE to determine the impact of these events on its computed PL. Note that often the correction data may still be sent even if not indicated as high enough quality for integrity purposes, as it is still of sufficient quality to improve accuracy even though integrity cannot be ensured.

9.4.1.1.2 Detection of Feared Events in Transmitting Data to the UE

Data integrity ensures that the end-to-end data transmission link needed to signal integrity assistance data across the network is secure and free from the possibility of data corruption, including the data link to the corrections service provider. Data integrity algorithms and related security architectures for the 5G system are individual work areas in 3GPP [17].

A related observation in the context of this SI (further addressed in Section ‘9.4.1.1.5 - Data Validation’ below) is that industry-specific functional safety standards (e.g. ISO-26262 for Automotive, IEC 62278 for Rail) are also required to validate integrity compliance for a given implementation. These standards include requirements that may be outside of the current RAN architecture. For example, consider the typical service interface between a corrections service provider sending GNSS assistance data to the UE via the NG-RAN. Both the correction service provider and UE can be designed and qualified with integrity compliance. However, the NG-RAN architecture, although rigorously specified with data security and integrity features in [17], may not comply with industry-specific functional safety standards by default. This implies that the integrity of the data transmission from the correction provider to the UE needs to be trusted and assured without any alterations via the NG-RAN.

One method for achieving this is by providing for the data to be signed by the correction provider and verified by the UE in accordance with the relevant functional standards[[1]](#footnote-1). Once the data has left the correction provider, any changes to the data would invalidate the certificate. This in turn means that, irrespective of whether the 3GPP architecture is compliant to the functional safety standards, appropriate procedures can be implemented to sign and verify the network integrity assistance data with minimal impacts to the NG-RAN – i.e. the NG-RAN can still be leveraged as an efficient data link. Further investigation is required through the SI/WI to determine whether new data integrity IEs are needed for positioning integrity or whether existing data integrity IEs are sufficient (e.g. to carry a data signature from the corrections service provider to the UE).

9.4.1.1.3 Detection of External Feared Events

The correction service provider systems can be used to detect the feared events which occur external to the correction networks and the UE equipment (e.g. GNSS feared events and atmospheric gradients). New assistance data can be defined in LPP to indicate these events to the UE via the NG-RAN, which in turn reduces overhead on the UE by offloading integrity monitoring to the network. It also enables the potential to achieve lower TIRs given the added monitoring and detection capabilities of the network. These methods are further described below.

In practice, feared events detected by the corrections service provider mean that, even outside the probability of a fault occurring (e.g. recognizing these probabilities can be estimated using threat models ), the correction network itself can be used to detect if the actual event occurs. For example, the correction provider network typically has the benefit of many GNSS reference stations distributed over a wide area. This additional observability can result in more effective detection of these events, removing the burden on the UE to detect them unassisted, and potentially increasing the probability with which these events can be detected (i.e. given the UE alone does not have the benefit of cross-checking data from surrounding GNSS reference stations). Examples of GNSS external feared events include satellite feared events, such as loss of signal, clock errors and constellation failures, and atmospheric feared events, such as large ionospheric and tropospheric gradients.

In addition to the network providing integrity assistance data corresponding to the detection of feared events, the network may also provide to the UE certain threat model parameters, allowing them to be updated based on the evolving operational history of the GNSS constellations. An example of this is found in the ARAIM Integrity Support Message (ISM) which contains parameters such as the assumed probability of satellite failure [23]. The scope of this SI is not intended to standardize the integrity algorithms implemented by the corrections service provider to detect the feared events. The study identifies the common set of feared events that can be indicated to the UE by specifying network-assistance data IEs.

9.4.1.1.4 Detection of UE Feared Events

UE-detected feared events depend on the hardware and software capabilities of the equipment and its internal integrity algorithms. This SI does not attempt to standardize the GNSS integrity algorithms at the network or the UE, but rather the network-assistance data needed to transport the integrity indicators derived from the algorithms. The assistance data can then be applied by the UE’s GNSS positioning function (i.e. independent of 3GPP).

This same logic applies to how the RTK and SSR GNSS assistance data has been standardized in previous 3GPP releases – i.e. the RTK and SSR algorithms used to derive GNSS corrections are implementation-defined. The assistance data used to transport the derived corrections are specified in LPP.

9.4.1.1.5 Positioning Integrity Validation

Positioning integrity can only be validated end-to-end, per-implementation. Validation requires a comprehensive Fault-Tree Analysis (as described in [24]) and a complete qualification dossier (e.g. documentation, methodologies, tests and traceability through the entire integrity qualification process).

Integrity validation is particularly crucial for safety-critical applications such as Automotive and Rail. Integrity validation takes into consideration a much wider suite of requirements than the assistance data used to supply the GNSS integrity parameters. For example, this includes the hardware components (e.g. ISO-26262 certified hardware and CPUs), tooling (e.g. ASIL-qualified compilers), software architecture design, safety manuals, test procedures etc, all of which vary for each integrity implementation. While 3GPP integrity assistance data is just one of multiple inputs for integrity validation, defining a standardized set of GNSS integrity assistance data ensures a wider ecosystem of connected devices can readily benefit from knowing what inputs are available from the network to support integrity validation.

9.4.1.1.6 Summary of UE-Based A-GNSS Integrity Assistance Information Considerations

Further to the general error sources described in Section 9.3.1.1 and the integrity methods described above, Table 9.4.1.1.6 summarises the potential error sources and assistance information to be considered for UE-Based A-GNSS positioning integrity, noting the assistance information and transport procedures remain FFS in the WI.

**Table 9.4.1.1.6: Summary of UE-based A-GNSS integrity assistance information considerations.**

\*FFS whether new integrity assistance information needs to be specified in LPP.

**\*\***not possible to mitigate with assistance data from the network, the UE is responsible for mitigating these feared events locally.

|  |  |  |
| --- | --- | --- |
| **Error source** | **Error source category** | **Examples of integrity assistance information (FFS)\*** |
| 1. Feared events in the correction data | Incorrect computation by provider, e.g. software bug, corrupt or lost data | Validity or quality flags for existing assistance information |
| External feared event impacting provider, e.g. station outages, or other external feared event, per (3) |
| 2. Feared events in transmitting the data to the UE | Data integrity faults | Data corruption check, e.g. CRC |
| Data Authentication / Signature |
| 3. External feared events | Satellite feared events | Bad Signal in Space |
| Bad Broadcast Navigation Data |
| Atmospheric feared events | Ionospheric indicator |
| Tropospheric indicator |
| Local Environment feared events, e.g. Multipath, Spoofing, Interference | FFS |
| 4. UE feared events | GNSS receiver measurement error | \*\* |
| Hardware faults | \*\* |
| Software faults | \*\* |

Figure 9.4.1.1.6 illustrates where each of the four error sources from Table 9.4.1.1.6 originates in the end-to-end positioning system.

**Figure 9.4.1.1.6: Relationship between the UE-Based GNSS Integrity feared events and the 3GPP UE positioning architecture (GNSS). Refer to [21] for a detailed description of the UE positioning architecture.**

Diagram

Description automatically generated

9.4.1.2 UE-Assisted A-GNSS Integrity Methods

Editor’s Note: UE-assisted methods are FFS.

9.4.1.3 Summary of A-GNSS Integrity Methods

Table 9.4.1.3 summarizes the network-assisted (UE-Based) and UE-assisted (LMF-Based) considerations for determining integrity.

**Table 9.4.1.3: Summary of network assisted (UE-Based) and UE-assisted (LMF-Based) considerations for determining Integrity.**

NOTE: the details are FFS and to be discussed in WI phase, including the LPP messages and transfer procedures.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Integrity method** | **Location service type** | **Source of KPIs** (e.g. TIR, AL, TTA etc) | **Source of Integrity results**  (e.g. PL, Integrity Availability etc) | **Integrity assistance information (FFS)** | **Spec impact (FFS)** |
| Network assisted (for UE-based positioning) | MO-LR | Obtained via UE internal implementation;  MO also need get data correction from LMF. | Keep inside the UE | From LMF to UE:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events | Procedure to transfer Integrity assistance information from LMF to UE  Trigger alert in UE  Redundancy data collection for RAIM |
| MT-LR | From LMF | From UE | From LMF to UE:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events | Procedure to transfer Integrity assistance information and KPIs from LMF to UE  Procedure to transfer Integrity results from UE to LMF  Trigger alert in LMF or target location server |
| UE assisted (for LMF-based positioning) | MO-LR | From UE | From LMF | From Service Provider to LMF:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events  From UE to LMF:  - UE feared events | Procedure to transfer Integrity assistance information and KPIs from UE to LMF  Procedure to transfer Integrity results from LMF to UE  Trigger alert in UE |
| MT-LR | Obtained via LMF implementation  UE feared from UE | LMF internal implementation | From Service Provider to LMF:  - Feared events in the correction data  - Feared events in transmitting the data to the UE  - External feared events  From UE to LMF:  - UE feared events | Procedure to transfer Integrity assistance information from UE to LMF  Trigger alert in LMF or target location server |

*End of Text proposal*

# 3. Conclusions

# References

[1] R2-xxxxxx [RAN2-112-e-Positioning-Relay-2020-11-13-1745\_eom.docx](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_112-e/Inbox/Chairmans_Notes/RAN2-112-e-Positioning-Relay-2020-11-13-1745_eom.docx),

<https://www.3gpp.org/ftp/tsg\_ran/WG2\_RL2/TSGR2\_112-e/Inbox/Chairmans\_Notes>.

[2] R2-2010879 TP on Integrity Error Sources, Swift Navigation.

[3] [Email Guideline - [Post112-e][618][POS] Integrity TPs](https://www.3gpp.org/ftp/Email_Discussions/RAN2/%5bRAN2%23112-e%5d/%5bPost112-e%5d%5b618%5d%5bPOS%5d%20Integrity%20text%20proposals%20(Swift)/)

[4] [[618] KPIs and Use Cases – PHASE 2 Draft TP](https://www.3gpp.org/ftp/Email_Discussions/RAN2/%5BRAN2%23112-e%5D/%5BPost112-e%5D%5B618%5D%5BPOS%5D%20Integrity%20text%20proposals%20(Swift)/PHASE%202/KPIs%20and%20Use%20Cases)

[5] [[618] Error Sources – PHASE 2 Draft TP](https://www.3gpp.org/ftp/Email_Discussions/RAN2/%5BRAN2%23112-e%5D/%5BPost112-e%5D%5B618%5D%5BPOS%5D%20Integrity%20text%20proposals%20(Swift)/PHASE%202/Error%20Sources)

[6] R2-2010675 Summary of 8.11.3.3 Methodologies for network-assisted and UE-assisted integrity, InterDigital.

1. Note that the requirements called out by integrity standards such as ISO-26262 can be extremely onerous for any entity that “processes” (i.e. modifies in any way) the data. This possibly includes use of qualified tools such as special compilers, as well as using ISO-26262 certified hardware and CPUs to perform the processing. [↑](#footnote-ref-1)