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| **Purpose** |
| This document describes the SW Requirements for the SW Component Precise Positioning Engine in the project GM OnStar Gen12 |

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| **Scope (validity area & date, replaced documents** |
| This document applies to supplier’s Precise Positioning Engine which shall be used by the above mentioned project. |

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# SW Component Overview

Within GM OnStar Gen12 project, there is the need to have a precise vehicle position. Such position would be the combination result of absolute position and relative position provided by different components in the system. Absolute precise position shall be made available by Precise Positioning Engine (PPE) component which is responsible for downloading and applying corrections coming from GM backend to GNSS baseband measurements.

The default expected output is a 10Hz GNSS corrected position which has a 2-sigma accuracy of below 1 meter. This position will be further used by other components, including a Dead Reckoning enhancing component in order to have a precise vehicle position.

An overview of the component context is depicted in below figure:



Figure 1 - PPE Context Diagram

## Assumptions and dependencies

Precise Positioning Engine would run within Qualcomm SA415M / SA515M Telematics SDK, meaning that there will be no direct interaction between Continental and PPE, but through Qualcomm’s defined API.

Though, as the correction data is coming from GM backend, Continental is responsible for setting up the connection with the server and pass the information back and forth, as needed by the PPE. For this matter, a Continental developed PPE Proxy component will be used by PPE.

# Functional Requirements

| **Req ID** | **Req Description** | **Release** |
| --- | --- | --- |
| GNSS\_Correction\_001 | PPE shall process GNSS baseband measurements for following bands:   * GPS L1 * GPS L5 * Galileo E1 * Galileo E5a * GLONASS G1 * BeiDou B1 * BeiDou B2a | v1 |
| GNSS\_Correction\_002 | PPE shall permit GNSS state space or GNSS observation state corrections injection.  Note: Corrections are provided by PPE Proxy. | v1 |
| GNSS\_Correction\_003 | PPE shall process GNSS state space / observation state corrections data (e.g. stream) without any pre-processing being needed from Continental SW components.  Note 1: Corrections must be provided in the format defined by PPE provider, through GM backend, over mobile IP.  Note 2: Corrections must have a common format in case they are provided for multiple world regions (e.g. North America, Europe, China). | v1 |
| GNSS\_Correction\_004 | PPE shall use PPE proxy for communication with backend. When PPE proxy provides data, PPE shall apply the corrections to GNSS baseband measurements.  Note 1: PPE Proxy will run in automatic mode and will provide data to PPE through a notification mechanism.  Note 2: In case PPE needs to send data back to backend, it should use the interface exposed by PPE Proxy. | v1 |
| GNSS\_Correction\_005 | PPE shall be able to compute and report a precise position for at least 2 minutes after data session disconnection. The reported position shall maintain its sub-meter accuracy during this time frame. | v1 |
| GNSS\_Correction\_006 | PPE shall report precise position at the same update interval at which GNSS device is configured to work. Configurable rates are:   * **1 Hz** * **2 Hz** * **5 Hz** * **10 Hz** | v1 |
| GNSS\_Correction\_007 | PPE shall provide a Single Point Position when Precise Position feature is activated and:   * No correction data was previously available   **OR**   * Data session was previously established, but it was lost and no correction data is available for more than 2 minutes   Note: Performance requirements do not apply to Single Point Position. | v1 |

| **Req ID** | **Req Description** | **Release** |
| --- | --- | --- |
| GNSS\_Correction\_008 | The output of the PPE shall be in the format defined by Qualcomm’s Telematics SDK and shall contain at least following fields:   * **UTC timestamp [ms]** * **Latitude [WGS-84]** * **Longitude [WGS-84]** * **Altitude [m - WGS-84]** * **Estimated 2D (horizontal) position error [m]** * **Estimated 3D position error [m]** * **Horizontal speed [m/s]** * **Estimated horizontal speed error [m/s]** * **Vertical speed [m/s]** * **Estimated vertical speed error [m/s]** * **Heading [degrees]** * **Estimated heading error [degrees]** * **PDOP** * **Flag indicating the reported position is SPP or PPP** | v1 |
| GNSS\_Correction\_009 | PPE shall not apply SBAS corrections to GNSS baseband measurements. | v1 |
| GNSS\_Correction\_010 | PPE shall not use any additional information (e.g. sensor data) for precise position computation. | v1 |
| GNSS\_Correction\_011 | PPE shall align fix data to the GPS integer second. | v1 |
| GNSS\_Correction\_012 | PPE shall support a debugging interface. This would mean, at minimum, to provide debug logs which can be analyzed later.  Note 1: Logs must be provided both on QXDM channels and to a file located at a configurable path.  Note 2: Logs must have configurable verbosity levels which shall be specified in a configuration file. | v1 |

# Specific groups of Requirements

## Safety Relevant Requirements

Not Applicable

## Security Relevant Requirements

|  |  |  |
| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_013 | PPE must use Continental defined mechanism for storing sensitive data.  Note: Requirement applies only in case PPE has such needs. | v1 |

## Interface Requirements

### SW Component External Interface Requirements

PPE is expected to run within Qualcomm’s Telematics SDK. Most of the external interfaces are expected to be defined by Qualcomm, the only exception being the interface between PPE and PPE Proxy.

PPE Proxy is expected to run in autonomous mode, meaning that it will manage the connection with the backend by itself. PPE will get the correction data through a notification mechanism, whenever PPE Proxy has some to provide. Additionally, in case it is needed, PPE can send data to backend through PPE Proxy.

### SW Component Internal Interface Requirements

Not Applicable

# SW Component Internal Data Requirements

Not Applicable

# Design Constraints

GM OnStar Gen 12 is developed on two Qualcomm modems:

* SA415M (former SDX 24)
* SA515M (former SDX 55)

Each modem has an application core, on which Linux OS runs. This is also the core on which PPE will be deployed.

Therefore, PPE shall:

* support both SA415M and SA515M baseband measurements for achieving sub-meter accuracy
* fully integrate with Qualcomm Telematics SDK

# SW Quality Characteristics

## Reliability

|  |  |  |
| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_014 | When **estimated 2D (horizontal) position error** field has a value below 1 meter, this field must be correct at least 98.5% of the time in open sky conditions. | v1 |

## Maintainability

|  |  |  |
| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_015 | PPE software updates must be backwards compatible.  Note: This is valid as long as compatibility at ABI level between Qualcomm Telematics SDK – PPE – PPE proxy is maintained. | v1 |
| GNSS\_Correction\_016 | In case correction data suffers changes, these must be backwards compatible.  Note: This is because there must be no forced PPE update required in case things are changing on backend. | v1 |

## Availability

|  |  |  |
| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_017 | PPE shall have no more than 1 hang / crash in 36000 km. | v1 |
| GNSS\_Correction\_018 | PEE shall have the ability to detect and recover from internal failures within 1 second. | v1 |
| GNSS\_Correction\_019 | PPE shall be aware of system states and must react to state transitions. The expected behavior is:   |  |  |  |  | | --- | --- | --- | --- | | **System state** | OFF | ON | Standby | | **PPE state** | OFF | ON | Suspended (RAM retained) | | v1 |

# Compatibility Requirements

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| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_020 | PPE shall support both SA415M and SA515M baseband measurements. | v1 |
| GNSS\_Correction\_021 | PEE shall process baseband measurements based on their availability.  Note: For instance, SA515M supports the B2a band. PPE shall have a single delivery version which can be deployed on SA415M and SA515M. Same version is expected to take into account B2a measurements when it is running on SA515M. | v1 |

# Performance, Sizing and Timing Requirements

## Performance

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| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_022 | PPE shall receive corrections in real time at a minimum of 1 differential correction message per 30 seconds. | v1 |
| GNSS\_Correction\_023 | PPE shall consistently achieve sub-meter horizontal accuracy with 95% confidence in open sky conditions when the following inputs are available:   * Full cycle of GNSS state space / observation state corrections (clock, orbit, ionosphere, troposphere, etc.) * Sufficient satellites in view with low PDOP * Sufficient GPS L1, GPS L5 and Galileo E1 / Galileo E5a / GLONASS G1 / BeiDou B1 / BeiDou B2 signals being tracked   Note 1: “Open sky” refers to an environment with the following characteristics:   * Minimal obscuration (< 1% of the time) * PDOP < 6.0 * Number of visible satellites > 3 * Nominal CNR > 40 dB-Hz   Note 2: “Sufficient” shall be interpreted, at minimum, as:   * 6 GPS L1 * 4 GPS L5 * 4 Galileo / GLONASS / BeiDou | v1 |
| GNSS\_Correction\_024 | PPE shall successfully converge to a sub-meter accuracy solution in no more than 6 seconds, giving the conditions specified in GNSS\_Correction\_023.  Note: The solution can be either float or fixed integer ambiguity. | v1 |
| GNSS\_Correction\_025 | PPE shall take less than 10ms to compute each individual precise position. | v1 |
| GNSS\_Correction\_026 | The following precise position fields must have at least **0.1 meters** resolution:   * **Altitude** * **Estimated 2D (horizontal) position error** * **Estimated 3D position error** * **Horizontal speed** * **Estimated horizontal speed error** * **Vertical speed** * **Estimated vertical speed error** | v1 |
| GNSS\_Correction\_027 | The following precise position fields must have at least 0.1 degrees resolution:   * **Heading** * **Estimated heading error** | v1 |
| GNSS\_Correction\_028 | GNSS correction data transfer rate (upload + download) shall not exceed 2kbps. | v1 |

## Sizing

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| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_029 | PPE shall not exceed following resource consumptions:   * Flash footprint: 5 MB * RAM usage: 10 MB * CPU usage: 400 DMIPS | v1 |

# Requirements for SW Verification

The SW Verification of PPE must be performed with the environment provided by Continental. There are two stages of verification:

* Integration
* Acceptance

**Integration**

During this phase it must demonstrated that PPE is successfully deployed on Continental boards and it is running without any hang or crash in Qualcomm Telematics SDK.

**Acceptance**

After the integration tests pass, the next step is to test functional and non-functional requirements. This is done both on bench and in test drives.

During test drives PPE performance will be assessed by comparing its output with a truth reference system chosen by Continental.

# Requirements for Delivery

|  |  |  |
| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_030 | PPE must be delivered in binary form and must integrate with Qualcomm Telematics SDK. | v1 |
| GNSS\_Correction\_031 | PPE must support board deployment without any extra configuration steps being performed.  Note: An example would be that a file or a list of files are received from the provider and the only thing to be done by Continental would be to deploy the file(s) at a specific path. | v1 |
| GNSS\_Correction\_032 | Each PPE delivery must be accompanied by a release notes document. The document shall contain, at minimum, following pieces of information:   * PPE version * PPE features * PPE limitations and bugs * Qualcomm Telematics SDK version on which PPE was developed | v1 |

# Production requirements

Precise Positioning is a feature which must be made selectively available during production phase. As production time matters and Continental is willing to have as less SW images as possible, there is a new need which arises: PPE to be deployed on all Continental boards, but have it enabled only on part of them.

TBD: Production requirements which are related to selective feature enablement. This will be done after the concept is thoroughly discussed with Qualcomm.

# Legal constraints and Standards Compliance

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| --- | --- | --- |
| **Req ID** | **Req Description** | **Release** |
| GNSS\_Correction\_033 | PPE shall not store any user private data, such as location or identification (e.g. unique device ID). | v1 |

# Terminology, Definitions and Abbreviations

**Acronyms and Abbreviations**

|  |  |
| --- | --- |
| **Acronym** | **Description** |
| **ABI** | **A**pplication **B**inary **I**nterface |
| **API** | **A**pplication **P**rogramming **I**nterface |
| **CNR** | **C**arrier-to-**N**oise **R**atio |
| **CPU** | **C**entral **P**rocessing **U**nit |
| **DSP** | **D**igital **S**ignal **P**rocessor |
| **GM** | **G**eneral **M**otors |
| **GNSS** | **G**lobal **N**avigation **S**atellite **S**ystem |
| **HAL** | **H**ardware **A**bstraction **L**ayer |
| **IP** | **I**nternet **P**rotocol |
| **OS** | **O**perating **S**ystem |
| **PPE** | **P**recise **P**ositioning **E**ngine |
| **PPS** | **P**ulse **P**er **S**econd |
| **QMI** | **Q**ualcomm **M**SM **I**nterface |
| **PDOP** | **P**osition **D**ilution **O**f **P**recision |
| **RAM** | **R**andom **A**ccess **M**emory |
| **SBAS** | **S**atellite-**B**ased **A**ugmentation **S**ystem |
| **SDK** | **S**oftware **D**evelopment **K**it |
| **SW** | **S**oft**w**are |

**Definitions**

|  |  |
| --- | --- |
| **Term** | **Description** |
| **BeiDou** | Chinese navigation satellite system |
| **Galileo** | European Union navigation satellite system |
| **GLONASS** | Russian Federation navigation satellite system |
| **GPS** | United States of America navigation satellite system |
| **QXDM** | Qualcomm eXtensible Diagnostic Monitor |
| **SA415M (SDX 24)** | Qualcomm’s 4G chipset used in GM OnStar Gen12 project |
| **SA515M (SDX 55)** | Qualcomm’s 5G chipset used in GM OnStar Gen12 project |
| **WGS-84** | U.S. DoD global reference system used by GPS constellation |

# Related documents

# Related Upstream Documents

1. eLC
2. Doc2\_ID SW Requirements Engineering Procedure, CAP0500050-F15
3. Doc2\_ID SW Requirements Engineering Method, CAP0500050-F17