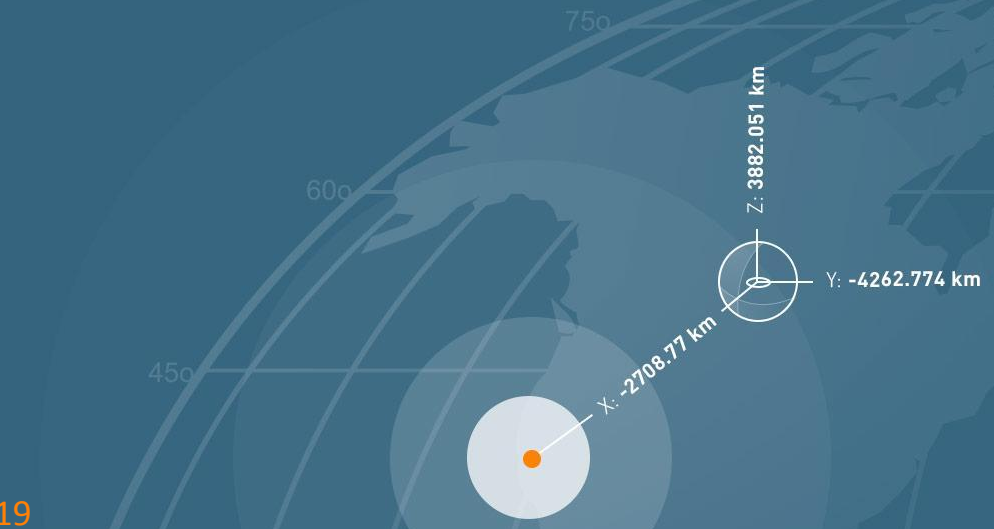
RP-190855



3GPP TSG RAN Meeting #84

Newport Beach, CA, USA, 3-6 June 2019

Agenda Item: 8

Document For: Discussion

Motivation for SI on Integrity Support for NR Positioning

Source: Swift Navigation

Background

- LPP is being extended to support High Accuracy GNSS (HA-GNSS) [1, 2, 3, 4, 5].
- LPP Release 15 [4] supports RTK, Network-RTK and basic PPP Assistance Data.
- A new Work Item on "NR Positioning Support" [5] was agreed at RAN#83:

  Define extensions of LPP protocol to support GNSS SSR (PPP-RTK support) based on the "Compact SSR" definitions specified for QZSS (Release 16).

- Implementation of the SSR Work Item is a foundation for developing GNSS Integrity extensions to LPP [2, 3, 5, 6].
- Integrity is broadly defined in the 3GPP study on positioning use cases [3]:

  "A measure of the trust in the accuracy of the position-related data provided by the positioning system and the ability to provide timely and valid warnings to the UE and/or the user when the positioning system does not fulfil the condition for intended operation."

Background

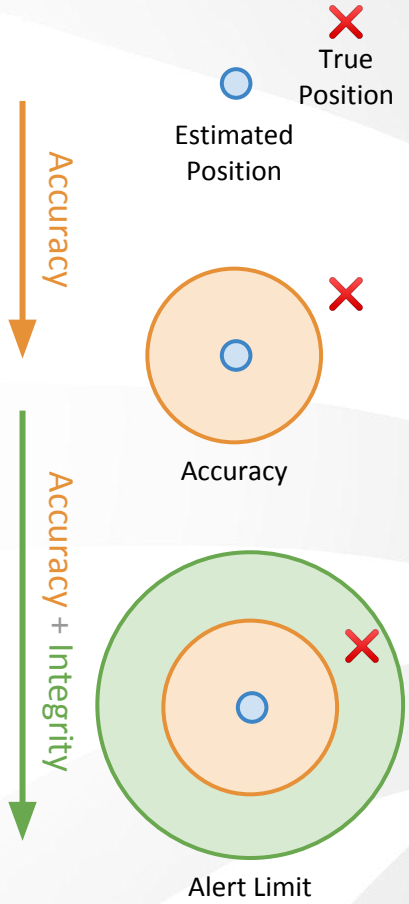
- Integrity will require additional IEs based on emerging integrity parameters:

  Time to Alert, Alert Limit, Target Integrity Risk, Protection Level etc.

- Examples of positioning use cases requiring GNSS Integrity include [3, 6, 7]:
  - *C-V2X*
  - *Road-User Charging*
  - *UAV Transport & Monitoring*
  - *Emergency Response*
  - *Rail*
  - *Autonomous Vehicles*
  - *Bike Sharing*
  - *Asset Tracking*
  - *etc...*

Primer on GNSS Integrity

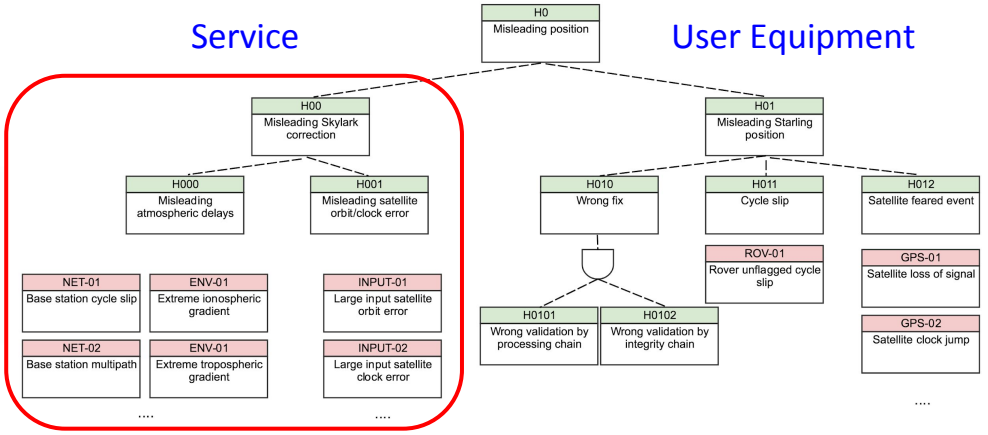
- The primary output is the user's estimated position.
  - This estimate will contain some error compared to the true position.
- To indicate the quality of the position, the accuracy is also estimated. This is typically given as e.g. a 1 sigma (68%) value.
  - This indicates 68% of position outputs are better than the reported accuracy.
  - This leaves 32% of positions worse than the stated accuracy - but how much worse?
- For high-assurance positioning, we want to bound the error to a much higher level of certainty. This is the concept of **Integrity**
  - Define **Alert Limit (AL)** which is an upper bound on position error.
  - Alert Limit is calculated for a **Target Integrity Risk (TIR).**
  - TIR gives an allowable rate of occurrence of error greater than the Alert Limit e.g. less than once per 100,000 hours ($< 10^{-5}$/hour).



Primer on GNSS Integrity

- To compute the Alert Limit for a low TIR it's not sufficient to consider just nominal performance.
- Rare fault conditions and "feared events" must be considered
  - e.g. degradation / failure of the GNSS satellite.
- These faults can be difficult to detect on the UE alone.
- **To achieve necessary integrity KPIs, it's essential for the GNSS network to monitor for certain faults** and provide assistance data to the UE to support integrity computation.

Example Fault Tree



Network side faults must be monitored and communicated, e.g. satellite feared events, atmospheric events, network events

Justification

- Integrity is an important KPI for 3GPP identified HA-GNSS use cases.
- Integrity requires assistance data from the network beyond that already under consideration.
  - e.g. fault flags on SSR IEs, correction alert limits, auxiliary corrections.
- Correction providers and UE vendors can already support this functionality, but there is no existing industry standard for interoperability for mass market adoption.

Sample Use Case - Road Use Charging

Problem

- RUC typically requires expensive fixed infrastructure.
- Desirable to replace with HA-GNSS based solution.
- *How do you assure the user is being charged correctly?*

Opportunity

- High Integrity can assure that positioning errors don't result in incorrect billing.
- Applicable to any road network with LTE/5G access.
- Tamper / fraud proof with high confidence.

Benefits

- Improve traffic flow and planning.
- Optimized routing and road maintenance.

Objectives

The objectives of this SI are to:

- Identify / evaluate Integrity KPIs
  - Alert Limit, Target Integrity Risk, Protection Level, Availability, Continuity etc.
- Identify feared events
  - Satellite feared events, atmospheric events, network events etc.
- Identify an approach to network assisted GNSS Integrity.
- Investigate extensions to LPP to support GNSS Integrity.
- Map the functional dependencies to UE and network equipment.
- Examine the primary use cases and timeline.

References

[1] RP-170210, Motivation to study high accuracy positioning of NR, RAN#75, European Space Agency (ESA), Deutsche Telekom, Fraunhofer IIS, DOCOMO, Toyota InfoTechnology Center, March 2017.

[2] R2-1804428, “Report of email discussion [99bis#57][LTE/Positioning] Future phase support of SSR”, u-blox AG, RAN2#101-Bis, April 2018.

[3] 3GPP TR 22.872, “Study on positioning use cases”.

[4] 3GPP TS 36.355, "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)".

[5] RP-190752, “New WID: NR Positioning Support”, RAN#83, March 2019.

[6] R2-1906809, Considerations on GNSS SSR assistance data for NR Positioning, RAN2#106, Swift Navigation, May 2019.

[7] European GNSS Agency, GNSS Market Report, Issue 5, 2017.

THANK YOU

Appendix

5G_HYPOS - Study on positioning use cases [2]

- Integrity applies to many positioning use cases.

Use cases		Potential requirements per use cases							
		Environment of Use	**Position Accuracy**	**Velocity**	**Avail.**	**Update rate or interval**	**TTFF**	**Latency**	**Integrity Study Item**
5.2.1	Bike Sharing	5G positioning service area - Outdoor	2m Horizontal		90 %		10s	1s	✓
		Enhanced positioning area - Outdoor	0.2m Horizontal		99 %		10s	1s	✓
5.2.2	Augmented Reality	Outdoor - 5G positioning service area	1-3m Horizontal 0.1-3m Vertical	2 m/s 10deg.	80 %	1 - 10 Hz	10s	1s	
5.2.3	Wearables	5G positioning service area - -Outdoor/Indoor	2m Horizontal 1-3m Vertical		90 %	30s - 300s	10s		
		5G positioning service area - -Outdoor/Indoor	2m Horizontal 1-3m Vertical		99 %	1s - 30s	10s	1s	

Table 6.1-1 – Use cases synthesis [2]. Integrity requirements can be added to the table.

5G_HYPOS - Study on positioning use cases [2]

Use cases		Potential requirements per use cases							
		Environment of Use	**Position Accuracy**	**Velocity**	**Avail.**	**Update rate or interval**	**TTFF**	**Latency**	**Integrity Study Item**
5.2.4	Advertisement push	5G positioning service area - Outdoor/Indoor	3m Horizontal 3m Vertical		90 %			60s	
5.2.5	Flow Management	Enhanced positioning- Outdoor/Indoor	10m Horizontal		80 %	10s	10s		
5.3.1	Person and Medical Equipment location in Hospital	Enhanced positioning- Outdoor/Indoor	3m Horizontal 2m Vertical		99 %			60s	✓
5.3.2	Patient Location (outside Hospital)	5G positioning service area Outdoor/Indoor	10m Horizontal 3m Vertical (floor)		99 %				✓

5G_HYPOS - Study on positioning use cases [2]

Use cases		Potential requirements per use cases							
		Environment of Use	Position Accuracy	Velocity	Avail.	Update rate or interval	TTFF	Latency	Integrity Study Item
5.3.3	Trolley	Enhanced positioning-Outdoor/Indoor	0.5m Horizontal 1-3m Vertical		99 %			20ms	✓
5.3.4	Waste Management	5G positioning service area - Outdoor	3m Horizontal		99 %	2h - 1 day		60s	
5.4.1	Emergency Call	5G positioning service area Outdoor/Indoor	50m Horizontal 3m Vertical		95 %		30s	60s	✓
5.4.2	Accurate Positioning for First Responders	Outdoor	1m Horizontal, 0.3 m Vertical		98 %		10s	5s	✓
		Indoor	1m Horizontal, 2 m Vertical		95 %		10s	1s	

5G_HYPOS - Study on positioning use cases [2]

Use cases		Potential requirements per use cases							
		Environment of Use	Position Accuracy	Velocity	Avail.	Update rate or interval	TTFF	Latency	Integrity Study Item
5.4.3	Alerting nearby Emergency Responders	5G positioning service area Outdoor/Indoor	50m Horizontal 3m Vertical (floor)		99%		10s		✓
5.4.4	Emergency Equipment loc. Outside Hospitals	5G positioning service area Outdoor/Indoor	10m Horizontal 3m Vertical (floor)		95%		10s		✓
5.5.1	Traffic Monitoring & Control	5G positioning service area - Outdoor	1-3m Horizontal 2.5m Vertical		95 %	10 Hz	10s	30ms	✓
5.5.2	Road User Charging	5G positioning service area - Outdoor Enhanced positioning-Tunnels	<1m (across track) 3m (along track)	2 m/s	99 %	1 Hz	10s		✓

5G_HYPOS - Study on positioning use cases [2]

Use cases		Potential requirements per use cases							
		Environment of Use	**Position Accuracy**	**Velocity**	**Avail.**	**Update rate or interval**	**TTFF**	**Latency**	**Integrity Study Item**
5.6.1	Asset Tracking and Management	5G positioning service area - Outdoor	10-30m Horizontal	5 m/s	99 %	300s-1day			✓
		Enhanced positioning - Outdoor	1m Horizontal		99 %	1s	1s in enhanced positioning area		
5.7.1	UAV (Data analysis)	5G positioning service area - Outdoor	0.1m Horizontal 0.1m Vertical	0.5 m/s 2 deg.	99 %		10s		✓
5.7.2	UAV (Remote control)	5G positioning service area - Outdoor	0.5m Horizontal 0.3m Vertical		99 %			150ms	✓
		Enhanced positioning area - Outdoor	0.5m Horizontal 0.1m Vertical		99.9 %			150ms	✓

5G_HYPOS - Study on positioning use cases [2]

Use cases		Potential requirements per use cases							
		Environment of Use	**Position Accuracy**	**Velocity**	**Avail.**	**Update rate or interval**	**TTFF**	**Latency**	**Integrity Study Item**
5.8.1	Support multiple different location service	5G positioning service area - Outdoor	2m Horizontal		90 %		10s	1s	✓
		Enhanced positioning area - Indoor	0.1m Horizontal		99 %		10s	1s	
5.8.2	Support location method negotiation	5G positioning service area Outdoor/Indoor							✓
Note: most use cases also feature potential requirements on modes of operation, intended for the UE, the Network or for the 5G system.									