Applanix POSPac Assure

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Introduction

This document provides guidelines, background and workflow support for Applanix POSPac Assure. Applanix POSPac Assure is a user-friendly web application, leveraging the POSPac Cloud server infrastructure, supporting three different features:

- **Real Time QC**
- **Calibration Mode**
- **Ground Truth**

The web application is a quick and easy tool for GNSS-INS system integrators to review the quality of their platform integration, including the support of calibrating setup parameters and the generation of a ground truth reference. The currently supported business applications are in the land, marine and advanced airborne mobility sector.

Supported Hardware

All Trimble Applanix GNSS-INS land and marine hardware products for mobile mapping applications are supported (POS systems, AP and AP+). All three features (*Real-Time QC*, *Calibration Mode* and *Ground Truth*) can be applied for these products. In addition, POSPac Assure supports various Real-Time (RT) systems, i.a. BD992-INS, BX992-ER and RT 200. The Real-Time systems can leverage the *Real Time QC* and *Calibration Mode* feature, not the *Ground Truth* module. The advanced airborne mobility product PX-1 benefits from the *Real Time QC* feature, others are not supported for this product.

Features and Details

Real Time QC

The *Real Time QC* feature allows the user to load the real-time logged GNSS/INS files into the web application to retrieve a report on the performance and quality of the real-time navigation solution. This is not only useful for reviewing integration status but also for assessing the direct georeferencing performance for real-time applications. There is no GNSS/INS post-processing applied. The most relevant plots from the report are:

- RealTime RNAV Performance Metrics, Position and Attitude RMS
  - *Estimated real-time accuracy for position and orientation (Fig 1)*
- Satellite Lock/Elevation
  - *Provides information about satellites tracking incl. cycle slip information (Fig 2)*
- Satellite L1/L2 SNR
  - *Provides information about GNSS signal quality (Fig 3)*
- Total Body Acceleration
  - *Provides information about the vibration level (Fig 4)*
- DMI Distance Traveled
  - *Provides information if DMI worked or not (Fig 5)*
- GAMS Solution Status
  - *Provides information if GAMS (dual antenna) was in use or not (Fig 6)*

Find below an example of the Real-Time navigation position RMS plot:

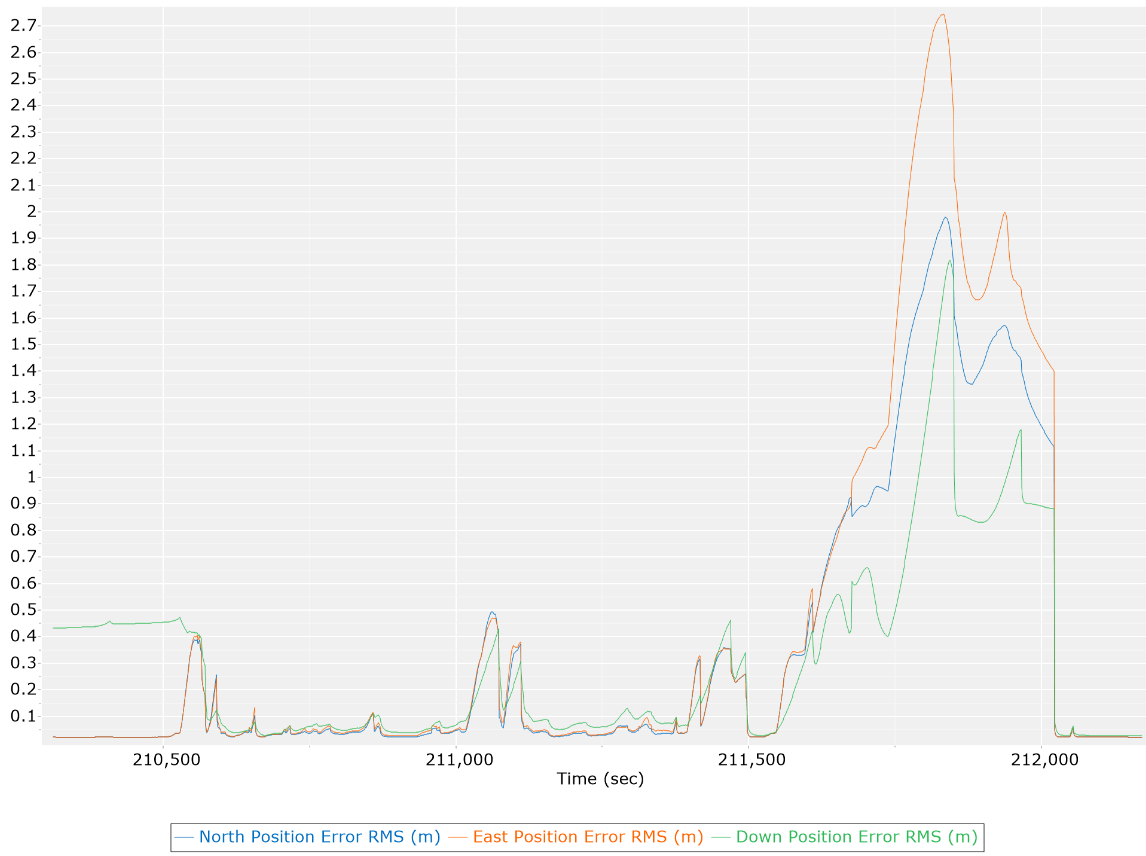

Fig 1: Real-Time Navigation Position RMS

What can you read from this graph? Towards the end of the mission the quality degrades. Either the GNSS environment became very poor or the real-time RTK correction signal disappeared. The centimeter level performance for the first part of the mission does suggest that real-time corrections were applied during the mission (e.g. CMR, CMRx, RTCM).

Another useful plot is the "Satellite Lock/Elevation":

Fig 2: GPS/GLONASS L1 Satellite Lock/Elevation

The red lines indicate signal cycle slips, which are epochs where a signal wasn't tracked - like a disconnect between a receiver and satellite. Cycle slips typically occur in environments with poor or no satellite visibility, such as urban or foliage environments. As you can see from the graph, during start and end of the mission the satellite tracking was clean. If you notice many cycle slips while the vehicle was in open-sky terrain, it may point to a GNSS integration issue. It could be the antenna model or location, the cable/connector or potential interferences from other electronics nearby. Plots for other satellite navigation systems (e.g. Beidou, Galileo) can also be inspected.

The Signal-To-Noise (SNR) ratio plots are also beneficial to detect GNSS integration issues:

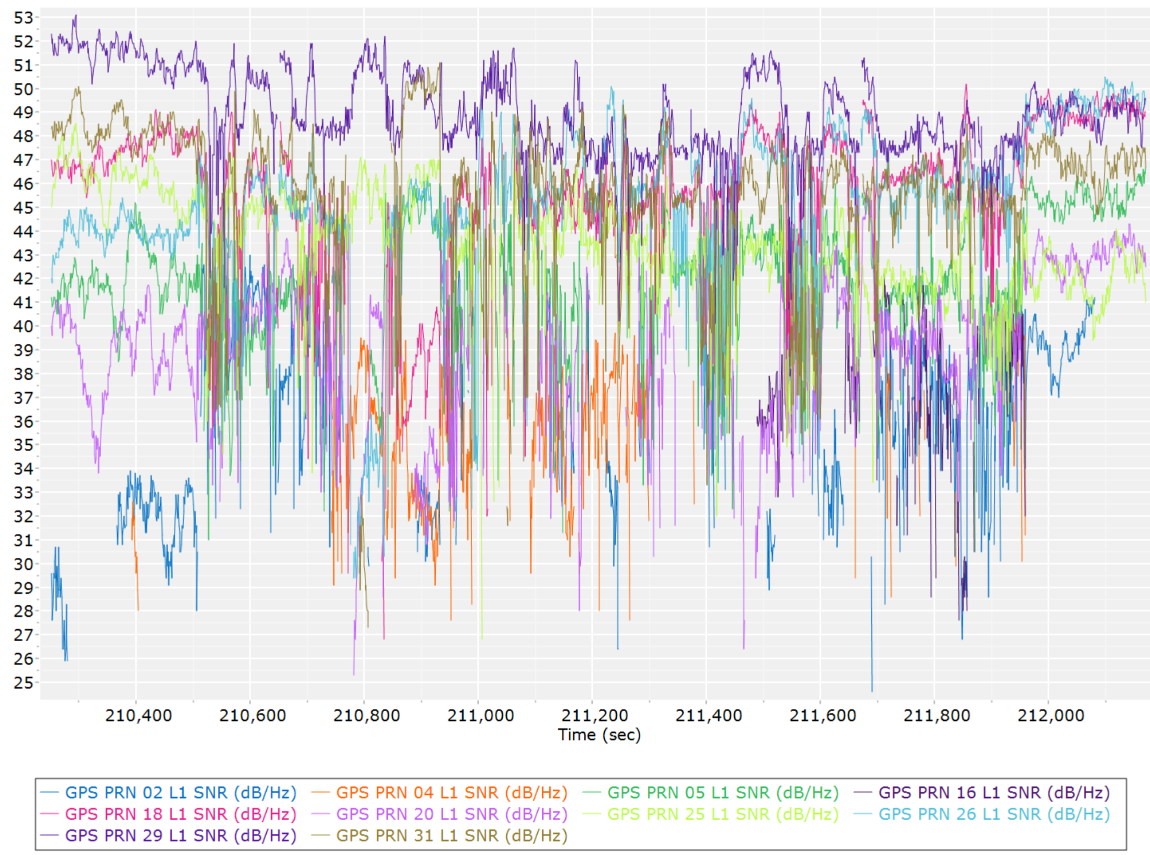

Fig 3: GPS L1 SNR

The acceptable L1 GPS SNR is between 40 - 55 dB on average. Should this drop < 40 dB in average, something is wrong with the integration. Same as above, it may be related to the antenna model, antenna location, the cable/connector or potential interferences from other electronics nearby. Due to the nature of the L2 signal, the SNR is typically lower than L1. However, the expectation is the same. The average signal quality should not drop below 40 dB significantly. The same applies to signals from Galileo, Beidou and QZSS. The signal SNR from satellites at a low elevation (< 25 degrees) is typically degraded, hence the inspection shall focus on satellites at higher elevation.

The total acceleration plot below provides an insight on a potential vibration conflict:

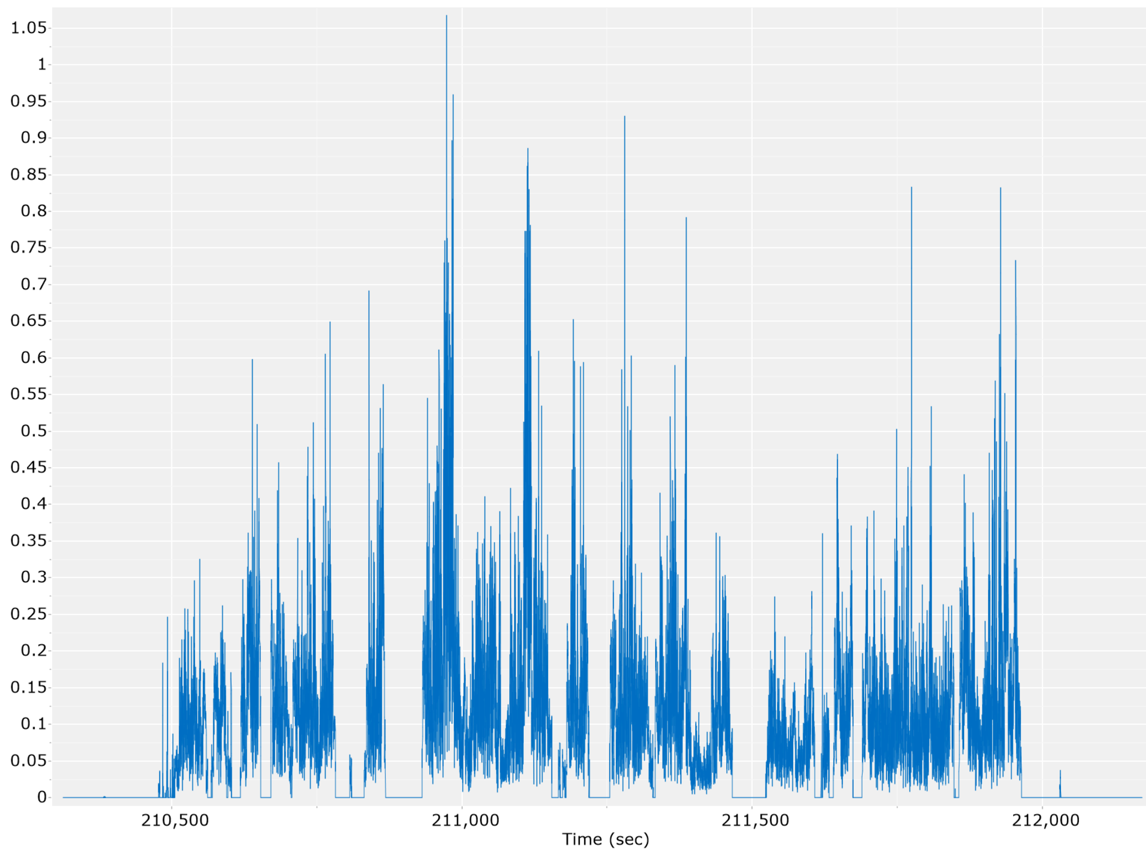

Fig 4: Total Body Acceleration

Most epochs for the total acceleration are typically in a range of 0 - 0.5 g. Higher peaks are normal, e.g. fast curves, fast acceleration/deceleration of the vehicle. An unwanted vibration level is present if the average acceleration is biased, leaning towards 1 g or even more. Having two many peaks going far over 1 g may also point to an unacceptable vibration level. If the platform vibration is too high, the IMU won't be able to properly sense the true platform motion, which can cause the GNSS/INS solution to be incorrect or even fail to generate. In this case, the platform needs to be isolated from the vibration source by using vibration dampers.

The “DMI Distance Traveled” plot is an indicator for the correct DMI integration:

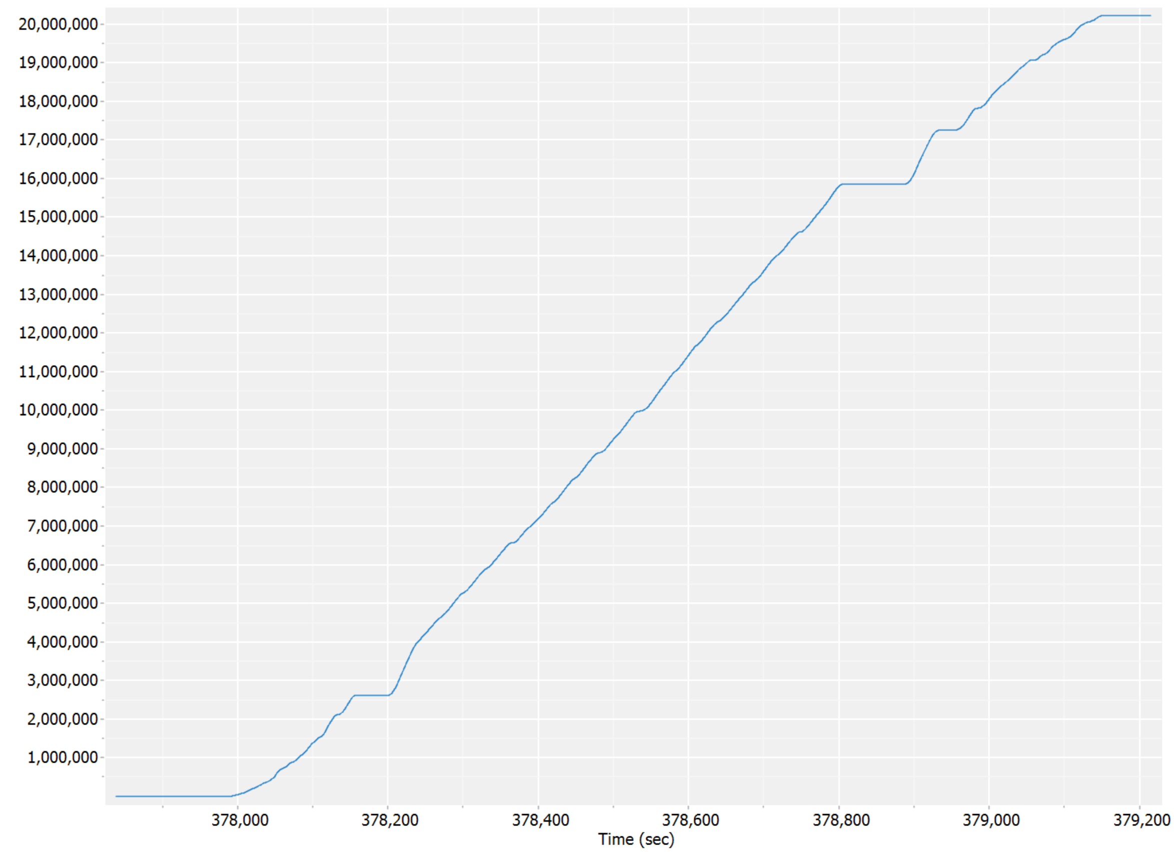

Fig 5: DMI Distance Traveled

A graph like the one above shows that proper pulses were registered from the odometer (DMI), translating into a traveled distance. Horizontal line sections indicate static data, which is expected for land applications. A permanent flat line would signify that the vehicle was stationary for the entire time, indicating a potential integration problem if kinematic data were collected. This could relate to a hardware issue, wrong DMI type selection or wrong scale factor setup.

The “GAMS Solution Status” plot is an indicator for the usage of the derived heading observables from the two antenna installation:

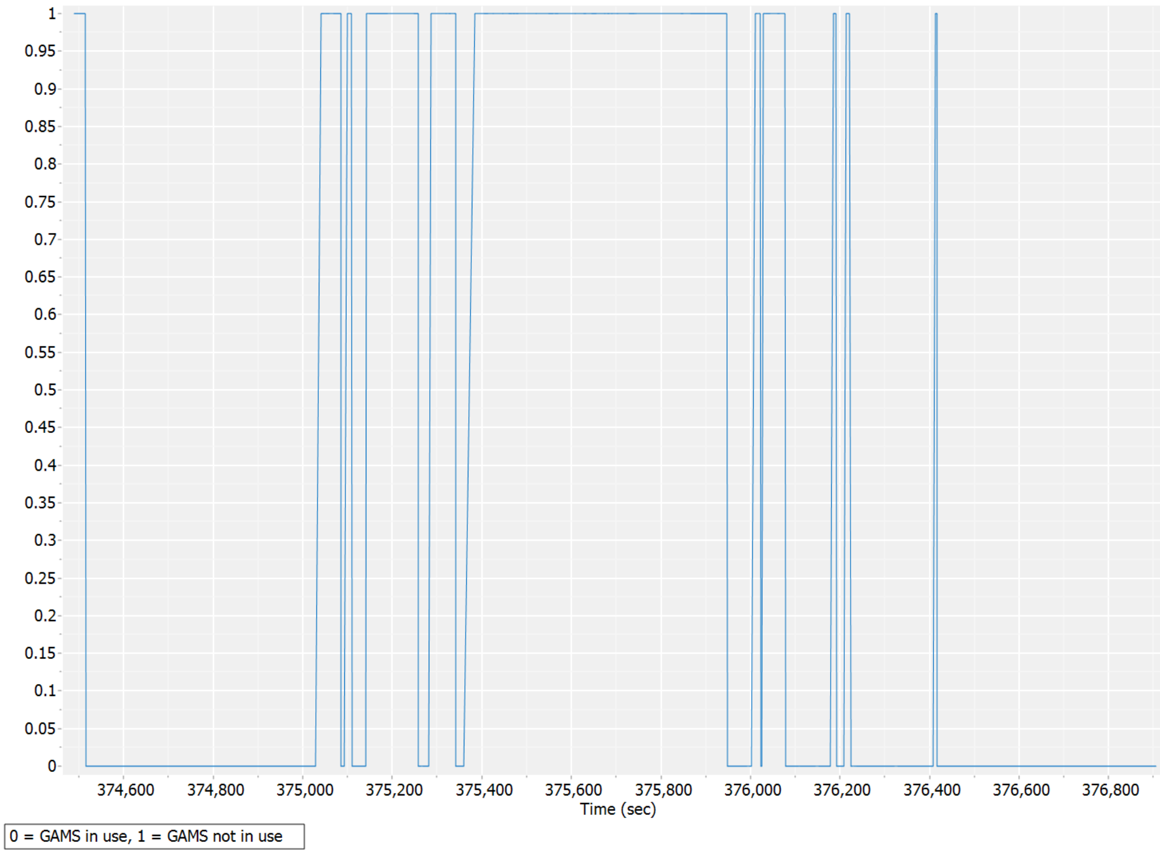

Fig 6: GAMS Solution Status

Often, not all epochs are in “GAMS in use” mode, especially in GNSS-critical environments. Aiding the additional heading from the dual antenna installation is only useful if sufficient GNSS signals are tracked. In standard land environments (urban, foliage, multipath) the plot looks typically like above. In open sky terrain, all epochs are expected to be in “GAMS in use” mode. Having all epochs being “not use” would certainly signify an integration problem - being a hardware issue or a wrong GAMS vector setting, given the system integrated supports the GAMS option in general.

Calibration Mode

The Calibration Mode entitles the user to calibrate the following parameter:

- GNSS Lever Arm (Reference Point to Antenna L1 Phase Center)
- GAMS Lever Arm (3D vector between 1st and 2nd Antenna in vehicle frame)
- DMI Lever Arm (Reference Point to DMI sensing point - in most cases where the tire with the installed DMI touches the ground - see Fig 7)
- DMI Scale Factor (translates DMI pulses into distance)
- Heading Boresight between Vehicle Frame and IMU Frame

Find below a figure illustrating the lever arm constellation for a land mobile mapping system:

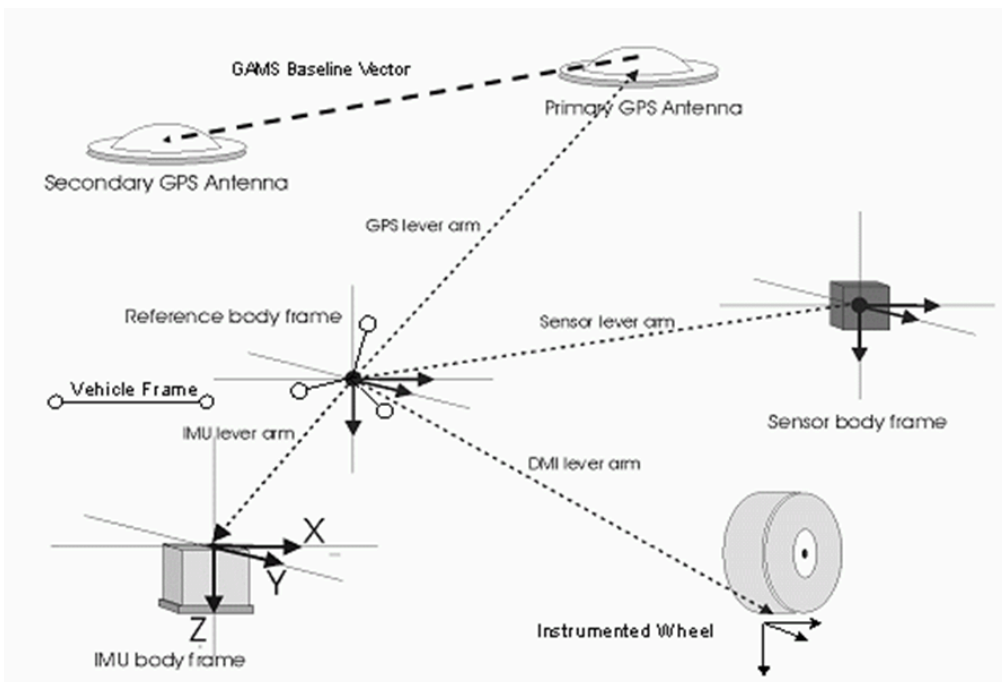

Fig 7: Lever Arms

For more background about lever arms and frames please refer to the installation and operation manuals for POS LV (*PUBS-MAN-003758*) or POS MV (*PUBS-MAN-004291*).

The DMI lever arm calibration (only for land application) in Y and Z direction is less reliable because the motion is sensed only in X direction (driving direction). However, the calibration result should be suitable to detect gross errors in the setup.

The most relevant plots/tables from the Calibration Mode report are:

- Heading Boresight between Vehicle and IMU
    - *Angular Heading misalignment between the Vehicle frame and IMU frame, most relevant for the autonomous vehicle industry*

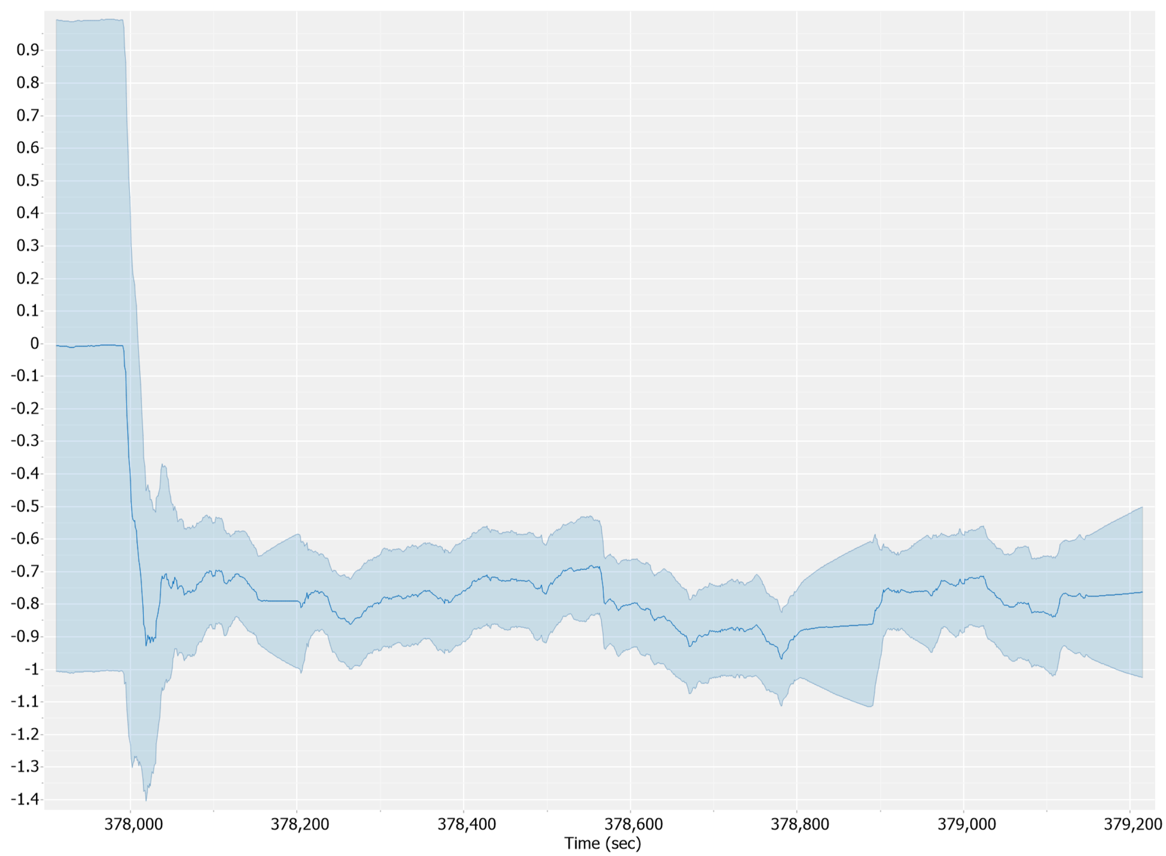

Fig 8: Heading Boresight between Vehicle and IMU

- GNSS QC Statistics
    - *Provides information about the GNSS processing quality, e.g. number of satellites, statistics about ambiguity solution*

GNSS QC Statistics

Statistics	Min	Max	Mean
Baseline length (km)	0.02	0.56	
Number of GPS SV	4	9	8
Number of GLONASS SV	0	6	5
Number of QZSS SV	0	0	0
Number of BEIDOU SV	0	6	5
Number of GALILEO SV	0	8	7
Total number of SV	6	29	25
PDOP	0.92	6.85	1.07
QC Solution Gaps	0.00	0.00	
Solution Type	Fixed	Float	No solution
Epoch (sec)	1385.00	0.00	0.00
Percentage	100.00	0.00	0.00

- Calibrated Installation Parameters
    - *Reference-Primary GNSS Lever Arm*
        - *Calibrated GNSS Lever Arm between reference point and Antenna L1 Phase Center*

Reference-Primary GNSS Lever Arm Automatic Calibration Results

Original Reference to Primary GNSS lever arm (m)	0.247	0.100	-0.550
Iteration 1 Reference to Primary GNSS lever arm (m)	0.250	0.098	-0.581
Primary GNSS Lever Arm In use	Iteration 1		

    - *Reference-DMI Lever Arm & Scale Factor*
        - *Calibrated DMI Lever Arm between reference point and DMI reference location (ground touchpoint tire)*
        - *Calibrated Scale Factor (Translation of pulses into traveled meters)*

DMI Calibration Results

Original DMI lever arm (m)	0.541	-0.771	2.041
Original DMI scale factor	-2119.996		
Calibrated DMI lever arm (m)	0.679	-0.773	1.925
Calibrated DMI scale factor	-2121.934		

- *GAMS Lever Arm*
    - *Calibrated lever arm between primary and secondary GNSS antenna*

GAMS Lever Arm (m)

GAMS Calibration Results

Original GAMS lever arm (m)	1.512	0.015	0.421
Calibrated GAMS lever arm (m)	1.390	0.021	0.456

- GAMS Solution Status
    - *Provides information about GAMS (heading between primary and secondary antenna) usage (Fig 6)*

The user shall apply the calibrated parameter in the hardware real-time setup (POSView or Browser UI) for future purposes. Since the web application purely relies on settings from hardware integration embedded in the POS or T04 file, there is no support to re-run the same dataset with the newly estimated calibration parameters.

In addition to the plots/tables above, all plots outlined for the Real Time QC feature may also be relevant for the Calibration Mode.

Ground Truth

The Ground Truth mode generates a post-processed trajectory (SBET) while all lever arms are fixed (small StdDEv) to avoid any noise in the final GNSS/INS solution. The assumption is that all lever arms have been entered correctly for the real-time platform setup (POSView or Browser UI). The web application does not support entering any lever arms, scale factors or even rotations between the reference frame and IMU frame (or Vehicle to IMU frame). The SBET file is part of the delivered ZIP file. The format of the SBET file is below:

Data	Units	Type
Time	seconds	double
Latitude	radians	double
Longitude	radians	double
Altitude	meters	double
x velocity	meters/second	double
y velocity	meters/second	double
z velocity	meters/second	double
Roll	radians	double
Pitch	radians	double
platform heading	radians	double
wander angle	radians	double
x body acceleration	meters/second2	double
y body acceleration	meters/second2	double
z body acceleration	meters/second2	double
x body angular rate	radians/second	double
y body angular rate	radians/second	double
z body angular rate	radians/second	double

Fig 9: SBET File Format

In addition, the post-processed trajectory is also provided as an ASCII file and KML file. Similar to the other features, the Report PDF file contains plots and tables to analyse the results. Find below some plots/table recommended to look at:

- Smoothed Performance Metrics
  - *Position Error (Fig 10)*
  - *Roll/Pitch Error RMS and Heading Error RMS*
- GNSS QC Statistics
  - *Provides information about the GNSS processing quality, e.g. number of satellites, statistics about ambiguity solution etc…(see table here)*
- GAMS Solution Status
  - *Provides information if GAMS (dual antenna) was in use or not (Fig 6)*
- Total Body Acceleration
  - *Provides information about the vibration level (Fig 4)*
- Satellite Lock/Elevation
  - *Provides information of how many satellites were tracked, including cycle slip information (Fig 2)*
- Satellite L1/L2 SNR
  - *Provides information about the GNSS signal quality (Fig 3)*
- IAKAR Separation
  - *Provides the difference between forward and reverse processing in time (Fig 11)*
- Processing Mode
  - *Provides information about the GNSS ambiguity solution success (Fig 12)*
- Smoothed Navigation Difference
  - *Provides the difference in position and orientation between the real-time navigation solution and the post-processed solution (Fig 13)*

The RMS position plot below indicates the estimated 3D performance after the GNSS/INS post-processing step (SBET generation):

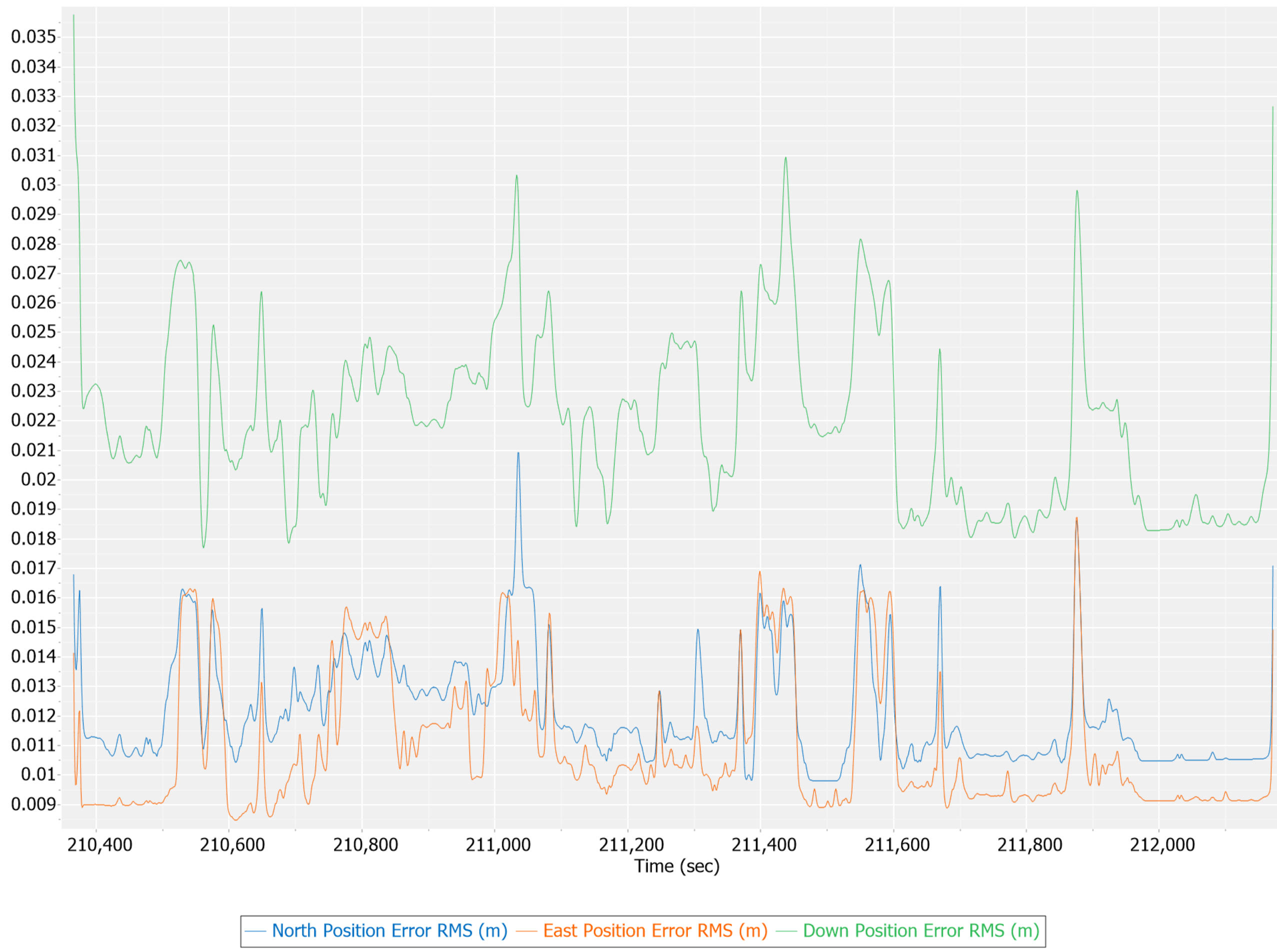

Fig 10: Position RMS

In perfect GNSS conditions the accuracy should be between 1 - 3 cm. In standard urban territory with a mix of good and bad signal tracking the accuracy typically switches in a range of 3 - 30 cm. In GNSS denied areas the error can grow to a meter level depending on the IMU grade and length of the GNSS outage.

The “SBET IAKAR Separation” plot shows the 3D difference in position between the forward and reverse post-processed solution:

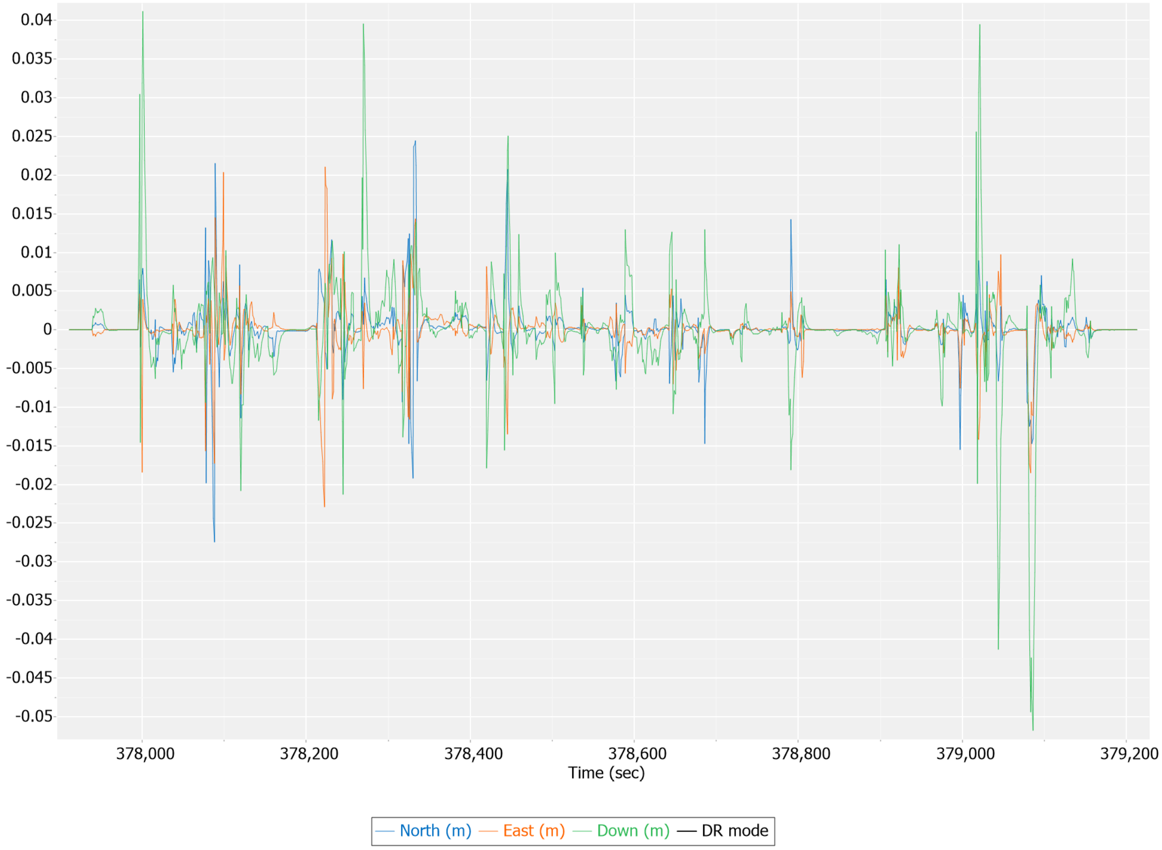

Fig 11: SBET IAKAR Separation

This plot is an indicator on how well the GNSS ambiguities match between the forward processing and backward processing in time. In a good constellation, the variation is typically within a range of 5 - 10 cm. The deviation will grow in critical or denied GNSS windows, which is also influenced by the IMU quality and the length of GNSS critical passages. This plot is a valuable indicator on how well the post-processing (base/rover merge) works and what to expect performance-wise from the final SBET file.

The “Processing Mode” plot is another indicator for the GNSS ambiguity solution:

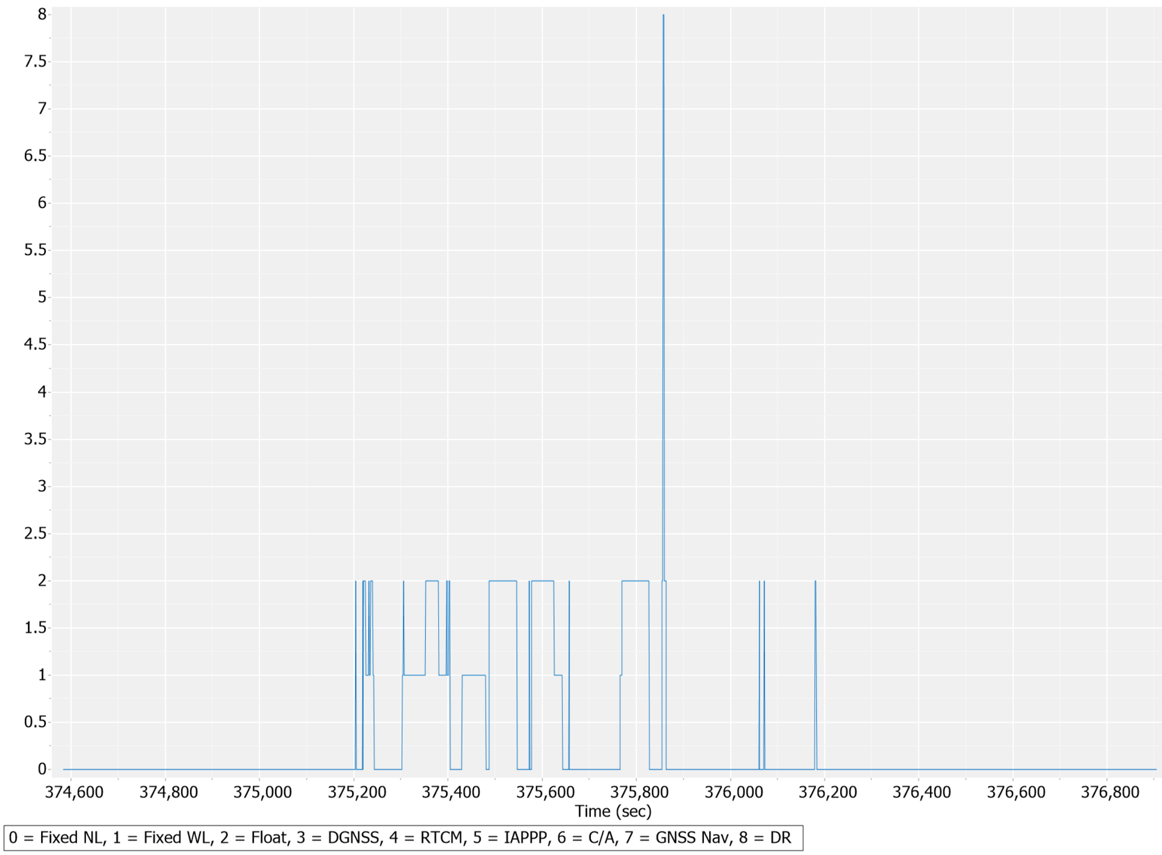

Fig 12: Processing Mode

The “Fixed NL” and “Fixed WL” signify the best possible solutions, triggered when sufficient satellites are tracked. In critical GNSS environments, the processing mode can become “Float”, or even worse in surroundings where no GNSS signals are available. This plot helps to understand which segments of the trajectory are good, medium or poor in accuracy. In standard land terrain, the epochs would typically jump between Fixed NL, Fixed WL and Float mode. In open sky terrain the user should expect pure Fixed solution epochs, provided the GNSS/INS integration is correct and the hardware healthy.

Another set of interesting plots is available from the “Smoothed Navigation Difference” category:

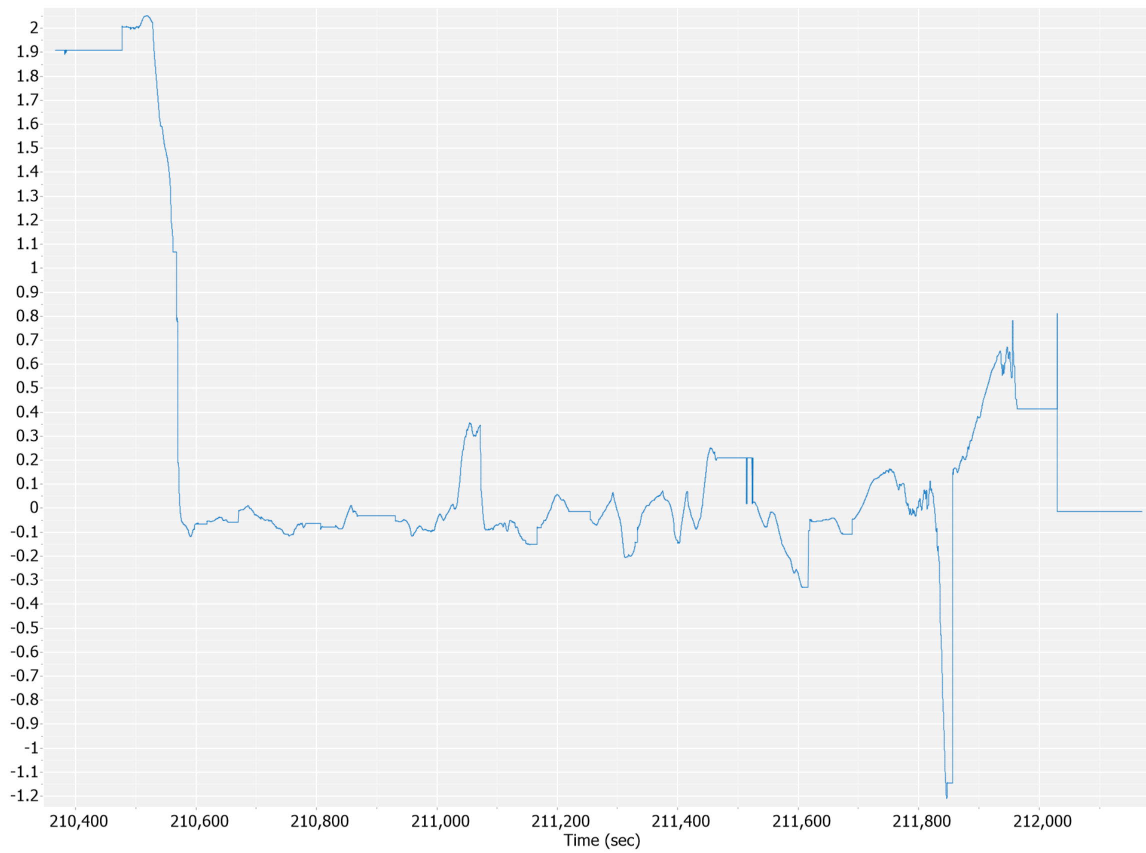

Fig 13: Down position difference

Above is the difference plot for the vertical component. Plots of other axes (North/East) are also available, as well as for angular differences. When comparing the real-time trajectory with the post-processed trajectory it is important to know in which frame (e.g. ITRF2020, NAD83, ETRS89) the solution is available. If the real-time trajectory is in a different frame than the post-processed solution, a direct comparison is not useful unless the bias is known and considered during the analysis. Please find more details in the Processing Mode section.

Processing Modes

Various post-processing modes for the Calibration and Ground Truth feature are available:

- **PP-RTX 2**
  - *Refer to details here.*
- **Single Base**
  - *Traditional merge of rover and base station data where base station shall be kept within a radius of 20 - 30 km. This mode requires the user to upload a base station file (T02, T04 or Rinex).*
- **Single Base (Automatic Download)**
  - *Same as above, just that POSPac Assure will automatically search for a base station from the database (see TGAP) and use it if available.*
- **RTK**
  - *POSPac Assure will post-process the data in Single Base mode with the real-time logged RTK corrections (e.g. CMR, CMRx, RTCM). Any RTK stream gaps will cause a degraded solution.*
- **SmartBase**
  - *A network of base stations will be used. Please read here for more information.*
- **Autonomous**
  - *POSPac Assure uses best available real-time corrections in post-processing mode. If none are available, it will leverage code measurements only.*

For the Single Base (SiB) mode with the user's provided base station, the user can choose the source of the reference coordinate. Three options are available:

- **RTX Base Position**
  - *Trimble's CenterPoint® RTX service is used to calculate the base coordinate. The requirements can be found [here](). The frame is handled automatically.*
- **From Base Station File**
  - *Coordinates are taken from the base file header. There is no information about the frame of the coordinates in the header. The post-processed trajectory will be tied to the coordinates of the base file header.*
- **Enter Base Position**
  - *Users can enter the coordinates. There is no frame selection. The post-processed trajectory will be tied to the entered coordinates.*

Below is the table showing the frame of the exported solution based on selected processing mode and coordinate source.

Single Base User Coordinates	Single Base RTX Coordinates	Single Base Rinex Coordinates	Single Base Auto Download	Single Base RTK	SmartBase	PP-RTX	Autonomous
Tied to User Coordinates	*ITRF2020 @2015.00*	*Tied to Rinex Coordinates*	*ITRF2020 @2015.00*	*Tied to RTK Coordinates*	*ITRF2020 @2015.00*	*ITRF2020 @2015.00*	*Tied to Real-Time Frame*

Table 1: Export Solution Frames

This information is important when running Ground Truth and comparing against a reference, e.g. map or another trajectory. It may imply transforming the solution into a different frame with 3rd party software.

Supported Web App Plans

Applanix POSPac Assure supports different subscription and add-on plans.

Fig 14: Subscriptions and Add-on plans

Applanix POSPac Assure supports a Base plan and a Professional plan. Both are monthly subscriptions which support 10 tokens each. One token translates into one mission which is one contiguous logged dataset. The monthly subscriptions hence support 10 missions. Should this not suffice, the user can purchase add-on plans. Each Add-on plan is a package of another 10 tokens. Multiple Add-on packages can be purchased at any time, with discounts varying depending on the tiers. The tokens from the add-on plan are valid for 12 months while the tokens from the monthly subscription reset monthly.

The Base plan supports the feature *Real Time QC* and *Calibration* Mode. The Professional plan supports additionally the *Ground Truth* Mode. An upgrade and downgrade process is supported while remaining tokens are converted equivalently.

Workflow

After the user has logged into the web application, the user can assign a project name and drag the rover file(s) into the map background. Alternatively, the user can click on “browse” and select the rover files from the Explorer. Should the user not specify a project name, the application will assign the name from the rover raw file. The real-time trajectory will be displayed in the background and additionally, the application will suggest the best suitable processing mode from available database corrections (applicable for the *Calibration* and *Ground Truth* Mode).

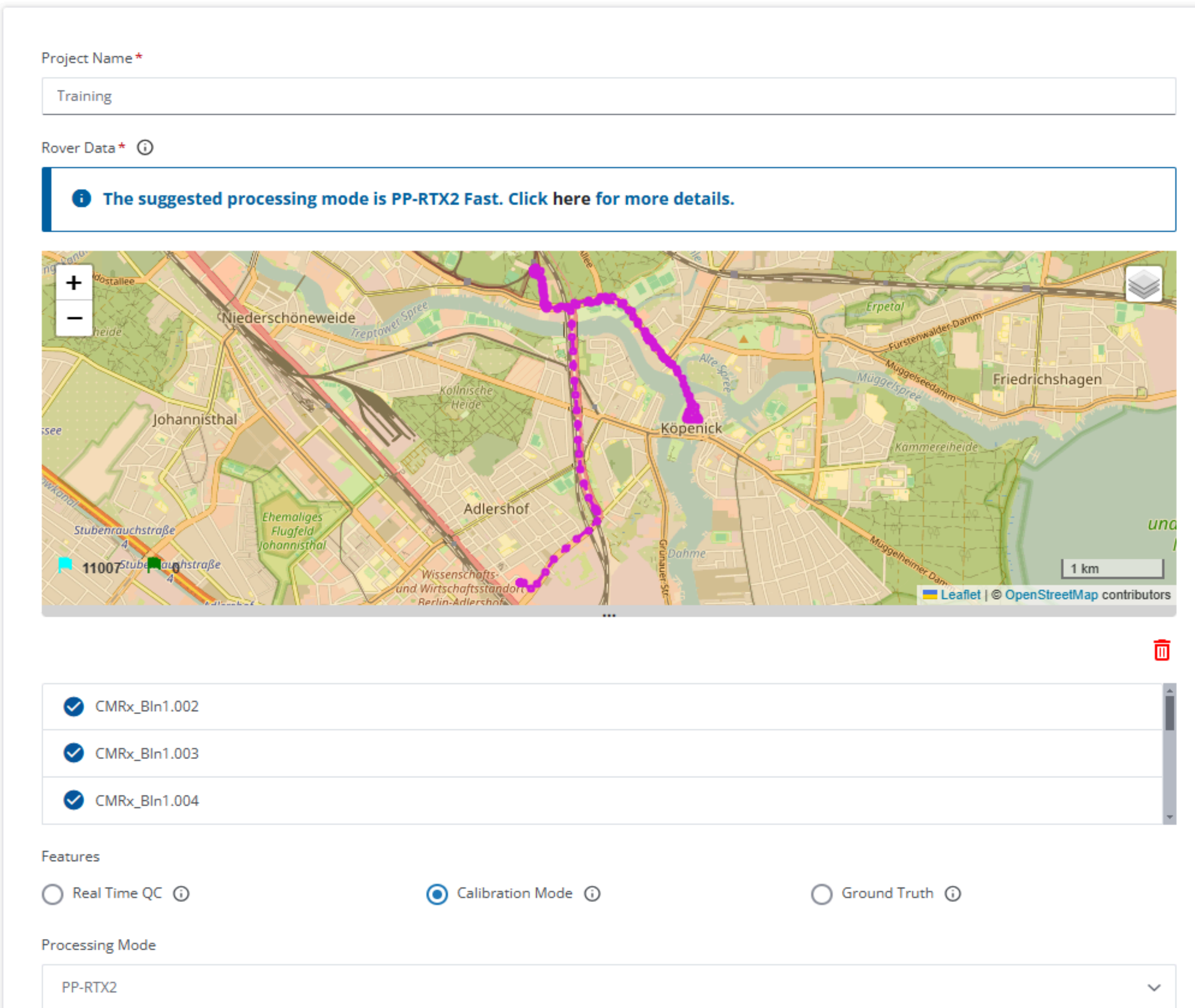

Fig 15: Project creation and Processing Mode

The user can then decide for the preferred feature, which is either Real Time QC, Calibration Mode or Ground Truth. If the processing mode is “Single Base”, the web application expects the user to upload a base station file. Same as for the rover data, the user can drag them into the application or open the “browse” mode to select the file(s) from the Explorer. The user will have to decide for the source of the base coordinates. The following selections are available:

- RTX Base Position
- From Base Station File
- Enter Base Position

Find more details about the three options under Processing Modes. Coordinates can be entered in degrees, minutes and seconds, or in decimal degrees. For the latitude, the user has to select “N” for North or “S” for South and for the Longitude “E” for East and “W” for West. This serves the proper hemisphere selection for the base station (see Fig 16). The antenna height can also be entered unless this information shall be read from the base file header.

Eventually, the user can choose the “IMU Mode” to be either “Auto” or “Onboard”. The “Auto” mode will trigger the processing for the remote IMU if available, otherwise it will process data with the onboard IMU. The “Onboard” selection will ignore any remote IMU data and enforce processing for the onboard IMU.

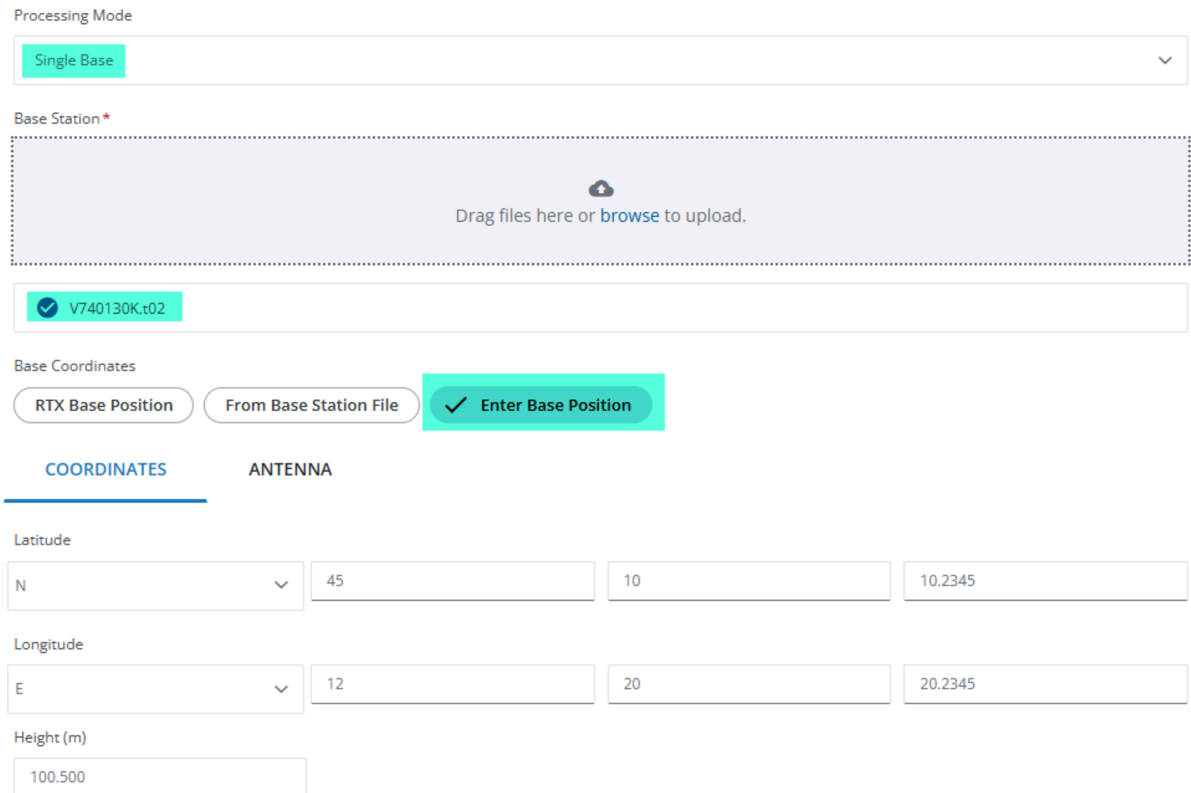

Fig 16: Manual Coordinates for Single Base Mode

The final step is to press “Submit Project”. The new project will be added to the Project History list. Details about submission date/time, project name, project ID, SBET minutes and project status are displayed. The user can download the results from the “Actions” column, whereas, the project results would also be sent in an email when it is completed in the cloud. The “Project ID” is important to share with our Customer Support if something fails and help is required.

PROJECT HISTORY

REFRESH

Time of Submission	Project	Project ID	SBET Minutes	Status	Actions
Tue, 14 Jan 2025 13:40:11 UTC	GT_344	6786693b599fe07f7895c543	35	Successful	
Tue, 14 Jan 2025 13:17:32 UTC	GT_Berlin	678663ec599fe07f7895c170	19	Successful	
Tue, 14 Jan 2025 13:12:35 UTC	GT_726	678662c3599fe07f7895c031	17	Successful	

Fig 17: Project History

Failed projects can be re-processed by using a different processing mode. Re-processing would not trigger a token deduction.

Deliveries

Applanix POSPac Assure delivers the results depending on the feature used. The minimum input from the user is the rover GNSS/INS raw file (POS or T04 file format). Below are the deliveries based on the selected feature:

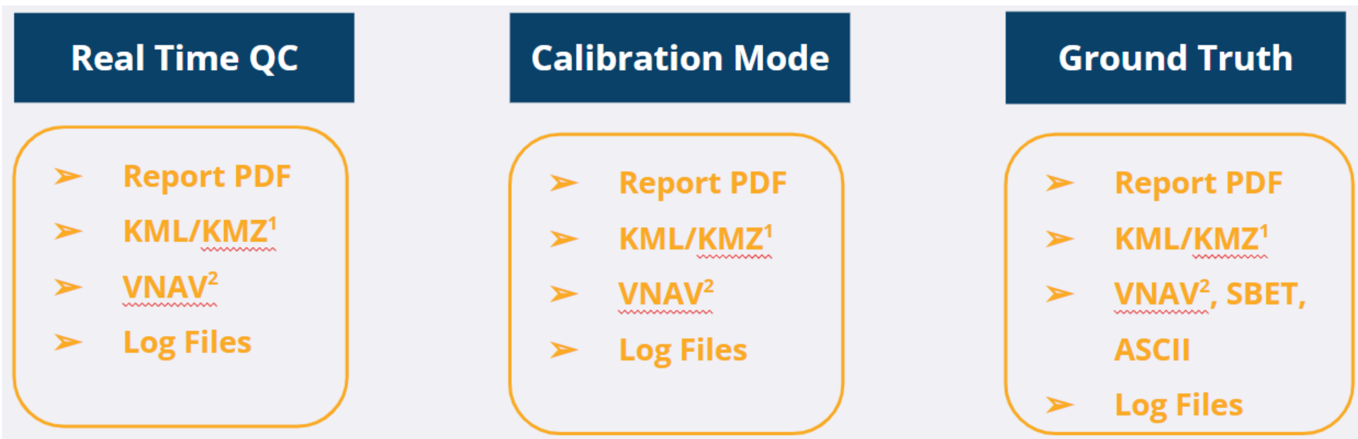

Fig 18: Deliveries based on Feature

[1] Only for T04 files

[2] Real-Time Vehicle Navigation Solution

All files are delivered in a single ZIP file. This file is sent to the registered email address or the user can directly download it from the web application itself under the Project History:

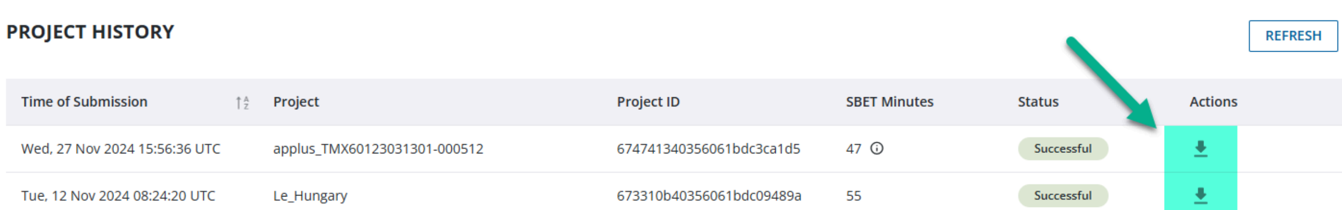

Fig 19: Download Results

For more information

For more information, contact our Customer Support Team (techsupport@applanix.com) or visit our Customer Support Portal.