Une image contenant extérieur, bâtiment, clôture, assis

Description générée automatiquement

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| Public Data Description Definition |
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| JULY 20, 2023  **Version 1.1** |



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Versions of the documents

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Executive summary

This document contains a description of the data recorded in the CLUG project and shared with the public.

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Acronyms

C

CA *Consortium Agreement*

D

DOP Dilution of Precision

E

ECEF Earth Centred / Earth Fixed

EDAS *EGNOS Data Access Service*

EMU *Electric Multiple Unit*

ETCS *European Train Control System*

G

GA *Grant Agreement*

O

OPG *Optical Pulse Generator*

P

PVT *Position Velocity Time*

R

RER *Réseau express régional d’Île-de-France*

RIMS Ranging Integrity Monitoring Stations

RINEX Receiver Independent Exchange Format

ROS *Robot Operating System*

S

SOG *Speed Over Ground*

U

UTC *Universal Time Coordinated*

W

WGS84 World Geodetic System 1984

1. **Test Trains, Test Tracks and Data Collection**

## Test Trains / Test Tracks / Data Collection

### Test Trains

While the generation of PVT, PL and other data through a fusion of sensors is being performed in a laboratory test system in WP4.3, the input data used will be collected on trains operating in the true railway environment as specified in WP4.2. The main train used is being provided by Swiss Federal Railway SBB in Switzerland, additional data collection campaigns are being set up with a train provided by SNCF in France and one provided by DB in Germany.

Each test train is being equipped with sensor types according to input received from WP3. The actual sensors chosen however differ between the three test trains, as sensors were already available or could not be installed due to local regulations. Data from these sensors is being collected in a time synchronised way in order to make it usable for the sensor fusion in WP4.3.

All data will be recorded with reference to UTC. According to Airbus the recorded data shall have a maximum time offset of 5 ms (systematic error plus jitter). If that value cannot be achieved a degradation of performance will result.

The collected field data will have to be downloaded by the respective partner and converted into a common data format as raw data for further processing.

Each test train will have to be operated as defined in the test plan in order to cover different environments and operational scenarios.

#### Test Train Switzerland

A Domino power car is being used for raw data collection in Switzerland. Domino trains are used in local and regional services. A total of 128 Domino trains were originally produced under the designation NPZ (Neuer Pendelzug) between 1984 and 1996. They have been refurbished and significantly upgraded between 2008 and 2013, when they were renamed as Domino. They consist of a power car (RBDe 560 216 on the test train), between one and three coaches and a control cab car.

The Domino power car was selected as it has already been used in the STARS project for similar work, most of the equipment required for CLUG has therefore already been installed as part of that project. While some equipment has been upgraded, and some additional sensors installed, the most time consuming and complex elements could be retained. This makes it possible to start collecting data much quicker than if a new vehicle had to be equipped, while also reducing cost.



Figure 1: Test Train in Switzerland

In the STARS project, a number of reasons led to the selection of the Domino power car as test vehicle. These reasons also apply for the CLUG project, it was therefore decided to keep the Domino train for testing. First, the train is equipped with ETCS, which provides the measurement equipment access to balise and tacho data required for generating ground truth data. Being equipped with ETCS also allows the train to operate on any line in Switzerland. The Domino power car also has a baggage compartment, which is not used operationally anymore, which provides sufficient space for the installation of the equipment and allows performing attended measurements even during commercial operation of the train without interfering with or disturbing the driver or the passengers. Several other reasons also make the Domino an ideal measurement platform:

* There is a quite larger fleet of identical trains, which rotate between different sites for maintenance reasons, resulting in operation over different lines in different environments and in different types of services.
* Thanks to the fleet size it is also possible to take the train out of commercial service for some time to perform dedicated measurement trips. This will allow the CLUG project to collect data also under unusual scenarios, such as at low speed over extended distances, and in critical environment.
* The GNSS multiband antenna is installed on top of the power car, which generates electromagnetic interferences similar to a locomotive, providing a more realistic environment for GNSS than on a coach.
* The domino power car also provides a fairly challenging environment for other sensors, such as IMUs and OPGs, due to its older design.

#### Test Train France



Figure 2 Test train (Martine) in France

The test train in France in named Martine. As it is shown in the previous figure, Martine is composed of:

* A freight locomotive BB 60 000. This is a diesel locomotive that can be considered as an intermediate power machine;
* A Corail coach (Martine), which is a type of passenger car from SNCF which have been put into service between 1975 and 1989. This car is equipped to run at speeds up to 200km/h.

Martine was chosen because it is the train used by the localisation team in France to make field trials together with AEF { XE “*Agence d'essai ferroviaire / Railway Test Agency of SNCF*” \t “”}. Multiple field trials have already been performed with Martine on the Vitry - Montereau line. Martine has been prepared to host localisation sensors such as IMU, GNSS or radio frequency receivers.

Moreover, Martine has been changed to be able to host very good antenna on its roof and to host localisation solution in racks thanks to a cabinet.

This test train has many advantages such as:

* Its availability: It is being used every two weeks (minimum journey);
* Its adaptability: It can be used on all commercial and service tracks, including for example RER tracks. It can also be used behind other locomotives for different operational scenarios (e.g. high speed). Thereby it can cover many scenarios and environments which is important for localisation.

#### Test Train Germany

The test train operated in Germany is a Diesel driven ICE test train, called Advanced TrainLab (ATL). The train consists of four segments, two traction units and two mid segments. The diesel-electric traction unit permits to run at a maximum speed of 200 km/h. The ATL has a specific mounting rack for flexible installation of perception and localization sensors. Besides, it provides a localization reference system and a data acquisition system.



Figure 3 Test ICE "Advanced TrainLab".

Figure 4 below shows various elements of the installation on the train:

* (1) the Rack with Lidar scanner and camera
* (2) Mounting for cameras
* (3) Mounting for cameras
* (4) Corrail Sensor (optical encoder)
* (5) DEUTA Radar (speed sensor)
* (6) Wheel encoder
* (7) GNSS antennas
* (8) Serverrack with Clock, IMAR IMU and modem



Figure 4 Train installation.

### Test Tracks

GNSS and other sensors are significantly impacted by environmental conditions. It is therefore essential to perform measurements in different environments, rather than on a single test track. Performing measurements however requires absolute position references, as well as highly accurate, GNSS referenced track data, which might not be available for all tracks on a network.

The selection of the appropriate tracks is therefore an essential part of WP4.

#### Test Tracks Switzerland

In Switzerland the entire standard gauge rail network has recently been converted to ETCS Level 1, or is equipped with ETCS Level 2, providing Eurobalises which can be used as absolute position references everywhere. Also, georeferenced track data of surveyor quality is available for the entire network. These two conditions will permit performing measurements and producing ground truth for any line in Switzerland, rather than for specifically prepared test tracks only.

Switzerland also provides very different environments, covering rural, mountainous, and urban areas. This circumstance will generate a much broader spectrum of raw data compared to performing measurements on dedicated test tracks.

The actual lines on which measurements will be performed during commercial operation is depending on the location where the train is stationed. This will either be Bellinzona or Lausanne, the two depots where Domino trains equipped with ETCS Level 2 are stationed. Both locations provide diverse environments. For dedicated measurements other lines might be chosen.

#### Test Tracks France

France provides a wide variety of environments, which cover most environments faced by trains in Europe, such as: urban areas, lines following rivers in valley, mountainous area, forests, tunnels (completely or partially closed) etc. This will allow to generate data which covers a broad spectrum of environments.

With the test train that can be used on any track of the French network, it will be possible to drive almost everywhere in France. The main test tracks will be on the Vitry - Montereau line, which is located in Île-de-France. Due to the adaptability of Martine it will however also be possible to operate the train on other lines, test trips are for example also planned in the south of France

#### Test Tracks Germany

The Advanced TrainLab can be operated on all tracks of the German railway network with the exception of:

* Tracks only equipped with ETCS
* Tracks with longer tunnels (due to diesel engine)

The train is not used for commercial operation and can be booked for dedicated data acquisition sessions. Thus, it can be used to acquire data in well-defined scenarios, which might not typically be encountered in commercial operation.

### Data Collection

The raw data provided by GNSS receiver or IMU are not only location depended, they are also time dependent. Due to changing satellite constellations, vibrations environments and weather its very likely to get different raw data at the same location during different train runs. It is therefore important to collect and analyse raw data from multiple test runs in same scenarios and on the same tracks.

#### Data Collection Switzerland

Data collection in Switzerland has started on the 3rd November 2020. Data will primarily be collected during commercial operation. This will generate large volumes of data for different lines, but also for the same line at different time of day, in different weather conditions etc., without requiring scheduling of special trips.

A certain time will be required to ensure that the entire tool chain, from data collection and pre-processing through PVT, PL and ground truth generation to data analysis, is working properly.

Once sufficient data has been collected, processed and analysed in commercial operation, it will be possible to identify critical locations and/or operational scenarios, in which the performance of the positioning solution is degraded. STARS data is also being used to identify such locations.

Dedicated test trips outside commercial operation will then be scheduled, during which extended measurements will be performed in the most critical environments and operational scenarios identified, which is difficult to do during commercial service. Examples are e.g. driving at slow speeds over longer distances, the execution of emergency brakes etc. Dedicated test trips will be scheduled at certain intervals, in order to permit feedback from the data analysis being used to adjust the environments and operational scenarios where data shall be collected.

Georeferenced topography as well as topology data will be provided by SBB. Such data has already been delivered to Siemens in the frame of the STARS project, so the process to import the data into the ground truth generating tool is already well established.

The data will be provided for the entire network, permitting data collection on each line the train operates. Track data will be updated at regular intervals, as significant changes are continuously taking place on the Swiss rail network due to many ongoing upgrade projects.

Supplementary information, such as GNSS augmentation data, weather data etc. will be collected trackside in parallel to the on-board measurements.

#### Data Collection France

In France, measurements campaigns focusing on train positioning have started already in 2018. Thanks to these campaigns with commercial and dedicated test trains, the main difficulties of an on-board localisation based on IMU, GNSS receivers and cartography have been identified.

In the frame of the CLUG project, SNCF will conduct field trials in challenging areas which have been identified in previous measurement, to collect a huge amount of data in order to improve the performance of the localisation solution. To do this, SNCF will schedule dedicated test trips to collect raw data in difficult environments through many operational scenarios.

The main test tracks will be on the Vitry - Montereau line, which is located in Île-de-France. Test trips are however also planned on other lines, such as in the south of France.

All the field data (from sensors) collected during these measurement campaigns will be provided. Besides, SNCF will provide grooves and mileage point of the journey. When it is possible, video of the travelled routes will also be provided.

#### Data Collection Germany

Data will be collected during dedicated data acquisition sessions, as described in 4.1.2.3. These sessions will be based on the test plan and cover defined scenarios.

### Sensors used for Raw Data

The setup of the data collection equipment will differ between the test trains in the three countries, their output will however have to be produced in the same format and quality if the data shall be processed and analysed using the same tool chain.

The actual sensors used on the test trains in the three countries might also be different. They should however be of comparable quality and deliver data of identical content. It will however be attempted to have at least a minimum number of identical sensors installed, first of all as a kind of reference, but also to be able to directly compare data from the different trains.

Data from all sensors which might be part of the sensor fusion will be recorded in parallel, and time stamped to the same reference time. The same applies to data from sensors which are used to generate ground truth information.

#### Sensors used for Raw Data Collection Switzerland

Field data will be recorded by a measurement system from National Instruments, which ensures that a high level of synchronicity is achieved. The system generates separate data files for each sensor, including those used to generate ground truth. Each of these files contains measured data referenced to a common time source.

It is currently planned to use the following sensors for data collection:

|  |  |  |
| --- | --- | --- |
| **Data** | **Sensor** | **Manufacturer/Type** |
| Absolute Location | Balise Reader | Siemens Trainguard 200 ETCS |
| Acceleration / Rotation | IMU | Analog Devices ADIS16545,  iMar iNAT-M200/STN-DA,  Bosch BMA456 |
| PVT | GNSS | Septentrio AsterRx4,  ublox NEO-ZED-F9P (2x) |
| Pseudo ranges / Ephemerides / Doppler measurements, Carrier phase and C/N0 | GNSS | ublox NEO-ZED-F9P (2x) |
| iQ | RF Front End | Naventik Front End |
| Speed | Radar | Deuta DRS05S1 |
| Pulses | Tacho | Hasler |
| Speed | Optical sensor | Hasler CORRail 1000 |
| Outside View | Camera | Basler BIP2-1000c-dc |
| Position | GNSS/IMU | iMar iNAT-M200/STN-DA,  Xsens-MTi-G710  GNSS receiver from FDC (TBC) |

Table 1 Sensor to be used in Switzerland

Note that additional sensors can be implemented with a limited effort, as long as they do not require installation outside the car body. Examples would be other GNSS receivers or high end IMUs.

#### Sensors used for Raw Data Collection France

SNCF is currently developing a measurement system that gathers the data from all sensors using a common time reference. Until this has been achieved, data from all the sensors (as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**) will be provided separately. So, the French system will provide a file for each sensor.

Here after, the list of currently used sensors for SNCF localisation system:

|  |  |  |
| --- | --- | --- |
| **Data** | **Sensor** | **Manufacturer/Type** |
| Absolute Location | Balise Reader | Alstom |
| Acceleration / Rotation | IMU | iXblue Atlans A7, SBG Ekinox |
| PVT | GNSS | Septentrio AsterRx4,  ublox NEO-M8T, ublox NEO-ZED-F9P, ublox NEO-ZED-F9P |
| Pseudoranges / Ephemerides | GNSS | Septentrio AsterRx4,  ublox NEO-M8T, ublox NEO-ZED-F9P, ublox NEO-ZED-F9P |
| iQ | RF Front End | Syntony |
| Pulses | Tacho | OPTEK OPB |
| Outside View | Camera | Smartphone,  GoPro |

Table 2 Sensors to be used in France

Note that additional sensors can be implemented with a limited effort, as long as they do not require installation outside the car body. Examples would be other GNSS receivers or a high end IMUs.

#### Sensors used for Raw Data Collection Germany

Field data will be recorded by a ROS based measurement system, which ensures time synchronised recording. The system generates separate data files for each sensor, including those used to generate ground truth.

It is currently planned to use the following sensors for data collection:

|  |  |  |
| --- | --- | --- |
| **Data** | **Sensor** | **Manufacturer/Type** |
| Absolute Location | Balise Reader | - |
| Acceleration / Rotation | IMU | iMAR iNAT-RQT-4001-3 |
| PVT | GNSS | iMAR iNAT-RQT-4001-3 |
| Pseudoranges | GNSS | iMAR iNAT-RQT-4001-3  Novatel PwrPak7D E1  Trimble BX992 |
| Ephemeris Data | GNSS | iMAR iNAT-RQT-4001-3 |
| iQ | RF Front End | - |
| Speed | Radar | Deuta DRS05 |
| Pulses | Tacho | Deuta DF17 |
| Speed | Optical sensor | Hasler Rail Corrail 1000 |
| Outside View | Camera | - |
| Position | GNSS/IMU | iMAR iNAT-RQT-4001-3 |

Table 3 Sensor to be used in Germany (to be completed)

1. **Sensors for Data Collection, data contents and formats**

## General Information

### Types of Sensors

Data for sensor fusion shall be recorded from the following types of sensors:

* GNSS receiver
* IMU
* Speed Sensor
* Track Map
* EGNOS EDAS\*

\*) EGNOS EDAS data can also be recorded offline.

Data from these types of sensors shall be collected on all test trains, as they are foreseen to be used by the sensor fusion algorithm implemented in the test system.

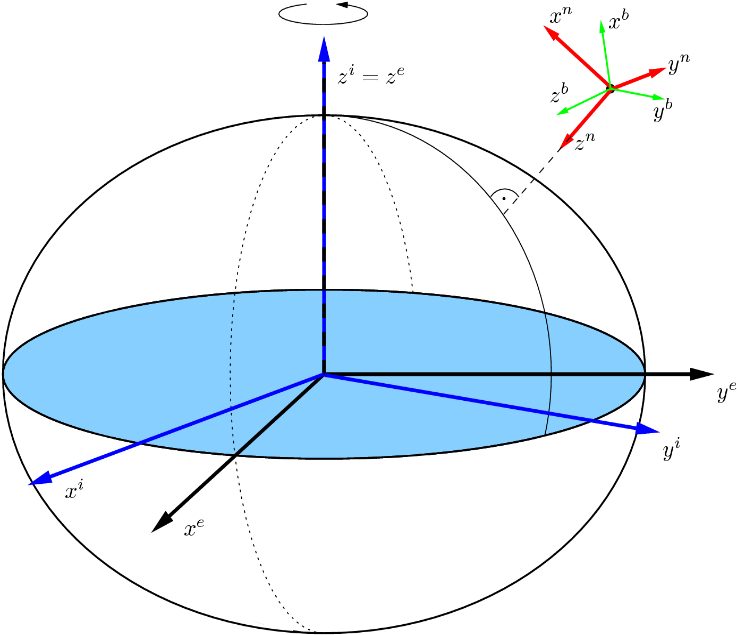
For GNSS, IMU and Speed Sensors multiple sensors shall be used, representing different technologies respectively qualities. This will allow the project to analyse the impact of the sensor quality on the calculated PVT, PL and other data. Different types can include the following:

* For GNSS: high quality and low-cost types
* For IMU: MEMS and possibly fibre optic types
* For Speed Sensors: Wheel tachometers, radars and optical sensors

Data will also have to be recorded for Ground Truth generation. This is however at the discretion of the partner responsible for the respective test train, for which ground truth shall be produced, as the method to generate Ground Truth will be different for the different test trains, respectively test sites.

### Coordinate Systems

The multiple data sets are represented in different coordinate systems. Some of them are described in this section, including those relevant for the project:



**Inertial Frame – i: (blue, not relevant for the CLUG project)**

Figure 5: General coordinate systems

* X, Y in equatorial plane, fix with reference to the stars
* Z coincides with polar axis North

**Earth Frame – e: (black, frame relevant for some calculations within the test system)**

* X, Y in equatorial plane
* X intersects Greenwich meridian
* Z coincides with polar axis North

**Navigation Frame – n: (red, frame relevant for navigating on the earth surface)**

* Origin at the vehicle location
* Axes aligned with north, east and local vertical (down) (also called local level or NED frame)

**IMU Body Frame – b: (green\*, coordinate system of the IMU, typically called Body Frame)**

* Origin at the vehicle location.
* Axes aligned, in the ideal case, with front, right, down as viewed from the vehicle. However, since the IMU Body frame is the one typically tracked by the sensor fusion algorithm, slight misalignments from the ideal case might occur. They can be due, for example, to unavoidable small errors in the IMU mounting. (error of installation in vehicle plus sensor internal mounting error (can be type specific “per datasheet”, or individual values for each sensor))

**Carriage Frame – c: (green\*, coordinate system of the carriage body)**

In the carriage frame the movement of the vehicle is in the direction of the x-axis. The attitude between carriage frame and body frame is described by a yaw angle and pitch angle. The roll angle between carriage and body frame is defined to be 0°.

\*) The carriage frame and the body frame are typically only misaligned slightly, so this does not show in Figure 9.

### Vehicle Geometry / Reference Point / Reference Location / Sensor Mounting Location

For several of the sensors listed below the mounting location inside the vehicle, the mounting location in reference to the other sensors as well as the geometry of the vehicle have to be known when using their data in a sensor fusion. For some sensors it is also relevant to which part of the vehicle they are mounted, e.g. the body of the vehicle, the boogie or the axle, as movements between these have to be assumed due to e.g. the suspension, or even due to active controls systems, such as on tilting trains. Finally, the geometry of the vehicle needs to be known as well, including e.g. the overall length, position of boogies etc.

The following rules shall be followed when installing sensors, respectively the following data shall be provided:

* IMU and GNSS antennas shall be mounted to the body of the vehicle
* They shall be mounted in the same body, if a vehicle consists of multiple bodies (such as modern EMUs.
* The location of each sensor, respectively antenna for GNSS, shall be provided with high accuracy (in mm), in reference to a common reference point, which can be anywhere on the body. From this the relative distances between the sensors can be calculated
* The geometry data shall include longitudinal, lateral and vertical position of each sensor, as well as the orientation of the sensor for those for which the orientation is relevant (alignment of the sensor axes with the body of the vehicle, to which the sensor is mounted).
* The geometry of the vehicle shall be provided, including distances of axles and bogie pins with respect to the same reference point used for the location of the sensors, as well as the tilt of vehicle body which is to be expected due to active tilting, passive tilting or due to the suspension.

No requirements are defined for the sensor installation. For most speed sensors for example, the mounting location is defined either by the type of sensor, or by the manufacturer’s mounting instructions. Tachos for example are typically mounted on the end of an axle, optical sensors to the frame of the boogie (as the position relative to the rail is critical) and radar sensors to the vehicle body (as they are much less susceptible to measurement errors resulting from e.g. lateral movements or variations in mounting height).

### Time Reference

For a sensor fusion a common time base is required. UTC shall be used for that purpose. The maximum time misalignment between sensors shall be 5 ms, so times of each sensor shall be accurate to +/- 2.5 ms in reference to UTC.

In the specification of the data to be provided there are typically two times specified, one for the time when the data has been recorded and one for the time to which the data relates. Depending on the type of sensor and the way the data is recorded the latter one can be derived from the data itself, or be calculated from known latency times. If no such conversion is possible or necessary, then the same time shall be included in both columns.

Note that these two times will allow evaluating the impact of latency times of sensors on the overall performance of the positioning solution.

iQ data will not be recorded against a time reference, the reference time can however be calculated from the extracted GNSS time

### Data Contents and Formats

The following sections specify the raw data to be provided for each sensor, as well as the common format, in which this data shall be provided.

For that purpose, a list is provided for each sensor, which contains the following columns:

* Pos.: This specifies the column, in which data shall be provided in the .CSV file
* Name: Name of the data item
* Unit: The unit, in which that data element shall be provided, typically an SI unit
* Range/Format: Data shall only be given withing a certain range, and in the format specified
* Description: This contains a very short description of the meaning of each data element
* Req.: Data specified as M (mandatory) shall be provided, as the sensor fusion will not work without that data, data specified as O (optional) can be left out if not available.

This representation directly specifies the format of the data in the .CSV file, in which most data shall be provided. The .CSV files shall include a first line with the names of the data elements, followed by the lines with the actual data.

In addition to the actual raw data, the configuration data to be provided is also specified for those sensors, where such configuration data is required in the sensor fusion.

If mandatory data cannot be provided, the respective column shall be filled with a default value, which in the case of qualifiers (e.g. “position valid”) shall be positive (e.g. “true” for “position valid”).

If optional data cannot be provided, then no data shall be included in the .CSV file between the commas of that column, meaning no “0”, “-“, “NA” or the like shall be included.

If a test train operator wants to include additional data for a sensor in a .CSV file (e.g. some diagnostic data or additional data values for future use) this is permitted, as long as the data column is added to the end of the data structure. Such data shall be given a specific name, and the unit, range/format and description shall be provided.

To support the implementation, Siemens will provide sample .CSV files for each sensor.

## Inertial Measurement unit

### Data

The following table contains the required values of an IMU measurement.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit | Range/Format | Description | Req. |
| 1 | time\_rec | ms | yyyymmdd-hhmmss.fff | Receiving time of the data set (in UTC) \*) | M |
| 2 | time\_val | ms | yyyymmdd-hhmmss.fff | Validity time of the data set (= receiving time – latency) \*) | M |
| 3 | acc\_val | boolean | 1/0 | Validity of the acceleration data (1 = valid, 0 = invalid) | M |
| 4 | gyro\_val | boolean | 1/0 | Validity of the gyroscope data (1 = valid, 0 = invalid) | M |
| 5 | acc\_x | m/s2 |  | Measured acceleration in x-direction of the IMU frame | M |
| 6 | acc\_y | m/s2 |  | Measured acceleration in y-direction of the IMU frame | M |
| 7 | acc\_z | m/s2 |  | Measured acceleration in z-direction of the IMU frame | M |
| 8 | gyro\_x | rad/s |  | Measured rotation around the x-axis of the IMU frame | M |
| 9 | gyro\_y | rad/s |  | Measured rotation around the y-axis of the IMU frame | M |
| 10 | gyro\_z | rad/s |  | Measured rotation around the z-axis of the IMU frame | M |
| … |  |  |  |  |  |

Table 4: Specification for IMU raw data

Other sensor specific values like misalignment, scale factor, power spectral density, etc. are independent from the configuration and mounting of the sensor. Therefore, an additional configuration file has to be created for each IMU type.

|  |  |  |  |
| --- | --- | --- | --- |
| Pos | Name | Unit | Description |
| 1 | name\* | - | Name of the sensor, e.g. Septentrio AsterRx4 |
| 2 | type\* | - | Type of the sensor, e.g. GNSS receiver, IMU |
| 3 | sensor\_id\* | - | Unique ID of the sensor, Siemens will maintain a list of assigned values |
| 4 | scale\_factor\_acc | - | Scale factor of the IMU internal accelerometer |
| 5 | scale\_factor\_gyro | - | Scale factor of the IMU internal gyroscope |
| 6 | velocity\_random\_walk | - | Velocity random walk of the IMU internal accelerometer |
| 7 | angular\_random\_walk | - | Angular random walk of the IMU internal gyroscope |
| 8 | bias\_repeatability\_acc | - | Bias repeatability of the IMU internal accelerometer |
| 9 | bias\_repeatability\_gyro | - | Bias repeatability of the IMU internal gyroscope |
| 10 | bias\_stability\_acc | - | In run bias stability of the IMU internal accelerometer |
| 11 | bias\_stability\_gyro | - | In run bias stability of the IMU internal gyroscope |
| … | - | - |  |

Table 5: Specification for the specific IMU

\*) Siemens will maintain a list of assigned values to name, type and sensor id.

### Sensors to be used

The following sensors shall be used to collect IMU data:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Data to be recorded | Swift Duro (BMI160 IMU) | iMAR iNAT-RQT-4001-3 | iMAR  iNAT-M200 | Xsens  MTi-G710 | Analog Devices ADIS 16545 | Bosch BMA456 | Atlans A7  Ixblue | SBG  Ekinox |
| Accelerometer Data | ü | ü | ü | ü | ü | ü | ü | ü |
| Rotation Data | ü | ü | ü | ü | ü | - | ü | ü |
| … | - | - | - | - | - | - | - | - |
| Train | ICE-ATL | ICE-ATL | Domino | Domino | Domino | Domino | Martine | Martine |

Table 6: IMUs to be used

## GNSS - Receiver

### PVT-Data

The PVT structure contains the data, that has been calculated based on GNSS raw data. The data source can be a GNSS receiver, that has sent the data directly to the measurement system or a standalone SW algorithm that has calculated the PVT solution offline.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit |  | Description | Req. |
| 1 | time\_rec | ms | yyyymmdd-hhmmss.fff | Receiving time of the data set | M |
| 2 | time\_val | ms | yyyymmdd-hhmmss.fff | Validity time of the data set (= receiving time – latency) | M |
| 3 | tow | ms |  | Time of week of the epoch | M |
| 4 | utc\_time | ms | yyyymmdd-hhmmss.fff | UTC time of the epoch | M |
| 5 | utc\_val | boolean | 1/0 | Validity of the UTC time (1 = valid, 0 = invalid) | M |
| 6 | utc\_time\_unc | ns |  | Uncertainty of the UTC time | M |
| 7 | fix | boolean | 1/0 | Indicator for the GNSS fix (1 = fix, 0 = no fix) | M |
| 8 | fix\_type | id |  | Type of the GNSS fix | M |
| 9 | satellites\_used | - |  | Number of satellites used for the PVT calculation | M |
| 10 | pos\_val | boolean | 1/0 | Validity of the calculated position (1 = valid, 0 = invalid) | M |
| 11 | latitude | rad |  | Latitude of the epoch | M |
| 12 | longitude | rad |  | Longitude of the epoch | M |
| 13 | height | m |  | Height of the epoche | M |
| 14 | latitude\_unc | m |  | Uncertainty of the given latitude | M |
| 15 | longitude\_unc | m |  | Uncertainty of the given longitude | M |
| 16 | height\_unc | m |  | Uncertainty of the given height | M |
| 17 | vel\_val | boolean | 1/0 | Validity of the calculated velocity (1 = valid, 0 = invalid) | M |
| 18 | velocity\_n | m/s |  | Velocity in north direction | M |
| 19 | velocity\_e | m/s |  | Velocity in east direction | M |
| 20 | velocity\_d | m/s |  | Velocity in down direction | M |
| 21 | velocity\_n\_unc | m/s |  | Uncertainty of the velocity in north direction | M |
| 22 | velocity\_e\_unc | m/s |  | Uncertainty of the velocity in east direction | M |
| 23 | velocity\_d\_unc | m/s |  | Uncertainty of the velocity in down direction | M |
| 24 | height\_amsl | m |  | Height above MSL | O |
| 25 | speed | m/s |  | Absolute speed | O |
| 26 | course | rad |  | Course over ground | O |
| 27 | course\_unc | rad |  | Uncertainty Course over ground | O |
| 28 | dop | m |  | DOP | O |
| … |  |  |  | Any other data |  |

Table 7: Specification for GNSS-PVT data

### Observation Data

The observation data contains all satellite values of GPS, Galileo and SBAS available for certain epochs. Those values are relevant for the calculation of the satellite position itself and receiver position. For the exchange of navigation messages the standard format RINEX shall be used. The minimum format version supported by the algorithm is version 3.02. **Es ist eine ungültige Quelle angegeben.**

*Further and more detailed information to the* RINEX format *can be found at the following links:*

*https://kb.igs.org/hc/en-us/articles/115003980628-RINEX-3-02*

The following data structure can be used to visualize the observation data with the SMO toolchain. Currently it’s not planned to read and visualize those values from a RINEX file.

The raw data interface contains the data for one satellite. Accordingly, it’s possible that there are multiple data sets per epoch, one for each satellite from which data is available. An epoch where no satellite data was received is displayed as one invalid message that is filled with default values.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit | Range/Format | Description | Req. |
| 1 | time\_rece | ms | yyyymmdd-hhmmss.fff | Receiving time of the data set | M |
| 2 | time\_val | ms | yyyymmdd-hhmmss.fff | Validity time of the data set (= receiving time – latency) | M |
| 3 | telegram\_val | boolean | 1/0 | Validity of the telegram. (0 = placeholder that no satellite data was received) | M |
| 4 | tow | ms |  | Time of week of the epoch | M |
| 5 | week | weeks |  | GNSS week number | M |
| 6 | leap\_seconds | s |  | GNSS leap seconds | M |
| 7 | leap\_seconds\_val | boolean | 1/0 | 1 = Leap seconds have been determined | M |
| 8 | clk\_reset | boolean | 1/0 | 1 = Clock reset applied | M |
| 9 | gnss\_id | - |  | GNSS identifier (GPS, Galileo, SBAS, …) | M |
| 10 | satellite\_id | - |  | Satellite identifier (unique number) | M |
| 11 | signal\_id | - |  | Signal identifier (L1/L2/L5/E1/E2/E5/…) | M |
| 12 | pseudorange | m |  | Pseudorange measurement | M |
| 13 | pseudorange\_unc | m |  | Standard deviation of the estimated pseudorange measurement | M |
| 14 | pseudorange\_val | boolean | 1/0 | Validity of the pseudorange (1 = valid, 0 = invalid) | M |
| 15 | carrier\_phase | cycles |  | Carrier phase measurement | M |
| 16 | carrier\_phase\_unc | cycles |  | Standard deviation of the estimated carrier phase measurement | M |
| 17 | carrier\_phase\_val | boolean | 1/0 | Validity of the carrier phase (1 = valid, 0 = invalid) | M |
| 18 | doppler | Hz |  | Doppler measurement | M |
| 19 | doppler\_unc | Hz |  | Standard deviation of the estimated doppler measurement | M |
| 20 | doppler\_val | boolean | 1/0 | Validity of the doppler (1 = valid, 0 = invalid) | M |
| 21 | carrier\_to\_noise | dBHz |  | Carrier-to-noise density ratio (signal strength) | M |
| 22 | half\_cycle | boolean | 1/0 | 1 = Half cycle valid | M |
| 23 | half\_cycle\_subtracted | boolean | 1/0 | 1 = Half cycle subtracted from phase | M |

Table 8: Specification for the GNSS raw data

### Navigation Messages

The navigation data contains the description of the satellite orbit and is needed to calculate the position of satellite. For the exchange of navigation messages the standard format RINEX shall be used. The minimum format version supported by the algorithm is version 3.02. **Es ist eine ungültige Quelle angegeben.**

*Further and more detailed information to the RINEX format can be found at the following links:*

[*https://kb.igs.org/hc/en-us/articles/115003980628-RINEX-3-02*](https://kb.igs.org/hc/en-us/articles/115003980628-RINEX-3-02)

### Sensors to be used

The following sensors shall be used to collect GNSS data:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Data to be recorded | Septentrio AsterRx4 | ublox  ZED-F9P | ublox  NEO-M8T | iMAR iNAT-RQT-4001- |
| PVT | ü | ü | ü | ü |
| Raw Data | ü | ü | ü | ü |
| Ephemerides | ü | ü | ü | ü |
| Time Pulse (PPS) | ü | ü | ü | ü |
| … | - | - | - | - |
| Train | Domino | Martine(2x) Domino(2x) | Martine Domino | Advanced Train Lab |

Table 9: GNSS sensors to be used

Note: It is possible to collect PVT or raw data from different antennas. It is however important for the lever arm calculation to document which antenna was connected to which receiver.

## IQ Data

IQ data is being recorded with a proprietary recording system provided by Naventik. The format in which the data is being recorded will be specified by Naventik once the data will be delivered as part of D4.2.

### Sensors to be used

|  |  |  |  |
| --- | --- | --- | --- |
| Data to be recorded | Naventik | Syntony | … |
| IQ Data | ü | ü | - |
| … | - | - | - |
| Train | Domino | Martine | - |

Table 10: IQ data recorder to be used

## Speed Sensor

### Speed Data

The speed / direction data interface is abstract, meaning the same data is generated regardless of the speed sensor from which it is provided. It will therefore be possible to feed the sensor fusion algorithm with speed data from different sensors like OPG , Radar or CorRail without having to specify individual, type specific interfaces.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit | Range/Format | Description | Req. |
| 1 | time\_rec | ms | yyyymmdd-hhmmss.fff | Receiving time of the data set | M |
| 2 | time\_val | ms | yyyymmdd-hhmmss.fff | Validity time of the data set (= receiving time - latency) | M |
| 3 | velocity\_val | boolean | 1/0 | Validity of velocity over ground measurement (SOG) (1 = valid, 0 = invalid) | M |
| 4 | velocity | m/s | 2CL2 | Measured velocity over ground (SOG) | M |
| 5 | velocity\_unc | m/s |  | Uncertainty of the measured velocity over ground (SOG) | M |
| 6 | direction | - | -1/0/1 | Direction of movement, forward = 1, backward = -1, unknown = 0 | M |
| 7 | direction\_val | boolean | 1/0 | Validity of the direction indicator (1 = valid, 0 = invalid) | M |
| 8 | motion | boolean | 1/0 | Indicator for vehicle movement (1 = moving, 0 = stopped) | O |
| 9 | motion\_val | boolean | 1/0 | Validity of the motion indicator (1 = valid, 0 = invalid) | O |
| 10 | distance\_val | boolean | 1/0 | Validity of the dsitance (1 = valid, 0 = invalid) | O |
| 11 | distance | m |  | Distance travelled since last telegram | O |
| 12 | distance\_unc | m |  |  | O |

Table 11: Interface specification for the speed data

There are multiple key values necessary for the usage of the speed information coming from different sources. The usage of the OPG for example requires knowledge regarding the wheel diameter or the amount of pulses per rotation. Those parameters are part of a specific configuration telegrams which are described in the following chapter.

### Sensors to be used

The following sensors shall be used to collect odometry data:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Data to be recorded | Hasler OPG | Deuta DRS05S1 | Deuta DF17 | Hasler CORRail 1000 | OPTEK  OPB |
| Pulse width | ü | - | - | - | ü |
| Speed | ü | ü | ü | ü | ü |
| Direction | ü | ü | ü | ü | ü |
| … | - | - | - | - | - |
| Train | Domino | ICE-ATL Domino | ICE-ATL | ICE-ATL Domino | Martine |

Table 12: Speed sensors to be used

## GNSS/INS Sensor

### PVT-Data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit | Range/Format | Description | Req. |
| 1 | time\_rec | ms | yyyymmdd-hhmmss.fff | Receiving time of the data set | M |
| 2 | time\_val | ms | yyyymmdd-hhmmss.fff | Validity time of the data set (= receiving time - latency) | M |
| 3 | tow | ms |  | Time of week of the epoch | M |
| 4 | utc\_time | ms |  | UTC time of the epoch | M |
| 5 | utc\_val | boolean | 1/0 | Validity of the UTC time (1 = valid, 0 = invalid) | M |
| 6 | utc\_time\_unc | ns |  | Uncertainty of the UTC time | M |
| 7 | satellites\_used | - |  | Number of satellites used for the PVT calculation | M |
| 8 | operation\_mode | - |  | Operation mode:   * 0 = not operational, invalid * 1 = operational, GNSS only * 2 = operational, GNSS/INS * 3 = operational, INS only * 4 = … | M |
| 9 | position\_val | boolean | 1/0 | Validity of the calculated position (1 = valid, 0 = invalid) | M |
| 10 | latitude | rad |  | Latitude of the vehicle position | M |
| 11 | longitude | rad |  | Longitude of the vehicle position | M |
| 12 | height | m |  | Height of the vehicle position | M |
| 13 | latitude\_unc | m |  | Uncertainty of the given latitude | M |
| 14 | longitude\_unc | m |  | Uncertainty of the given longitude | M |
| 15 | height\_unc | m |  | Uncertainty of the given height | M |
| 16 | velocity\_val | boolean | 1/0 | Validity of the calculated velocity (1 = valid, 0 = invalid) | M |
| 17 | velocity\_n | m/s |  | Velocity in north direction | M |
| 18 | velocity\_e | m/s |  | Velocity in east direction | M |
| 19 | velocity\_d | m/s |  | Velocity in down direction | M |
| 20 | velocity\_n\_unc | m/s |  | Uncertainty of the velocity in north direction | M |
| 21 | velocity\_e\_unc | m/s |  | Uncertainty of the velocity in east direction | M |
| 22 | velocity\_d\_unc | m/s |  | Uncertainty of the velocity in down direction | M |
| 23 | attitude\_val | boolean | 1/0 | Validity of the calculated attitude (1 = valid, 0 = invalid) | M |
| 24 | yaw | rad |  | Yaw angle of the IMU frame w.r.t the navigation frame | M |
| 25 | roll | rad |  | Roll angle of the IMU frame w.r.t the navigation frame | M |
| 26 | pitch | rad |  | Pitch angle of the IMU frame w.r.t the navigation frame | M |
| 27 | yaw\_unc | rad |  | Uncertainty of the yaw angle | M |
| 28 | roll\_unc | rad |  | Uncertainty of the roll angle | M |
| 29 | pitch\_unc | rad |  | Uncertainty of the pitch angle | M |
| 30 | bias\_acc\_x |  |  | Estimated acceleration bias in x-direction | M |
| 31 | bias\_acc\_y |  |  | Estimated acceleration bias in y-direction | M |
| 32 | bias\_acc\_z |  |  | Estimated acceleration bias in z-direction | M |
| 33 | bias\_acc\_x\_unc |  |  | Uncertainty of the estimated acceleration bias in x-direction | M |
| 34 | bias\_acc\_y\_unc |  |  | Uncertainty of the estimated acceleration bias in y-direction | M |
| 35 | bias\_acc\_z\_unc |  |  | Uncertainty of the estimated acceleration bias in z-direction | M |
| 36 | bias\_gyro\_x |  |  | Estimated acceleration bias of the x-axis | M |
| 37 | bias\_gyro\_y |  |  | Estimated acceleration bias of the y-axis | M |
| 38 | bias\_gyro\_z |  |  | Estimated acceleration bias of the z-axis | M |
| 39 | bias\_gyro\_x\_unc |  |  | Uncertainty of the estimated gyroscope bias of the x-axis | M |
| 40 | bias\_gyro\_y\_unc |  |  | Uncertainty of the estimated gyroscope bias of the y-axis | M |
| 41 | bias\_gyro\_z\_unc |  |  | Uncertainty of the estimated gyroscope bias of the z-axis | M |
| 42 | motion | boolean | 1/0 | Indicator for vehicle movement (1 = moving, 0 = stopped) | M |
| 43 | motion\_val | boolean | 1/0 | Validity of the motion indicator (1 = valid, 0 = invalid) | M |
| 44 | direction | boolean | 1/0 | Driving direction (1 = forward, 0 = backward) | M |
| 45 | direction\_val | boolean | 1/0 | Validity of the driving direction (1 = valid, 0 = invalid) | M |
| 46 | sbas\_used | boolean | 1/0 | 1 = Indicator that SBAS was used for the PVT calculation | M |
| 47 | rtk\_used | boolean | 1/0 | 1 = Indicator that RTK was used for the PVT calculation | M |
| 48 | map\_used | boolean |  | 1 = Indicator that track data was used for the PVT calculation | M |
| … |  |  |  |  |  |

Table 13: Specification for the GNSS/INS PVT data

### Sensors to be used

The following sensors shall be used to collect PVT data:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Data to be recorded | iMAR iNAT-RQT-4001-3 | iMAR  iNAT-M200 | Xsens  MTi-G710 | Atlans A7 Ixblue | SBG  Ekinox |
| PVT | ü | ü | ü | ü | ü |
| … | - | - | - | - | - |
| Train | ICE-ATL | Domino | Domino | Martine | Martine |

Table 14: PVT sensors to be used

## Track Map / Route Data

Track map and route data are to be provided as inputs for the sensor fusion algorithm. The two data elements are to be provided in separate files.

Track map data is provided as a simple list of track edges, of which each consists of a sequence points, which are described as 3D coordinates, plus an offset from the start of the edge, measured along the track. These points shall be listed in sequence for each track edge, with the first one having an offset of 0 and the last one an offset, which corresponds to the length of the track edge, measures along the edge. Intermediate points shall be listed in sequence of increasing distance from the start point. Figure 6 below shows how the track data shall be provided as input to the fusion algorithm:

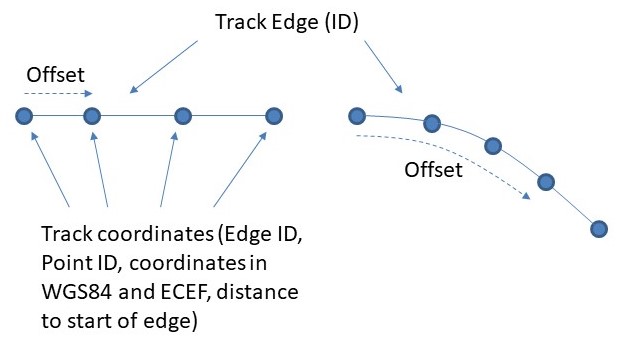


Figure 6 Structure of Track Map data

The track map data shall contain the following values:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit | Range/Format | Description | Req. |
| 1 | edge\_id | - | 0-1000000 | ID of track edge | M |
| 2 | track\_coordinate id | - | 0-1000000 | ID of track coordinate point | M |
| 3 | latitiduel | deg | –-180 -+180 | Latitude of the vehicle position in WGS84 | M |
| 4 | longitudel | deg | -180 -+180 | Longitude of the vehicle position in WGS84 | M |
| 5 | altitudea | m | -10000 - +10000 | Height of the vehicle position in WGS84 | M |
| 6 | ecef\_x | m | -6500000 - +6500000 | ECEF position in x axis | M |
| 7 | ecef\_y | m | -6500000 - +6500000 | ECEF position in y axis | M |
| 8 | ecef\_z | m | -6500000 - +6500000 | ECEF position in z axis | M |
| 9 | offset | m | 0-1000000 | Distance travelled from start of track edge id, measured along the track spine | M |
| 10 | validity | boolean | 1/0 | Validity of the map element | O |

Table 15: Track Map data

The route data shall be provided as a list of the track edges, over which the train has run, together with the time at which the train has entered the respective track edge. The route data shall contain the following values:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit | Range/Format | Description | Req. |
| 1 | time\_utc | ms | yyyymmdd-hhmmss.fff | UTC time when track edge has been entered | M |
| 2 | edge\_id | - | 0-xxx | ID of track edge | M |
| 3 | time\_gps | s | 0-xxx | GPS time when track has been entered | M |
| 4 | track\_segment | - | 0-xxx | ID of track segment | O |

Table 16: Route Data

## Ground Truth Data

The ground truth data shall be generated offline and individually for each test train and for each test run. The generate output shall contain the following values:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pos | Name | Unit | Range/Format | Description |  |
| 1 | time\_utc | ms | yyyymmdd-hhmmss.fff | UTC time of calculated position | M |
| 2 | position\_type | - | Absolute / Relative / Other | Type of the position:   * Absolute (i.e. balise based) * Relative (i.e. interpolated) * Other (i.e. based on GNSS/INS) | M |
| 3 | position\_val | boolean | 1/0 | Validity of the calculated position (1 = valid, 0 = invalid) | M |
| 4 | latitude | deg | -180 -+180 | Latitude of the vehicle position in WGS84 | M |
| 5 | longitude | deg | -180 -+180 | Longitude of the vehicle position in WGS84 | M |
| 6 | altitude | m | -10000 - +10000 | Height of the vehicle position in WGS84 | M |
| 7 | latitude\_unc | m | 10000 - +10000 | Uncertainty of the given latitude | M |
| 8 | longitude\_unc | m | 10000 - +10000 | Uncertainty of the given longitude | M |
| 9 | altitude \_unc | m | 10000 - +10000 | Uncertainty of the given height | M |
| 10 | ecef\_x | m | -6500000 - +6500000 | ECEF position in x axis | M |
| 11 | ecef\_y | m | -6500000 - +6500000 | ECEF position in y axis | M |
| 12 | ecef\_z | m | -6500000 - +6500000 | ECEF position in z axis | M |
| 13 | ecef\_x\_unc | m | -10000 - +10000 | Uncertainty of the ECEF position in x axis | M |
| 14 | ecef\_y\_unc | m | -10000 - +10000 | Uncertainty of the ECEF position in y axis | M |
| 15 | ecef\_z\_unc | m | -10000 - +10000 | Uncertainty of the ECEF position in z axis | M |
| 16 | velocity\_valid | boolean | 1/0 | Validity of the calculated velocity (1 = valid, 0 = invalid) | M |
| 17 | velocity | m/s | 0 - 200 | Absolute velocity of the vehicle | M |
| 18 | velocity\_unc | m/s | 0 - 200 | Uncertainty of the absolute velocity of the vehicle | M |
| 19 | attitude\_val | boolean | 1/0 | Validity of the calculated attitude (1 = valid, 0 = invalid) | O |
| 20 | roll | rad | -Pi - +Pi | Roll angle of the IMU frame w.r.t the navigation frame | M |
| 21 | pitch | rad | -Pi - +Pi | Pitch angle of the IMU frame w.r.t the navigation frame | M |
| 22 | yaw | rad | -Pi - +Pi | Yaw angle of the IMU frame w.r.t the navigation frame | M |
| 23 | roll\_unc | rad | 0 - Pi | Uncertainty of the roll angle | M |
| 24 | pitch\_unc | rad | 0 - Pi | Uncertainty of the pitch angle | M |
| 25 | yaw\_unc | rad | 0 - Pi | Uncertainty of the yaw angle | M |
| 26 | motion | boolean | 1/0 | Indicator for vehicle movement (1 = moving, 0 = stopped) | M |
| 27 | motion\_val | boolean | 1/0 | Validity of the motion indicator (1 = valid, 0 = invalid) | M |
| 28 | direction | boolean | 1/0 | Driving direction (1 = forward, 0 = backward) | M |
| 29 | direction\_val | boolean | 1/0 | Validity of the driving direction (1 = valid, 0 = invalid) | M |

Table 17: Specification for the ground truth data

(1 sigma uncertainty resulting from how GT is generated, such as from GNSS/IMU sensor or from to odometry error compared to balise distance)

## EGNOS Data

EGNOS data will play an important role in a GNSS based positioning solutions, both for improving the accuracy as well as for achieving the required safety level. EGNOS data received from the geostationary satellites is however only available on a fraction of the rail network. It is therefore foreseen to provide EGNOS data to the on-board positioning system via radio. In order to simulate this in the post processing, EGNOS data will be downloaded from the EGNOS Data Access Service EDAS.

Currently only the EGNOS messages are foreseen to be used in the fusion algorithm. Nevertheless, the other data shall be collected to provide a complete set.

As the exact nature of the inclusion of EGNOS data in the sensor fusion has not yet been defined, three different data blocks will be collected from the EGNOS Data Access Service:

* EGNOS messages (format RINEX B 2.10)
* Consolidated RIMS navigation messages (format RINEX 2.11)
* Ionospheric data (format IONEX 1.0)

An internal module of the fusion algorithm will convert the EGNSO data to the required input format.

## Train Setup

There is also some further information required for the sensor fusion algorithm regarding the general train setup. Especially the mounting position of the available and used antennas as well as the distances to the bogies for example.

A template will be provided by Siemens to record the data, once the required information has been clarified with WP3. The following table lists some of the information which will be required.

The configuration excel fil contains six sheets for GENERAL, GNSS, IMU, OTHER, RADAR and WIG specific values. All six sheets and their content are explained in the following tables. The character *X* can be replaced with the sensor specific id.

### GENERAL - Sheet

|  |  |  |  |
| --- | --- | --- | --- |
| Pos | Name | Unit | Description |
| 1 | Bogie1DistanceHoT | m | Distance between the first bogie and head of train |
| 2 | Bogie2DistanceHoT | m | Distance between the second bogie and head of train |
| 3 | TotalBodyLength | m | Total length of the waggon |
| 4 | AntXDistanceHoT | m | Distance between antenna 1 and head of train (x-direction) |
| 5 | AntXLateralOffset | m | Perpendicular distance between antenna 1 and the centre line of the vehicle (y-direction) |
| 6 | AntXHeightToR | m | Distance between antenna 1 and head of rail (z-direction) |
| … | … | … | The required values for additional antennas can be added to the end of the file. |

Table 18: Specification for the GENERAL sheet of the configuration file

### GNSS - Sheet

|  |  |  |  |
| --- | --- | --- | --- |
| Pos | Name | Unit | Description |
| 1 | XXXX\_InstallPoint | m | Name of the installation point |
| 2 | XXXX\_AntUsed | m | ID of the antenna connected to the GNSS receiver |
| … | … | … | The required values for additional GNSS receivers can be added to the end of the file. |

Table 19: Specification for the GNSS sheet of the configuration file

### IMU - Sheet

|  |  |  |  |
| --- | --- | --- | --- |
| Pos | Name | Unit | Description |
| 1 | XXXX\_InstallPoint | m | Name of the installation point |
| 2 | XXXX\_DistanceHoT | m | Distance between the IMU and head of train (x-direction) |
| 3 | XXXX\_LateralOffset | m | Perpendicular distance between the IMU and the centre line of the vehicle (y-direction) |
| 4 | XXXX\_HeightToR | m | Distance between the IMU and head of rail (z-direction) |
| 5 | XXXX\_AxisDriving | string | IMU axis pointing in driving direction forward. Possible values are:   * -x | +x | -y | +y | -z | +z |
| 6 | XXXX\_AxisAbeam | m | IMU axis pointing in driving direction forward to the right: Possible values are:   * -x | +x | -y | +y | -z | +z |
| … | … | … | The required values for additional IMUs can be added to the end of the file. |

Table 20: Specification for the IMU sheet of the configuration file

### OTHER – Sheet

The sensor type OTHER is used for additional speed sensors like CorRail.

|  |  |  |  |
| --- | --- | --- | --- |
| Pos | Name | Unit | Description |
| 1 | XXXX\_DistanceHoT | m | Distance between the sensor and head of train (x-direction) |
| 2 | XXXX\_LateralOffset | m | Perpendicular distance between the sensor and the centre line of the vehicle (y-direction) |
| 3 | XXXX\_HeightToR | m | Distance between the sensor and head of rail (z-direction) |
| 4 | XXXX\_CalibFactor\* | - | Calibration factor of the speed information, if required. Default value is 1. |
| 5 | XXXX\_Direction | 1/0 | Driving direction (1 = forward, 0 = backward) |
| 6 | XXXX\_LatencyInternal | s | Latency of the sensor |
| … | … | … | The required values for additional sensors can be added to the end of the file. |

Table 21: Specification for the OTHER sheet of the configuration file

\*) From experience the CorRail sensor requires a calibration / correction factor. This factor is calculated offline.

### RADAR - Sheet

|  |  |  |  |
| --- | --- | --- | --- |
| Pos | Name | Unit | Description |
| 1 | XXXX\_DistanceHoT | m | Distance between the radar and head of train (x-direction) |
| 2 | XXXX\_LateralOffset | m | Perpendicular distance between the radar and the centre line of the vehicle (y-direction) |
| 3 | XXXX\_HeightToR | m | Distance between the radar and head of rail (z-direction) |
| 4 | XXXX\_CalibFactor\* | - | Calibration factor of the speed information, if required. Default value is 1. |
| 5 | XXXX\_InstallPoint | - | Name of the installation point |
| 6 | XXXX\_Direction | 1/0 | Driving direction (1 = forward, 0 = backward) |
| … | … | … | The required values for additional sensors can be added to the end of the file. |

Table 22: Specification for the RADAR sheet of the configuration file

\*) From experience the Radar sensor requires a calibration / correction factor. This factor is calculated offline.

### WIG - Sheet

|  |  |  |  |
| --- | --- | --- | --- |
| Pos | Name | Unit | Description |
| 1 | XXXX\_DistanceHoT | m | Distance between the radar and head of train (x-direction) |
| 2 | XXXX\_LateralOffset | m | Perpendicular distance between the radar and the centre line of the vehicle (y-direction) |
| 3 | XXXX\_HeightToR | m | Distance between the radar and head of rail (z-direction) |
| 4 | XXXX\_PulsePerRevolution | - | Amount of pulses per revolution |
| 5 | XXXX\_WheelDiam | m | Diameter of the wheel where the odometer is mounted on |
| 6 | XXXX\_InstallPoint |  | Name of the installation point |
| 7 | XXXX\_Direction | 1/0 | Driving direction (1 = forward, 0 = backward) |
| 8 | XXXX\_CalibFactor \* | - | Calibration factor of the speed information, if required. Default value is 1. |
| … | … | … | The required values for additional sensors can be added to the end of the file. |

Table 23: Specification for the WIG sheet of the configuration file

\*) OPG sensors require a calibration / correction factor, which changes over time. The measured wheel diameter is however only available and valid when provided by the train operator after a wheel overhaul. As the diameter then changes continuously it is necessary to provide a correction factor.

1. **Cloud Storage**

## General Description

### General Description

WP4 will require the exchange of significant amounts of data between partners, including raw data, auxiliary data (e.g. EGNOS and weather data), ground truth data, fusion algorithms, fusion results (PVT+) and outputs from the data analysis.

A cloud service is being established by SNCF, via which this data exchange between partners will take place.

### Cloud Access

SNCF will produce detailed instructions how to access the Cloud for all partners, once the service has been established.

## Structure of the Data Storage

### Introduction

The data processing by WP4.3 will be highly automated, as large volumes of data will have to be processed, and as the processing might be repeated multiple times for different releases of the fusion algorithm. The structure of how data is stored on the Cloud, as well as file names therefore need to be harmonised between partners. The following sections describe this data naming and storage structure.

### Naming Convention

As the names of data files and storage folders need to be standardised a naming convention has been defined. This convention is being used in **Fehler! Verweisquelle konnte nicht gefunden werden.** in 3.2.3 and in Table 25 in 3.2.4

Elements of the naming convention:

* YYYY = Year (4 digits, e.g. 2021)
* MM = Month (2 digits, e.g. 01)
* DD = Day (2 digits, e.g. 01)
* HH = Hour (2 digits, e.g. 01)
* MM = Minute (2 digits, e.g. 01)
* SS = Second (2 digits, e.g. 01)
* Vehicle = Vehicle, with which data has been recorded (one of the following: ATL, Martine, Domino)
* ID = Unique sensor id per country (4 digits, e.g. 1001)
* Name = Name of the sensor (String, e.g. Hasler, Corrail, UbloxF9P, ….)
* Type = Type of the sensor (one of the following: Wig, Gnss-Pvt, Gnss-Raw, Gnss-Eph, Imu, Acc, Gyr, Radar, Corrail, Balise (Notes: Wig is used for wheel based tachos, GNSS is split into three logical units to provide PVT, Raw Data or Ephemeris, IMU is used for GNSS based IMUs)
* Version = Version number of the sensor fusion algorithm (TBD)
* Eval = Type of the evaluation or name of the app used for the evaluation

### High Level Structure

Table 24 contains a high-level description of the data structure used in the cloud storage.

|  |  |  |
| --- | --- | --- |
| Directory | Description | Provided by |
| /Raw/ Vehicle/YYYY/MM/DD/ | Collected daily field data, converted to common format | Siemens / SNCF / DB for their test trains |
| /Rinex/ Vehicle/YYYY/MM/DD/ | Collected GNSS field data, converted to RINEX format | Siemens / SNCF / DB for their test trains |
| /IQ/ Vehicle/YYYY/MM/DD/ | Collected IQ field data | Siemens / SNCF / DB for their test trains |
| /Configuration/ MetaCLUG\_Vehicle/ | Description of the sensor configuration, installation parameters etc. | Siemens / SNCF / DB for their test trains |
| /EGNOS/ YYYY/MM/DD/ | EGNOS Augmentation Data for sensor fusion, downloaded from the EDAS web service | Siemens, for all three test trains |
| /GroundTruth/ Vehicle/YYYY/MM/DD/ | Ground truth data generated offline | Siemens / SNCF / DB for their test trains |
| /Map/ Vehicle/YYYY/MM/DD/ | Map data of the tracks the vehicle has passed, including time stamps for each track section | Siemens / SNCF / DB for their test trains |

Table 24: High Level Data Structure in Cloud

### Detailed Data Structure

The following table contains the details on the format and file names in which the data shall be stored in the respective folders:

|  |  |  |  |
| --- | --- | --- | --- |
| Directory | File Name | File Type | Description |
| /Raw/ Vehicle/YYYY/MM/DD/ | Vehicle\_YYYYMMDD-hhmmss\_ID\_Name\_Type | .csv | CSV file with decoded field data |
| /Rinex/ Vehicle/YYYY/MM/DD/ | Vehicle\_YYYYMMDD-hhmmss\_ID\_Name\_Type | .nav/ .obs | Rinex file with decoded field data |
| /IQ/ Vehicle/YYYY/MM/DD/ | Vehicle\_YYYYMMDD-hhmmss\_IQ | .log/ .nastr | IQ data |
| /Configuration/ Vehicle/ | MetaGeneral\_Vehicle | .xlsx | Sensor configuration data\* |
| /EGNOS/ YYYY/MM/DD/… | As received from EDAS server |  | EDAS data downloaded from the EDAS web service |
| /GroundTruth/ Vehicle/YYYY/MM/DD/ | Vehicle\_YYYYMMDD-hhmmss\_GroundTruth | .csv | CSV file with the ground truth |
| /Map/ Vehicle/YYYY/MM/DD/ | Vehicle\_YYYYMMDD-hhmmss\_MapSingleTrack | .csv | CSV file with the map data of the tracks the train has passed. |

Table 25: Detailed Data Structure in Cloud

