INSPIRe

D5.1 – UK EGNOS Performance Coverage Prototype Tool

Prepared for:

esa

Prepared by:	GMV INSPIRe TEAM
	GRAD INSPIRe TEAM
Approved by:	M Pattinson (GMV)
Authorized by:	T Richardson (GMV)

Code:	INSPIRe-GMV-D5.1-v1.0 - Draft
Version:	1.0
Date:	October 2023

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES 3

1 INTRODUCTION 4

1.1 PURPOSE 4

1.2 SCOPE 4

1.3 DEFINITIONS AND ACRONYMS 4

1.3.1 Definitions 4

1.3.2 Acronyms 5

2 REFERENCES 6

2.1 REFERENCE DOCUMENTS 6

3 REQUIREMENTS CONSOLIDATION 7

3.1 EGNOS AVAILABILITY FORECAST PERFORMANCE 7

3.2 UK EGNOS PERFORMANCE COVERAGE TOOL REQUIREMENTS 8

3.2.1 Functional Requirements 8

3.2.2 Interface Requirements 9

4 UK EGNOS PERFORMANCE COVERAGE TOOL 11

4.1 UK EGNOS PERFORMANCE COVERAGE TOOL DESIGN 11

4.1.1 Inputs 11

4.1.2 Processing 12

4.1.3 Outputs 16

4.2 UK EGNOS PERFORMANCE COVERAGE PROTOTYPE TOOL TEST SPECIFICATION 16

5 VALIDATION RESULTS 20

5.1 TC.MPT.001 20

5.2 TC.MPT.002 34

5.3 TC.MPT.003 41

5.4 TC.MPT.004 48

5.5 TC.MPT.005 59

5.6 TC.MPT.006 67

5.7 TC.MPT.007 74

5.8 TC.MPT.008 81

5.9 TC.MPT.009 88

5.10 TC.MPT.010 95

6 USER MANUAL FOR THE TOOL 102

6.1 INSPIRE UK EGNOS PERFORMANCE COVERAGE PROTOTYPE GENERAL DESCRIPTION 102

6.2 INSPIRE UK EGNOS PERFORMANCE COVERAGE PROTOTYPE USAGE 103

6.2.1 Input and Output Files 103

6.2.2 Running the Tool 115

7 IDENTIFICATION OF STEPS AND TIMESCALES FOR DEVELOPMENT AND IMPLEMENTATION OF AN OPERATIONAL TOOL 119

7.1 OPERATIONAL PERFORMANCE COVERAGE PROTOTYPE TOOL ACTIVITIES 119

7.1.1 Action #1. Incorporation of M(G)RAIM proposed solution 119

7.1.2 Action #2. Service Provision Analysis 120

7.1.3 Action #3. Prediction Tool Core Processing Development 120

7.1.4 Action #4. Development of Performance Coverage Prototype Tool Interfaces....121
7.1.5 Action #5. Deployment of monitoring network stations (Optional) 123
7.1.6 Action #6. Performance Coverage Prototype Tool Test Bed....123
7.1.7 Action #7. Maritime User Engagement....124
7.2 OPERATIONAL PERFORMANCE COVERAGE PROTOTYPE TOOL ROADMAP....125
8 HIGH LEVEL ESTIMATED COST REPORT 126

List of Tables and Figures

Table 1-1 Definitions 4

Table 1-2 Acronyms 5

Table 2-1 Reference Documents 6

Table 4-1. MGRAIM Functional Test Specification 17

Table 8-1 High-level estimate cost 126

Figure 3-1. EGNOS Availability Forecast output example [RD.4] 8

Figure 4-1. UK EGNOS Performance Coverage prototype tool 11

Figure 6-1. M(G)RAIM Performance Prediction prototype. Tool Directory Structure 103

Figure 6-2. Input file. Constellation ephemeris 104

Figure 6-3. M(G)RAIM Performance Prediction prototype. Simulations Directory Structure 105

Figure 6-4. M(G)RAIM Performance Prediction prototype. Example of ACC95 along time .106

Figure 6-5. M(G)RAIM Performance Prediction prototype. Example of HPL along time 107

Figure 6-6. M(G)RAIM Performance Prediction prototype. Example of test SOL along time 107

Figure 6-7. M(G)RAIM Performance Prediction prototype. Example of number of estimated satellites along time 108

Figure 6-8. M(G)RAIM Performance Prediction prototype. Example of dilution of precision along time 109

Figure 6-9. M(G)RAIM Performance Prediction prototype. Example continuity status along time 109

Figure 6-10. M(G)RAIM Performance Prediction prototype. Example of 95 percentile for the Acc95 over Europe 110

Figure 6-11. M(G)RAIM Performance Prediction prototype. Example of 99.8 percentile for the HPL over Europe 111

Figure 6-12. M(G)RAIM Performance Prediction prototype. Example of availability over Europe 112

Figure 6-13. M(G)RAIM Performance Prediction prototype. Example of Satellite visibility over Europe 113

Figure 6-14. M(G)RAIM Performance Prediction prototype. Example of integrity flag over Europe 114

Figure 6-15. M(G)RAIM Performance Prediction prototype. Example of continuity status over Europe 115

Figure 6-16. inspire_svs input configuration files location 116

Figure 6-17. Configuration file 117

Figure 6-18. run_create_config file 117

Figure 6-19. inspire_svs add to Path Directories 118

Figure 6-20. run_TC function 118

Figure 7-1. Operational Performance Coverage Prototype Tool Roadmap. 125

1 INTRODUCTION

1.1 Purpose

This document is a support document to WP5, intended to describe the requirements for an EGNOS coverage and availability tool. The purpose of this document is to describe:

- The requirements for the tool, in particular where they differ from the WP6 development work.
- Functional design and functional test specification for the prototype tool
- Software design and test specification for the prototype tool
- Verification and validation plan for the prototype tool
- Validation results
- User manual for the tool
- Identification of steps and timescales for development and implementation of an operational tool

1.2 Scope

Following the introduction to the document presented in Section 1, the layout of the remainder of the document is as follows:

- **Section 2** contains a list of applicable and reference documents.
- **Section 3** provides a review and consolidation of the current RAIM Prototype performance prediction tool being developed.
- **Section 4** This section provides a high-level design for the Performance Coverage Tool, software design and its test specification.
- **Section 5** contain the validation results from the aforementioned verification and validation plan detailed in the previous section.
- **Section 6** provides the UK EGNOS Performance Coverage Prototype Tool user manual.
- **Section 7** details the roadmap and for the development of an operational M(G)RAIM Performance Prediction tool.
- **Section 8** details the estimated operational M(G)RAIM Performance Prediction tool including the development, implementation and operations, highlighting assumptions and data sources.

1.3 Definitions and Acronyms

1.3.1 Definitions

Concepts and terms used in this document and need defining are included in the following table:

Table 1-1 Definitions

Concept / Term	Definition

1.3.2 Acronyms

Acronyms used in this document and need defining are included in the following table:

Table 1-2 Acronyms

Acronym	Definition
AL	Alert Limits
ARAIM	Advanced Receiver Autonomous Integrity Monitoring
CDF	Cumulative distribution function
DFMC	Dual Frequency Multiconstellation
DGNSS	Differential GNSS
DGPS	Differential GPS
DOP	Dilution of Precision
EUROPEAN	EuropeanEuropean Civil Aviation Conference
EGNOS	EuropeanEuropean Geostationary Navigation Overlay Service
ESA	EuropeanEuropean Space Agency
FD	Fault Detection
FDE	Fault Detection and Exclusion
GBAS	Ground-Based Augmentation System
GEAS	GNSS Evolutionary Architecture Study
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRAD	GLA Research and Development
GSA	EuropeanEuropean GNSS Agency
HAL	Horizontal alarm Limit
HDOP	Horizontal Dilution of Precision
HMI	Hazardous Misleading Information
HPE	Horizontal Position Error
HPL	Horizontal Protection Level
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICAO	International Civil Aviation Organisation
IEC	International Electrotechnical Commission
INSPIRe	Integrated Navigation System-of-Systems PNT Integrity for Resilience
IMO	International Maritime Organisation
IR	Integrity Risk
ISM	Integrity Support Message
LPV	Localizer Performance with Vertical guidance
MHSS	Multiple Hypothesis Solution Separation
MOPS	Minimum Operational Performance Standards
MGRAIM	Maritime General RAIM
MRAIM	Maritime RAIM
MSC	Maritime Safety Committee
MSI	Maritime Safety Information
MSR	Multi-system shipborne receiver
N/A	Not Applicable
NLOS	Non-Line of sight
NPA	Non-Precision Approach
PFA	Probability of False Alarm
PL	Protection Level
PHMI	Probability of Hazardously Misleading Information
PMD	Probability of Miss detection
PNT	Positioning Navigation and Timing
PVT	Position, Velocity and Time
RAIM	Receiver Autonomous Integrity Monitoring
RTCA	Radio Technical Commission for Aeronautics
RTK	Real-time kinematic positioning
SARPS	Standards and Recommended Practices
SBAS	Satellite Based Augmentation System
SIS	Signal in Space
SOLAS	Safety at Life at Sea
TBC	To Be Confirmed
TTA	Time to Arrival
VAL	Vertical alarm Limit
VHF	Very High Frequency

2 REFERENCES

2.1 Reference Documents

Although not part of this document, the following documents amplify or clarify its contents.

Table 2-1 Reference Documents

Ref.	Title	Code	Version	Date
[RD.1]	INSPIRe Algorithm documentation (GPS M(G)RAIM)	INSPIRe-GMVNSL-Alg2.1	1.1	02/2023
[RD.2]	INSPIRe Algorithm documentation (DFMC M(G)RAIM)	INSPIRe-GMVNSL-Alg3.1	1.0	03/2023
[RD.3]	AUGUR Web Page Link: https://augur.eurocontrol.int	-	V2.11	02/2023
[RD.4]	EGNOS forecast availability tool Link: https://egnos-user-support.essp-sas.eu/services/safety-of-life-service/forecast-performance/apv1-availability-performance	-	-	02/2023
[RD.5]	Trimble GNSS Planning Online Link: https://www.gnssplanning.com/	-	-	02/2023
[RD.6]	INSPIRe Consolidated Requirements V0.1 Internal	X-062-001-002	0.1	03/08/22

3 REQUIREMENTS CONSOLIDATION

This section provides a review and consolidation of the EGNOS Performance Coverage Tool requirements.

3.1 EGNOS Availability Forecast Performance

EGNOS Availability Forecast Performance tool is a web application that provides maps for EGNOS service area that depicts expected EGNOS Performance. It requires the following information:

- The day covered (within 96h of the present day at 00:00 UTC)
- The GPS constellation almanac
- The NANUs (Notice Advisory to Navstar Users) issued by the US Coast Guard at the USCG NAVCEN web site (https://www.navcen.uscg.gov/)
- RIMS health status
- Historic data about GPS sigmas broadcasted by EGNOS that are extrapolated to the forecasted days

The notable requirements are the need for error models, and the impact of RIMS health status into the service performance. These models may be estimated from historical data and the expected availability of the system, for example estimating the accuracy of the orbital error depending on the number of RIMS available. Estimation requires a deep knowledge of the system and its design.

Then, with these inputs, performances for a user grid over the EGNOS service area are computed and the following figures are depicted:

- EGNOS APV-I Availability: defined as the percentage of epochs for which the Protection Level is below the Alert Limit for the APV-I service (HPL<40m and VPL<50m) over the total period.
- Corresponding HPL and VPL for the Combined GEO satellite footprints.
- APV-I Availability delta map showing the predicted underperformance for the selected day with respect to the nominal system status.

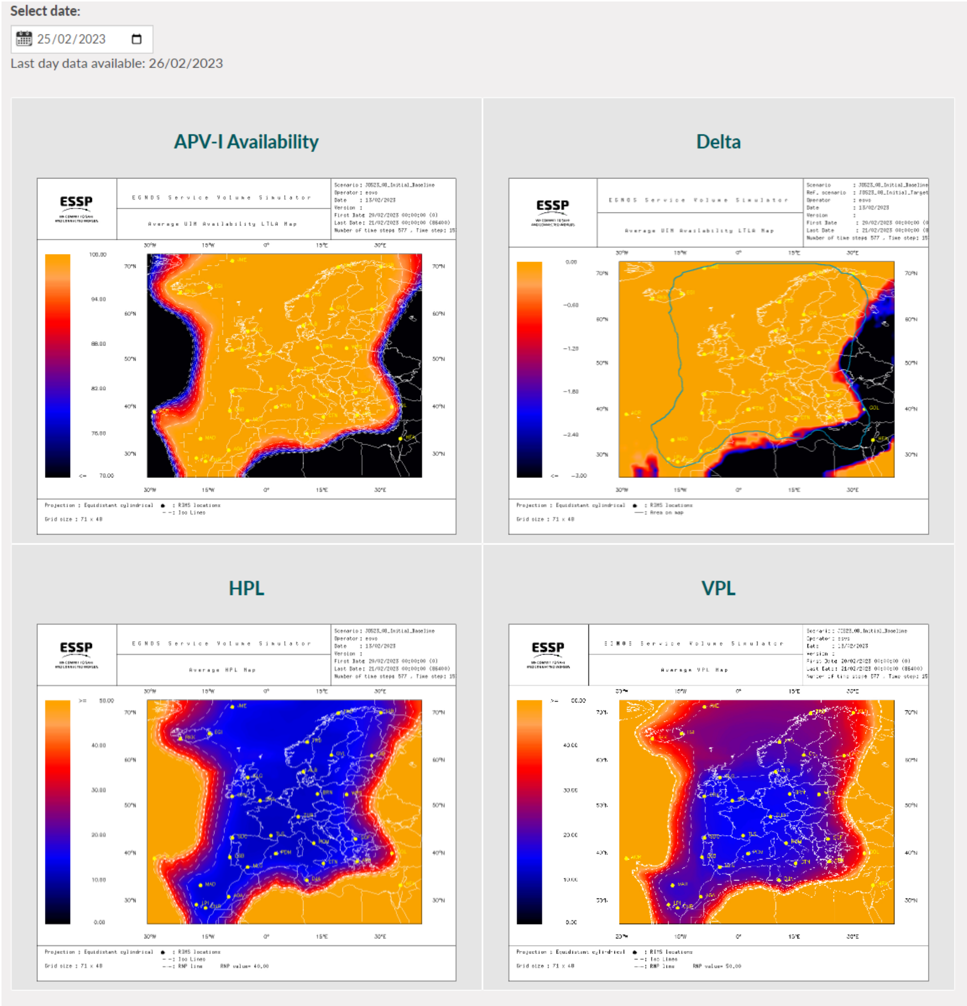


Figure 3-1. EGNOS Availability Forecast output example [RD.4]

The tool has the capability to compute the performance over an area, and this allows it to create these performance maps.

3.2 UK EGNOS Performance Coverage Tool Requirements

This tool shall operate in a very similar way to the EGNOS Availability Forecast but shall not operate using future dates – it will not provide a prediction of future performance, only the past achieved performance and the current status of the system.

3.2.1 Functional Requirements

FUN.PCT.001.

The tool shall be able to display EGNOS performance metrics for a variety Aviation approach category, Maritime navigation phases, and (as necessary) metrics for other EGNOS User Sectors, such as road or rail.

In practice, the INSPIRE project will only implement Ocean and Coastal navigation phases for the Maritime user.

FUN.PCT.002.

The tool shall function in two modes: Average Performance and Instant Performance.

FUN.PCT.003.

Operating in Instant Performance Mode the tool shall be able to provide the instantaneous status of EGNOS, as monitored from the UK. The performance metrics shown shall depend on the navigation phase selected, and shall be displayed as a map over a grid of user positions, these metrics shall include:

- Accuracy (horizontal).
- Availability status (as Boolean logic: true / false).
- Protection Levels (HPL).

Instant Performance Mode can also be configured to show the value of these performance metrics that were achieved by the system at any date in the past.

FUN.PCT.004.

Operating in Average Performance Mode the tool shall be able to provide the historical, cumulative performance that EGNOS has achieved, up to the current date. The performance metrics shall be displayed as a map over a grid of user positions, these metrics shall include:

- Average Accuracy (vertical and / or horizontal).
- Availability (the percent of all epochs for which instant availability is true).
- Average Protection Levels (HPL and / or VPL).
- Continuity (as a percent over the defined operational window)

It is suggested that the computation of cumulative performance figures is not performed "live" by the tool but is updated infrequently (for example once per month) and accessed from an archive when selected by the user.

FUN.PCT.005.

The tool shall be able to provide performance maps for any user location on the Earth's surface, although practically this will be constrained to Europe.

FUN.PCT.006.

The tool shall be able to allow the following configuration parameters:

- User grid definition.
- Selection of either Instant Performance, or Average Performance.
- Selection of User Segment and Approach Category.

The navigational phase (approach category for aviation users) determines what constitutes each epoch to be "Available": it defines the performance limits in terms of Accuracy, HPL (if applicable) or Geometry (if applicable).

3.2.2 Interface Requirements

INT.PCT.001.

The tool shall take as input the last available complete GNSS constellation ephemeris and last available complete set of active EGNOS data.

INT.PCT.002.

The tool shall take as input a historical record of GNSS constellation ephemerides, and EGNOS broadcast data.

INT.PCT.003.

The tool shall take into account the aforementioned User Segment / Approach Category configuration parameters.

INT.PCT.004.

The tool shall be able to provide, over a grid of user positions, the following information:

- Availability maps (Instant as binary yes / no, and Average as a percent)
- Continuity maps.
- PL size maps (Instant and Average)
- 95% Accuracy map (Instant and Average)

INT.PCT.005.

The tool shall be able also to provide the output information in plain text mode.

4 UK EGNOS PERFORMANCE COVERAGE TOOL

This section provides a high-level overview of the Performance Coverage Tool, including its main processing modules, inputs, and expected outputs. It also presents an overview of the experimentation plan for evaluating the prototype prediction tool and a summary of the functional testing results.

4.1 UK EGNOS Performance Coverage Tool Design

The prototype tool is based on the following main modules:

- **Monitor Node Location & Satellite visibility**: This module takes as input the configured location of the UK-based EGNOS monitor network, the GNSS constellation almanac, and the active set of EGNOS data. It computes the visibility of EGNOS-corrected GNSS satellites to the network, and EGNOS ionosphere grid points (IGPs) that would be employed by the monitor receivers. It returns a set of binary flags (monitored / not monitored) depending on whether each GNSS satellite, and each IGP is within visibility of the network.
- **User Location & Satellite visibility**: This module takes as input the desired user location (each point in the grid of user positions) and the GNSS constellation almanac, and the current set of EGNOS data, and the output from the Monitor Node module to compute GNSS satellite visibility, user solution geometry and EGNOS error models (UDRE and UIRE). Satellites and IGPs set as "not monitored" by the network are excluded from this calculation.
- **Error model computation**: This module considers the EGNOS broadcast errors, and operating procedures (local noise and multipath models) to compute the pseudo-range errors and weight matrix.
- **Performance Statistics & Availability Module**: These modules take the user geometry, and user error models and computes the performance metrics: Accuracy, Protection Level (if needed) and Geometric Screening terms (if needed). It is then determined whether the metrics achieved for the user meet the minimum requirements of the selected Approach Category (e.g., Accuracy, PL<AL, Geometry screening etc.)
- **Historic Analysis module (run intermittently)**: This module computes the time between service outages (epochs where availability==false) using historic availability data to compute a continuity percentage over the desired operational interval (e.g., 15 minutes). It also averages the historic Accuracy and PL values for each user location and determines the historic Availability as the percentage of epochs for which the service is available at the user's position.

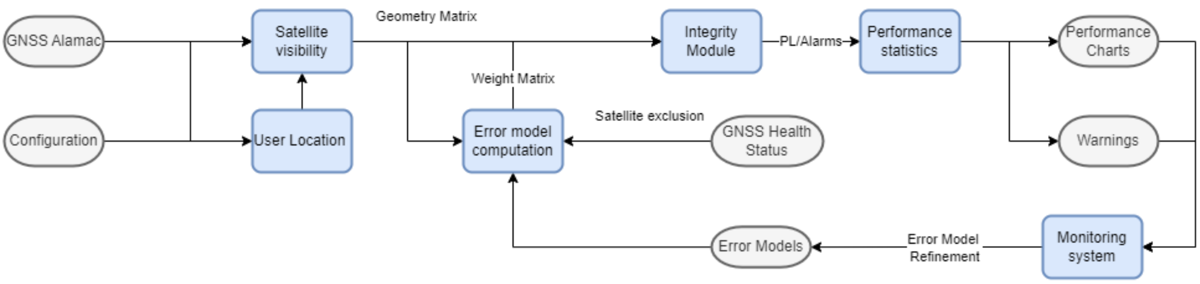


Figure 4-1. UK EGNOS Performance Coverage prototype tool

4.1.1 Inputs

The UK EGNOS Performance Coverage Tool requires the following inputs:

- **Configuration**: The tool considers the following configuration parameters:
  - User location / User grid definition
  - Date (if not the current date)

- Approach Category (Navigational Phase)
- Selection of either Instantaneous Performance or Historic Performance.

- **GNSS almanac**: The tool requires the GNSS constellation ephemeris for the time epoch in question. These ephemeris in an operational tool will be obtained from the monitor network, compared across all receivers and collated to remove missing data, or data corrupted by reception errors. However, in this prototype the almanac will be obtained from a navigation RINEX file or a plain text file with the satellite orbital information.
- **EGNOS data**: The tool requires the active set of EGNOS correction and error data for the time epoch in question. These ephemeris in an operational tool will be obtained from the monitor network, compared across all receivers and collated to remove missing data, or data corrupted by reception errors. However, in this prototype the data will be obtained from an EGNOS data file or a plain text file containing the EGNOS data.
- **Monitor Health Status**: The operational tool should take as input the current alarm status from each monitor receiver. However, in this prototype it shall be assumed that the alarm status of all monitor receivers is clear (False Alarm by design is negligible, and an alarm indicates a catastrophic failure of EGNOS integrity, which should not happen).
- **Error models**: Finally, a model of errors local to the user (noise and multipath) are needed for each User Segment. These will need to be defined for non-aviation users. In the prototype tool this function will be performed by adopting either the standard SBAS aviation models, or the maritime model developed under SEASOLAS.

4.1.2 Processing

The UK EGNOS Performance Coverage Tool should perform the following high-level functions:

4.1.2.1 Monitor Node Location & Visibility

This module takes as input the configured location of the UK-based EGNOS monitor network, the GNSS constellation almanac, and the active set of EGNOS data. It computes the visibility of EGNOS-corrected GNSS satellites to the network and EGNOS ionosphere grid points (IGPs) that would be employed by the monitor receivers. It returns a set of binary flags (monitored / not monitored) depending on whether each GNSS satellite and each IGP is within visibility of the network.

- **Inputs**:
    - Monitor Node Locations: These will be pre-configured and fixed based on the location of the monitor receivers in the network. For the prototype tool, nominal locations based on UK lighthouses (former DGPS beacons) have been proposed, and these locations will be used.
    - Date and time: If different from the current epoch. Note that the prototype tool is strictly an analysis tool for past EGNOS performance data and is not a prediction service for future epochs.
    - GNSS almanac: Orbital parameters of the GNSS satellites are required to estimate the satellite locations for the desired time.
    - Active EGNOS data: These are needed to determine which GNSS satellites are being corrected by EGNOS, and which IGPs are active.
- **Processing**:

The input information should be handled according to the following steps:

- Satellite orbital information is decoded and satellite position, of every satellite configured, is propagated to the configured time epoch. Satellite position shall be computed in an Earth Centred Earth Fixed (ECEF) reference frame.
- The following steps shall be performed per Monitor Node configured:
  - Receiver location is converted from coordinates (lat, lon, h) into an ECEF xyz vector.
  - Rotation matrix ECEF<->ENU/NED reference is computed for the receiver location.
  - The relative satellite position from the user's point of view is computed in ECEF reference frame, and then is converted into ENU/NED.
  - Satellite azimuth and elevation are then computed, and elevation mask exclusion is applied to identify visible satellites.
  - The EGNOS data is applied, as per the receiver MOPS to determine which of the visible satellites are currently "healthy", and which IGPs will be interpolated to determine an ionosphere correction for each line of sight to each healthy satellite.
  - A set of logical (true / false) flags are then determined, indicating which of the GNSS satellites, and which of the EGNOS active IGPs are monitored by each network node.
- The set of logical flags is then collated using a logical OR operator (if any satellite or IGP is monitored, by any node, then this is sufficient to consider it usable).

■ **Outputs**:

- One set of Boolean true / false flags indicating which EGNOS-corrected GNSS satellites, and which EGNOS IGPs in the active mask are being monitored by the UK network.

4.1.2.2 User Location & Satellite visibility

This module takes as input the desired user location (each point in the grid of user positions) and the GNSS constellation almanac, and the current set of EGNOS data, and the output from the Monitor Node module to compute GNSS satellite visibility, user solution geometry and EGNOS error models (UDRE and UIRE).

■ **Inputs**:

- User Location: Each point in the grid of defined positions is used.
- Date and time: If different from the current epoch.
- GNSS almanac: Orbital parameters of the GNSS satellites are required to estimate the satellite locations for the desired time.
- Active EGNOS data: These are needed to determine which GNSS satellites are being corrected by EGNOS, which IGPs are active, and the broadcast error data (UDRE, GIVE, and inflation parameters) for the corresponding satellites and grid points.
- The output from the Monitor Node Location & Visibility module: This is the set of logical (true / false) flags indicating which of the GNSS satellites, and which of the IGPs are currently monitored by the UK network.

■ **Processing**:

The input information should be handled according to the following steps:

- Satellite orbital information is decoded and satellite position, of every satellite configured, is propagated to the configured time epoch. Satellite position shall be computed in an Earth Centred Earth Fixed (ECEF) reference frame.
- The following steps shall be performed per User Location configured:

- User location is converted from coordinates (lat, lon, h) into an ECEF xyz vector.
- Rotation matrix ECEF<->ENU/NED reference is computed for the user location.
- The relative satellite position from the user's point of view is computed in ECEF reference frame, and then is converted into ENU/NED.
- Satellite azimuth and elevation are then computed, and elevation mask exclusion is applied to identify visible satellites.
- The set of monitored / not-monitored flags generated by the Monitor Node Visibility module are applied, any GNSS satellites or IGP values that are "not monitored" are excluded at this step.
- EGNOS data is applied as per the receiver MOPS to determine which of the remaining visible satellites are currently "healthy", which monitored IGPs will be interpolated to determine an ionosphere correction for each line of sight, and to determine the range error at the user (sigma-UIRE, sigma-flt).

- **Outputs**:
  - The satellite geometry for each user location: azimuths and elevation angles. Also the EGNOS error data for the monitored GNSS satellites: User Iono Range Error (sigma-UIRE) and Fast-&-Long-Term correction to the range error (sigma-flt).

4.1.2.3 Error model computation

This module considers the EGNOS broadcast errors, and operating procedures (local noise and multipath models) to compute the pseudo-range errors and weight matrix.

- **Inputs**:
  - Satellite relative positioning: Azimuth and Elevation.
  - Configured Error models: Either the standard aviation MOPS models for noise and multi-path, or sector specific models for non-aviation users (yet to be defined).
  - EGNOS Error Models: As per the MOPS.
  - EGNOS Messages: SBAS solution.
- **Processing**:

The input information should be handled according to the following steps:

  - The following steps shall be performed per user:
    - Configured Error models are applied to each visible satellite measurement, depending on satellite elevation. One range error model is obtained per line of sight.
- **Outputs**:
  - One range error value per user, per line of sight.

4.1.2.4 Performance Statistics

This takes the user geometry, and user error models and computes the performance metrics: Accuracy, Protection Level (if needed) and Geometric Screening terms (if needed).

- **Inputs**:
  - Geometry: Satellite azimuth and elevation for each satellite, and each user position.
  - Range Error: One range error value per user, per line of sight

- Approach Category Requirements: These are the minimum navigational requirements for the configured phase of navigation for the selected User Sector.
  - Accuracy: A maximum allowable 95% Accuracy, either in the horizontal and / or vertical domain may apply.
  - Alert Limit: Again, a vertical (VAL) or horizontal (HAL) limit may apply, depending on the configured phase of navigation.
  - Geometry: some availability metrics (MG-RAIM Geometry Screening) may stipulate geometric terms to compute user position and / or RAIM availability.

- **Processing**: the input information should be handled according to the following steps:
  - For the maritime user MRAIM or MGRAIM processing is performed according to the detailed information contained in D2.1 and D3.1 [RD.1][RD.2].
  - For the non-maritime user, the prototype tool is not required to compute performance metrics.
- **Outputs**:
  - Protection Level (if applicable): Depending on the phase of navigation, and the type of RAIM algorithm applied.
  - Accuracy Level: An estimate of the 95% fault-free Accuracy performance.
  - Availability (yes / no). A logical Boolean true / false value per user location is defined which indicates whether adequate performance metrics were computed for the navigational phase in question.

4.1.2.5 Historical Analysis (Performed Intermittently)

This module computes the historical performance of UK-monitored EGNOS over a given time-period. This can be the preceding month, or since the start of monitoring.

The process will be processor intensive and so should be run intermittently, with the results archived, and retrieved to display to the user if requested.

Effectively, this module applies all of the above processing, over an extended period of time, using a historical archive of GNSS constellation ephemerides, and EGNOS data. For each epoch in the simulation, the resulting Outputs from the Performance Statistics module (PL, Accuracy, Availability flags) can be archived so that this processing does not need to be run a second time. It is suggested that new archive epochs should correspond to each new issue of data (IOD) field, every time the active set of EGNOS data is updated.

For simplicity, the functional description of this module will not re-iterate the above processing but shall assume an archive of Performance Statistics is available.

- **Inputs**:
  - Time period: Can either be this month (cumulative to date), and previous month (selected from a calendar), or an all-time analysis since the system's inception.
  - Archived Accuracy: A series of Accuracy maps, output from the Performance Statistics module, run for each epoch of the computation.
  - Archived Protection Levels: A series of PL maps, output from the Performance Statistics module, run for each epoch of the computation.
  - Archived Availability: A series of maps of logical (true / false) Availability flags, output from the Performance Statistics module, run for each epoch of the computation.
- **Processing**:

For each user position, the input information should be handled according to the following steps:

- The Accuracy data is averaged over each epoch.
- The Protection Level data is averaged over each epoch.
- The percentage of epochs for which Availability is true is computed.
- The time between outages (when Availability switches from true to false) is computed and averaged. A Continuity value is computed according to:

$$C = 1 - \frac{MTBF}{CTI}$$

MTBF is the mean time between failures – effectively the average of all outage intervals computed. If no outages are observed for a user location, this is zero.

CTI is the Continuity Time Interval and depends on the approach category or navigational phase. For the maritime user this is 15 minutes.

- **Outputs**:
  - Average Protection Level (if applicable)
  - Average Accuracy Level
  - Computed Availability as a percentage
  - Computed Continuity as a percentage

4.1.3 Outputs

Finally, the UK EGNOS Performance Coverage Tool provides the following outputs:

- **Performance charts**:
  - The tool (in Instant Performance Mode) provides maps of:
    - PL size (if appropriate)
    - Expected 95% Accuracy performance
    - Availability as a logical yes / no.
  - The tool (in Average Performance Mode) provides maps of:
    - Average PL size (if appropriate)
    - Average Accuracy performance
    - Availability as a percentage.
    - Continuity performance as a percentage.

  Please note that an operational tool may provide this information via a web interface or a devoted report in, for example, pdf format. However, these charts are provided by the prototype tool in as independent images.

- **Other outputs**: Finally, the tool also provides the output information in plain text mode.

4.2 UK EGNOS Performance Coverage Prototype Tool Test Specification

This section contains the test cases for the INSPIRe UK EGNOS Performance Coverage Prototype Tool described in this document. The following test specification describes which tests are to be executed and provide a high-level description of the purpose of the test along with required data and test tools.

Table 4-1 below identifies a set of test cases proposed. To demonstrate that the UK EGNOS Performance Coverage Prototype Tool is compliant with its functional and interface requirements, it is necessary to provide a trace of the system requirements in the test activities. Each requirement will be traced to the test that verifies it.

Each test case will be defined based on the following format:

- **TC** - Prefix to indicate this is a Test Case Identifier.
- **[Function]** - is the name of the software component under testing.
- **[ID#] -** sequential numbering for each case.

Table 4-1. MGRAIM Functional Test Specification

Test Case ID	Objective/Test sets	Description	Success Criteria	Traceability Requirements
TC.PCT.001	To check that files are read, and a solution is generated as expected	Execution of the Performance Coverage Prototype tool using a nominal configuration which includes: ▪ Single user selection ▪ Forecast for the following day (24h) ▪ GPS + Galileo ▪ Nominal error models configured for Dual Frequency mode. ▪ Nominal error models configured for Single Frequency mode. ▪ Coastal navigation	The tool shall be able to provide for the 24h selected: ▪ Satellite visibility information ▪ Expected service outages. ▪ PL size ▪ Foreseen alarms ▪ Warnings to those users when the expected performances are not suitable. ▪ Output information in plain text mode	FUN.PCT.001 FUN.PCT.005 INT.PCT.001 INT.PCT.004 INT.PCT.005 INT.PCT.007 INT.PCT.008
TC.PCT.002	To check that tool can provide a forecast for at least 72h	Same configuration as TC.PCT.001 but the forecast is selected for the following 72h	The tool shall be able to provide for the 72h selected the same output as TC.PCT.001	FUN.PCT.001 FUN.PCT.002 FUN.PCT.005 INT.PCT.004
TC.PCT.003	To check that tool is able to provide a forecast for the past days	Same configuration as TC.PCT.001 but the forecast is selected for longer than 1 week before the test.	The tool shall be able to provide for the 24h selected the same output as TC.PCT.001	FUN.PCT.001 FUN.PCT.004 FUN.PCT.005 INT.PCT.001 INT.PCT.004 INT.PCT.005 INT.PCT.007 INT.PCT.008

TC.PCT.004	To check that tool is able to provide a forecast of every surface constrain to ENP (Extended Europe and North Africa) area	Same configuration as TC.PCT.001 but a grid of users is selected to cover the European area and the UK area	The tool shall be able to provide for the 24h selected: ▪ Availability maps ▪ PL size maps ▪ Continuity maps ▪ Foreseen alarms for a given area ▪ Warnings to those users when the expected performances are not suitable ▪ Output information in plain text mode	FUN.PCT.001 FUN.PCT.003 FUN.PCT.005 INT.PCT.004 INT.PCT.006 INT.PCT.007 INT.PCT.008
TC.PCT.005	To check that tool is able to provide a forecast excluding satellites from NANUs, NAGUs or equivalent	Same configuration as TC.PCT.001 and provide a synthetic NANUs and NAGUs message excluding one satellite in each constellation	The tool shall be able to provide for the 24h selected the same output as TC.PCT.001 excluding the two satellites considered	FUN.PCT.001 INT.PCT.001 INT.PCT.002
TC.PCT.006	To check that tool is able to provide a forecast considering augmentation system information	Same configuration as TC.PCT.001 but: ▪ Single-frequency error models ▪ GPS only constellation including SBAS L1 (EGNOS) messages	The tool shall be able to provide for the 24h selected the same output as TC.PCT.001 taking into account Satellite integrity and error characterisation information	FUN.PCT.001 INT.PCT.001 INT.PCT.003
TC.PCT.007	To check that tool is able to provide a forecast considering augmentation system information	Same configuration as TC.PCT.001 including SBAS DFMC messages ▪ Dual-frequency error models	The tool shall be able to provide for the 24h selected the same output as TC.PCT.001 taking into account Satellite integrity and error characterisation information	FUN.PCT.001 INT.PCT.001 INT.PCT.003

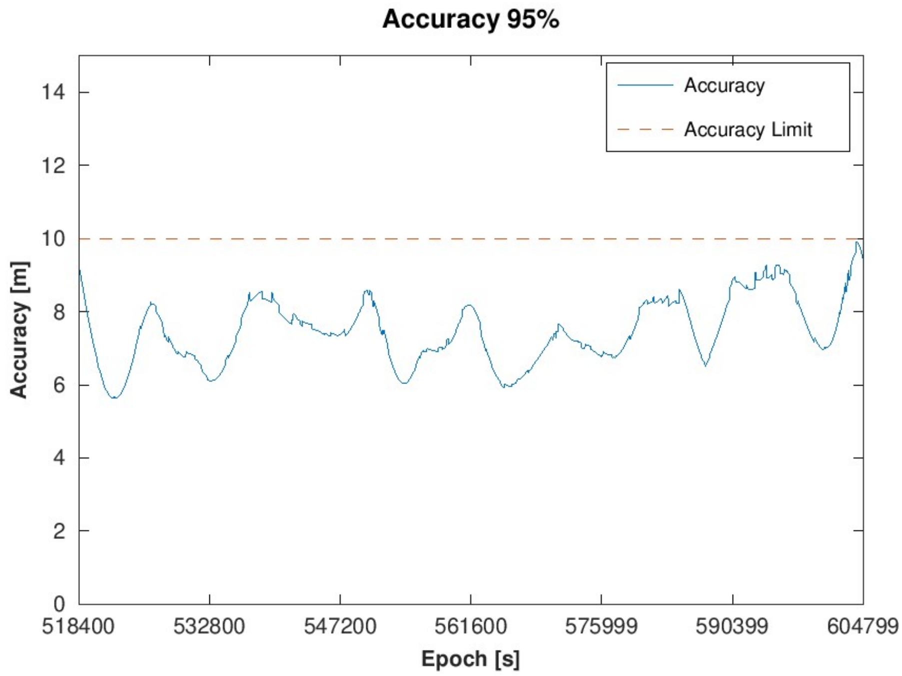
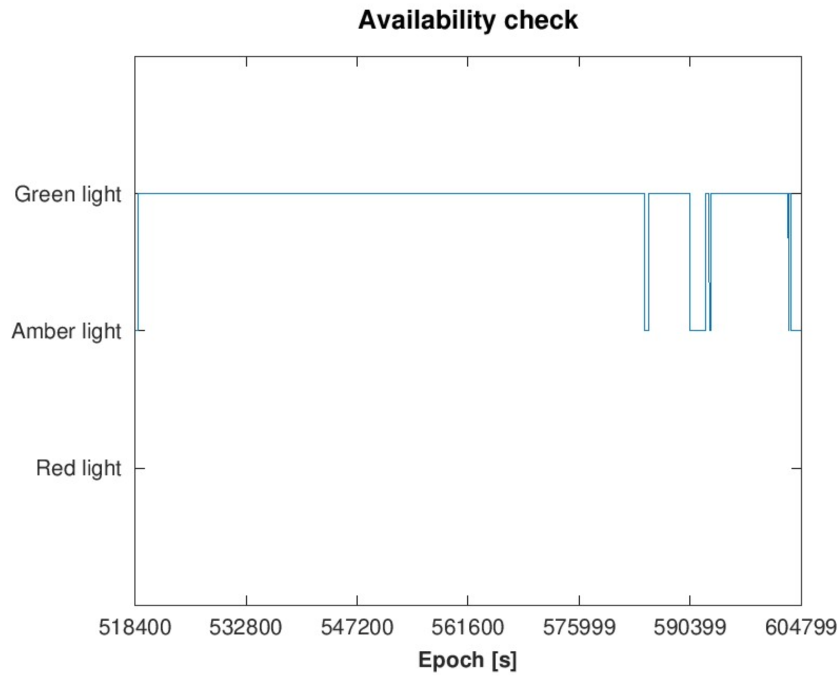
TC.PCT.008	To check that tool is able to provide a forecast considering augmentation system information	Same configuration as TC.PCT.001 but: ▪ Single-frequency error models ▪ GPS only constellation including SBAS L1 (UK SBAS) messages	The tool shall be able to provide for the 24h selected the same output as TC.PCT.001 taking into account Satellite integrity and error characterisation information	FUN.PCT.001 INT.PCT.001 INT.PCT.003
TC.PCT.009	To check that tool is able to provide a forecast for different navigation phase	Same configuration as TC.PCT.001 for Port navigation phase	The tool shall be able to provide for the 24h selected the same output as TC.PCT.001 with much less alarms, due to the less demanding navigation phase	FUN.PCT.001 FUN.PCT.005 INT.PCT.001 INT.PCT.004 INT.PCT.005 INT.PCT.007 INT.PCT.008
TC.PCT.010	To check that tool is able to provide a forecast considering different frequencies of usage	Same configuration as TC.PCT.001 but: ▪ Single-frequency error models ▪ GPS only constellation	The tool shall be able to provide for the 24h selected the same output as TC.PCT.001 taking into account error models for Single frequency cases and only GPS constellation	FUN.PCT.001 FUN.PCT.005 INT.PCT.001 INT.PCT.004 INT.PCT.005 INT.PCT.007 INT.PCT.008

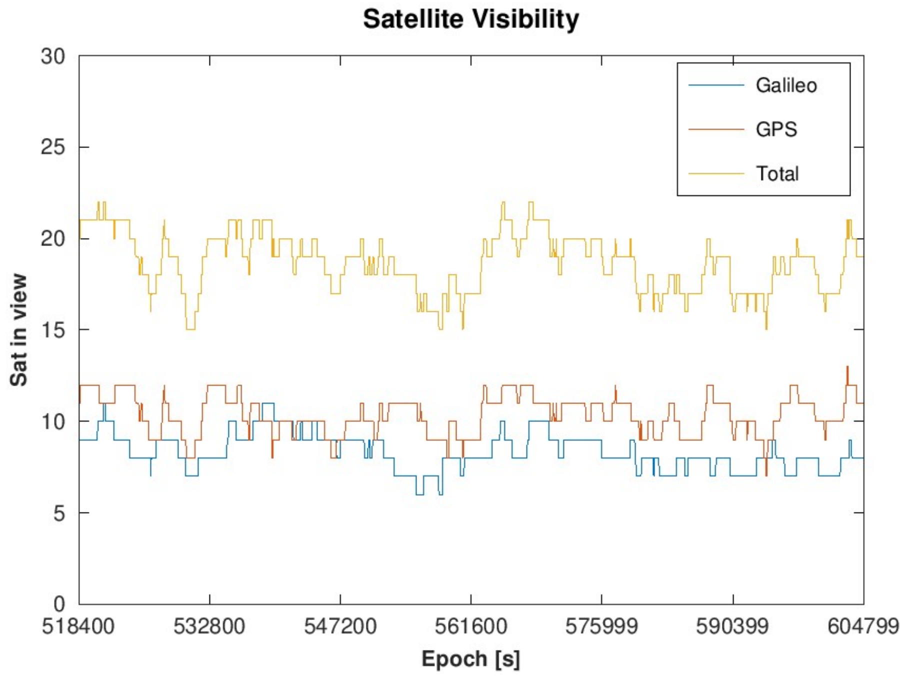
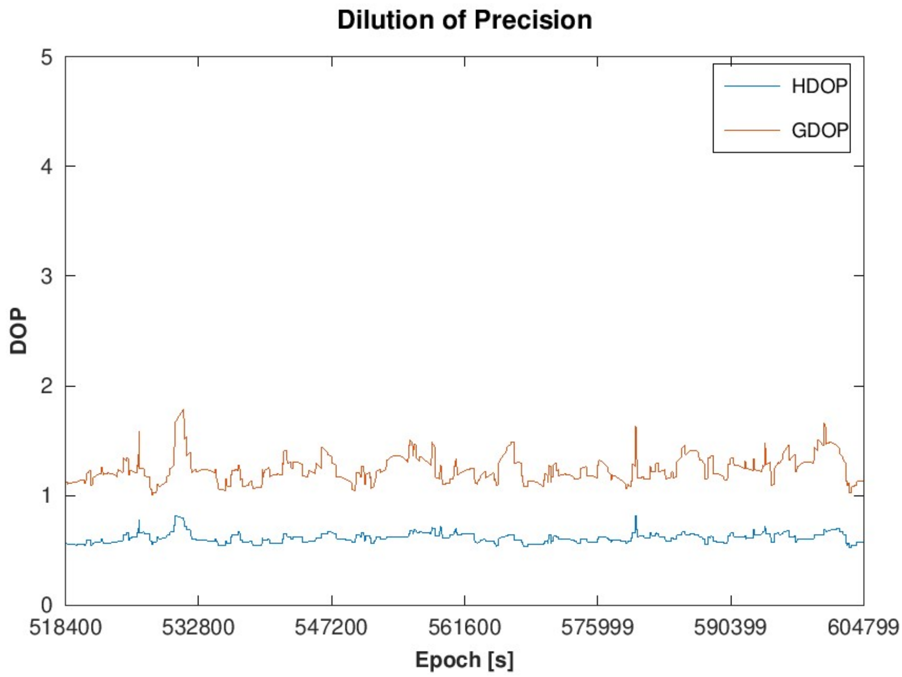
5 VALIDATION RESULTS

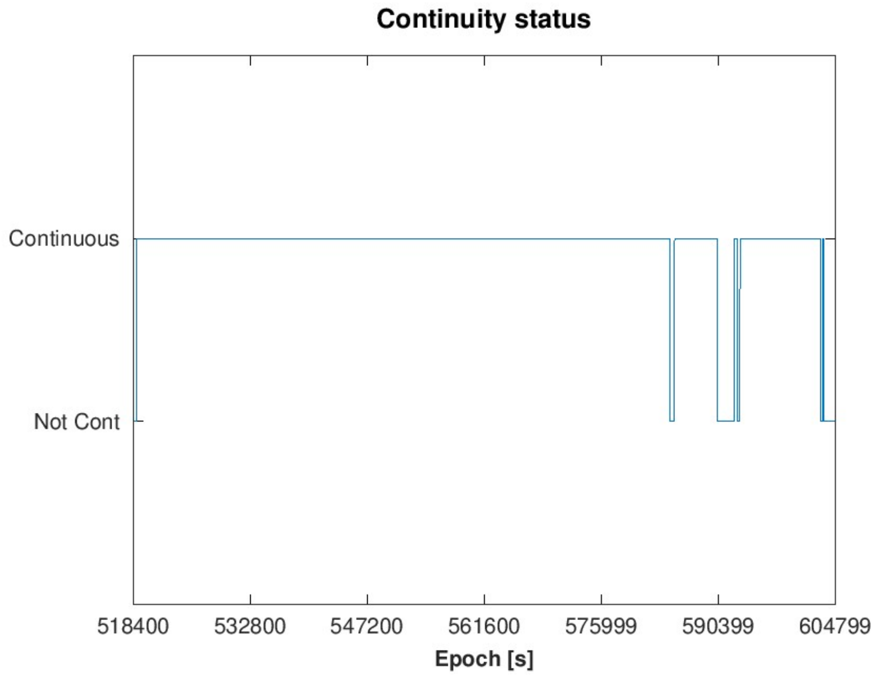
This section will contain the validation results from the verification and validation plan detailed in the previous section.

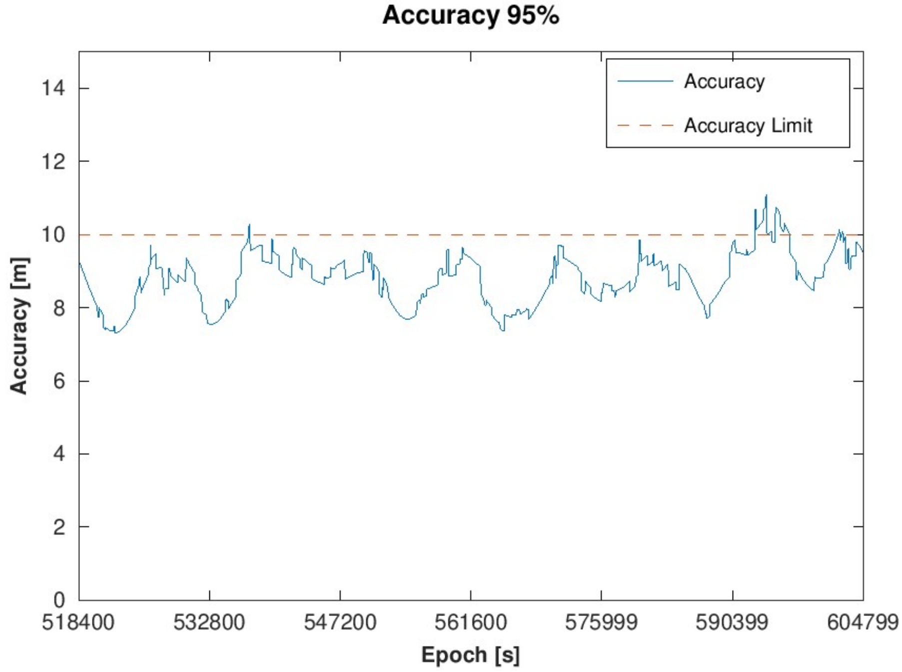
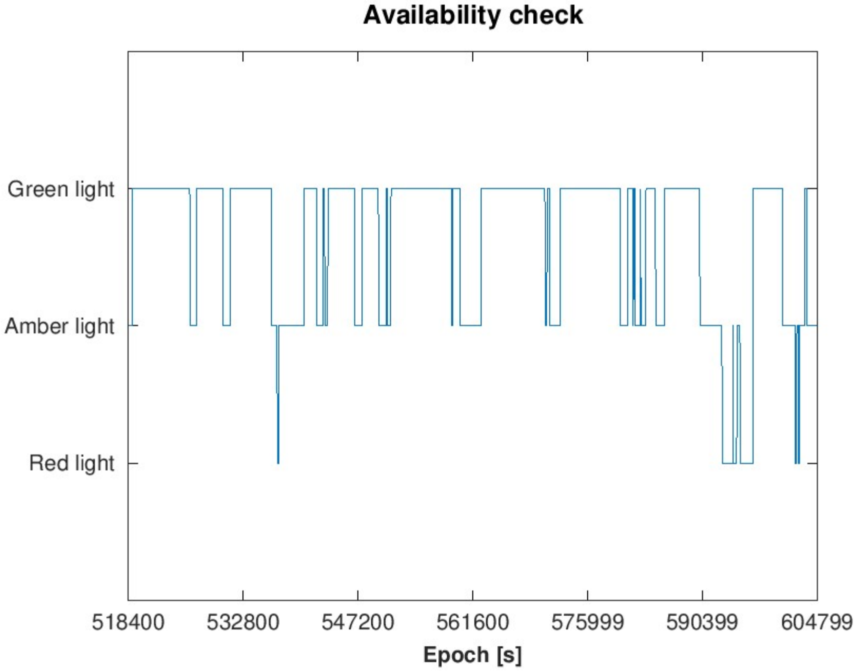
5.1 TC.MPT.001

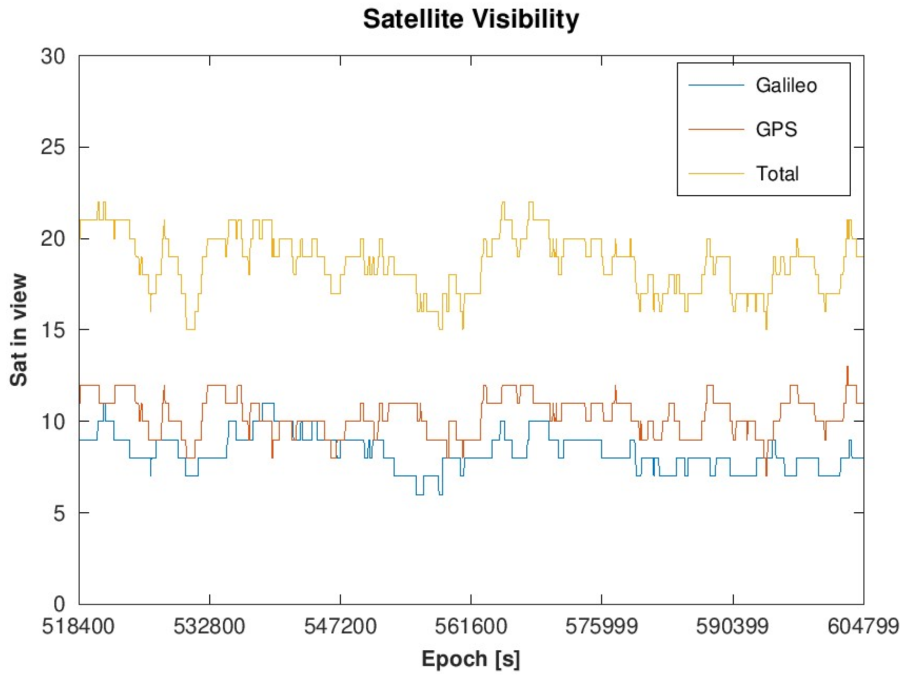
<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.001 MGRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period. Dual Frequency Multiconstellation (GPS+Galileo) and Single Frequency Multiconstellation (GPS+Galileo) scenarios studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 50 s time step
Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
▪ MGRAIM algorithm selection
▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59
▪ GPS + Galileo
▪ Nominal error models configurable. Dual Frequency error model applied [RD.2]
▪ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">▪ The tool shall decode, process the information and provide accuracy 95% results in the range of [5-10]m for the Dual frequency configuration and [7-12]m for the Single frequency configuration
▪ The tool shall decode, process the information and provide traffic light status along the scenario
▪ The tool shall decode, process the information and provide satellite visibility along the scenario
▪ The tool shall decode, process the information and provide Dilution of precision along the scenario
▪ The tool shall decode, process the information and provide continuity along the scenario
▪ The tool shall provide the outputs in plain text mode</td></tr>
<tr><td>Outcome (Pass/Fail)</td><td colspan="3">PASS</td></tr>
<tr><td>Results</td><td colspan="3">The tool decodes and processes the information, giving Accuracy 95% values between the range previously mentioned.</td></tr>
</table>

	 The tool provides an output of traffic light for the whole scenario. Considering that the Accuracy threshold is 10 meters in coastal navigation, the following results are obtained.  The tool decodes, processes the information, and provides satellite visibility across the scenario.

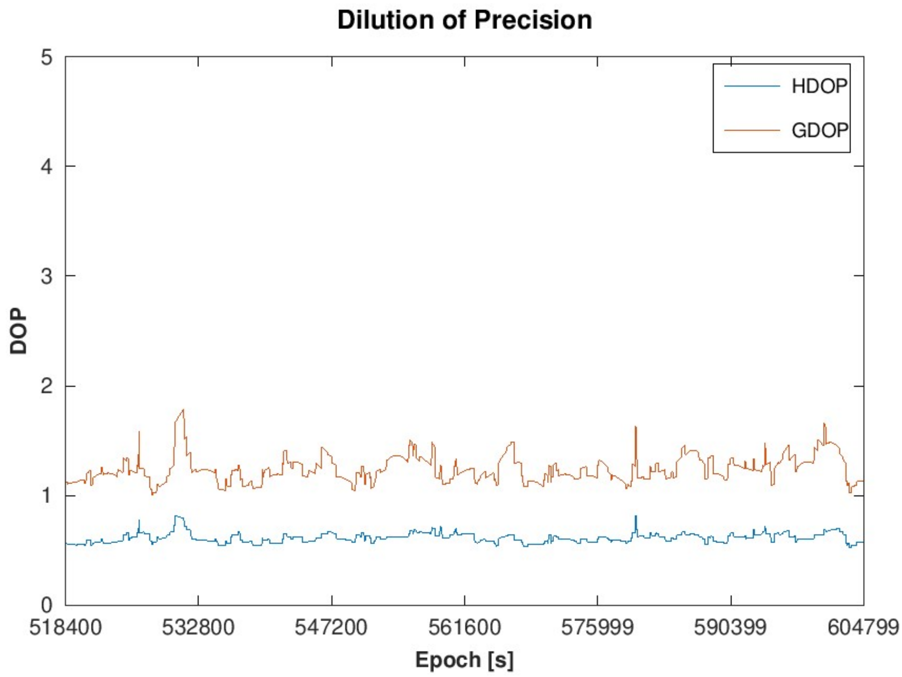
	 The tool decodes, processes the information, and provides dilution of precision across the scenario.  The tool decodes, processes the information, and provides system continuity status across the scenario.

	 The tool provides the outputs in plain text mode:  simulation_data_
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MGRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ■ GPS + Galileo ■ Nominal error models configurable. *Single Frequency error model applied [RD.2]* ■ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m
Outcome criteria	■ The tool shall decode, process the information and provide accuracy 95% results in the range of [5-7]m for the configuration selected ■ The tool shall decode, process the information and provide traffic light status along the scenario ■ The tool shall decode, process the information and provide satellite visibility along the scenario ■ The tool shall decode, process the information and provide Dilution of precision along the scenario ■ The tool shall decode, process the information and provide continuity along the scenario ■ The tool shall provide the outputs in plain text mode
	PASS
Outcome (Pass/Fail) **Results**	The tool decodes and processes the information, giving Accuracy 95% values between the range previously mentioned.

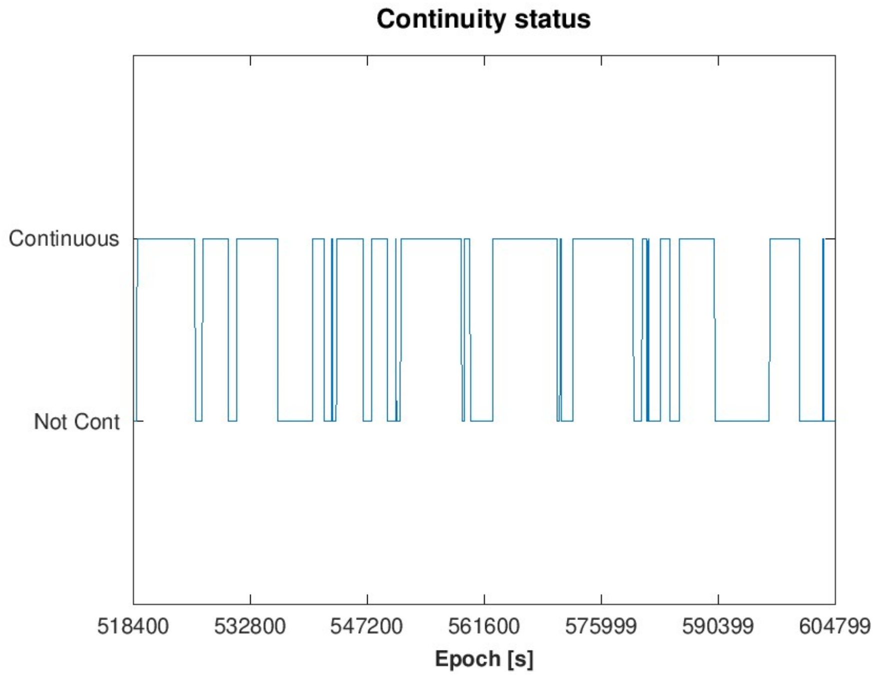
	 The tool provides an output of traffic light for the whole scenario. Considering that the Accuracy threshold is 10 meters in coastal navigation, the following results are obtained.  The tool decodes, processes the information, and provides satellite visibility across the scenario.

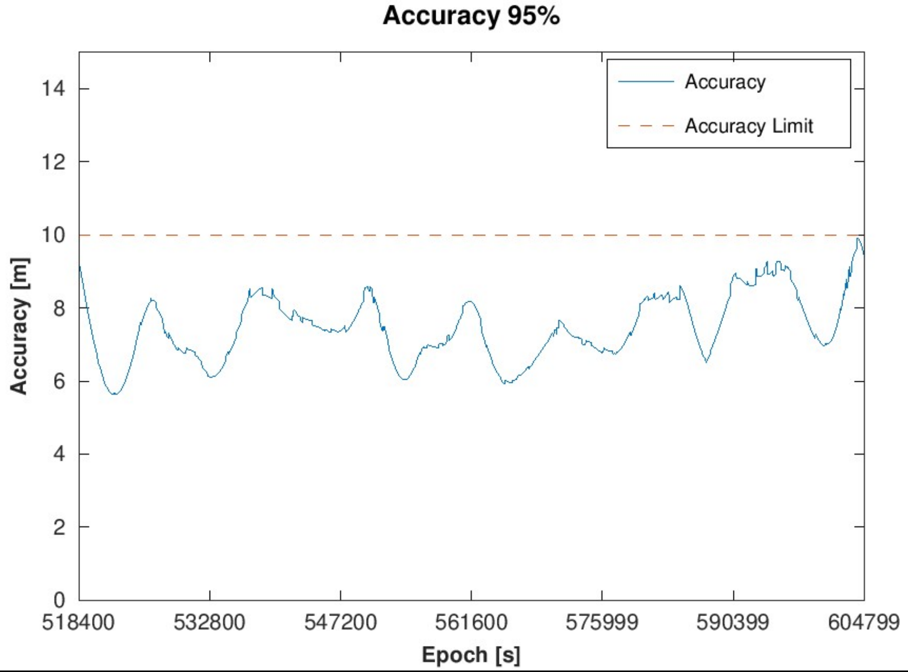


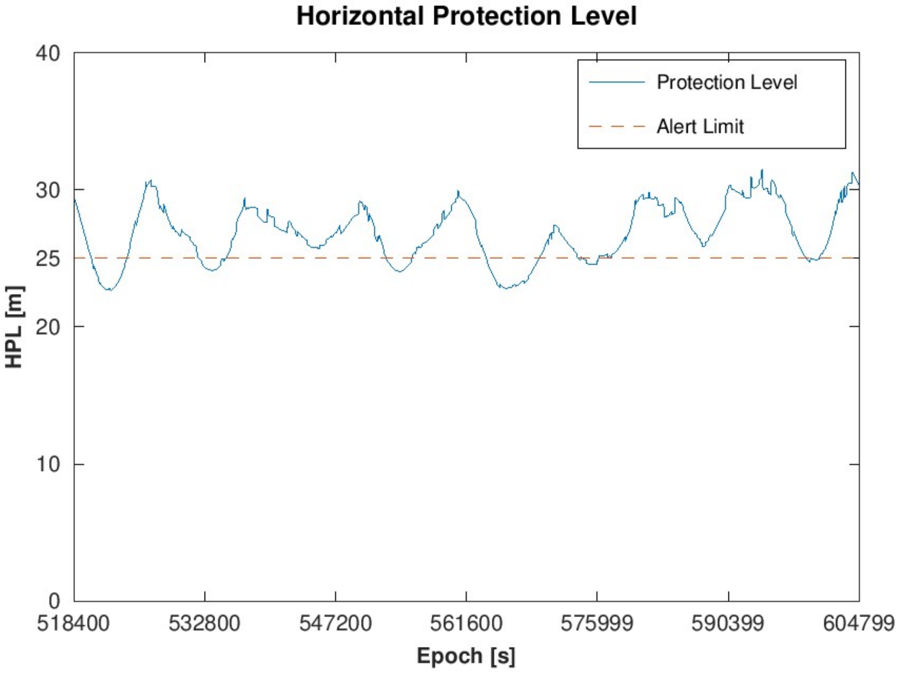
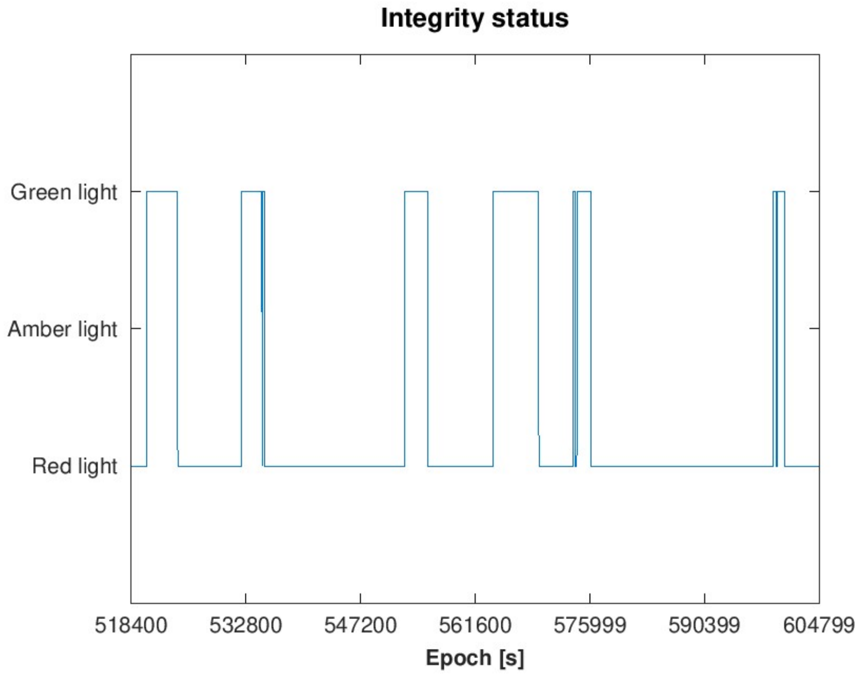
The tool decodes, processes the information, and provides dilution of precision across the scenario.

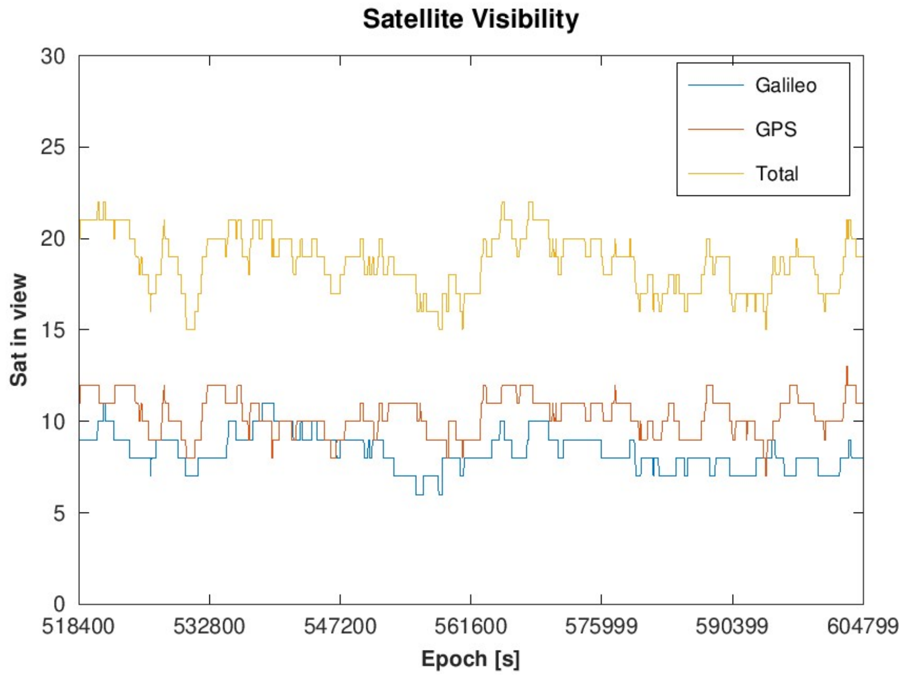


The tool decodes, processes the information, and provides continuity status across the scenario.

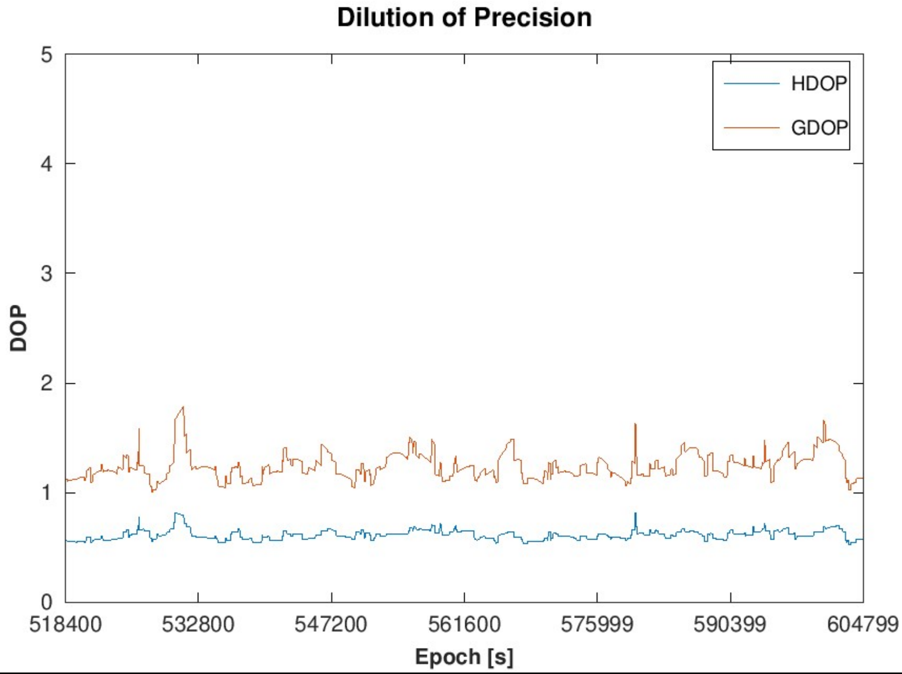
	 The tool provides the outputs in plain text mode: simulation_data_

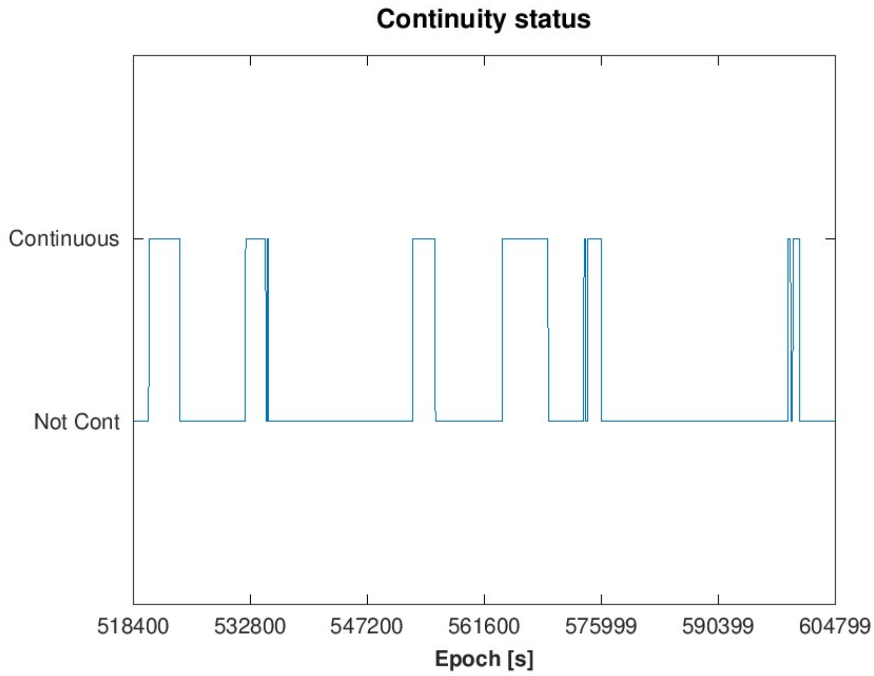
Test Code	TC.MPT.001 MRAIM		
Test Objective	To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period. Dual Frequency Multiconstellation (GPS+Galileo) and Single Frequency Multiconstellation (GPS+Galileo) scenarios studied for Coastal navigation.		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation	GPS, Galileo		
Duration Time	The execution: 50 s timestep Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	Galileo ephemerides GPS ephemerides		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ■ GPS + Galileo ■ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ■ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m		
Outcome criteria	■ The tool shall decode, process the information and provide Accuracy 95% results in the range of [8-15]m for the configuration selected ■ The tool shall decode, process the information and provide HPL results in the range of [20-35]m for the configuration selected ■ The tool shall decode, process the information and provide traffic light status along the scenario ■ The tool shall decode, process the information and provide satellite visibility along the scenario ■ The tool shall decode, process the information and provide dilution of precision along the scenario ■ The tool shall decode, process the information and provide continuity status along the scenario ■ The tool shall provide the outputs in plain text mode		
Outcome (Pass/Fail) **Results**	**PASS** The tool decodes and processes the information, giving Accuracy 95% values of Accuracy between the range previously mentioned. 		

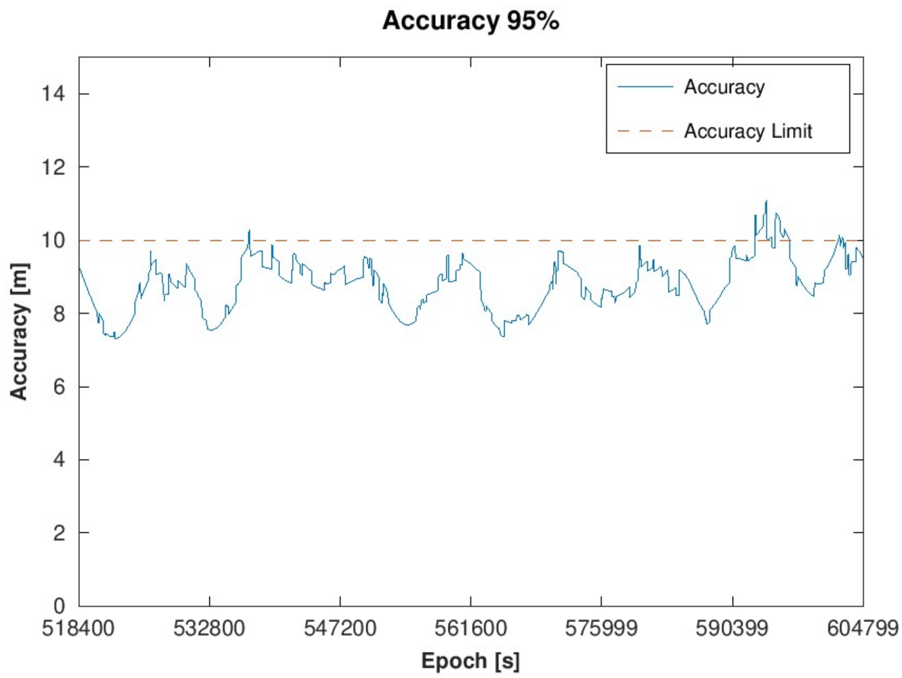
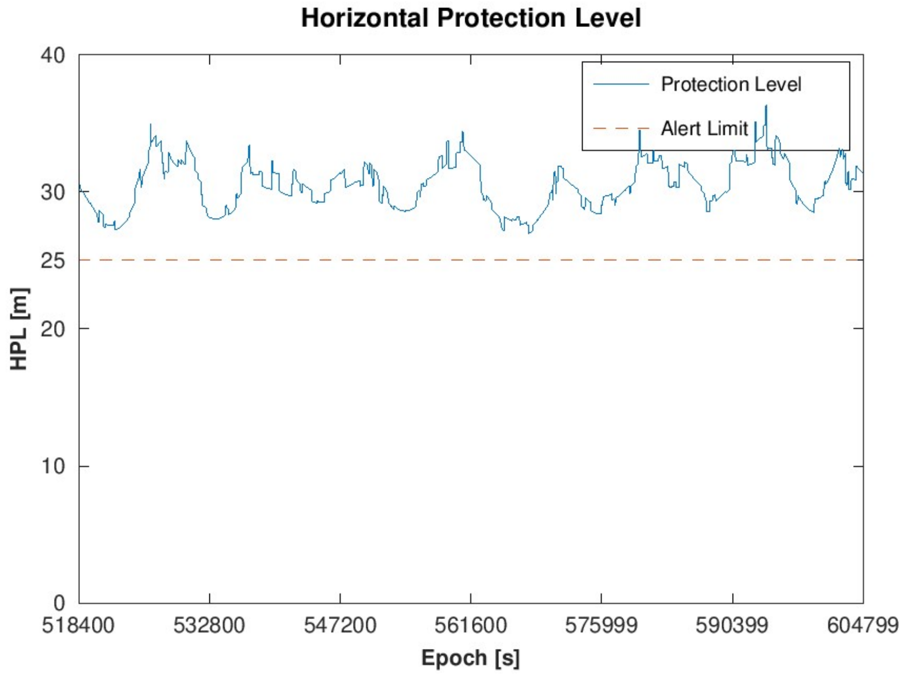
	The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m. The tool decodes and processes the information, giving Accuracy 95% values of Horizontal protection levels between the range previously mentioned.  The tool provides an output of traffic light for the whole scenario. Considering that the Alert Limit is 25 meters in coastal navigation, the following results are obtained.  The tool decodes, processes the information, and provides satellite visibility across the scenario.

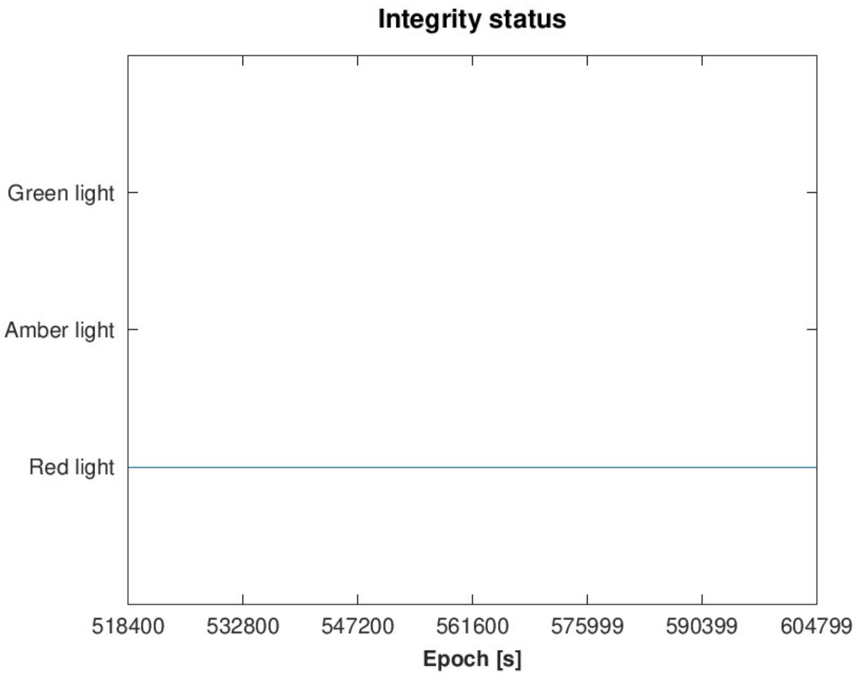
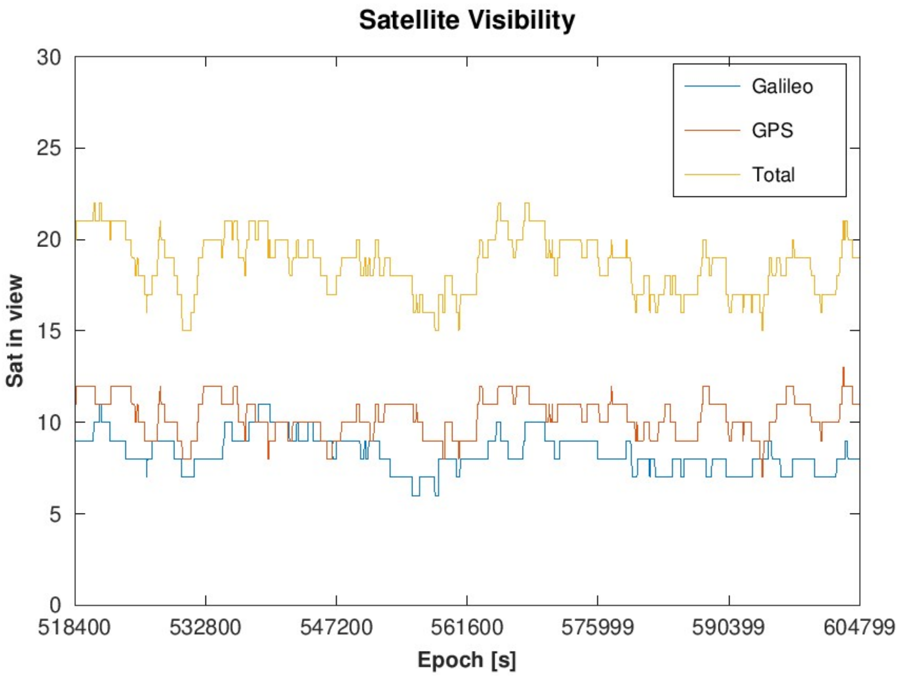


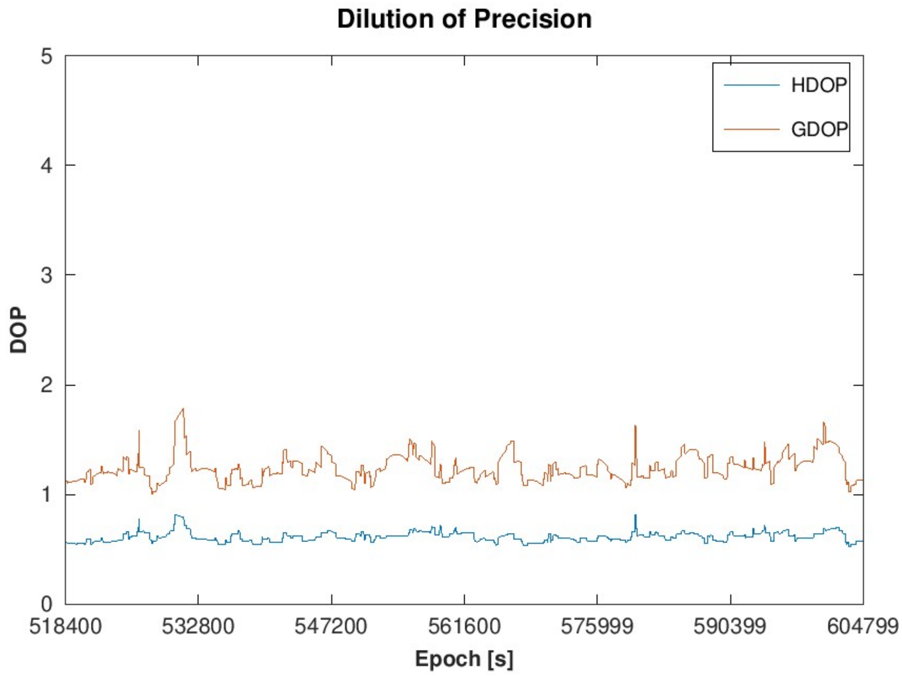
The tool decodes, processes the information HDOP and GDOP.



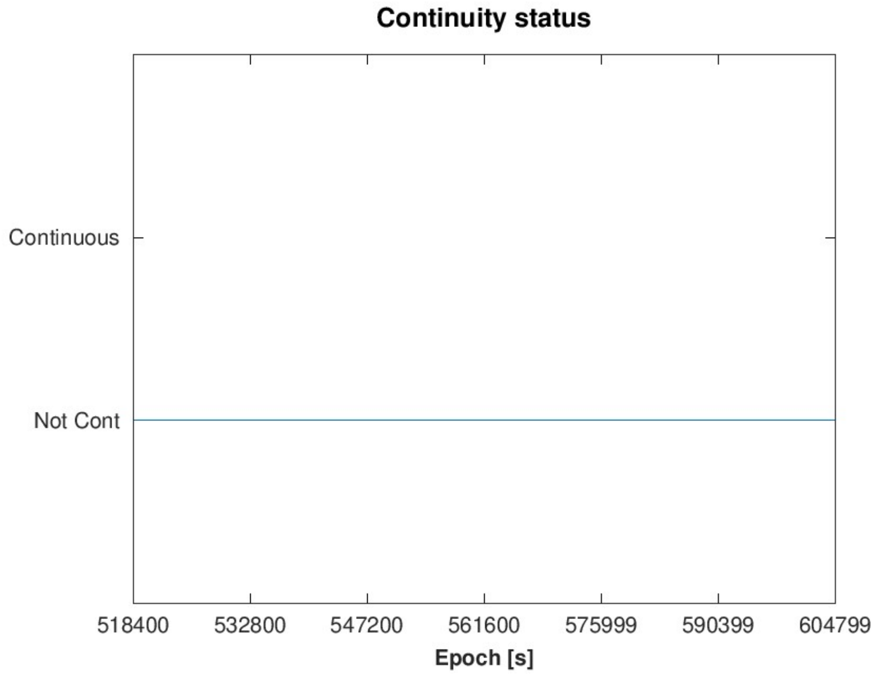
	The tool decodes, processes the information, and provides system continuity status across the scenario.  The tool provides the outputs in plain text mode: 
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ■ GPS + Galileo ■ Nominal error models configurable. *Single Frequency error model applied [RD.2]* ■ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m
Outcome criteria	■ The tool shall decode, process the information and provide Accuracy 95% results in the range of [5-15]m for the configuration selected ■ The tool shall decode, process the information and provide HPL results in the range of [5-15]m for the configuration selected ■ The tool shall decode, process the information and provide traffic light status along the scenario ■ The tool shall decode, process the information and provide satellite visibility along the scenario ■ The tool shall decode, process the information and provide dilution of precision along the scenario ■ The tool shall decode, process the information and provide continuity status along the scenario ■ The tool shall provide the outputs in plain text mode
Outcome (Pass/Fail) **Results**	**PASS**
	The tool decodes and processes the information, giving Accuracy 95% values of Accuracy between the range previously mentioned.

	 The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m. The tool decodes and processes the information, giving Accuracy 95% values of Horizontal protection levels between the range previously mentioned.  The tool provides an output of traffic light for the whole scenario. Considering that the Alert Limit is 25 meters in coastal navigation, the following results are obtained.

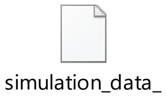
	 The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information HDOP and GDOP.



The tool decodes, processes the information, and provides system continuity status across the scenario.



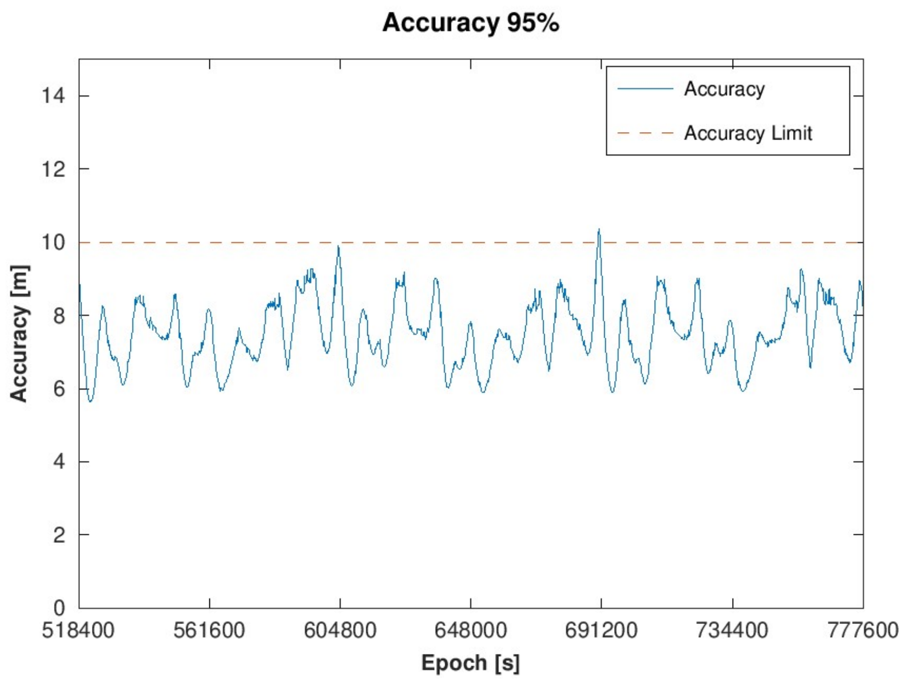
The tool provides the outputs in plain text mode:



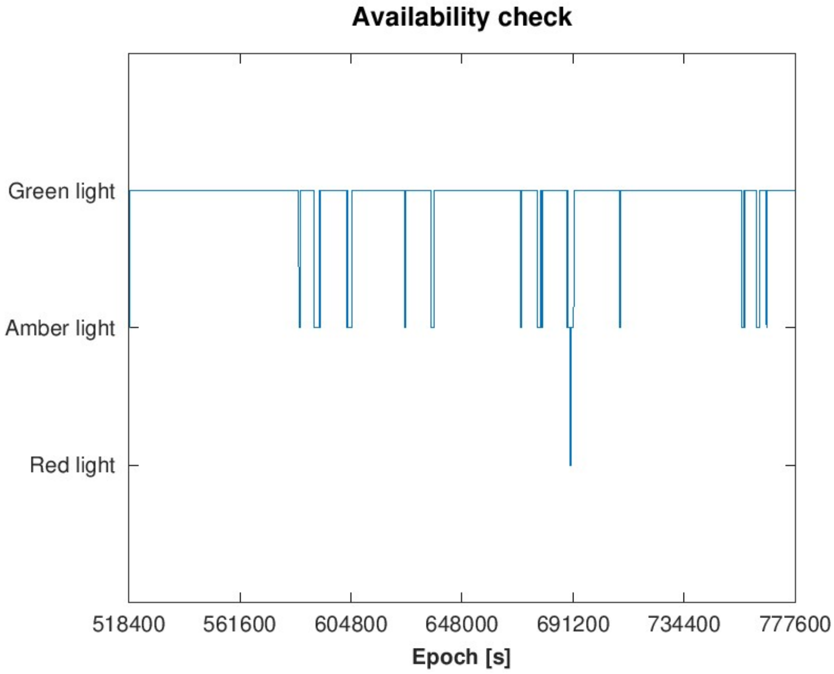
5.2 TC.MPT.002

<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.002 MGRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 72h period. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time[s]</td><td colspan="3">The execution: 50 s timestep

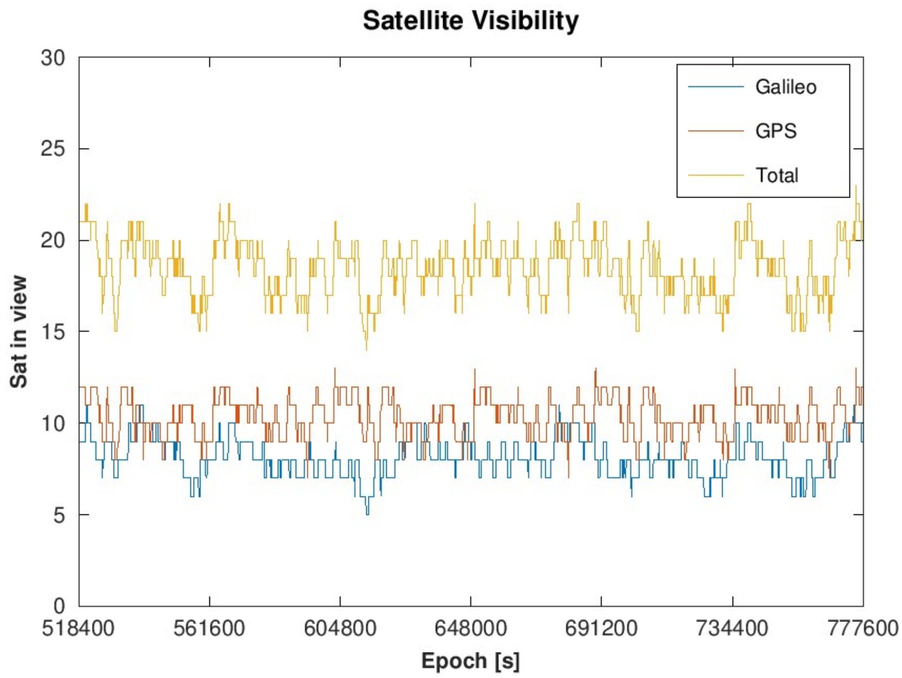
Period studied 72 h, forecast for 23/09/2023 from 00:00:00 to 25/09/2023 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
▪ MGRAIM algorithm selection
▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
▪ Forecast for 23/09/2023 from 00:00:00 to 25/04/2023 23:59:59
▪ GPS + Galileo
▪ Nominal error models configurable. Dual Frequency error model applied [RD.2]
▪ Coastal navigation. Accuracy threshold = 10 m; Integrity Alert Limit = 25 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">▪ The tool shall decode, process the information and provide accuracy 95% results in the range of [5-15]m for the configuration selected, in particular for 72h ahead
▪ The tool shall decode, process the information and provide traffic light status along the scenario, in particular for 72h ahead
▪ The tool shall decode, process the information and provide satellite visibility along the scenario, in particular for 72h ahead
▪ The tool shall decode, process the information and provide Dilution of precision along the scenario, in particular for 72h ahead
▪ The tool shall decode, process the information and provide Continuity status along the scenario, in particular for 72h ahead
▪ The tool shall provide the outputs in plain text mode</td></tr>
<tr><td rowspan="2">Outcome (Pass/Fail)

Results</td><td colspan="3">PASS</td></tr>
<tr><td colspan="3">The tool decodes and processes the information, giving Accuracy 95% values between the range previously mentioned.
</td></tr>
</table>

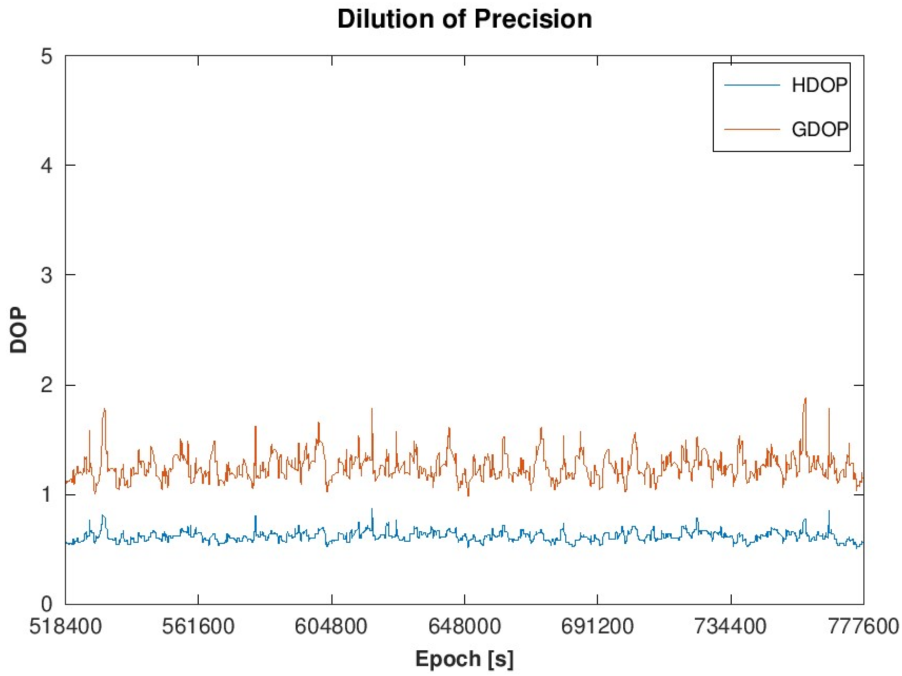
The tool provides an output of traffic light for the whole scenario. Considering that the Accuracy threshold is 10 meters in coastal navigation, the following results are obtained.



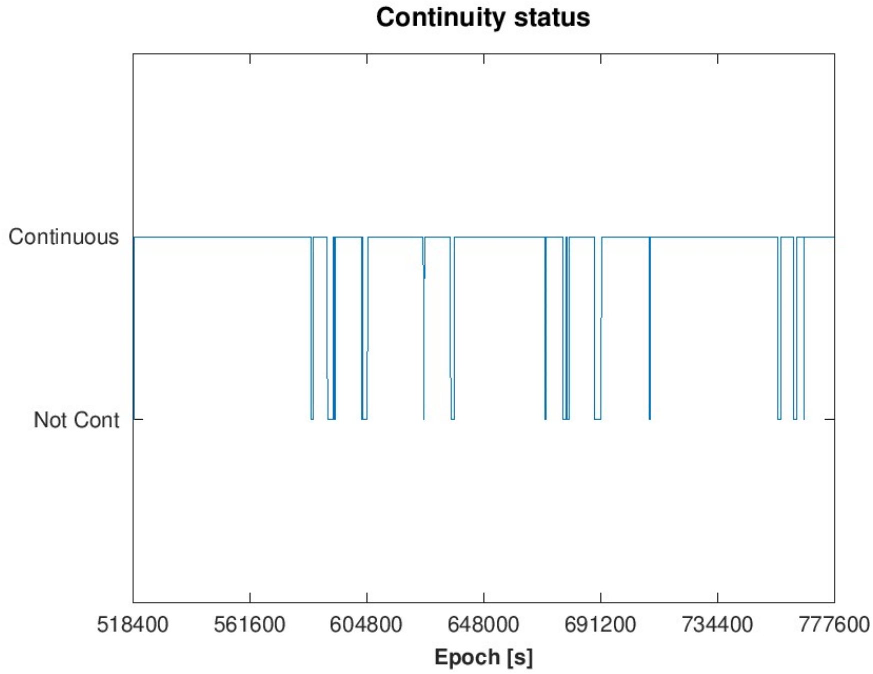
The tool decodes, processes the information, and provides satellite visibility across the scenario.



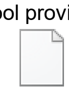
The tool decodes, processes the information, and provides dilution of precision across the scenario.



The tool decodes, processes the information, and provides continuity status across the scenario.

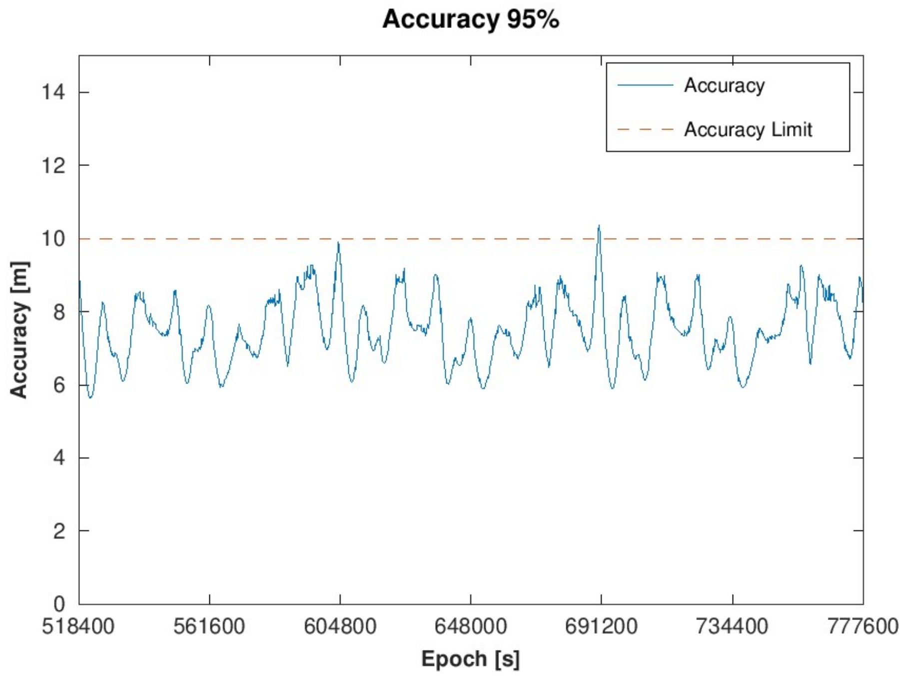
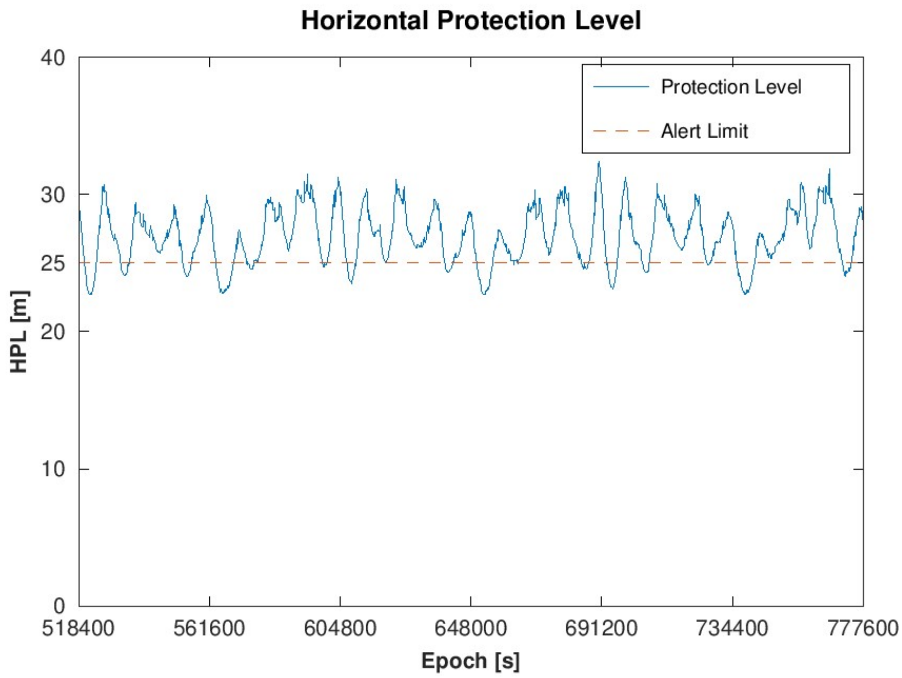


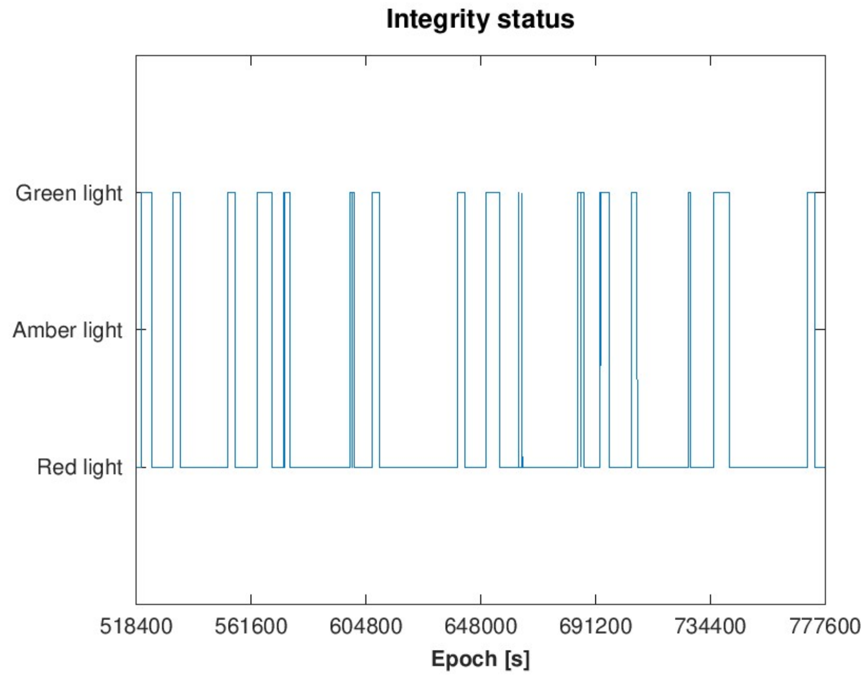
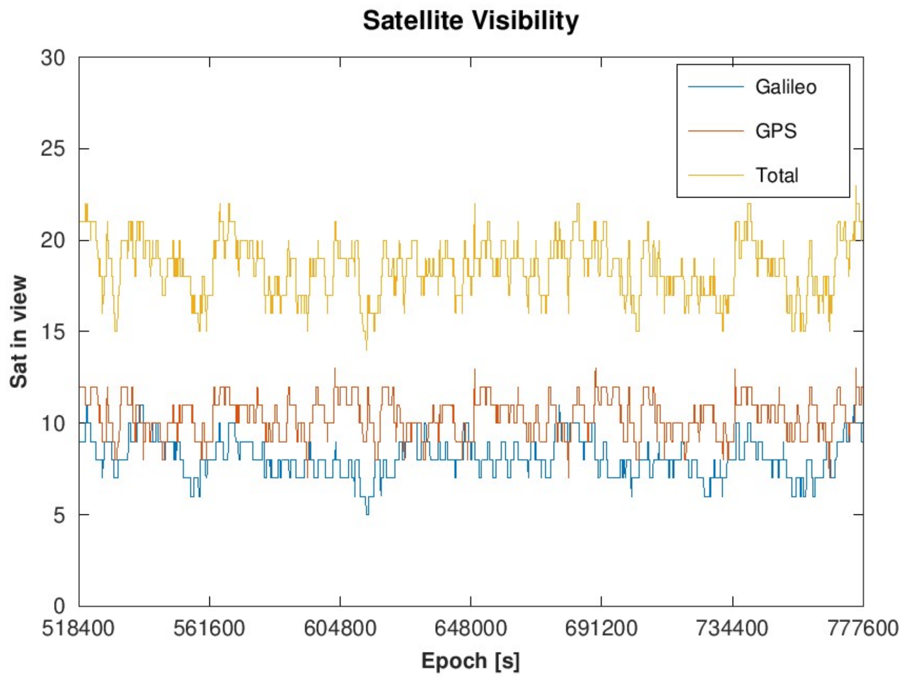
The tool provides the outputs in plain text mode:

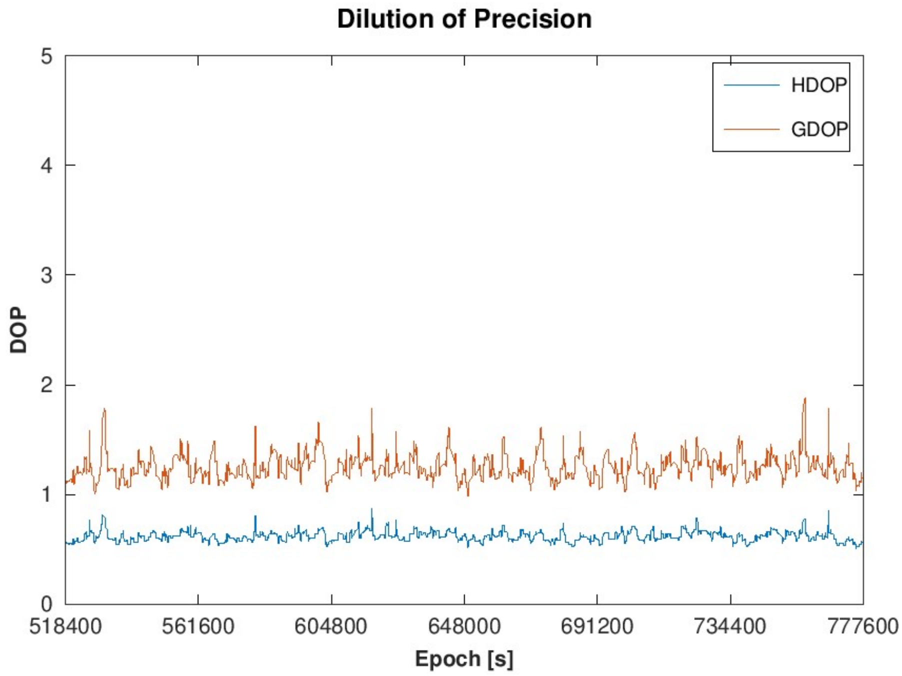


simulation_data_

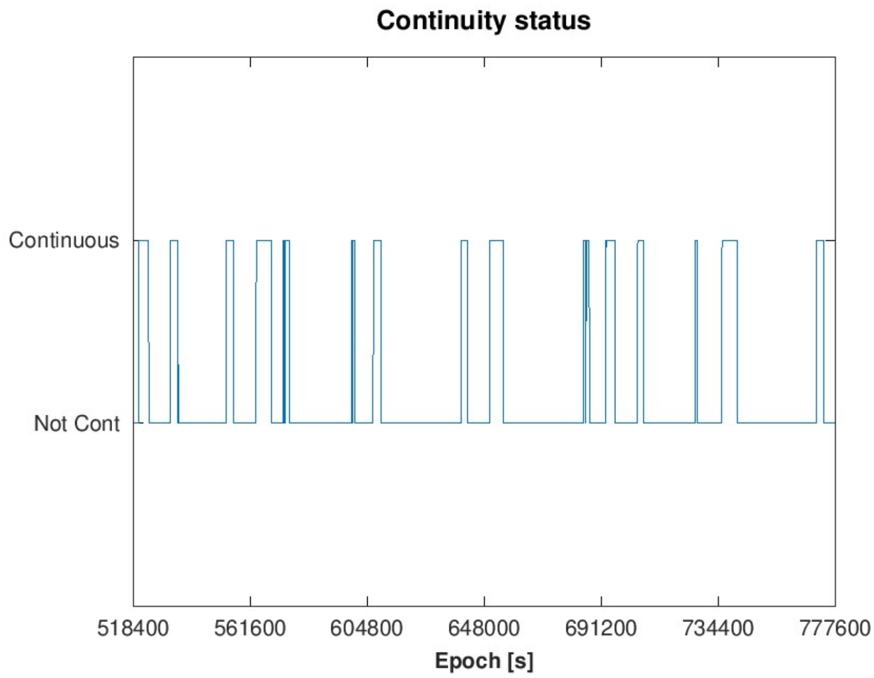
Test Code	TC.MPT.002 MRAIM		
Test Objective	To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 72 h period. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS, Galileo		
Duration Time[s]	The execution: 50 s time step Period studied 72h, forecast for 23/09/2023 from 00:00:00 to 25/09/2023 23:59:59		
Input Data	Galileo ephemerides GPS ephemerides		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ■ GPS + Galileo ■ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ■ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m		
Outcome criteria	■ The tool shall decode, process the information and provide Accuracy 95% results in the range of [8-15]m for the configuration selected, in particular for 72h ahead ■ The tool shall decode, process the information and provide HPL results in the range of [20-40]m for the configuration selected, in particular for 72h ahead ■ The tool shall decode, process the information and provide traffic light status along the scenario, in particular for 72h ahead ■ The tool shall decode, process the information and provide satellite visibility along the scenario, in particular for 72h ahead ■ The tool shall decode, process the information and provide dilution of precision along the scenario, in particular for 72h ahead ■ The tool shall decode, process the information and provide continuity status along the scenario, in particular for 72h ahead ■ The tool shall provide the outputs in plain text mode		
Outcome (Pass/Fail)	**PASS**		
Results	The tool decodes and processes the information, giving Protection Level values in the range previously mentioned.		

	 The tool decodes and processes the information, giving Protection Level values in the range previously mentioned. The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m.  The tool provides an output of traffic light for the whole scenario. Considering that the Alert Limit is 25 meters in coastal navigation, the following results are obtained.

	 The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information HDOP and GDOP across the scenario.



The tool decodes, processes the information, and provides system continuity status across the scenario.

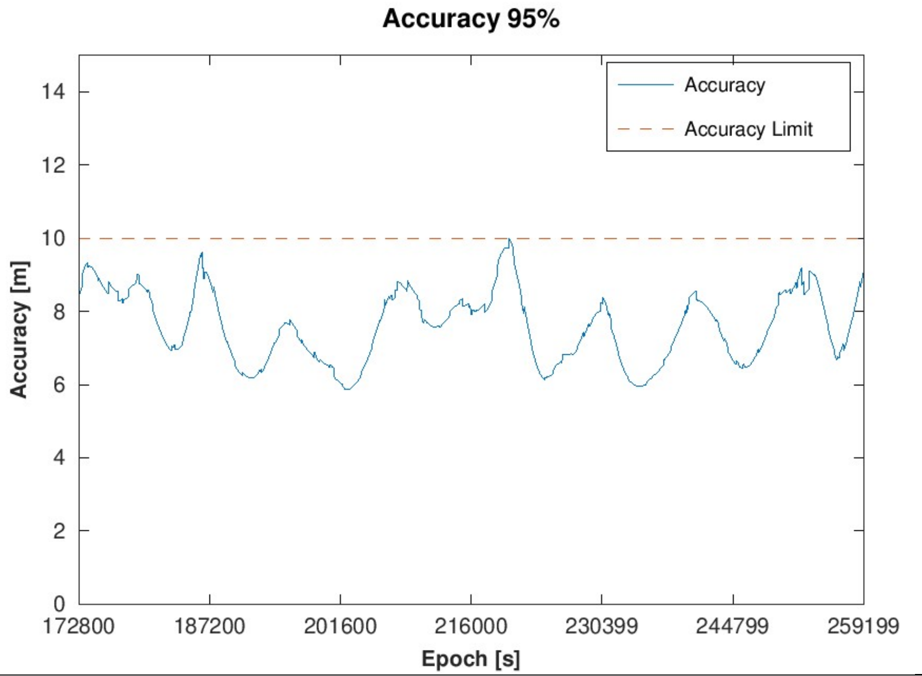


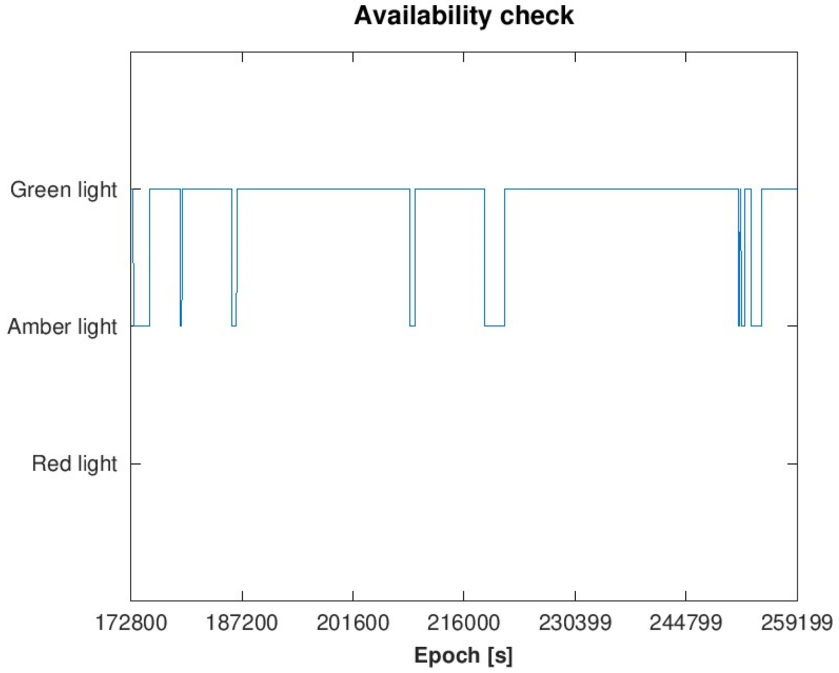
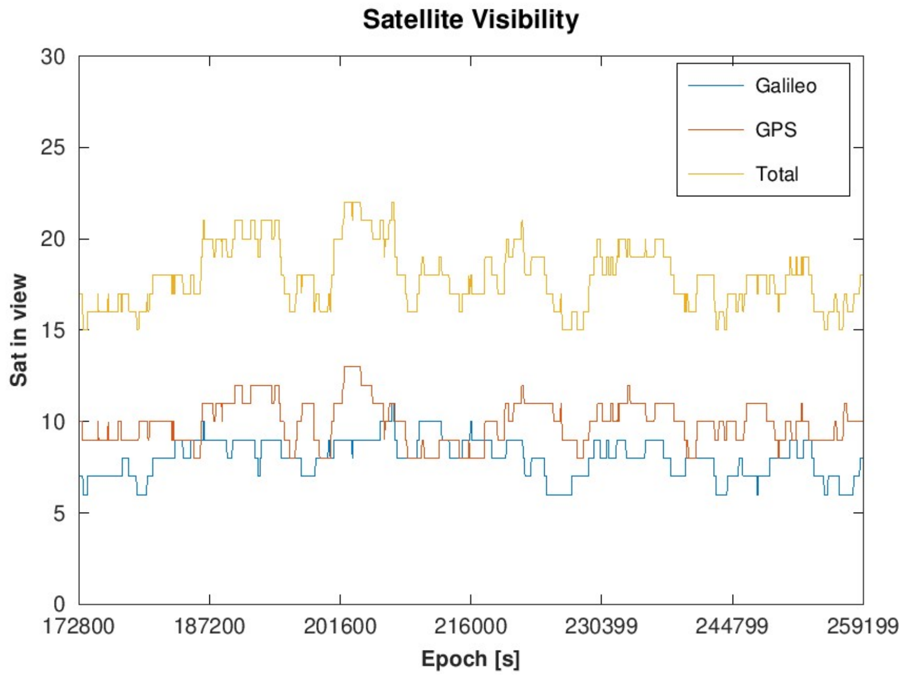
The tool provides the outputs in plain text mode:

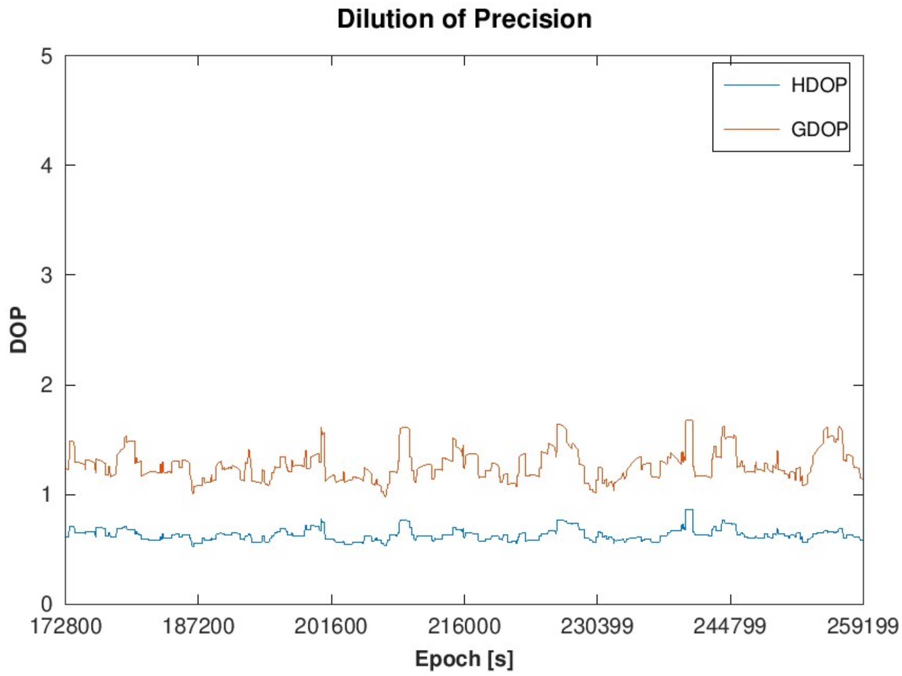
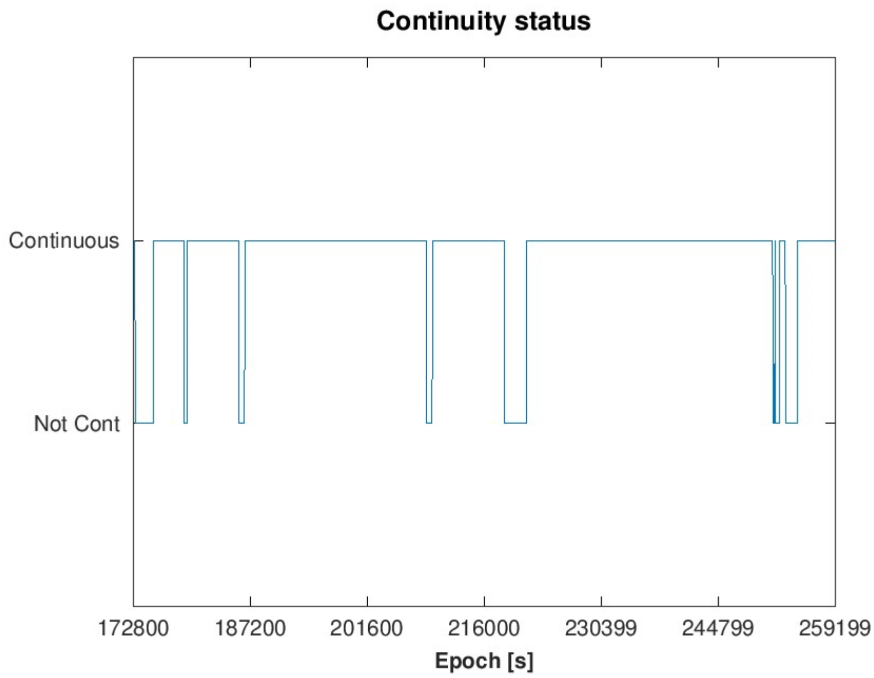
simulation_data_

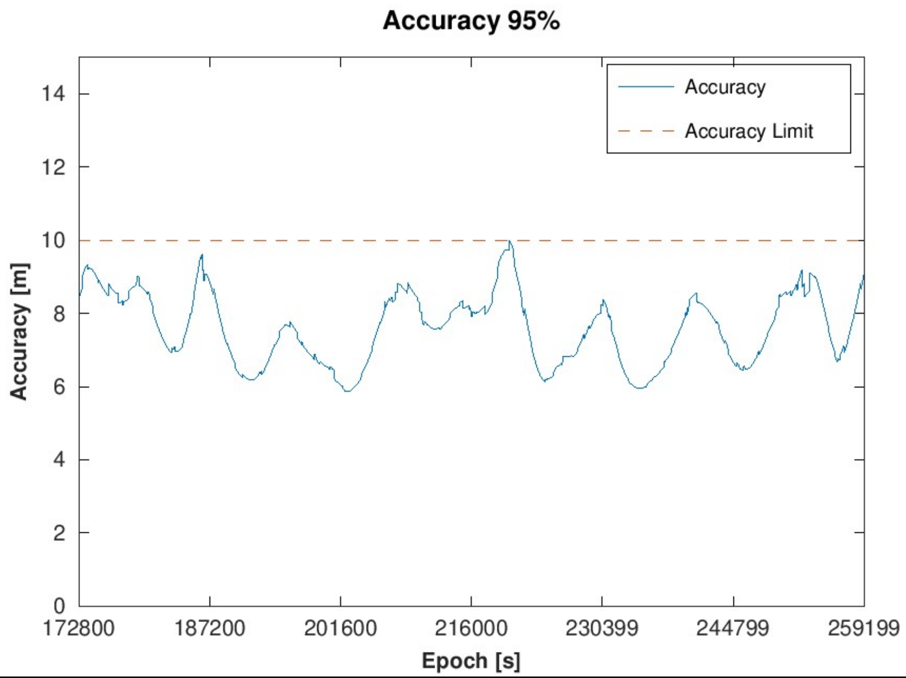
5.3 TC.MPT.003

<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.003 MGRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period previous the period in TC.MPT.001. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 50 s time step
Period studied 24h, forecast for 03/04/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
▪ MGRAIM algorithm selection
▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
▪ Forecast for 18/07/2023 from 00:00:00 - 23:59:59
▪ GPS + Galileo
▪ Nominal error models configurable. Dual Frequency error model applied [RD.2]
▪ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">▪ The tool shall decode, process the information and provide accuracy 95% results in the range of [5-10]m for the configuration selected
▪ The tool shall decode, process the information and provide traffic light status along the scenario
▪ The tool shall decode, process the information and provide satellite visibility along the scenario
▪ The tool shall decode, process the information and provide Dilution of precision along the scenario
▪ The tool shall decode, process the information and provide continuity along the scenario
▪ The tool shall provide the outputs in plain text mode</td></tr>
<tr><td rowspan="2">Outcome (Pass/Fail)

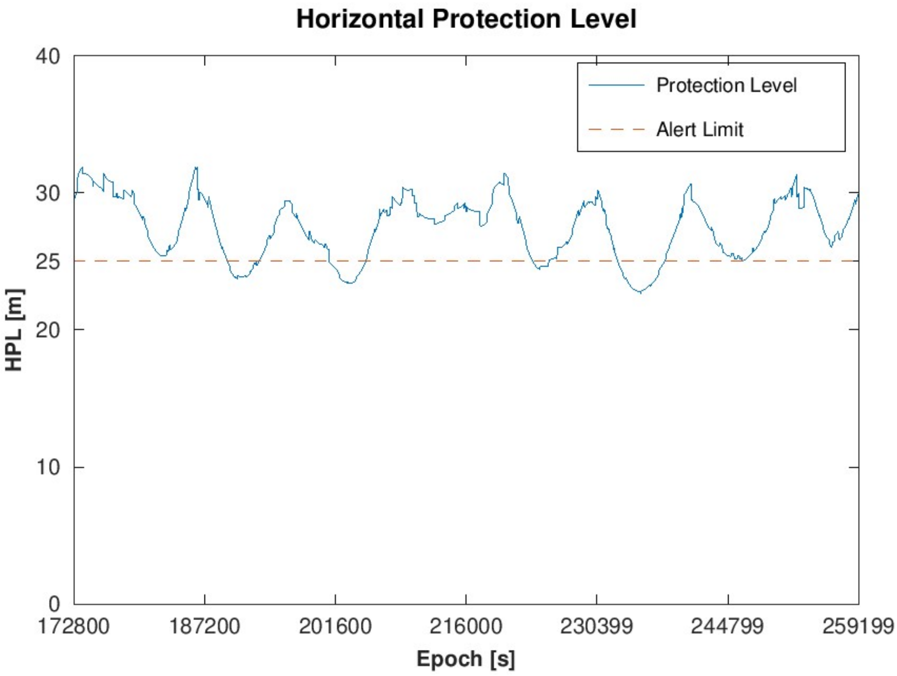
Results</td><td colspan="3">PASS</td></tr>
<tr><td colspan="3">The tool decodes and processes the information, giving Accuracy 95% values between the range previously mentioned.

</td></tr>
</table>

	The tool provides an output of traffic light for the whole scenario. Considering that the Accuracy threshold is 10 meters in coastal navigation, the following results are obtained.  The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information, and provides dilution of precision across the scenario.

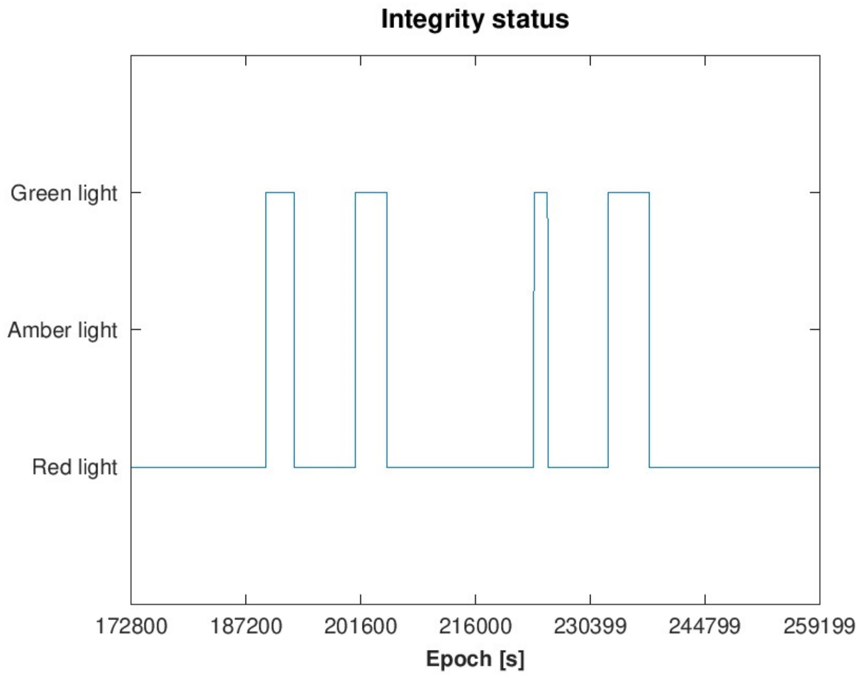
	 The tool decodes, processes the information, and provides continuity status across the scenario.  The tool provides the outputs in plain text mode: 

Test Code	**TC.MPT.003 MRAIM**		
Test Objective	To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period previous the period in TC.MPT.001. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS, Galileo		
Duration Time[s]	The execution: 50 s time step Period studied 24h, forecast for 18/07/2023 from 00:00:00 - 23:59:59		
Input Data	Galileo ephemerides GPS ephemerides		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 03/04/2023 from 00:00:00 - 23:59:59 ■ GPS + Galileo ■ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ■ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m		
Outcome criteria	■ The tool shall decode, process the information and provide Accuracy 95% results in the range of [8-15]m for the configuration selected, in particular for past days ■ The tool shall decode, process the information and provide HPL results in the range of [20-40]m for the configuration selected, in particular for past days ■ The tool shall decode, process the information and provide traffic light status along the scenario, in particular for past days ■ The tool shall decode, process the information, and provide satellite visibility along the scenario , in particular for past days ■ The tool shall decode, process the information, and provide dilution of precision along the scenario , in particular for past days ■ The tool shall decode, process the information, and provide continuity status along the scenario , in particular for past days ■ The tool shall provide the outputs in plain text mode		
Outcome (Pass/Fail) **Results**	**PASS** The tool decodes and processes the information, giving Accuracy 95% values previously mentioned. 		

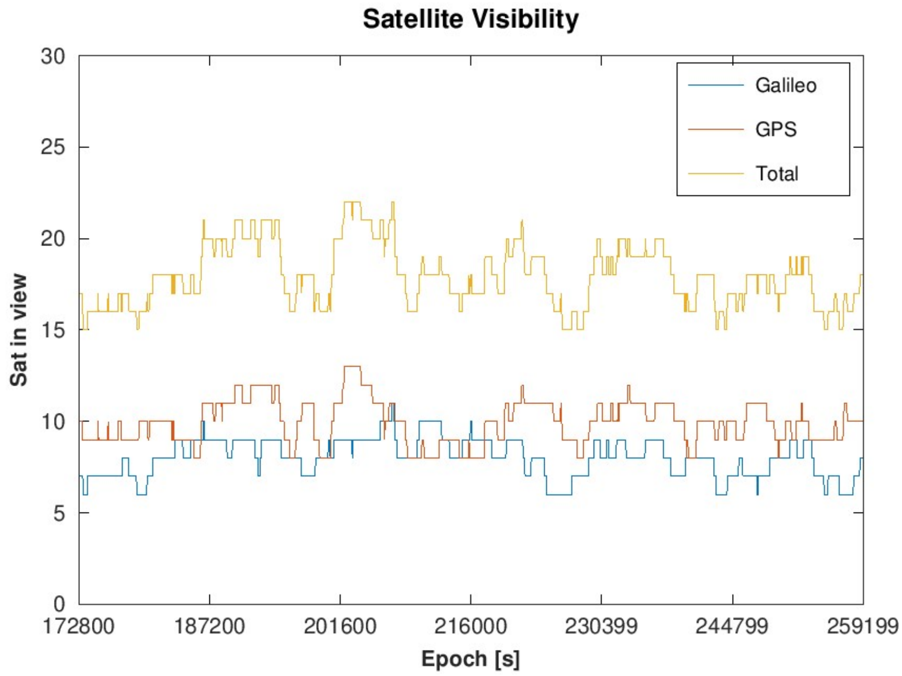
The tool decodes and processes the information, giving Protection Level values previously mentioned. The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m.



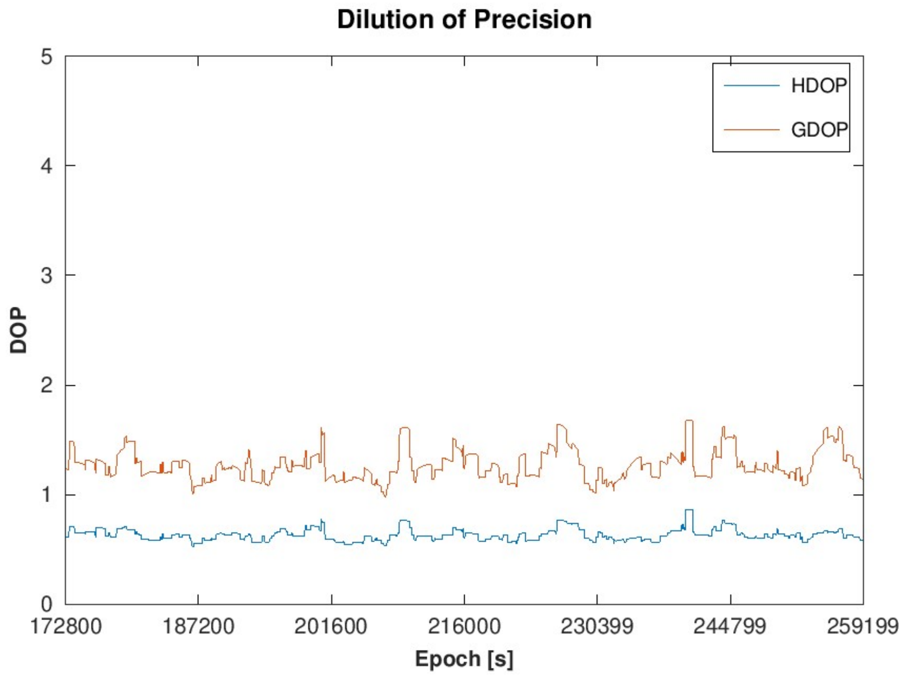
The tool provides an output of traffic light for the whole scenario. Considering that the Accuracy threshold is 10 meters in coastal navigation, the following results are obtained.



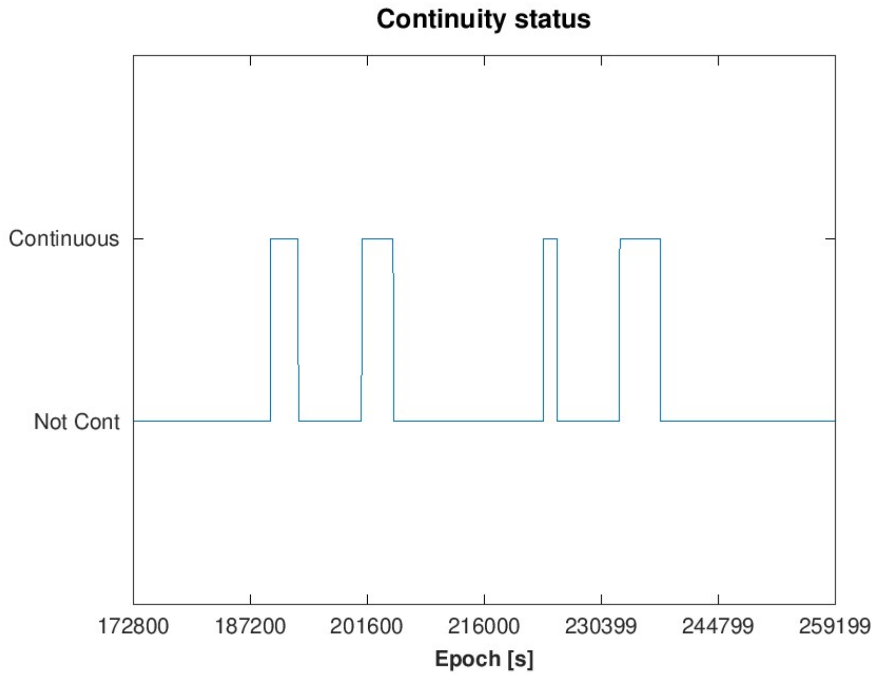
The tool decodes, processes the information, and provides satellite visibility across the scenario.



The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario.



The tool decodes, processes the information, and provides system continuity across the scenario.

	 The tool provides the outputs in plain text mode:  simulation_data_

5.4 TC.MPT.004

<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.004 MGRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period for every surface on Earth in a grid mode. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 2000 s time step

Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
▪ MGRAIM algorithm selection
▪ Grid mode selection
▪ Forecast for 18/09/2023 from 00:00:00 - 23:59:59
▪ GPS + Galileo
▪ Nominal error models configurable. Dual Frequency error model applied [RD.2]
▪ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">▪ The tool shall decode, process the information, and provide Accuracy results for a grid of users over European area and over UK area. The percentile 95% will be depicted in maps and will provide values in the range of [5-10]m over UK area and over European area

▪ The tool shall decode, process the information, and provide availability status for a grid of users over European area and over UK area. This information will be depicted in availability maps

▪ The tool shall decode, process the information, and provide foreseen alarms for a grid of users over European area and over UK area. This information will be depicted in satellite traffic light status maps called integrity status 95%, being 0 red flag, 1 amber flag and 2 green flag

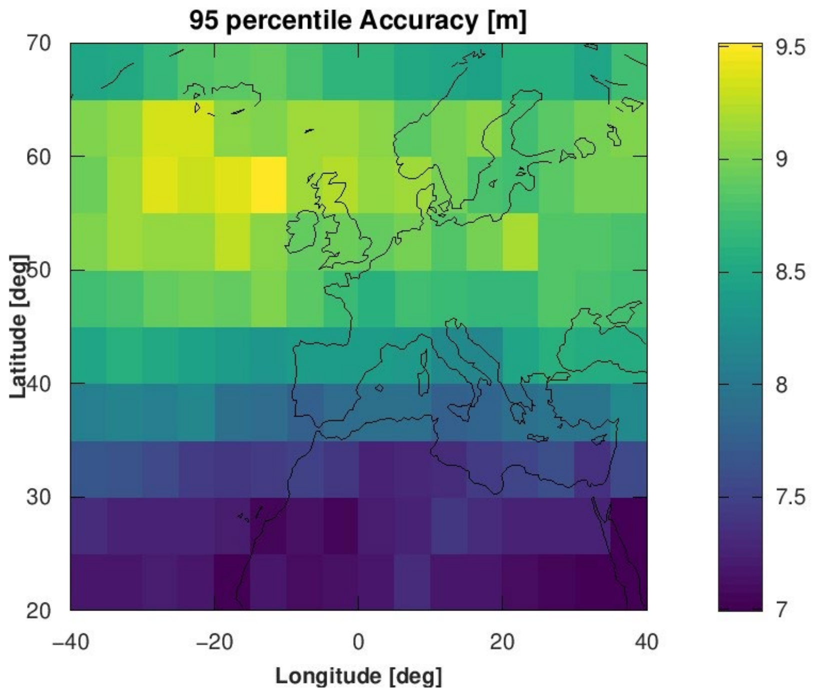
▪ The tool shall decode, process the information, and provide satellite visibility 95% for a grid of users over European area and over UK area. This information will be depicted in satellite visibility percentile maps

▪ The tool shall decode, process the information, and provide continuity status for a grid of users over European area and over UK area. The percentile 99.97% of the traffic status will be depicted in continuity maps, being 0 Not continuous, and 1 continuous

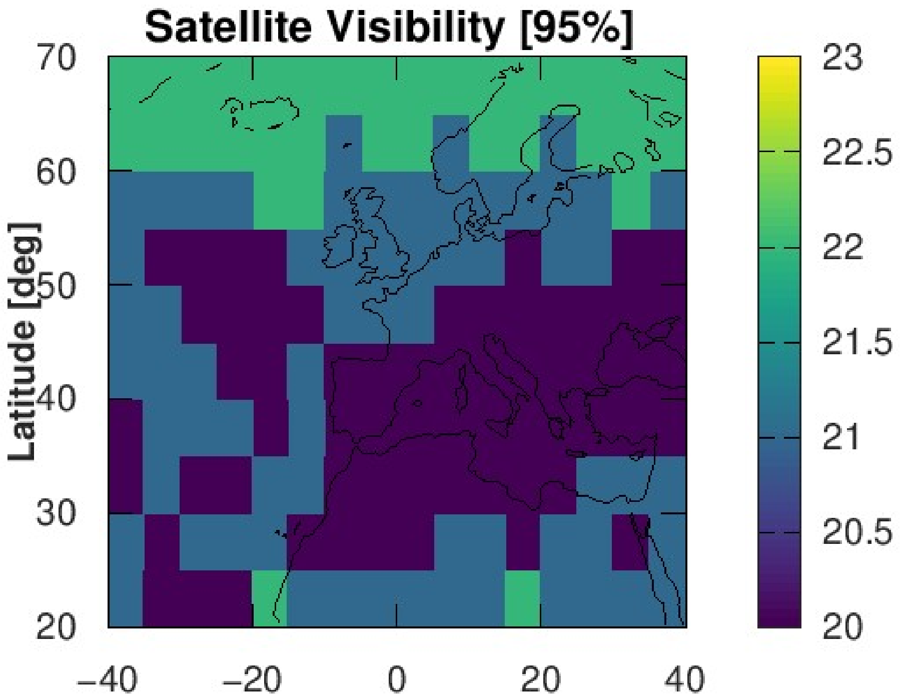
▪ The tool shall provide the outputs in plain text mode</td></tr>
<tr><td rowspan="2">Outcome (Pass/Fail)

Results</td><td colspan="3">PASS</td></tr>
<tr><td colspan="3">Results for Europe:

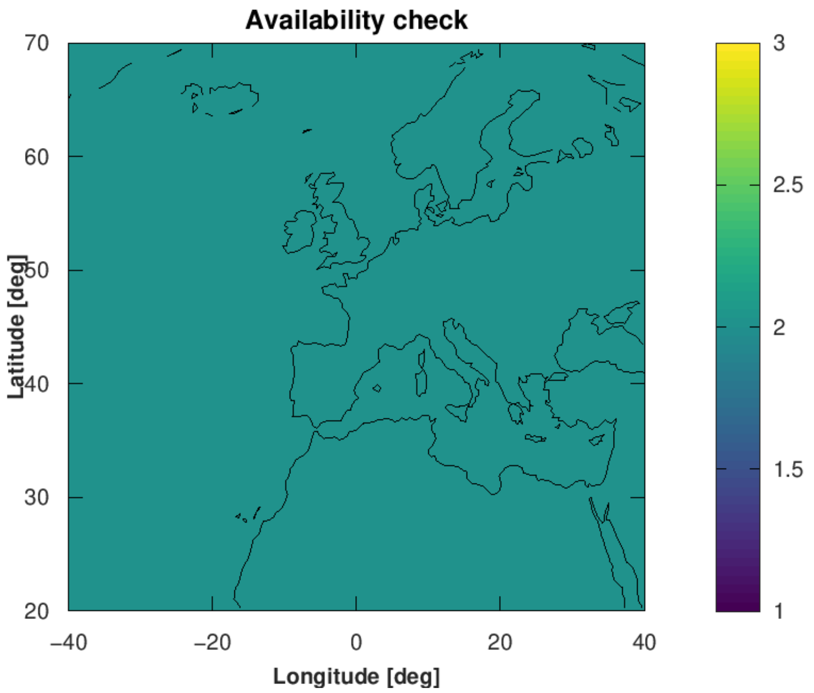
The tool decodes and processes the information, giving the percentile 95% in the range previously mentioned.</td></tr>
</table>



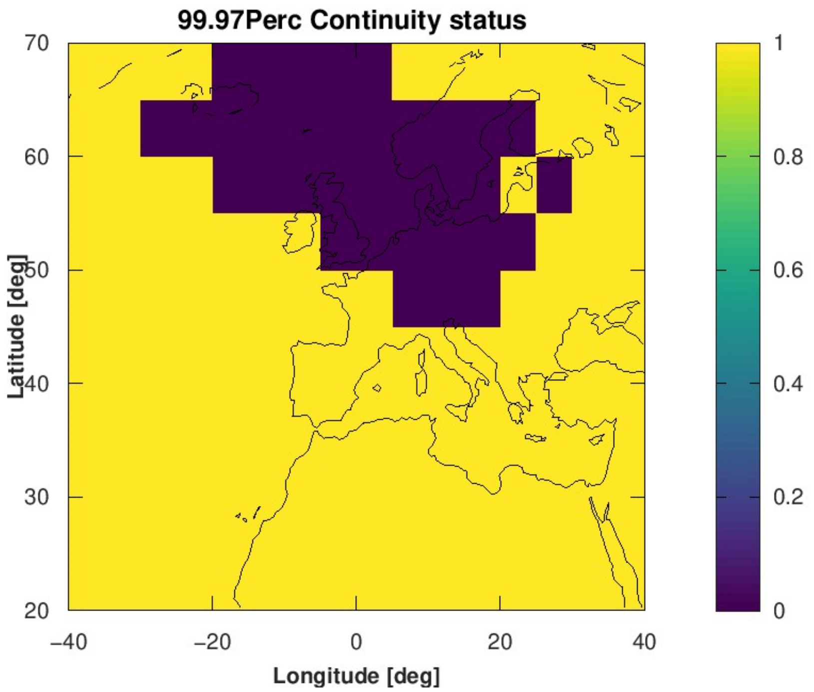
The tool decodes, processes the information, and provides satellite visibility across the scenario.



The tool decodes, processes the information, and provides the traffic light availability status across the scenario for users the European area.



The tool decodes, processes the information, and provides Continuity status across the scenario.

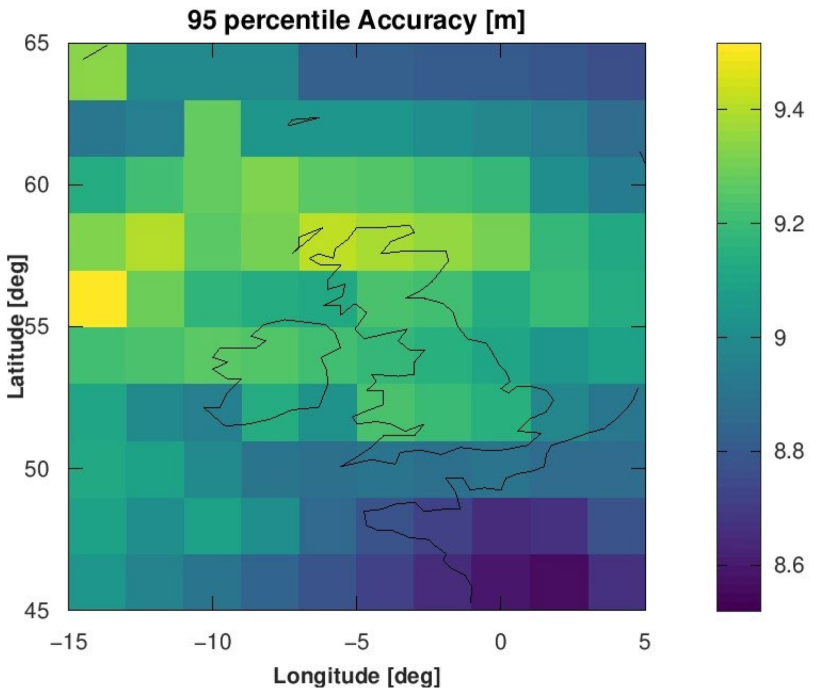
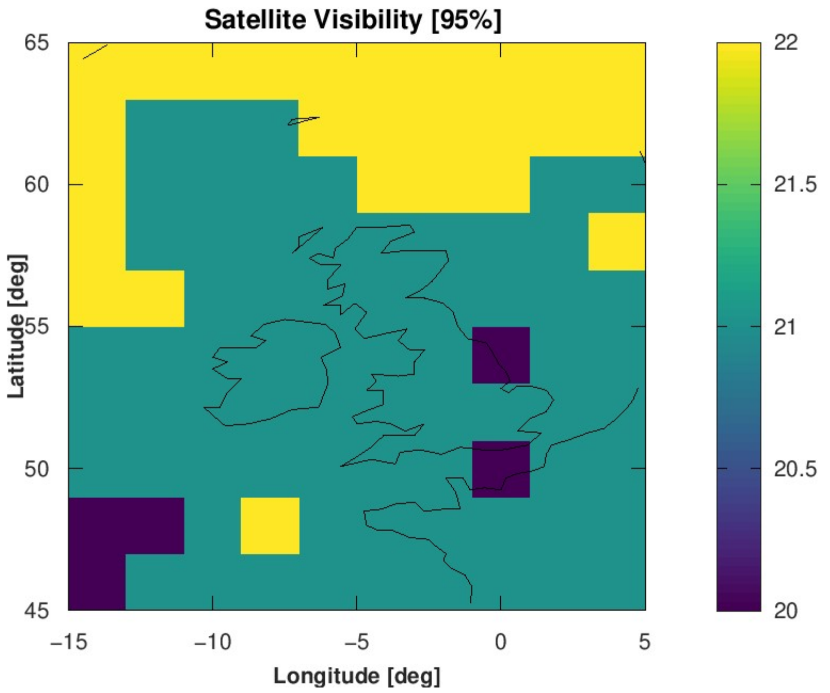


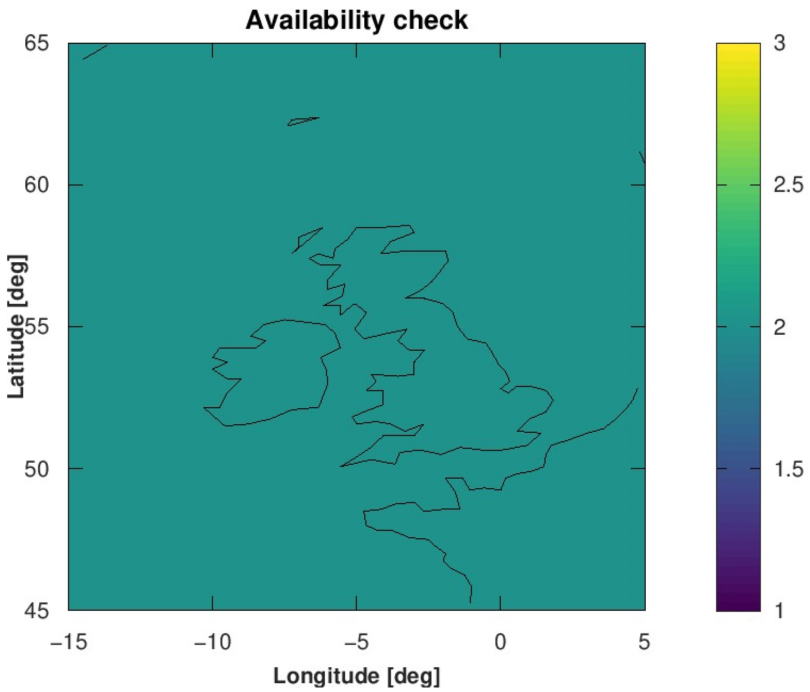
The tool provides the outputs in plain text mode

simulation_data_

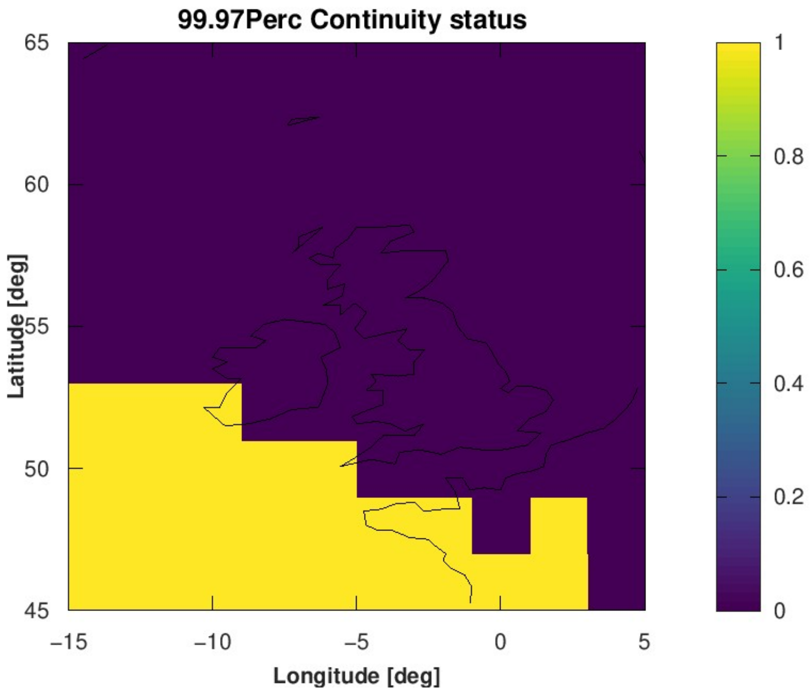
Results for the UK area:

The tool decodes and processes the information, giving the percentile 95% in the range previously mentioned.

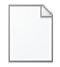
	 The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information, and provides the traffic light availability status across the scenario for users the UK area.



The tool decodes, processes the information, and provides Continuity status across the scenario.



The tool provides the outputs in plain text mode



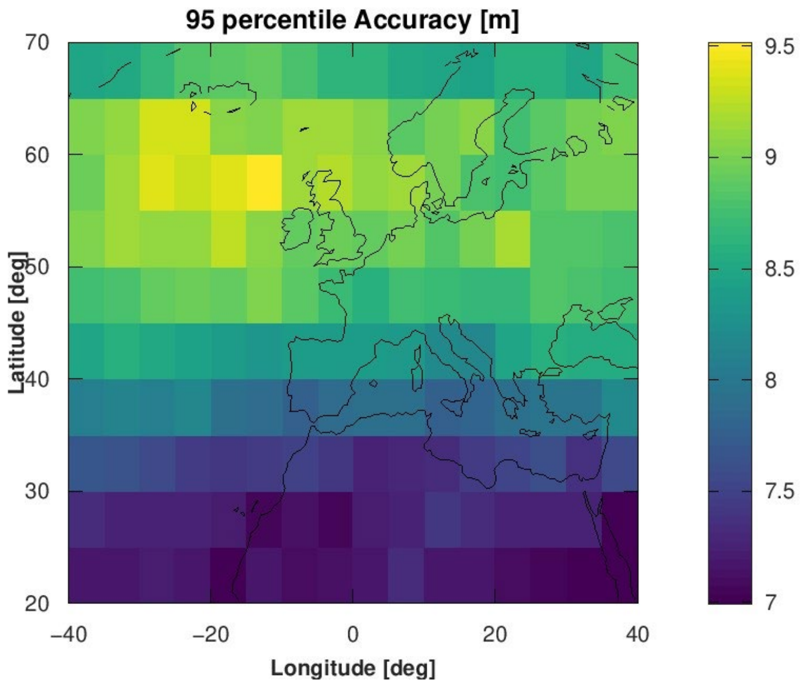
<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.004 MRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period for every surface on Earth in a grid mode. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 2000 s time step

Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
▪ MRAIM algorithm selection
▪ Grid mode selection
▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59
▪ GPS + Galileo
▪ Nominal error models configurable. Dual Frequency error model applied [RD.2]
▪ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">▪ The tool shall decode, process the information, and provide Accuracy results for a grid of users over European area and over UK area. The percentile 95% will be depicted in maps and will provide values in the range of [5-10]m over UK area and over European area
▪ The tool shall decode, process the information, and provide HPL results for a grid of users over European area and over UK area. The percentile 99.8% will be depicted in maps and will provide values in the range of [25-35]m over UK area and over European area

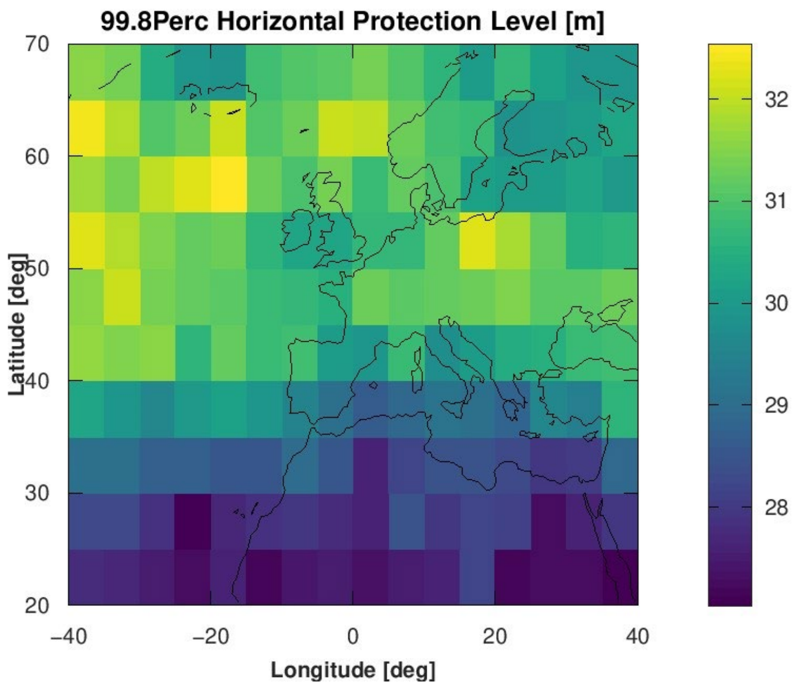
▪ The tool shall decode, process the information, and provide foreseen alarms for a grid of users over European area and over UK area. This information will be depicted in satellite traffic light status maps called integrity status 95%, being 0 red flag, 1 amber flag and 2 green flag
▪ The tool shall decode, process the information, and provide satellite visibility 95% for a grid of users over European area and over UK area. This information will be depicted in satellite visibility percentile maps
▪ The tool shall decode, process the information, and provide continuity status for a grid of users over European area and over UK area. The percentile 99.97% of the traffic status will be depicted in continuity maps, being 0 Not continuous, and 1 continuous
▪ The tool shall provide the outputs in plain text mode</td></tr>
<tr><td rowspan="2">Outcome (Pass/Fail)

Results</td><td colspan="3">PASS</td></tr>
<tr><td colspan="3">Results for European area

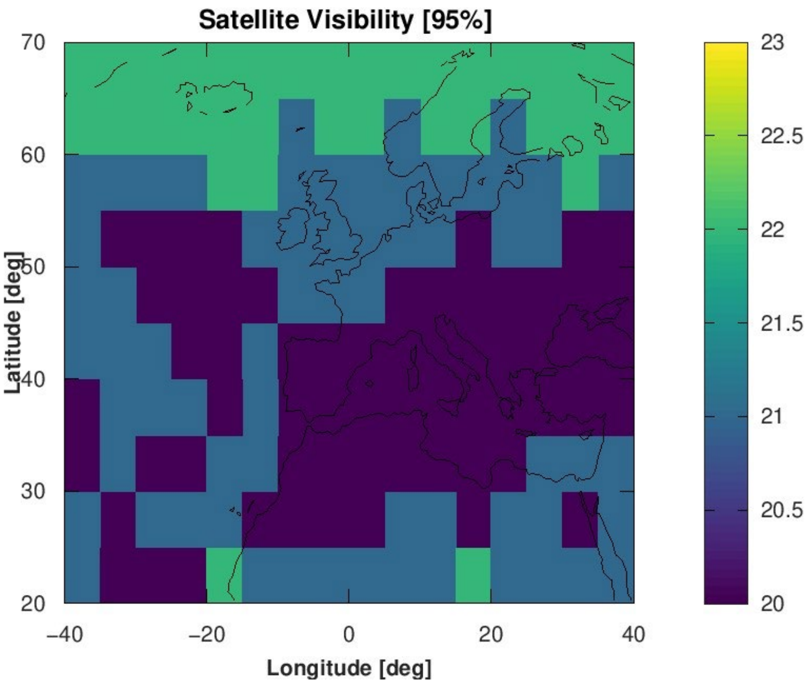
The tool decodes and processes the information, giving Accuracy 95% values for users in the European area.</td></tr>
</table>



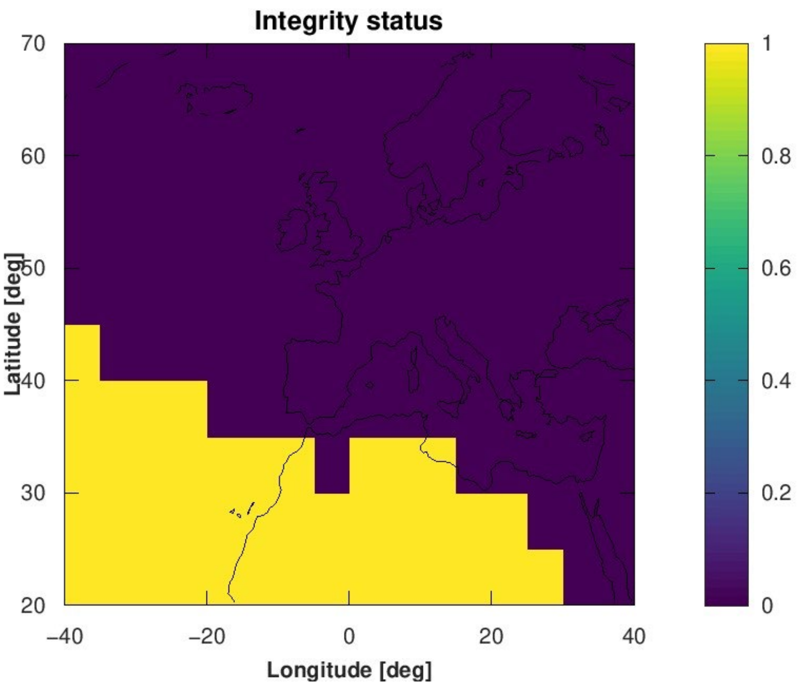
The tool decodes and processes the information, giving Protection Level values for users in the European area.



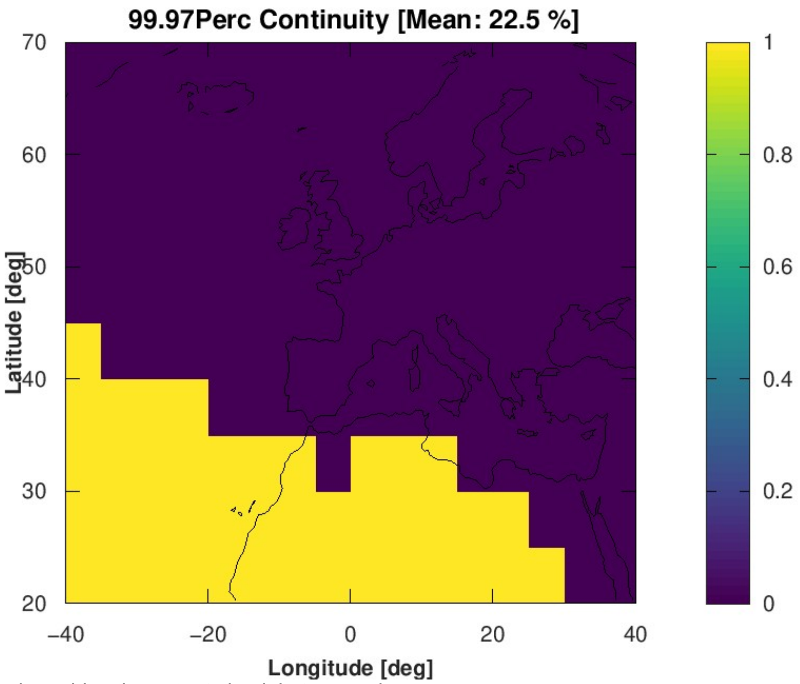
The tool decodes, processes the information, and provides satellite visibility across the scenario for users the European area.



The tool decodes, processes the information, and provides the system integrity status across the scenario for users the European area. In the plot can be seen the representation of the 95percentile of the traffic lights, where 0 indicates in the purple area of the map the 95% of the time the PL > AL and 1 indicates in the yellow area that the 95% of the time there are not available enough satellites to create subsets.



The tool decodes, processes the information, and provides the system continuity status across the scenario for users the European area. In the plot can be seen the representation of the 99.97percentile of the continuity flag, where 0 indicates in the purple area of the map the 99.97% of the time the solution is not continuous and 1 indicates in the yellow area that the 99.97% of the time the solution is continuous.

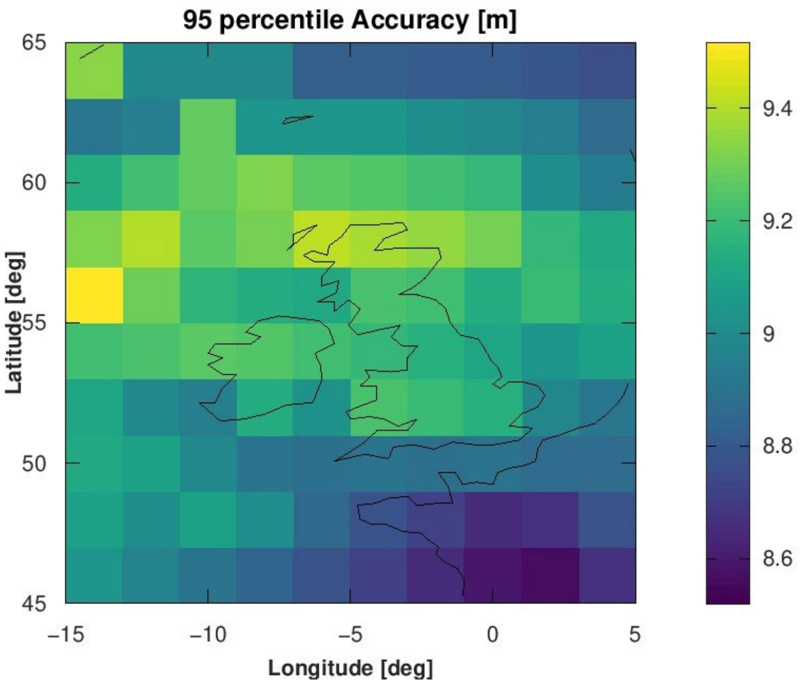


The tool provides the outputs in plain text mode.

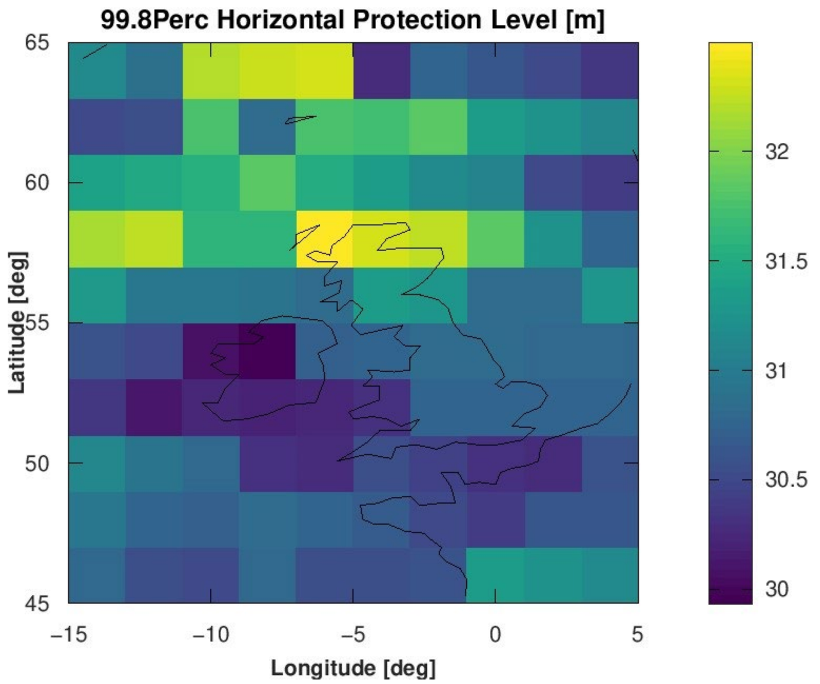
simulation_data_

Results for the UK area

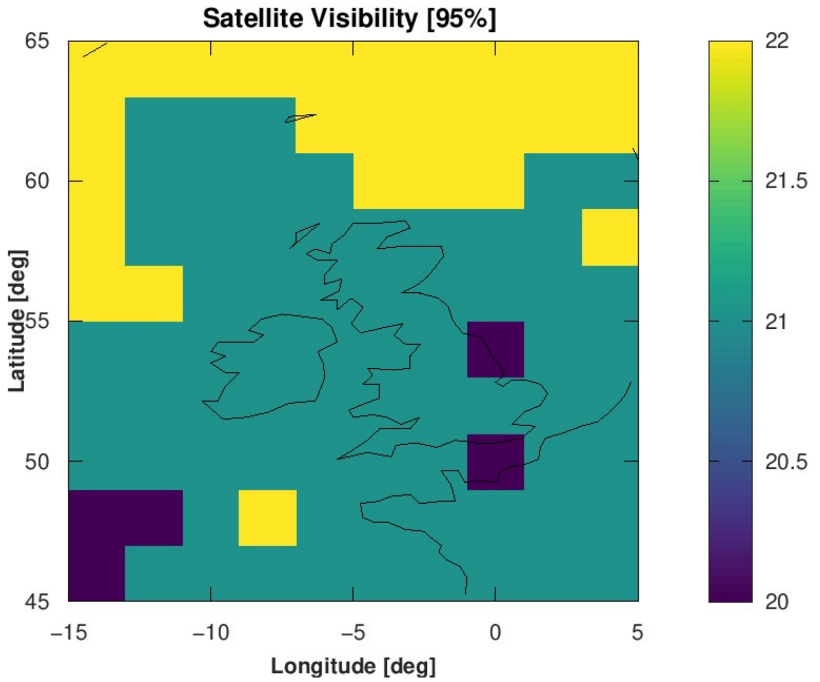
The tool decodes and processes the information, giving Accuracy 95% values for users in the European area.



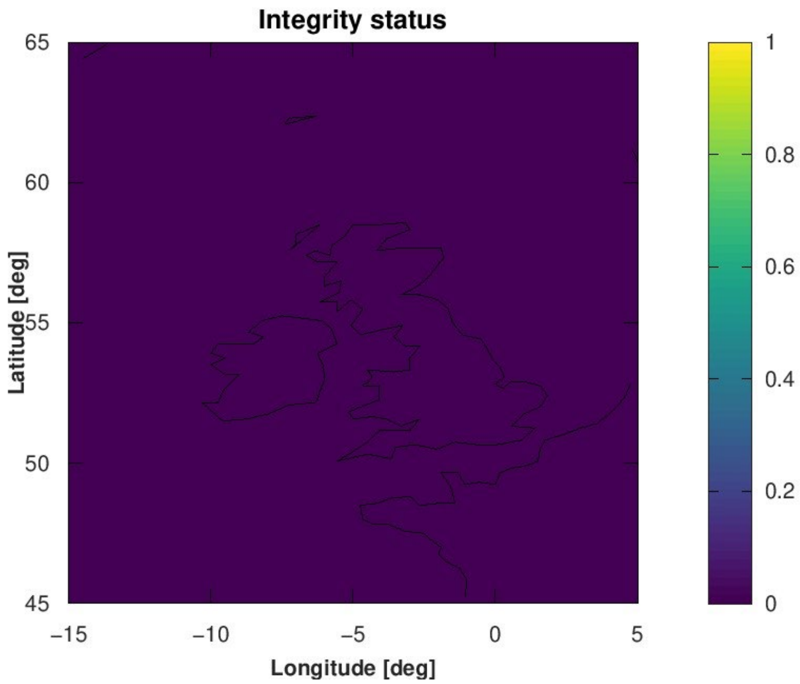
The tool decodes and processes the information, giving Protection Level values in the range previously mentioned.



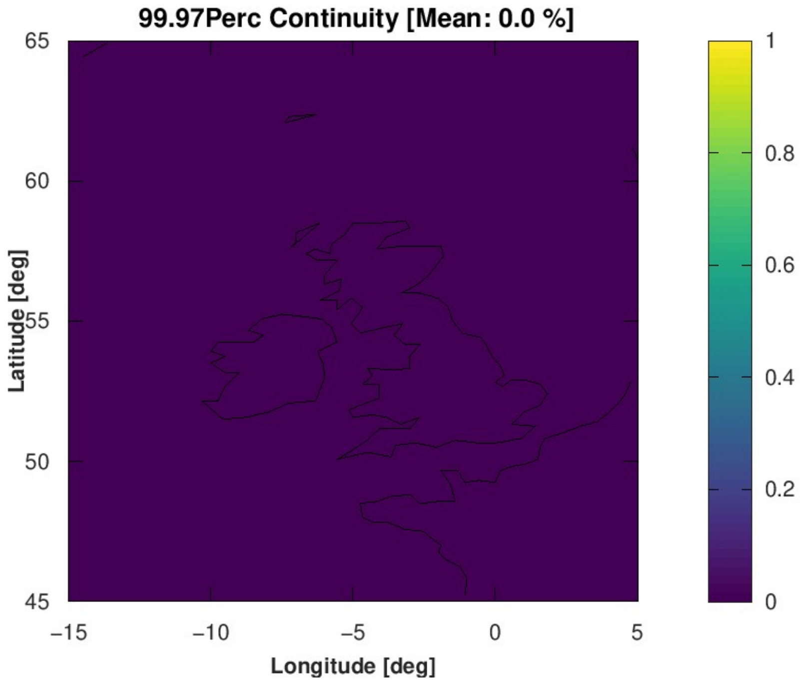
The tool decodes, processes the information, and provides satellite visibility across the scenario for a grid of users in the UK area.



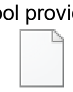
The tool decodes, processes the information, and provides the system integrity status across the scenario for users the UK area.



The tool decodes, processes the information, and provides the system continuity status across the scenario for users the UK area.



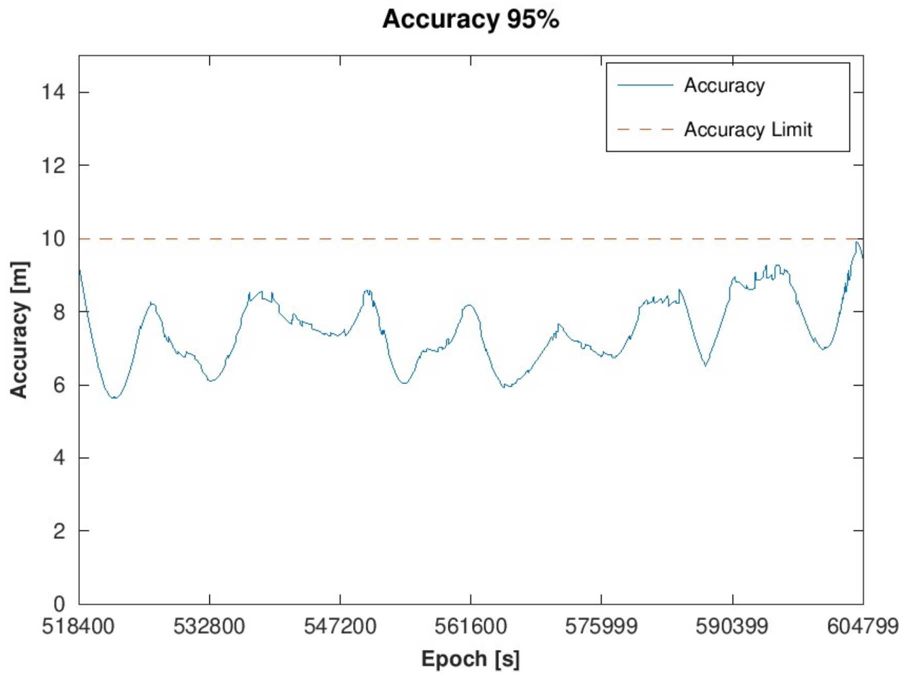
The tool provides the outputs in plain text mode.



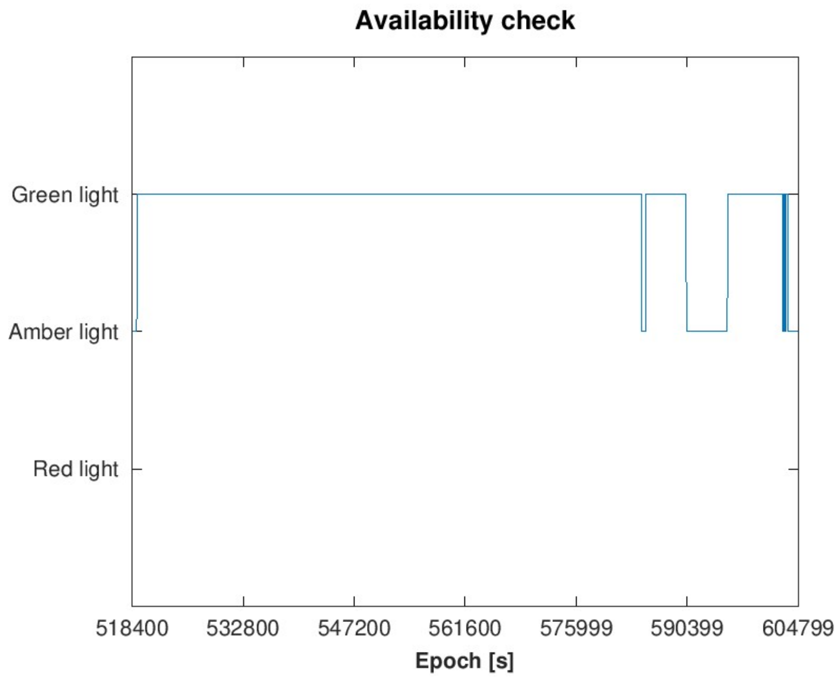
simulation_data_

5.5 TC.MPT.005

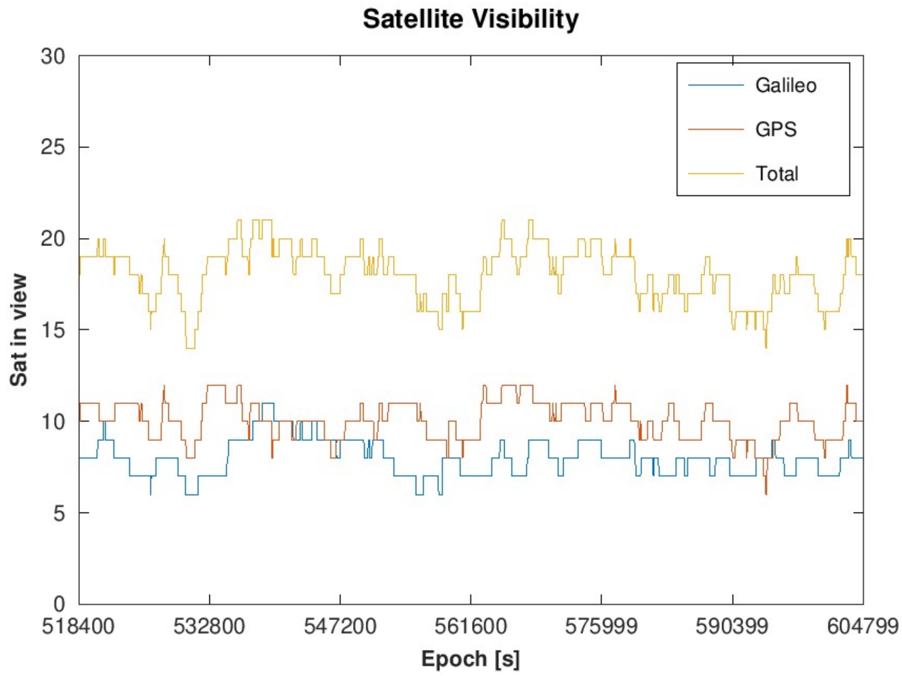
<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.005 MGRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period excluding satellites from NANUs, NAGUs or equivalent. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 50 s time step
Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
MGRAIM algorithm selection
Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
Forecast for 18/09/2023 from 00:00:00 - 23:59:59
GPS + Galileo
Nominal error models configurable. Dual Frequency error model applied [RD.2]
Coastal navigation: Accuracy threshold = 10 m
A synthetic NANUs and NAGUs message excluding one satellite in each constellation, in this case G25 E24</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">The tool shall decode, process the information, and provide Accuracy 95% results in the range of [5-10]m for the selected configuration, and they will be higher compared to the TC.MPT.001
The tool shall decode, process the information and provide traffic light status along the scenario
The tool shall decode, process the information, and provide satellite visibility along the scenario . This information shall clearly indicate that satellites are not visible when applying the integrity information if compared against TC.MPT.001 results
The tool shall decode, process the information, and provide dilution of precision along the scenario
The tool shall decode, process the information, and provide continuity status along the scenario
The tool shall provide the output in plain text mode</td></tr>
<tr><td>Outcome (Pass/Fail)</td><td colspan="3">PASS</td></tr>
<tr><td>Results</td><td colspan="3">The tool decodes and processes the information, giving Accuracy 95% values between the range previously mentioned.</td></tr>
</table>



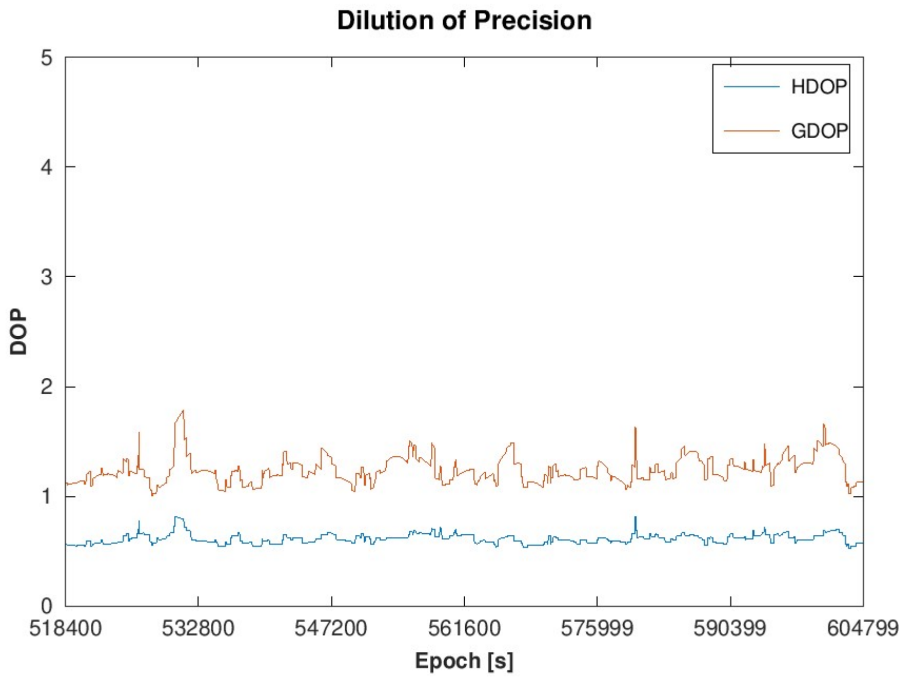
The tool provides an output of traffic light for the whole scenario. Considering that the Accuracy threshold is 10 meters in coastal navigation, the following results are obtained.



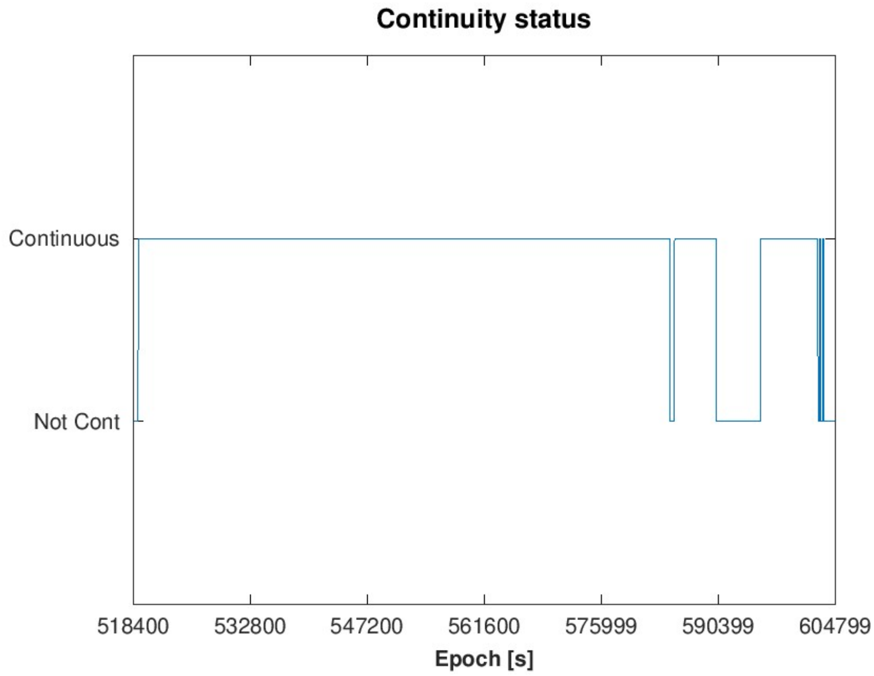
The tool decodes, processes the information, and provides satellite visibility across the scenario.



The tool decodes, processes the information, and provides Dilution of precision across the scenario.

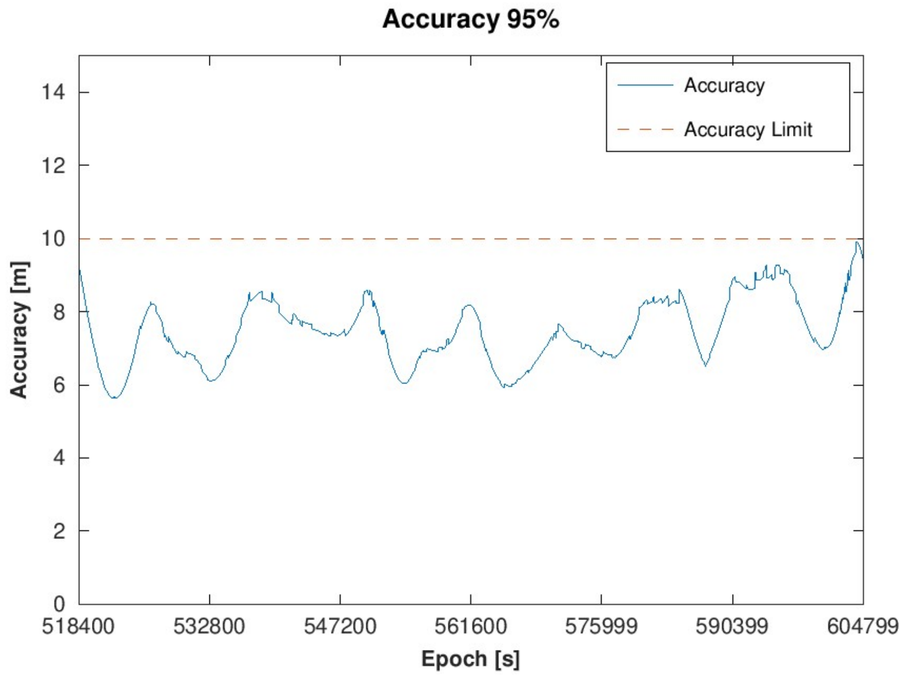


The tool decodes, processes the information, and provides continuity status across the scenario.

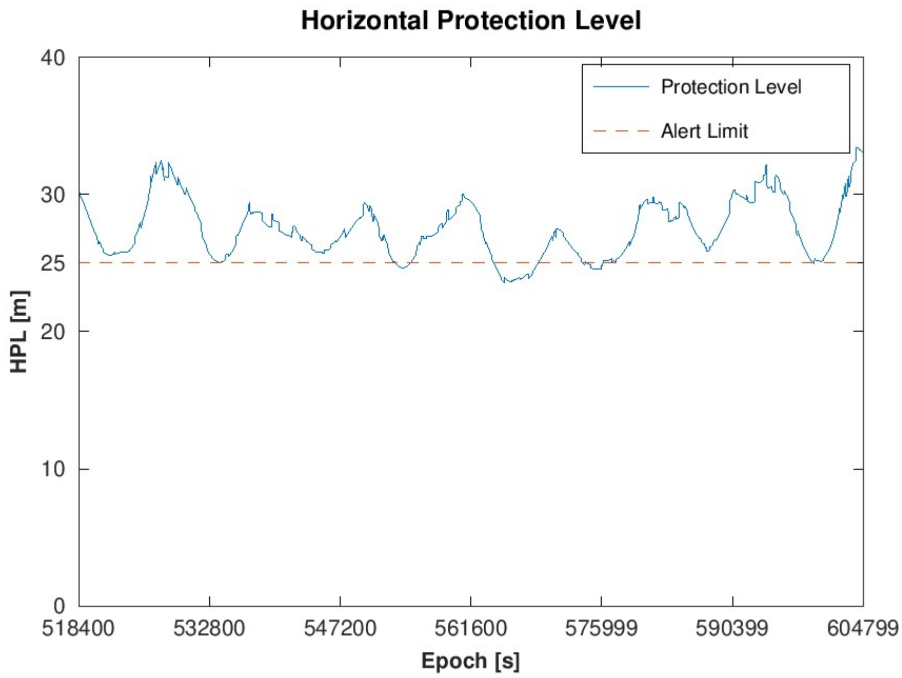
	 The tool provides the outputs in plain text mode. simulation_data_

<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.005 MRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period excluding satellites from NANUs, NAGUs or equivalent. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 50 s time step

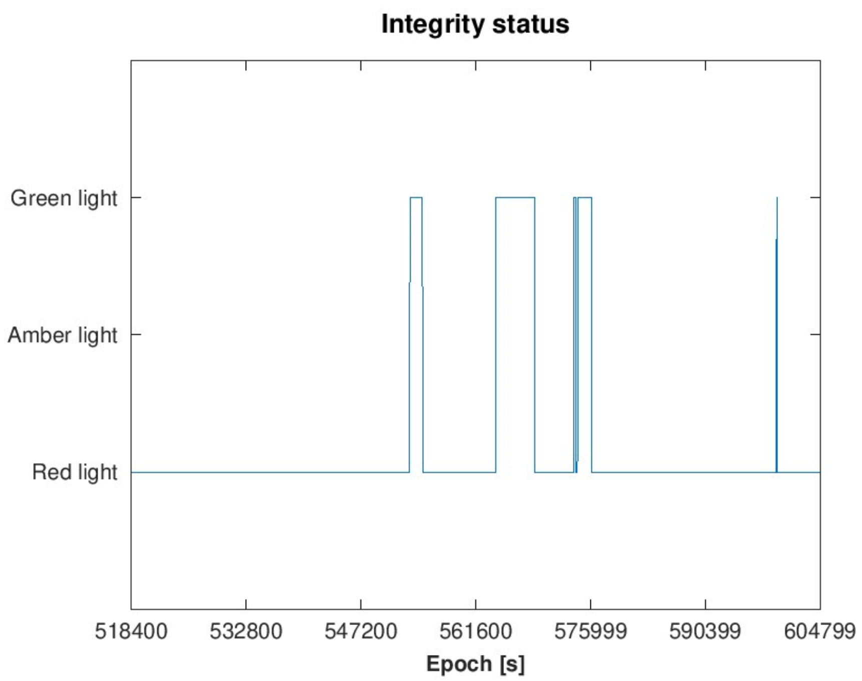
Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
MRAIM algorithm selection
Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
Forecast for 23/09/2023 from 00:00:00 - 23:59:59
GPS + Galileo
Nominal error models configurable. Dual Frequency error model applied [RD.2]
Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m
A synthetic NANUs and NAGUs message excluding one satellite in each constellation, in this case G29 E12</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">The tool shall decode, process the information, and provide Accuracy 95% results in the range of [8-14]m for the selected configuration, and they will be higher compared to the TC.MPT.001
The tool shall decode, process the information, and provide HPL results in the range of [20-35]m for the selected configuration, and they will be higher compared to the TC.MPT.001
The tool shall decode, process the information and provide traffic light status along the scenario
The tool shall decode, process the information, and provide satellite visibility along the scenario . This information shall clearly indicate that satellites are not visible when applying the integrity information if compared against TC.MPT.001 results
The tool shall decode, process the information, and provide dilution of precision along the scenario
The tool shall decode, process the information, and provide continuity status along the scenario
The tool shall provide the outputs in plain text mode</td></tr>
<tr><td>Outcome (Pass/Fail)</td><td colspan="3">PASS</td></tr>
<tr><td>Results</td><td colspan="3">The tool decodes and processes the information, giving Accuracy values in the range previous mentioned.</td></tr>
</table>



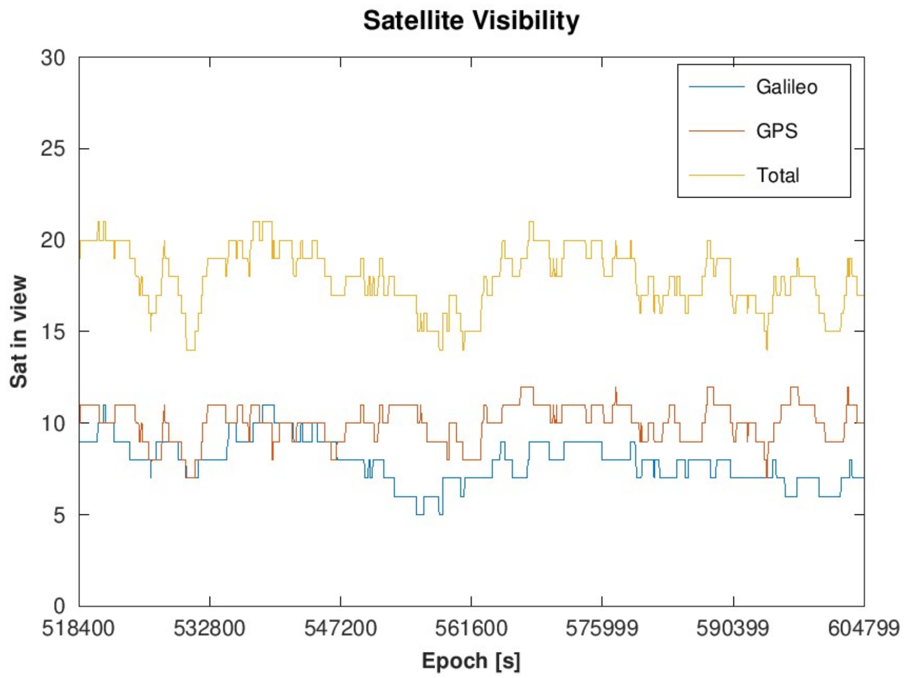
The tool decodes and processes the information, giving Protection Level values in the range previous mentioned. The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m.



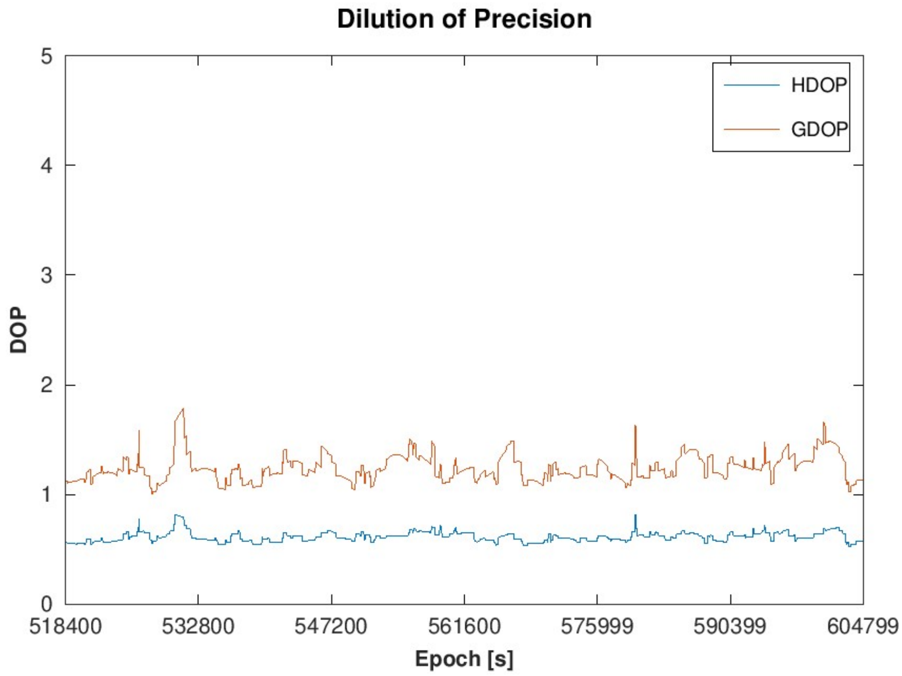
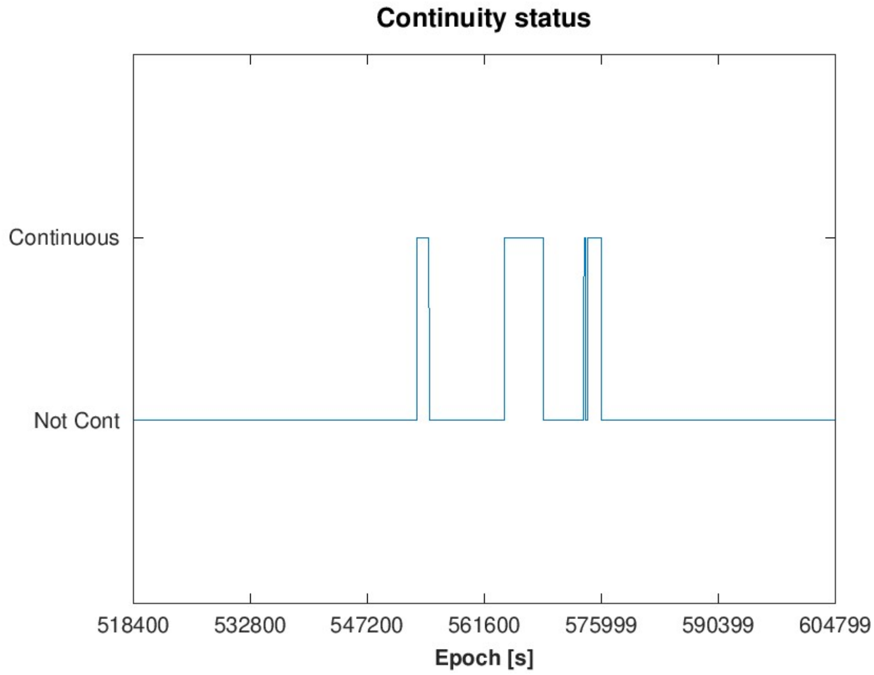
The tool provides an output of traffic light for the whole scenario. Considering that the Integrity Alert Limit is 25 meters in coastal navigation, the following results are obtained.



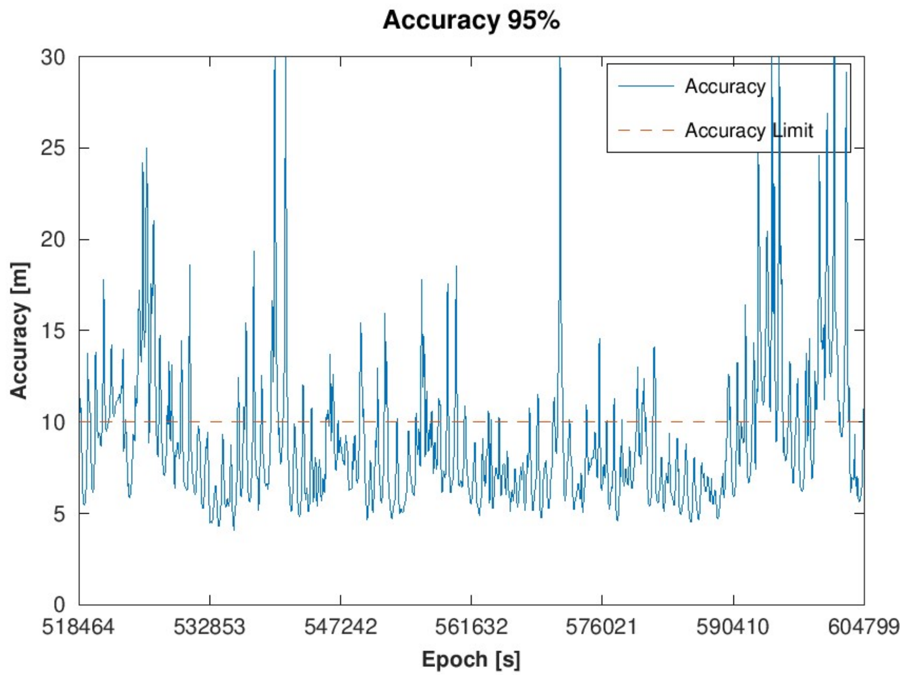
The tool decodes, processes the information, and provides satellite visibility across the scenario.

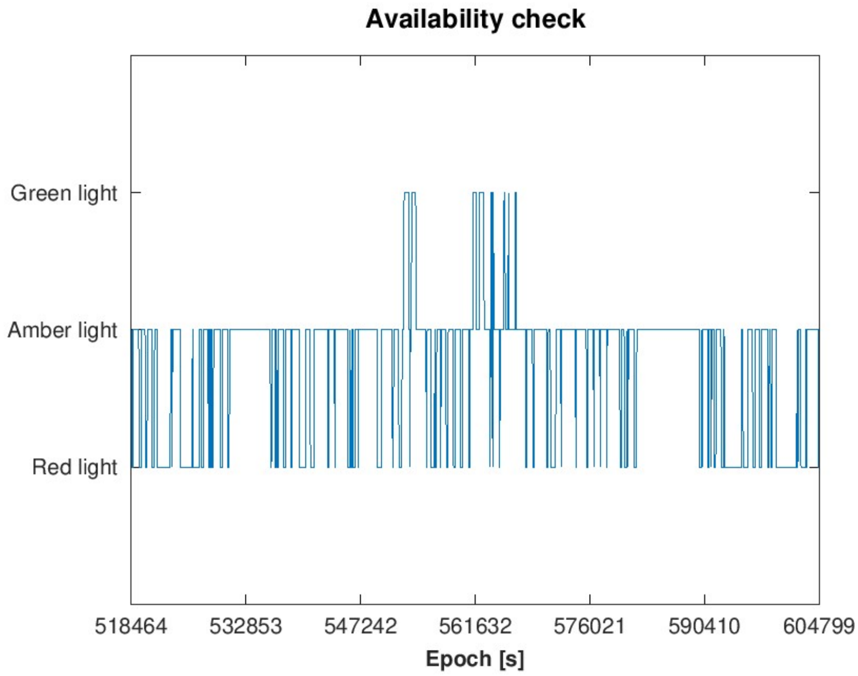
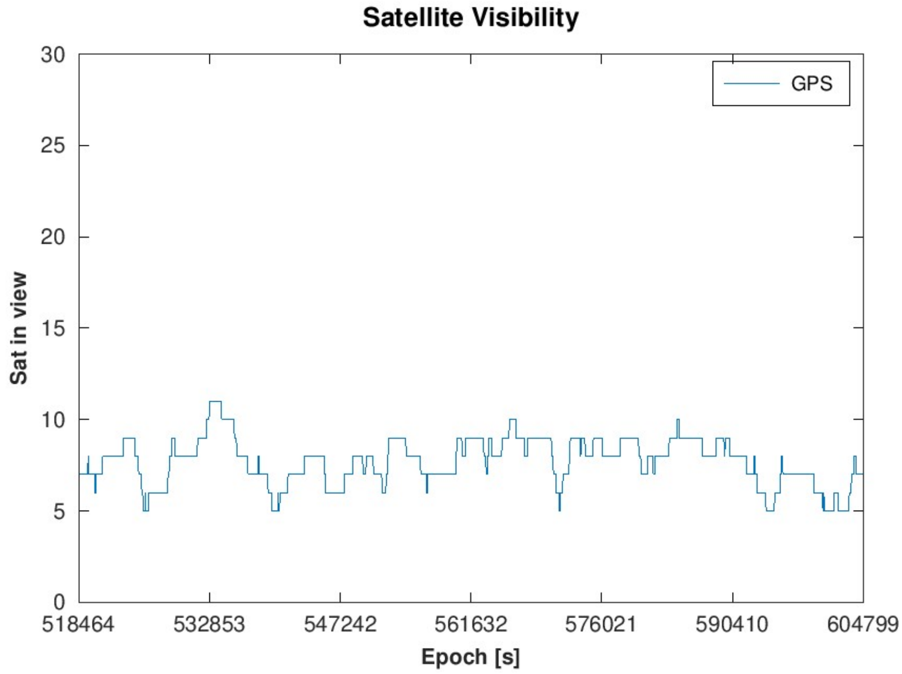


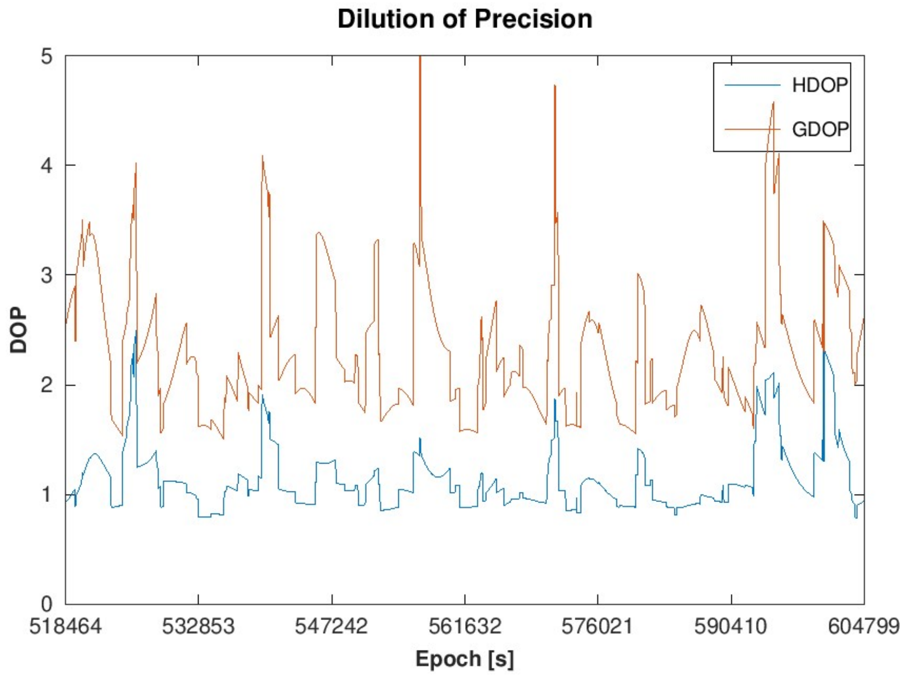
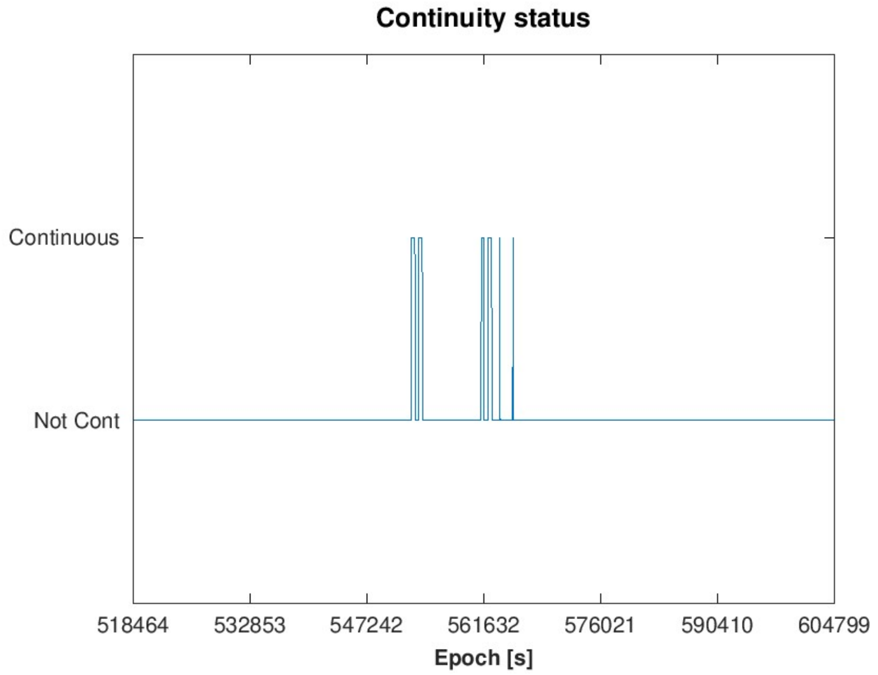
The tool decodes, processes the information HDOP and GDOP across the scenario.

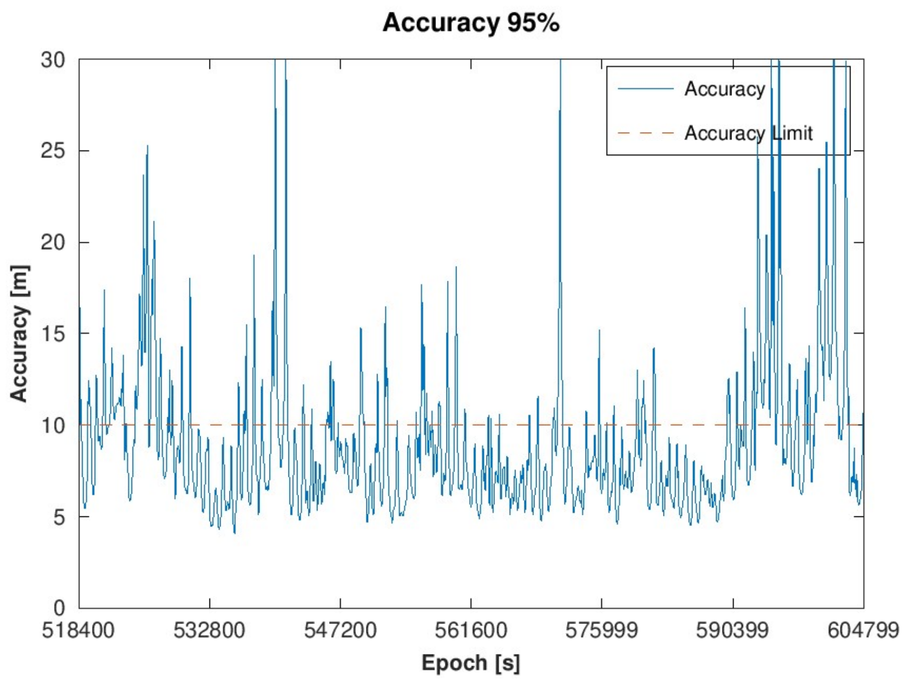
	 The tool decodes, processes the information, and provides system continuity across the scenario.  The tool provides the outputs in plain text mode:  simulation_data_

5.6 TC.MPT.006

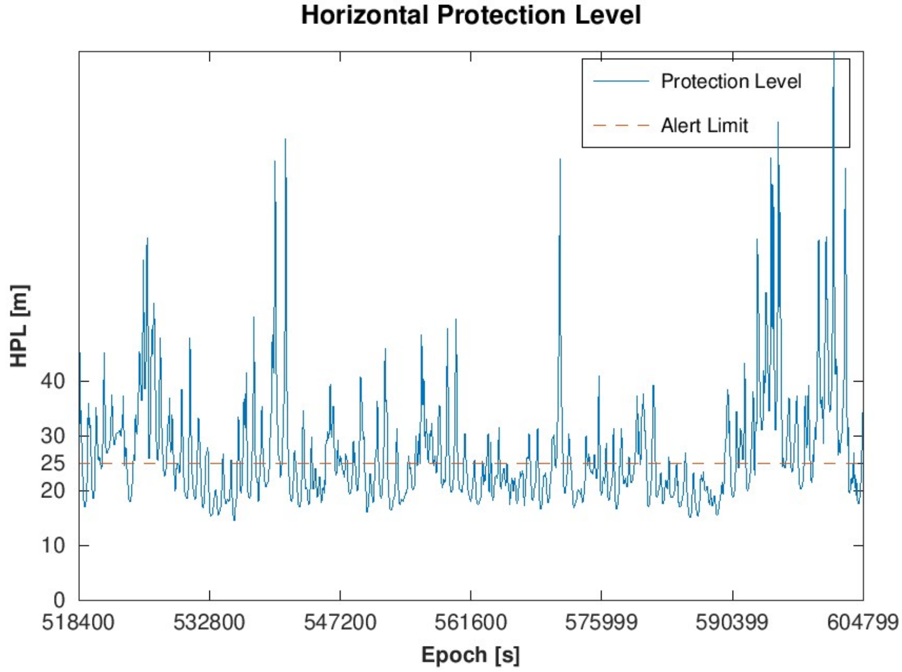
Test Code	TC.MPT.006 MGRAIM		
Test Objective	To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period. Single Frequency single constellation + SBAS L1 (GPS only+ EGNOS) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS		
Duration Time	The execution: 50 s time step Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	GPS ephemerides EGNOS messages		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ▪ MGRAIM algorithm selection ▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ▪ GPS + EGNOS ▪ Nominal error models configurable. *Single Frequency error model applied [RD.2]* ▪ Coastal navigation: Accuracy threshold = 10 m		
Outcome criteria	▪ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [2-6]m for the configuration selected. ▪ The tool shall decode, process the information and provide traffic light status along the scenario ▪ The tool shall decode, process the information, and provide satellite visibility and dilution of precision along the scenario ▪ The tool shall decode, process the information, and provide continuity status along the scenario ▪ The tool shall provide the output in plain text mode		
Outcome (Pass/Fail) **Results**	**PASS** The tool decodes and processes the information, giving Accuracy 95% values in the range previous mentioned.  The tool provides an output of traffic light for the whole scenario.		

	 The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario.

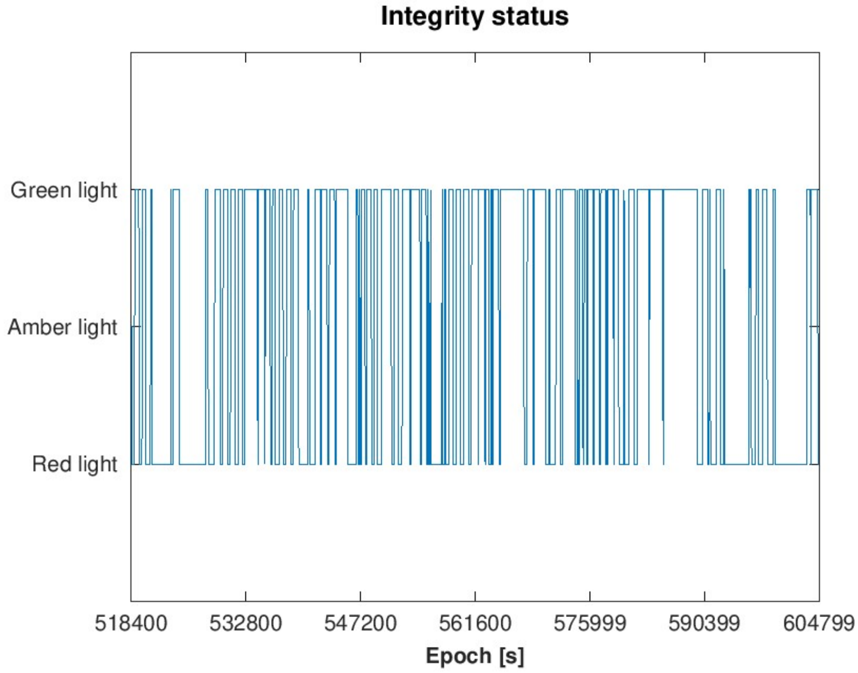
	 The tool decodes, processes the information, and provides system continuity across the scenario.  The tool provides the outputs in plain text mode: 

Test Code	TC.MPT.006 MRAIM		
Test Objective	To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period. Single Frequency single constellation + SBAS L1 (GPS only+EGNOS) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS		
Duration Time	The execution: 50 s time step Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	GPS ephemerides EGNOS messages		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ▪ MRAIM algorithm selection ▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ▪ GPS + EGNOS ▪ Nominal error models configurable. *Single Frequency error model applied [RD.2]* ▪ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m		
Outcome criteria	▪ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [5+]m for the configuration selected. ▪ The tool shall decode, process the information, and provide HPL results in the range of [15+]m for the configuration selected. ▪ The tool shall decode, process the information and provide traffic light status along the scenario ▪ The tool shall decode, process the information, and provide satellite visibility and dilution of precision along the scenario ▪ The tool shall decode, process the information, and provide continuity status along the scenario ▪ The tool shall provide the output in plain text mode		
Outcome (Pass/Fail) **Results**	**PASS** The tool decodes and processes the information, giving Accuracy 95% values in the range previous mentioned.  The tool decodes and processes the information, giving Protection Level values in the range		

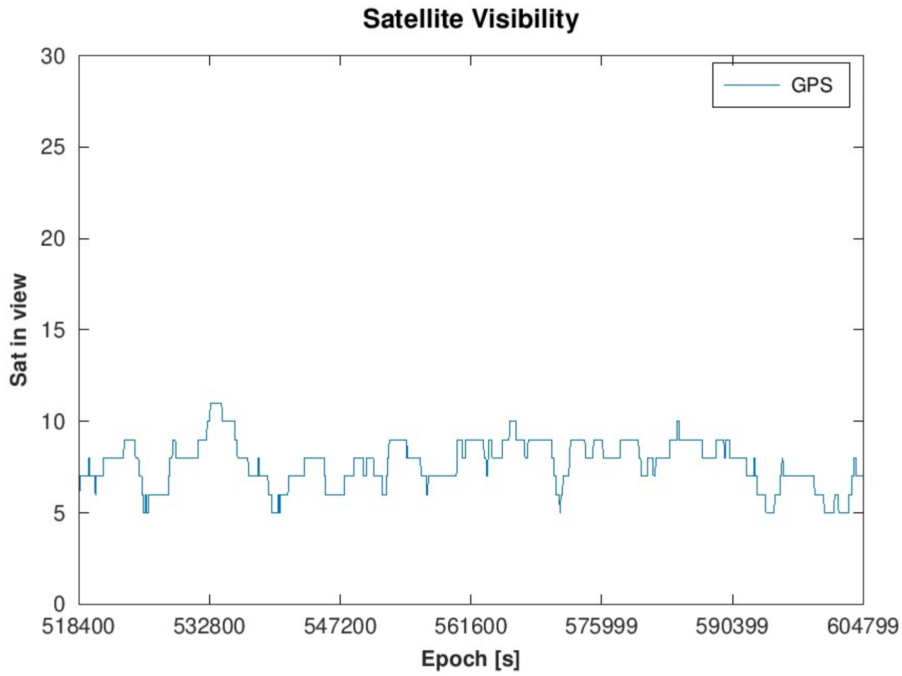
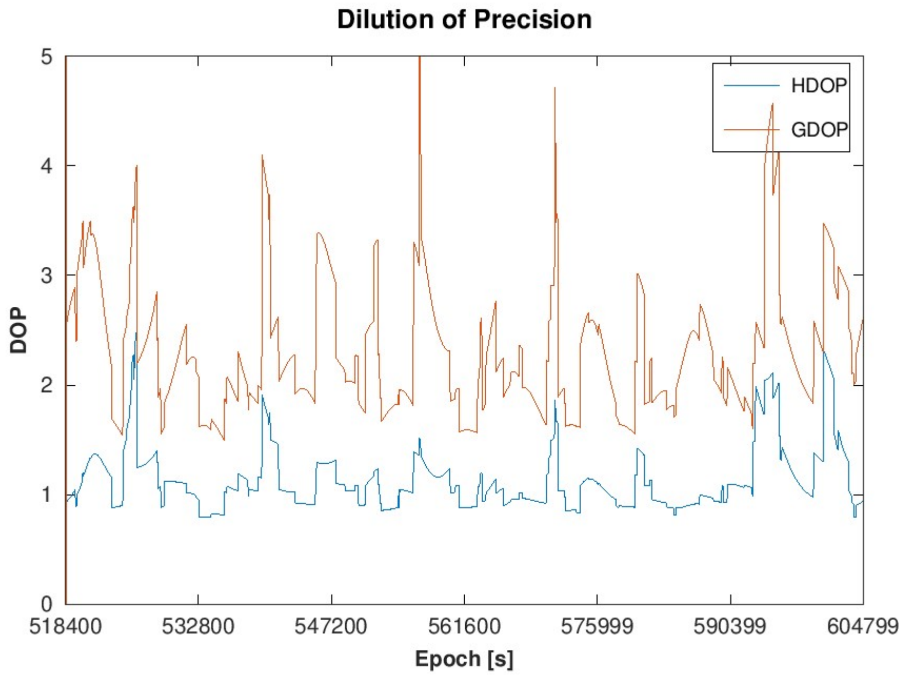
previous mentioned. The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m.

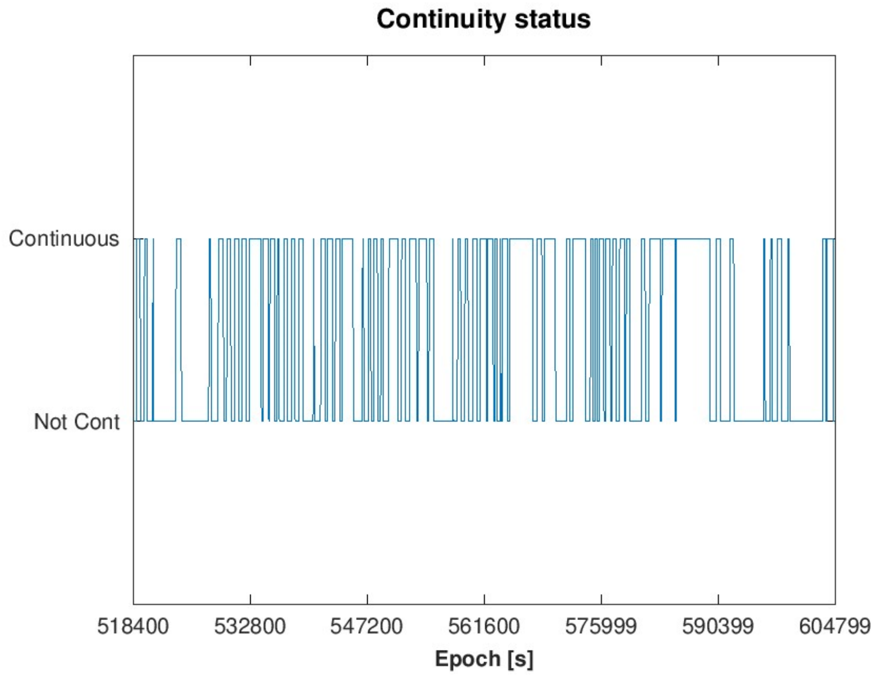


The tool provides an output of traffic light for the whole scenario. Considering that the Integrity Alert Limit is 25 meters in coastal navigation, the following results are obtained.

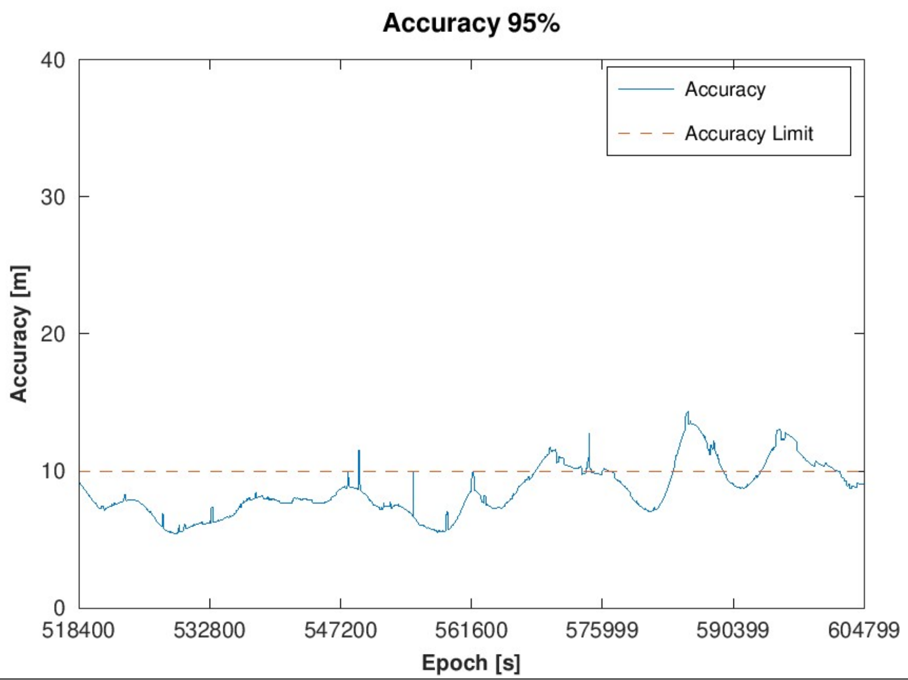


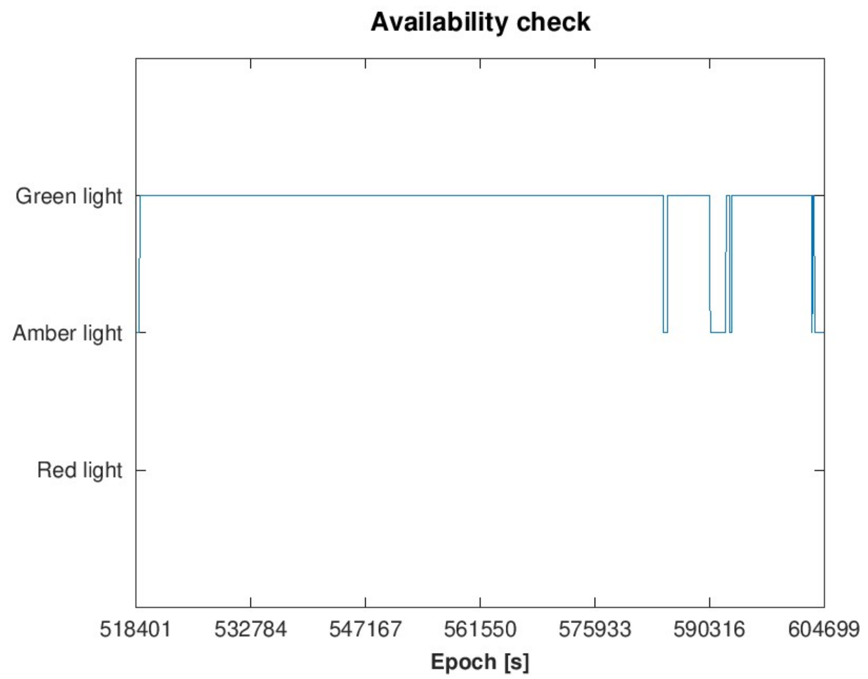
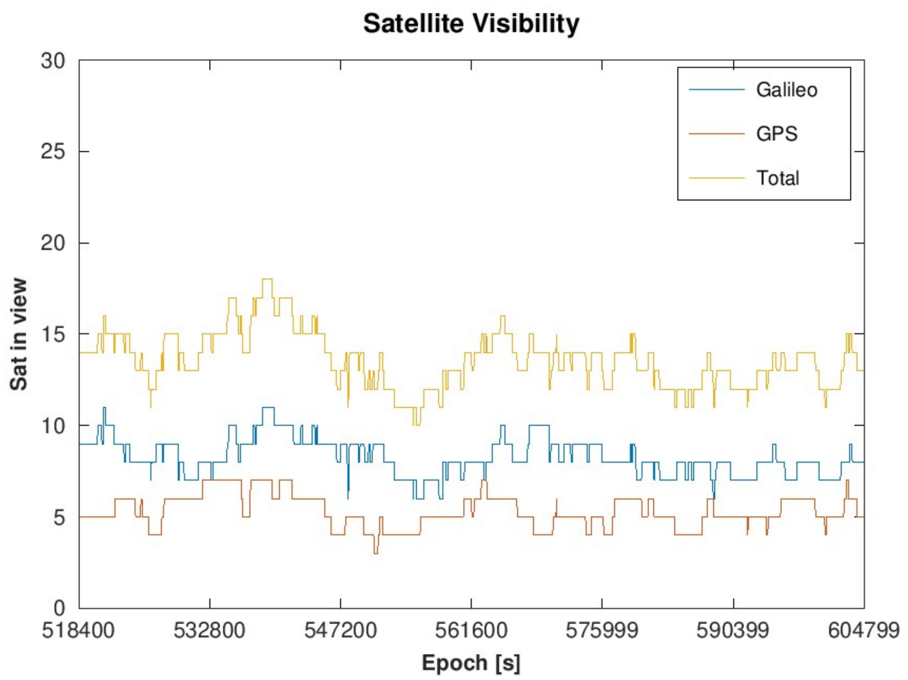
The tool decodes, processes the information, and provides satellite visibility across the scenario.

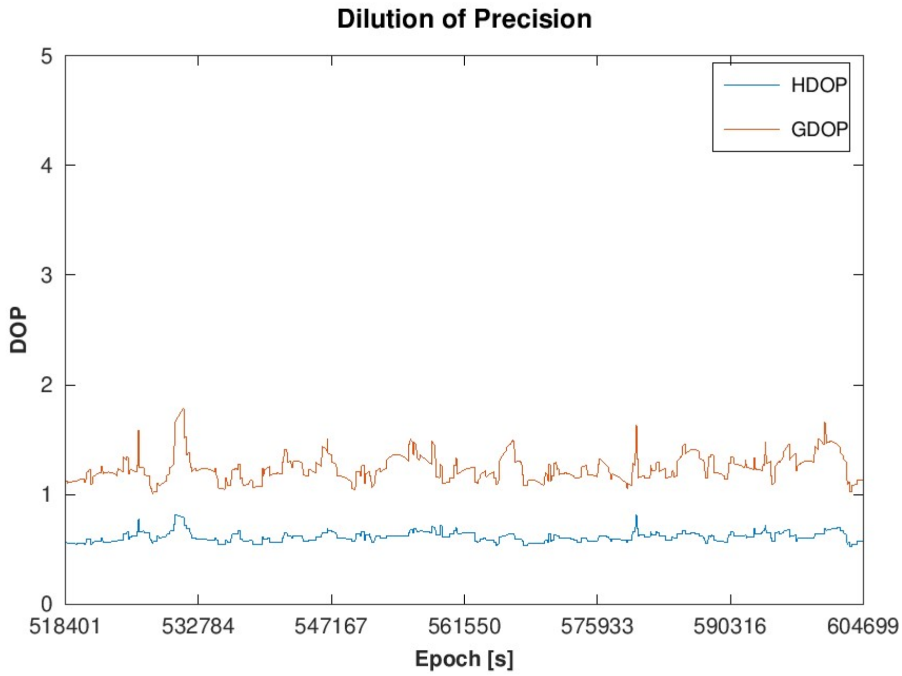
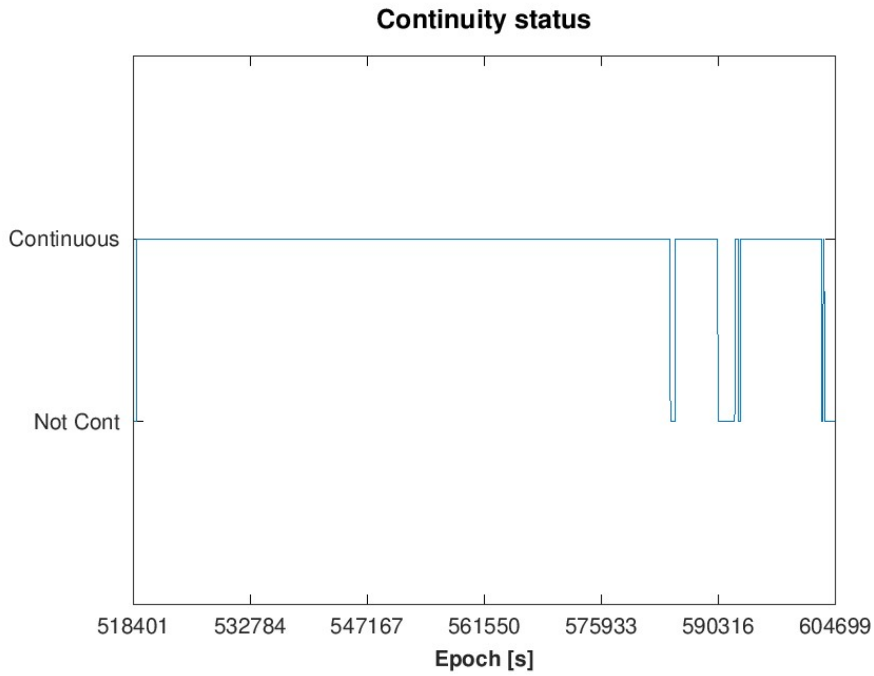
	 The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario.  The tool decodes, processes the information, and provides system continuity across the scenario.

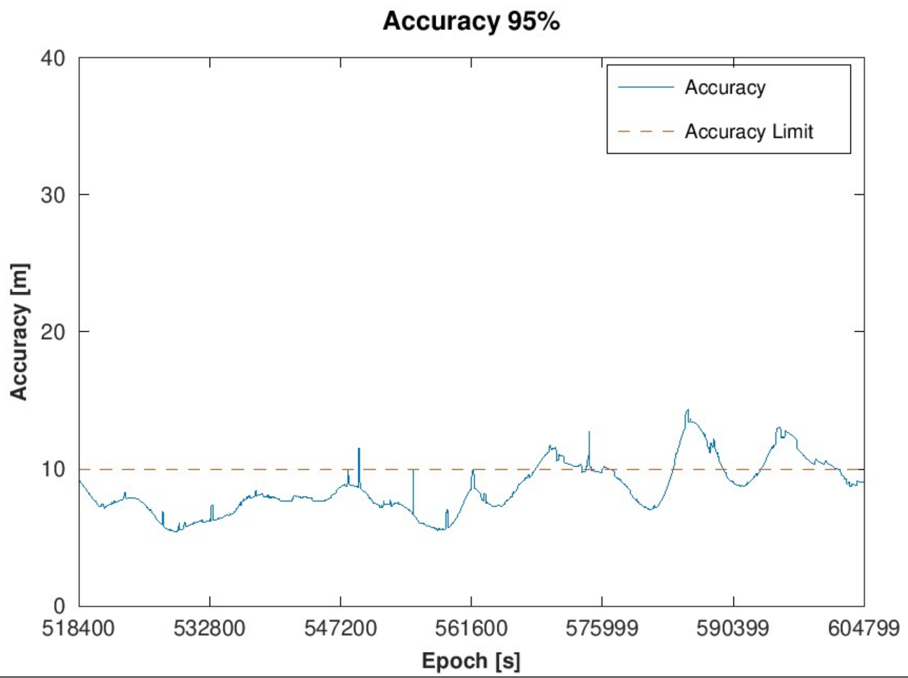
	 The tool provides the outputs in plain text mode: 

5.7 TC.MPT.007

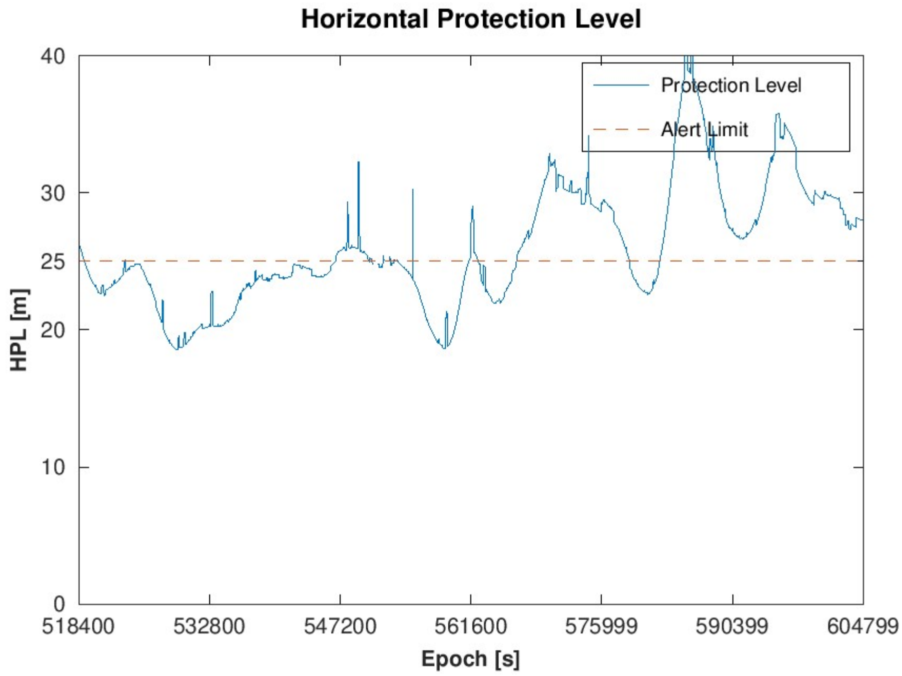
Test Code	TC.MPT.007 MGRAIM		
Test Objective	To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period. Dual Frequency Multiconstellation + SBAS L5 (GPS+Galileo) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS, Galileo		
Duration Time	The execution: 50 s time step Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	GPS ephemerides Galileo ephemerides UK SBAS L5 messages		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ▪ MGRAIM algorithm selection ▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ▪ GPS + Galileo+ UK SBAS ▪ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ▪ Coastal navigation: Accuracy threshold = 10 m		
Outcome criteria	▪ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [6+]m for the configuration selected. ▪ The tool shall decode, process the information and provide traffic light status along the scenario ▪ The tool shall decode, process the information, and provide satellite visibility and dilution of precision along the scenario ▪ The tool shall decode, process the information, and provide continuity status along the scenario		
Outcome (Pass/Fail) **Results**	**PASS** The tool decodes and processes the information, giving Accuracy 95% values in the range previous mentioned. 		

	The tool provides an output of traffic light for the whole scenario.  The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario.

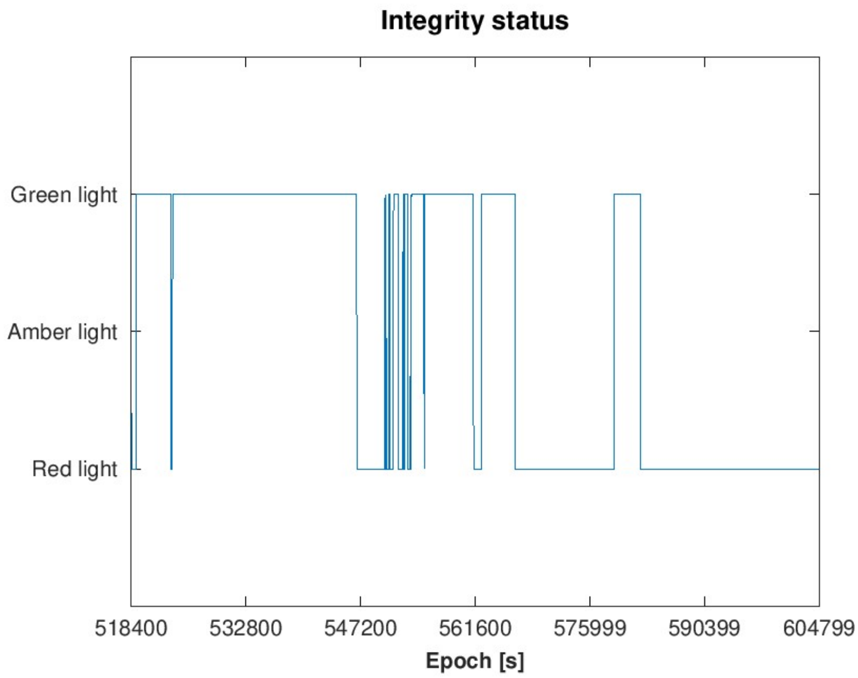
	 The tool decodes, processes the information, and provides system continuity across the scenario.  The tool provides the outputs in plain text mode: 

Test Code	TC.MPT.007 MRAIM		
Test Objective	To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS, Galileo		
Duration Time	The execution: 50 s time step Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	GPS ephemerides Galileo ephemerides UK SBAS L5 messages		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ▪ MRAIM algorithm selection ▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ▪ GPS + SBAS (EGNOS) ▪ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ▪ Coastal navigation: Accuracy threshold = 10 m; Alert Limit=25 m		
Outcome criteria	▪ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [6+]m for the configuration selected. ▪ The tool shall decode, process the information, and provide HPL results in the range of [18+]m for the configuration selected. ▪ The tool shall decode, process the information, and provide traffic light status along the scenario ▪ The tool shall decode, process the information, and provide satellite visibility and HDOP and GDOP along the scenario ▪ The tool shall decode, process the information, and provide continuity status along the scenario		
Outcome (Pass/Fail) **Results**	**PASS** The tool decodes and processes the information, giving Accuracy values in the range previous mentioned. The results are the same as TC.MPT.001 results. 		

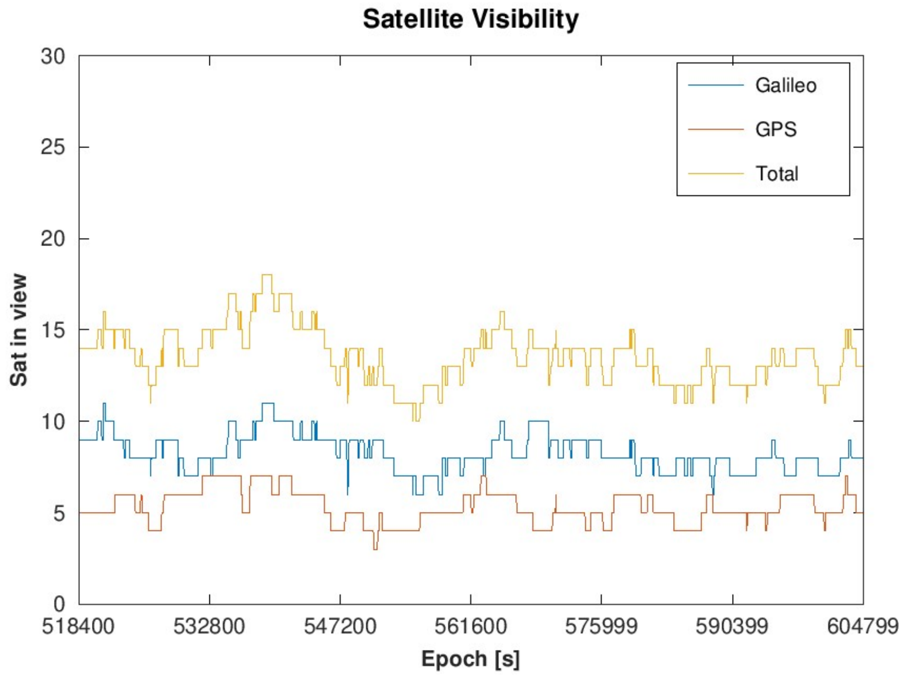
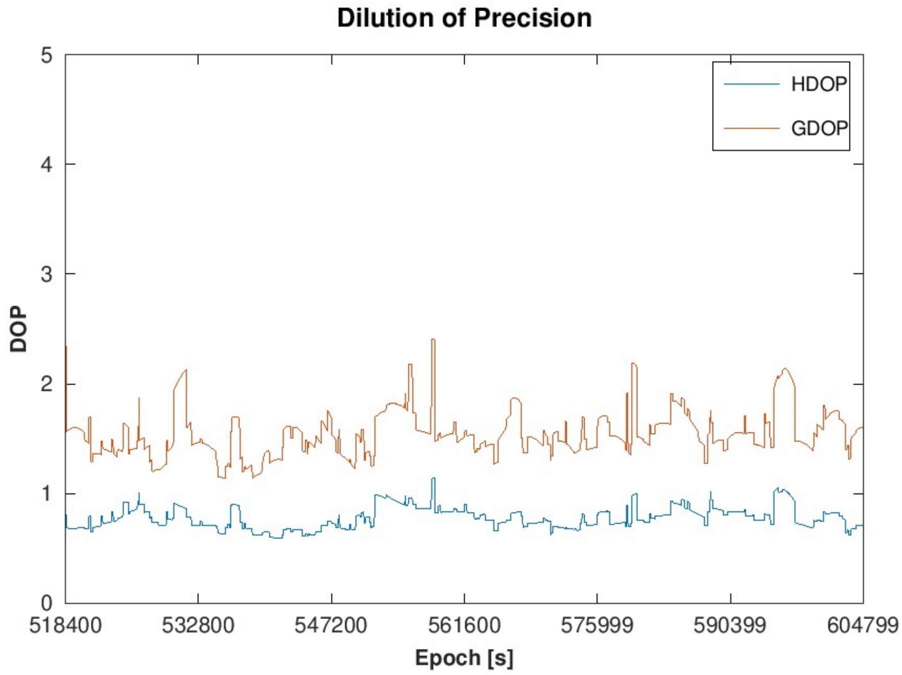
The tool decodes and processes the information, giving Protection Level values in the range previous mentioned.

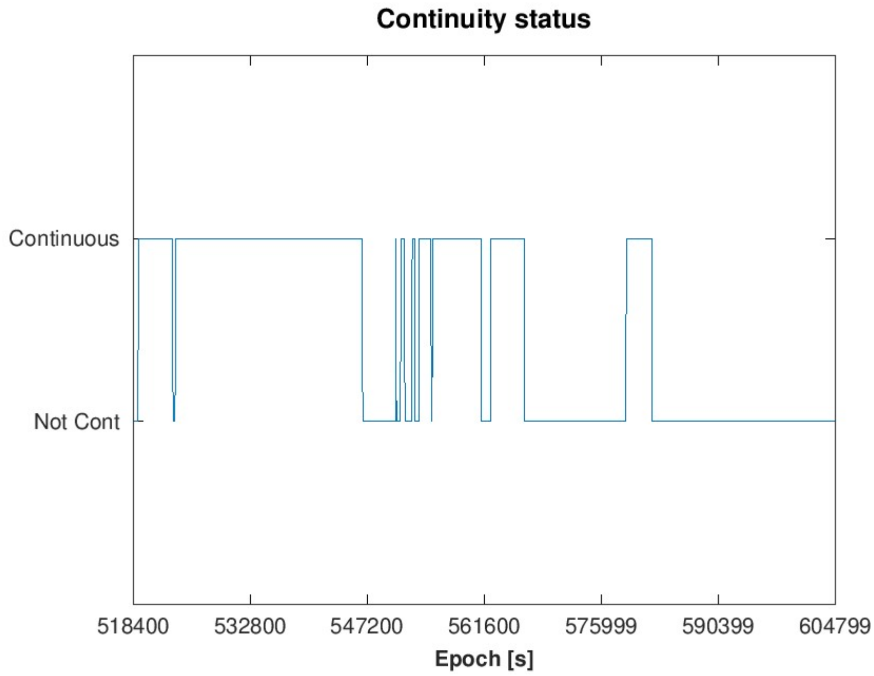


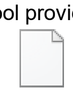
The tool provides an output of traffic light for the whole scenario.



The tool decodes, processes the information, and provides Availability status across the scenario.

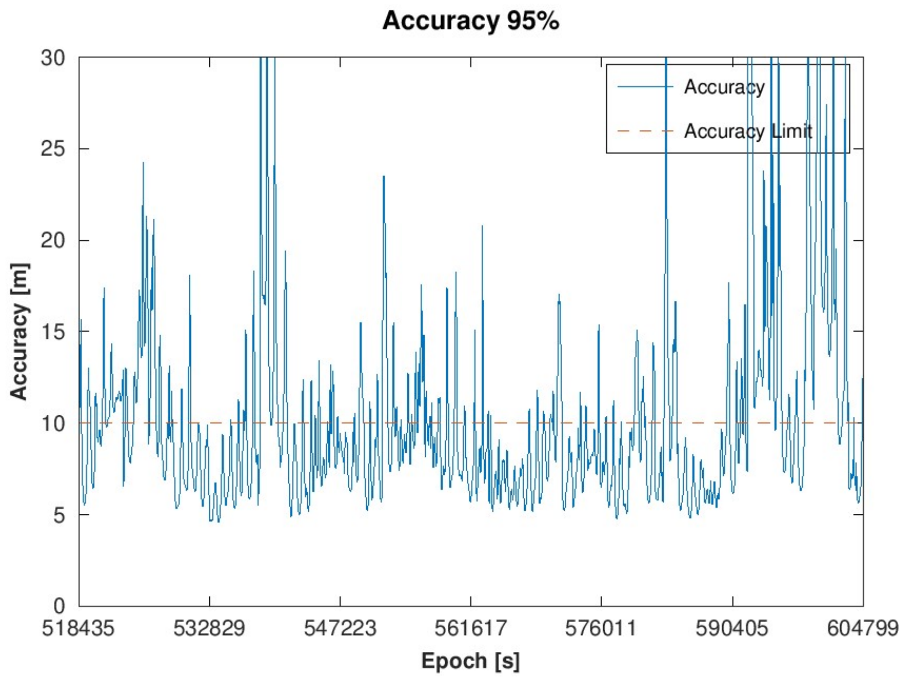
	 The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario.  The tool decodes, processes the information, and provides continuity status across the scenario.

<table>
<tr>
<td></td>
<td>


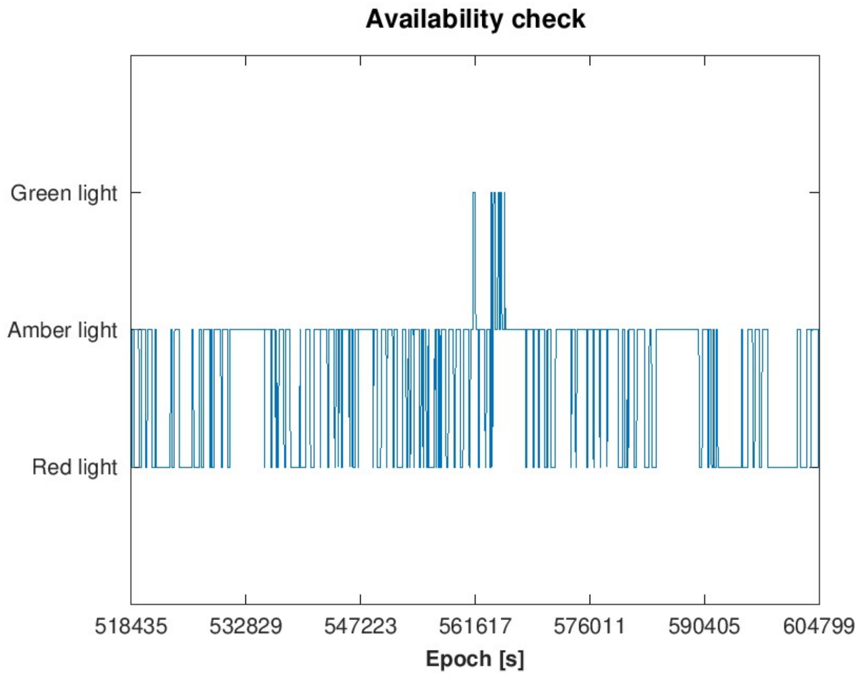
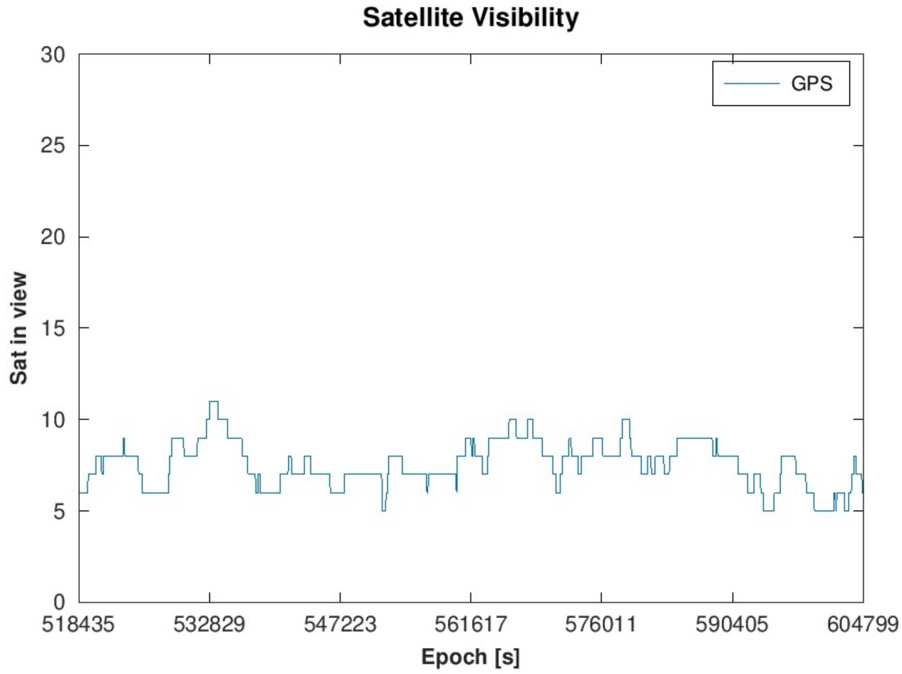
The tool provides results in a text plain mode.

simulation_data_
</td>
</tr>
</table>

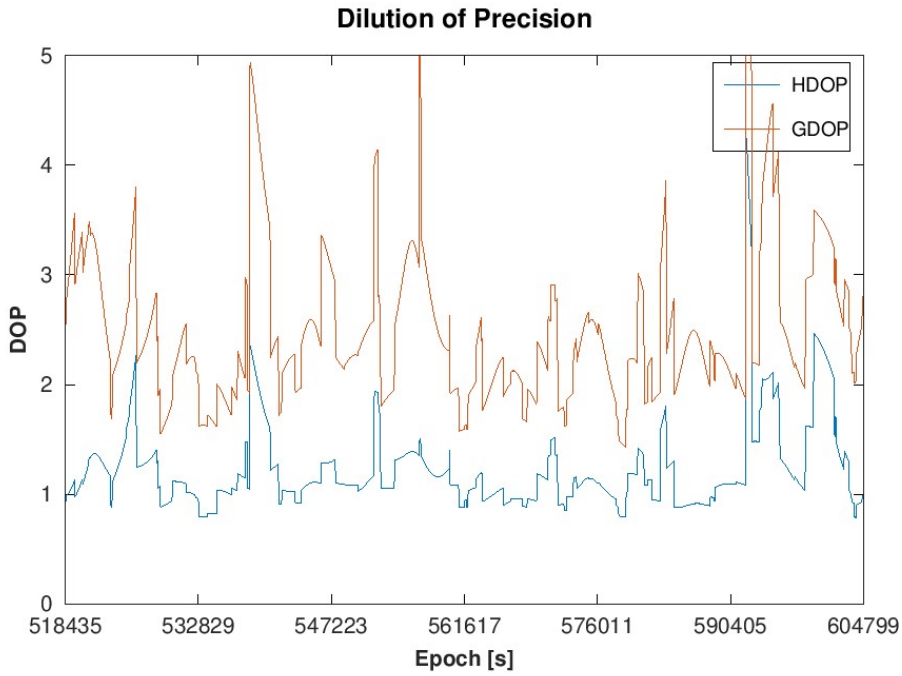
5.8 TC.MPT.008

<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.008 MGRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period. Single Frequency single constellation + SBAS L1 (GPS only+ UKSBAS) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 50 s time step
Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">GPS ephemerides
UK SBAS L1 messages</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
▪ MGRAIM algorithm selection
▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59
▪ GPS + UK SBAS
▪ Nominal error models configurable. Single Frequency error model applied [RD.2]
▪ Coastal navigation: Accuracy threshold = 10 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">▪ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [5+]m for the configuration selected.
▪ The tool shall decode, process the information and provide traffic light status along the scenario
▪ The tool shall decode, process the information, and provide satellite visibility and dilution of precision along the scenario
▪ The tool shall decode, process the information, and provide continuity status along the scenario</td></tr>
<tr><td rowspan="2">Outcome (Pass/Fail)

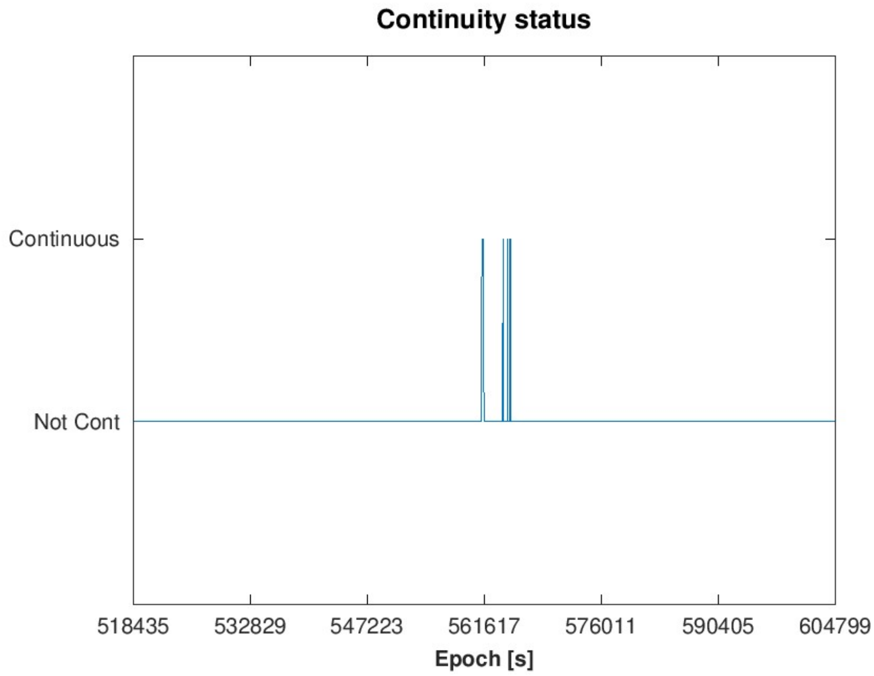
Results</td><td colspan="3">PASS</td></tr>
<tr><td colspan="3">The tool decodes and processes the information, giving Accuracy 95% values in the range previous mentioned.


The tool provides an output of traffic light for the whole scenario.</td></tr>
</table>

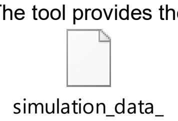
	 The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario.



The tool decodes, processes the information, and provides system continuity across the scenario.

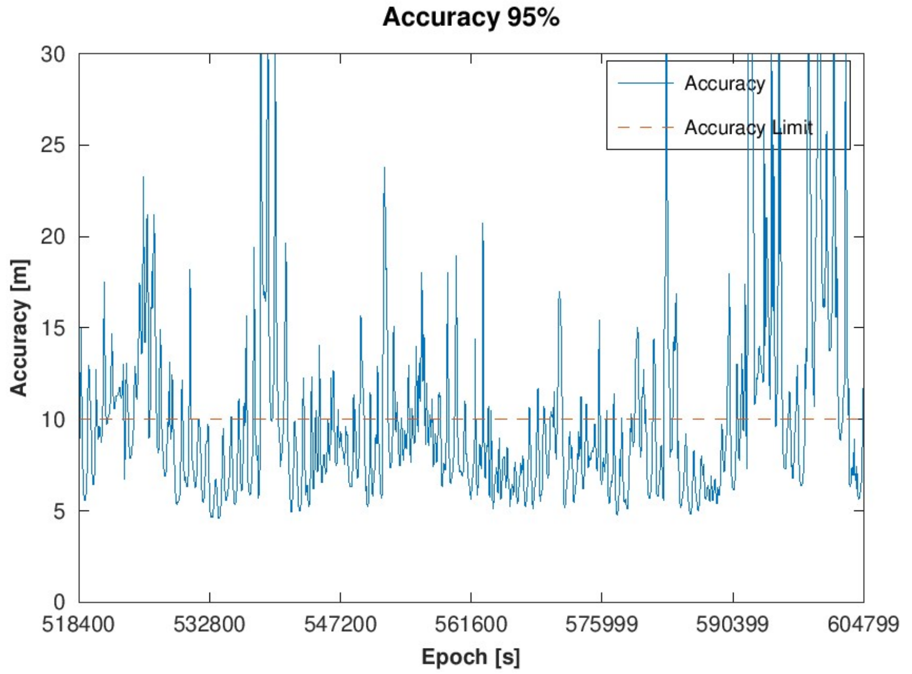


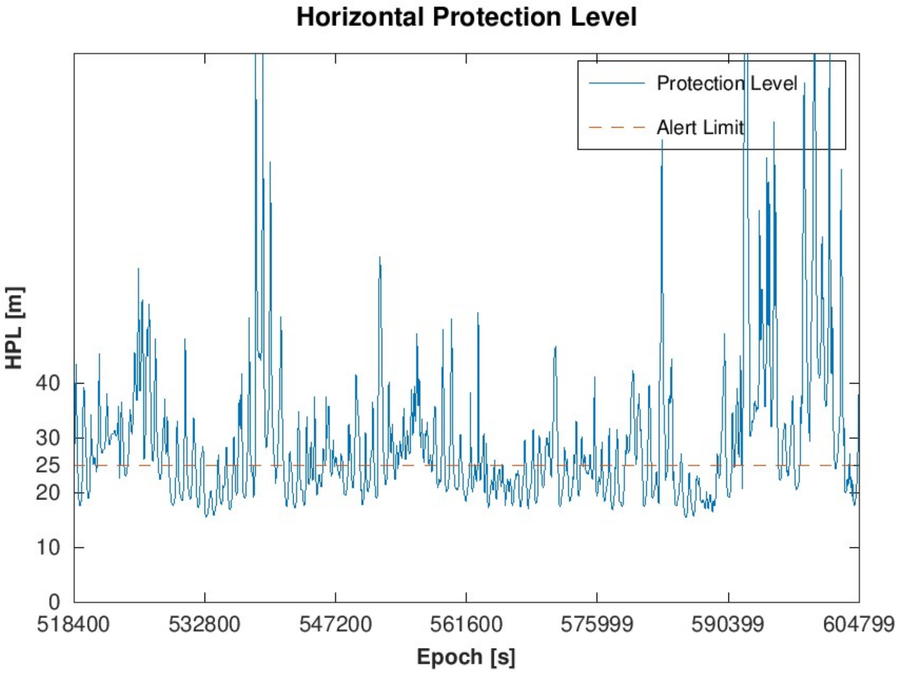
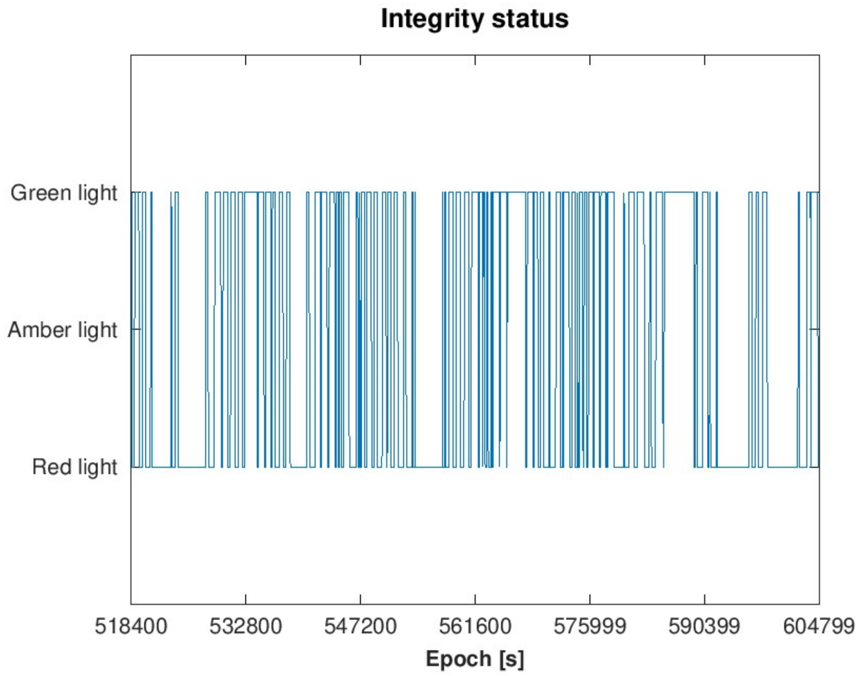
The tool provides the outputs in plain text mode:

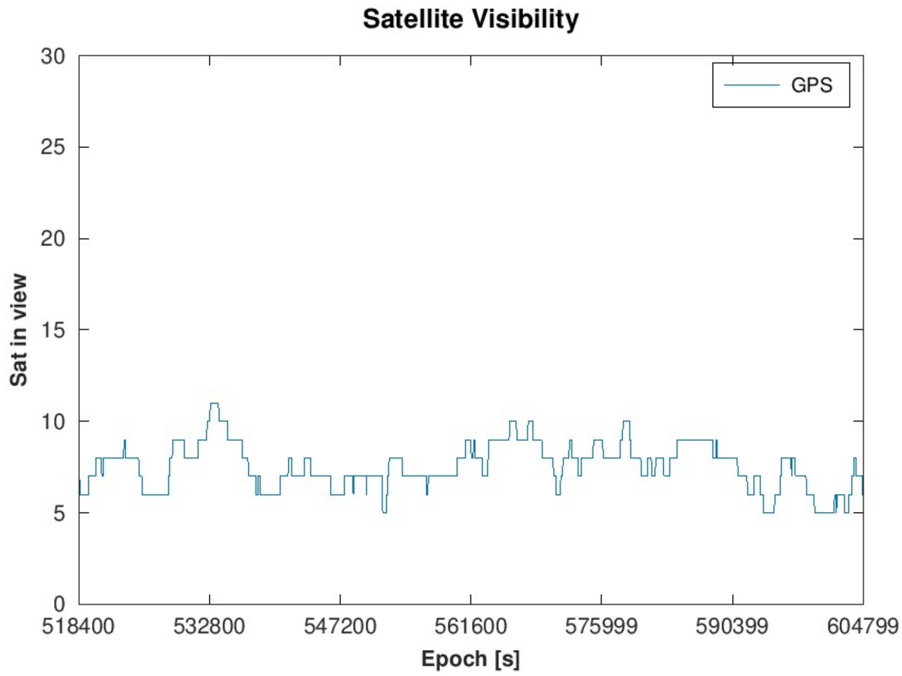
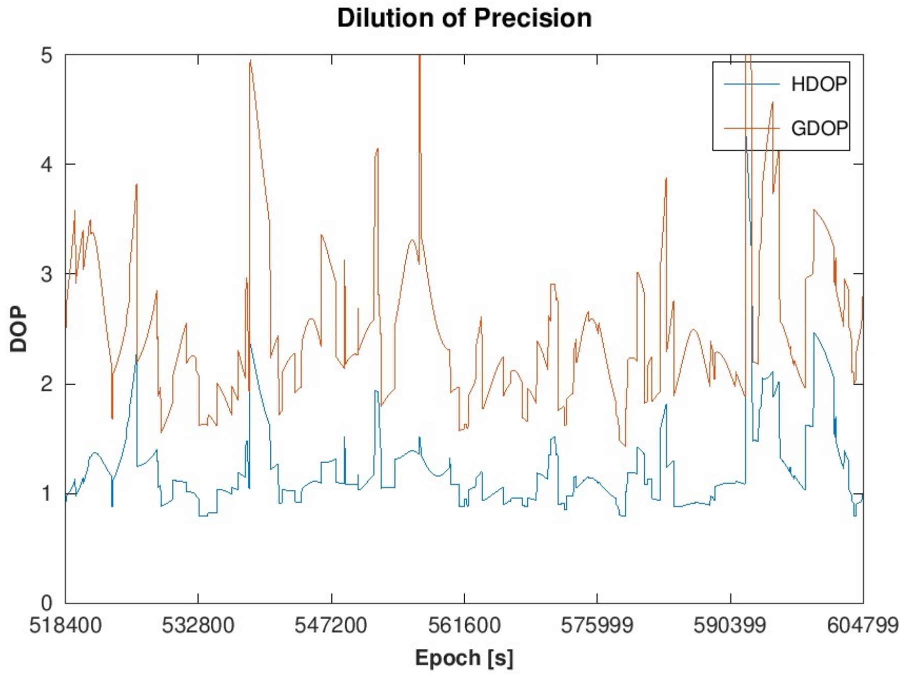


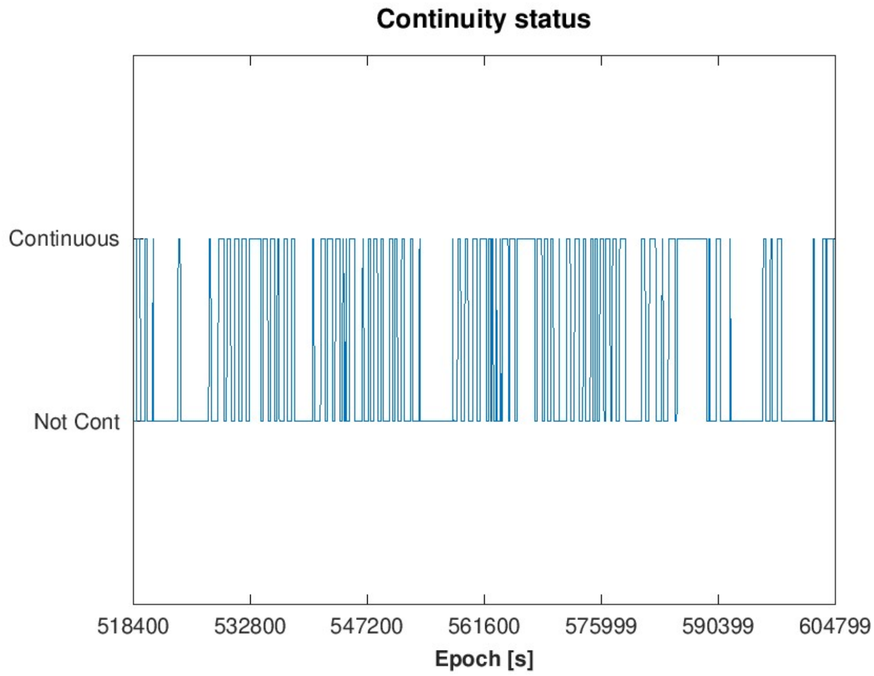
<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.008 MRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period. Single Frequency single constellation + SBAS L1 (GPS only+ UK SBAS) scenario studied for Coastal navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 50 s time step

Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">GPS ephemerides
UK SBAS L1 messages</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
▪ MRAIM algorithm selection
▪ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
▪ Forecast for 23/09/2023 from 00:00:00 - 23:59:59
▪ GPS + UK SBAS
▪ Nominal error models configurable. Single Frequency error model applied [RD.2]
▪ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">▪ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [5+]m for the configuration selected.
▪ The tool shall decode, process the information, and provide HPL results in the range of [15+]m for the configuration selected.
▪ The tool shall decode, process the information, and provide traffic light status along the scenario
▪ The tool shall decode, process the information, and provide dilution of precision along the scenario
▪ The tool shall decode, process the information, and provide continuity status along the scenario</td></tr>
<tr><td rowspan="2">Outcome (Pass/Fail)

Results</td><td colspan="3">PASS</td></tr>
<tr><td colspan="3">The tool decodes and processes the information, giving Accuracy values in the range previous mentioned.
</td></tr>
</table>

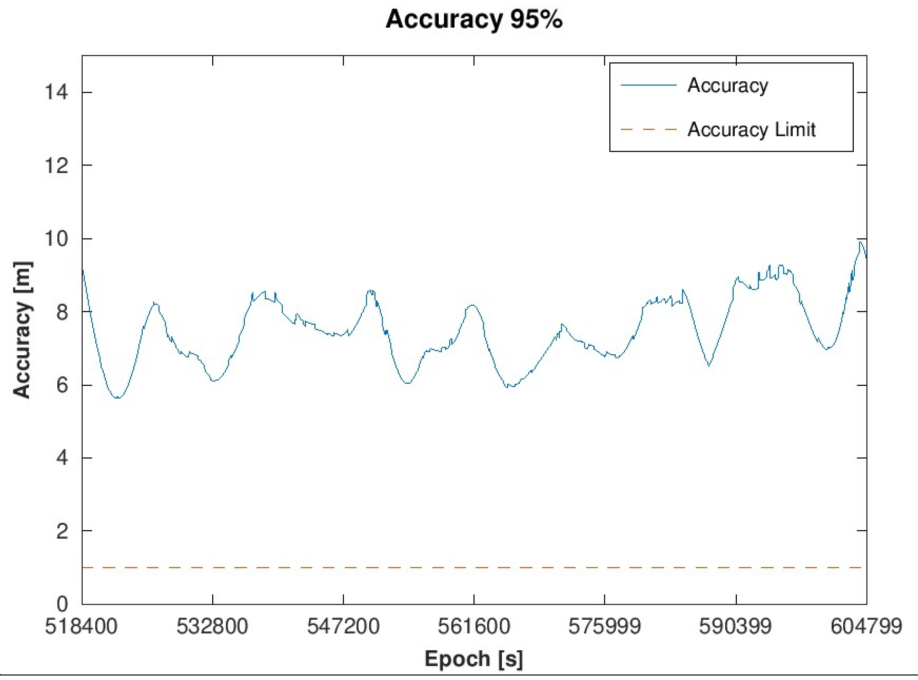
	The tool decodes and processes the information, giving Protection Level values in the range previous mentioned. The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m.  The tool provides an output of traffic light for the whole scenario. More alarms can be seen compared to TC.MPT.010.  The tool decodes, processes the information, and provides satellite visibility across the scenario.

	 The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario. Here, as in the previous case, the DOP is higher.  The tool decodes, processes the information, and provides system continuity across the scenario.

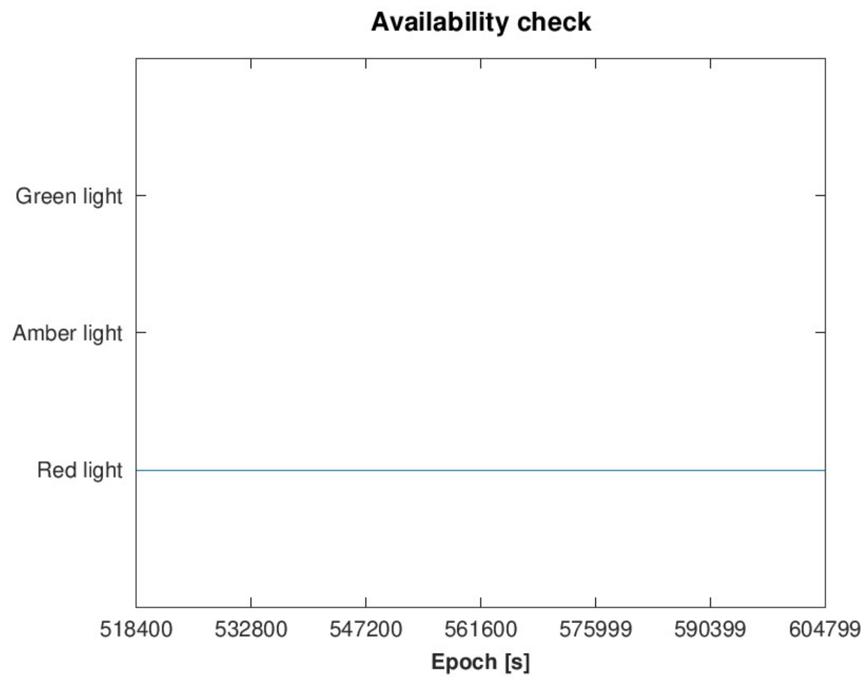
	 The tool provides results in a text plain mode.  simulation_data_

5.9 TC.MPT.009

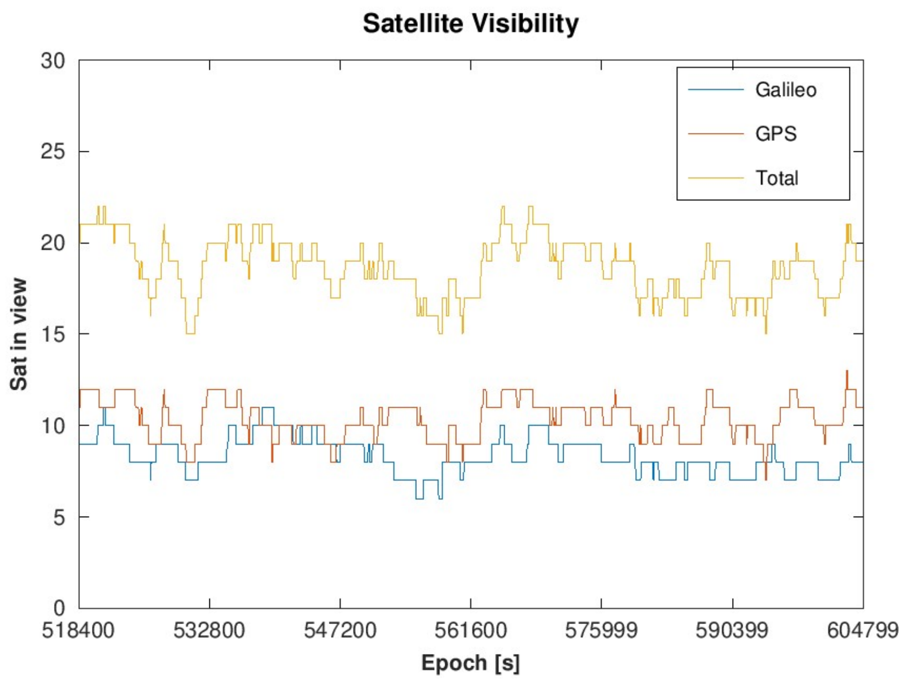
<table>
<tr><th>Test Code</th><th colspan="3">TC.MPT.009 MGRAIM</th></tr>
<tr><td>Test Objective</td><td colspan="3">To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Port navigation</td></tr>
<tr><td>Test Experiment Location</td><td>GMV Laboratory</td><td>Test Experiment Equipment</td><td>PC or laptop running Windows OS</td></tr>
<tr><td>Dependence SW</td><td colspan="3">Octave 6.1.0</td></tr>
<tr><td>Constellation used</td><td colspan="3">GPS, Galileo</td></tr>
<tr><td>Duration Time</td><td colspan="3">The execution: 50 s time step
Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59</td></tr>
<tr><td>Input Data</td><td colspan="3">Galileo ephemerides
GPS ephemerides</td></tr>
<tr><td>Processing</td><td colspan="3">Execution of the Performance Prediction Prototype tool using a nominal configuration which includes:
■ MGRAIM algorithm selection
■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800]
■ Forecast for 18/09/2023 from 00:00:00 - 23:59:59
■ GPS + Galileo
■ Nominal error models configurable. Dual Frequency error model applied [RD.2]
■ Port navigation: Accuracy threshold = 1 m</td></tr>
<tr><td>Outcome criteria</td><td colspan="3">■ The tool shall decode, process the information, and provide accuracy 95% results in the range of [5-10]m for the configuration selected
■ The tool shall decode, process the information, and provide traffic light status along the scenario
■ The tool shall decode, process the information, and provide satellite visibility along the scenario
■ The tool shall decode, process the information, and provide Dilution of precision along the scenario
■ The tool shall decode, process the information, and provide continuity status along the scenario</td></tr>
<tr><td rowspan="2">Outcome (Pass/Fail)

Results</td><td colspan="3">PASS</td></tr>
<tr><td colspan="3">The tool decodes and processes the information, giving Accuracy 95% values in the range previous mentioned.
</td></tr>
</table>

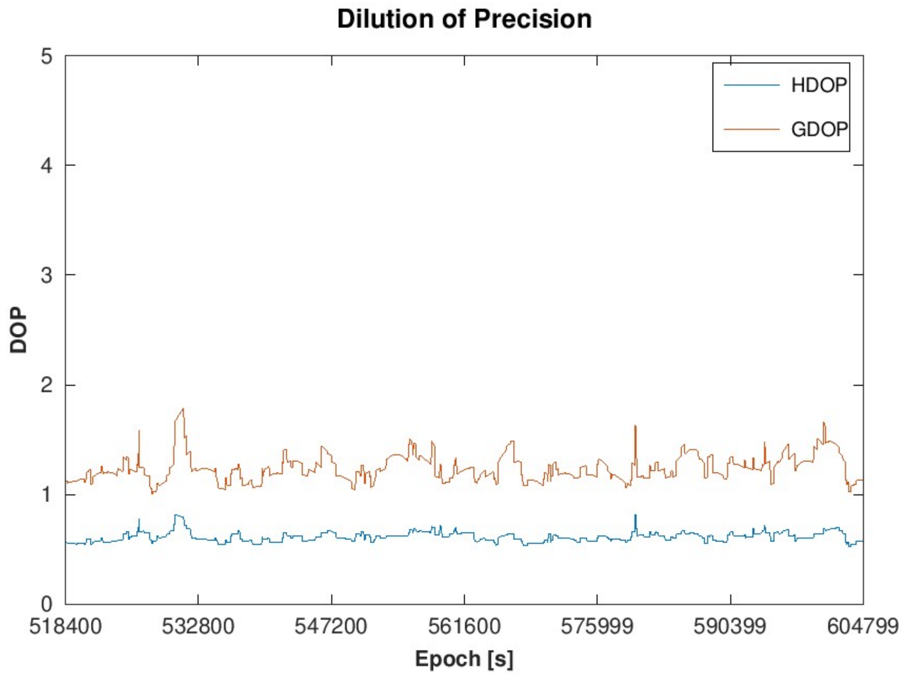
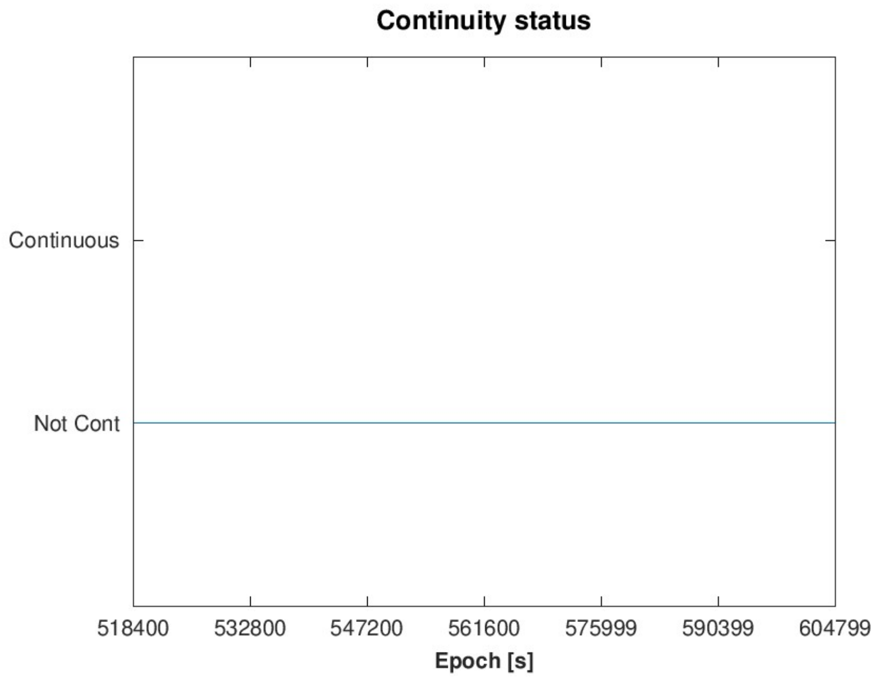
The tool decodes, processes the information, and provides traffic light along the scenario



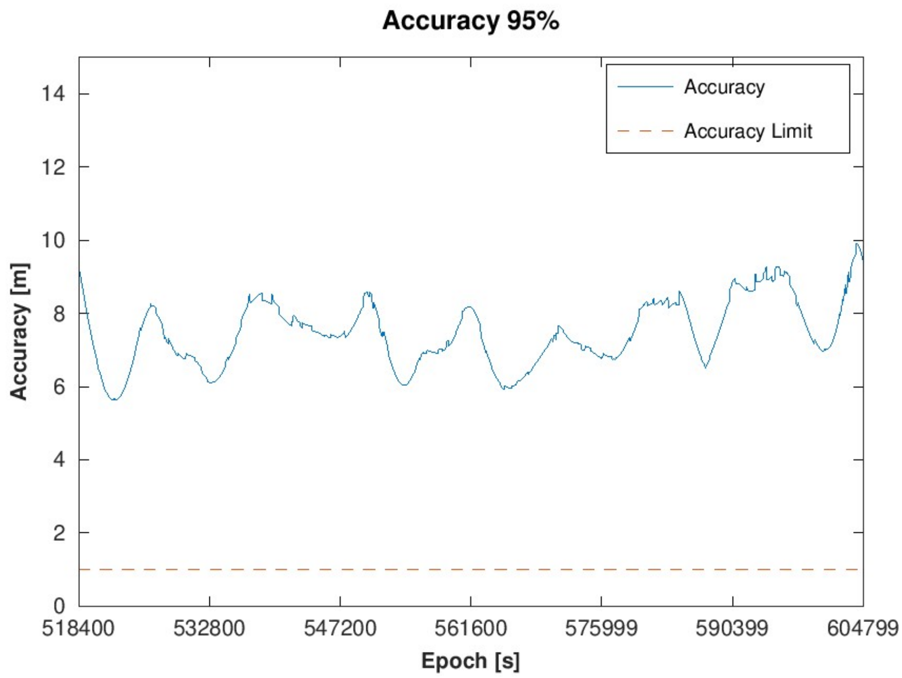
The tool decodes, processes the information, and provides satellite visibility along the scenario.



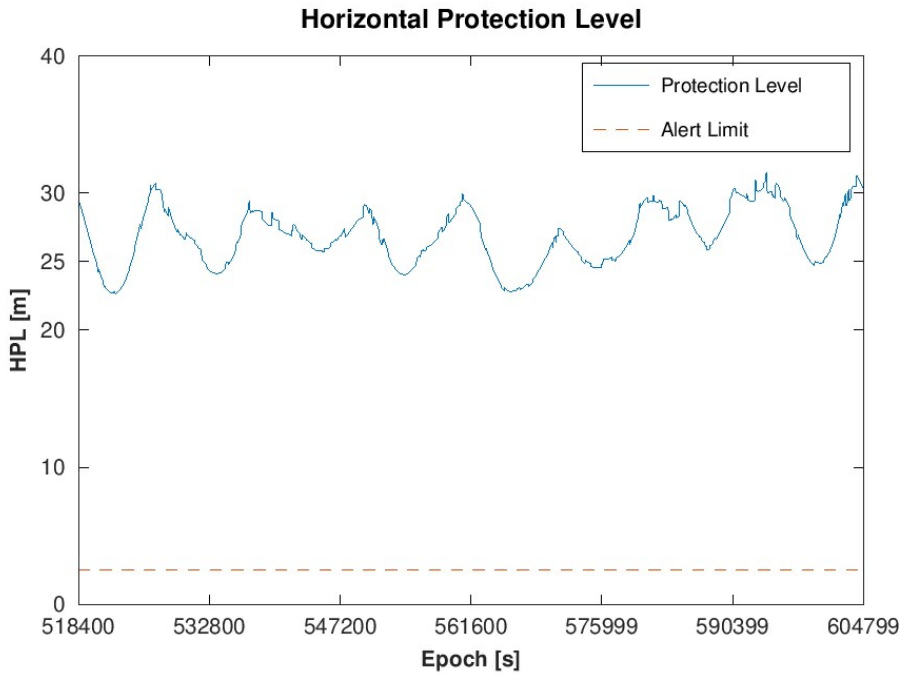
The tool decodes, processes the information, and provides Dilution of precision along the scenario.

	 The tool decodes, processes the information, and provides continuity status along the scenario.  The tool provides results in a text plain mode.  simulation_data_

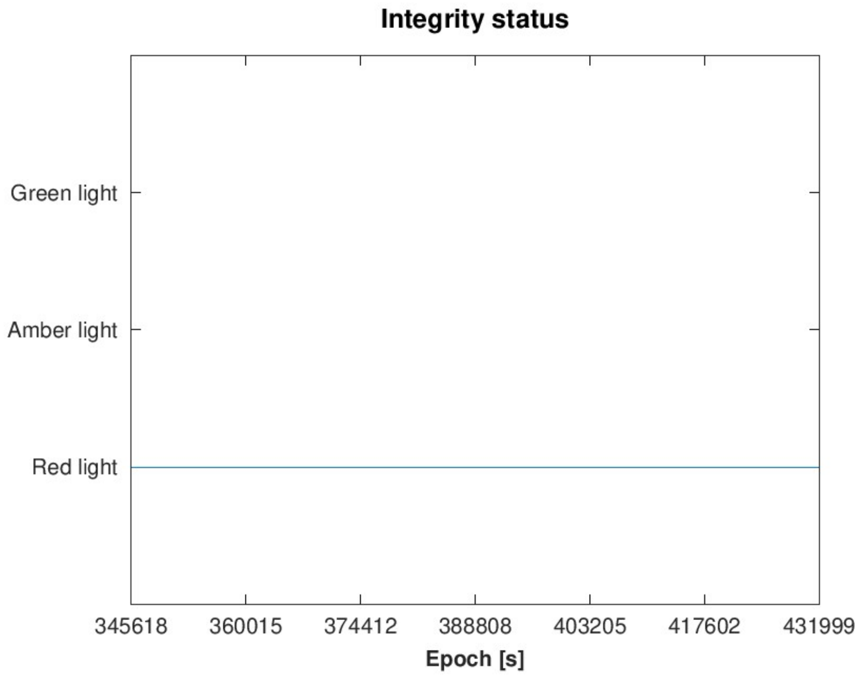
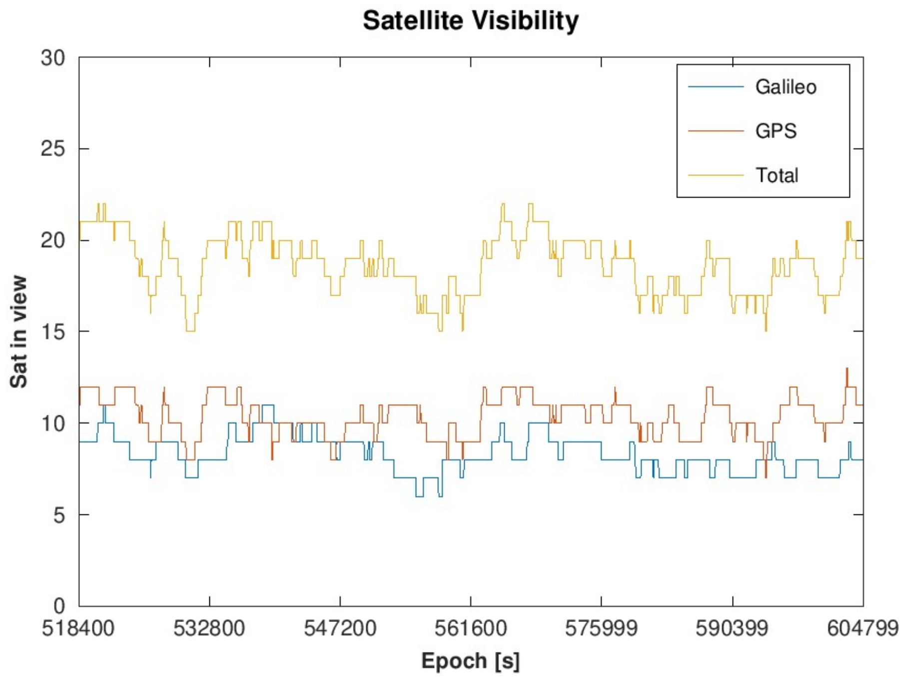
Test Code	TC.MPT.009 MRAIM		
Test Objective	To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period. Dual Frequency Multiconstellation (GPS+Galileo) scenario studied for Port navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation	GPS, Galileo		
Duration Time	The execution: 50 s timestep Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	Galileo ephemerides GPS ephemerides		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ■ GPS + Galileo ■ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ■ Port navigation: Accuracy threshold = 1 m; Integrity Alert Limit = 2.5 m		
Outcome criteria	■ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [8-15]m for the configuration selected ■ The tool shall decode, process the information, and provide HPL results in the range of [20-35]m for the configuration selected ■ The tool shall decode, process the information, and provide traffic light status along the scenario ■ The tool shall decode, process the information, and provide satellite visibility along the scenario ■ The tool shall decode, process the information, and provide dilution of precision along the scenario ■ The tool shall decode, process the information, and provide continuity status along the scenario Considering a more stringent phase navigation, the integrity status, availability status and continuity are expected to be red light, not available and not continuous.		
Outcome (Pass/Fail)	**PASS**		
Results	The tool decodes and processes the information, giving Accuracy 95% values of Accuracy between the range previously mentioned.		

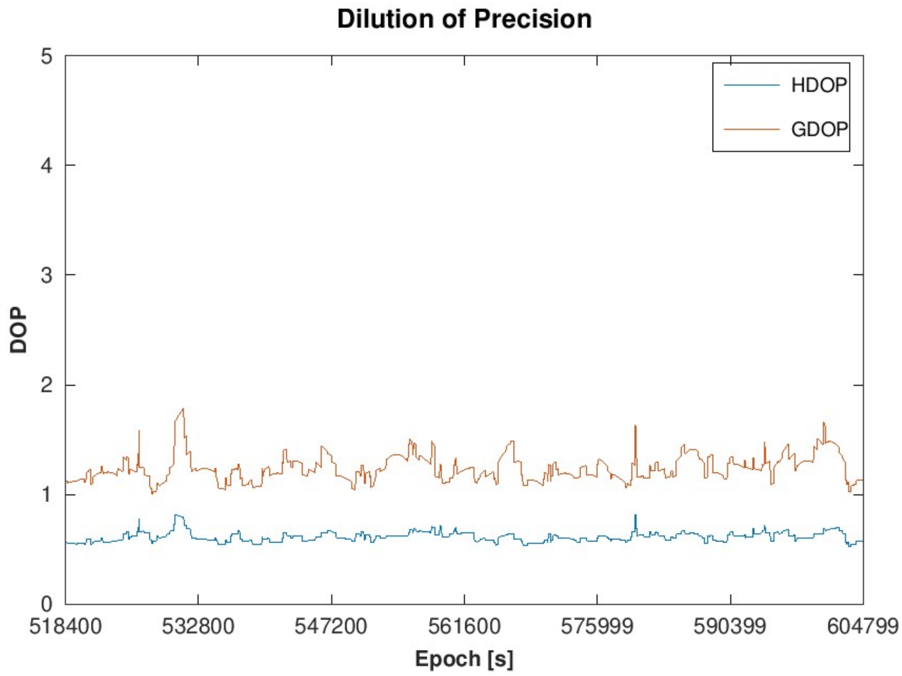


The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m. The tool decodes and processes the information, giving Accuracy 95% values of Horizontal protection levels between the range previously mentioned.

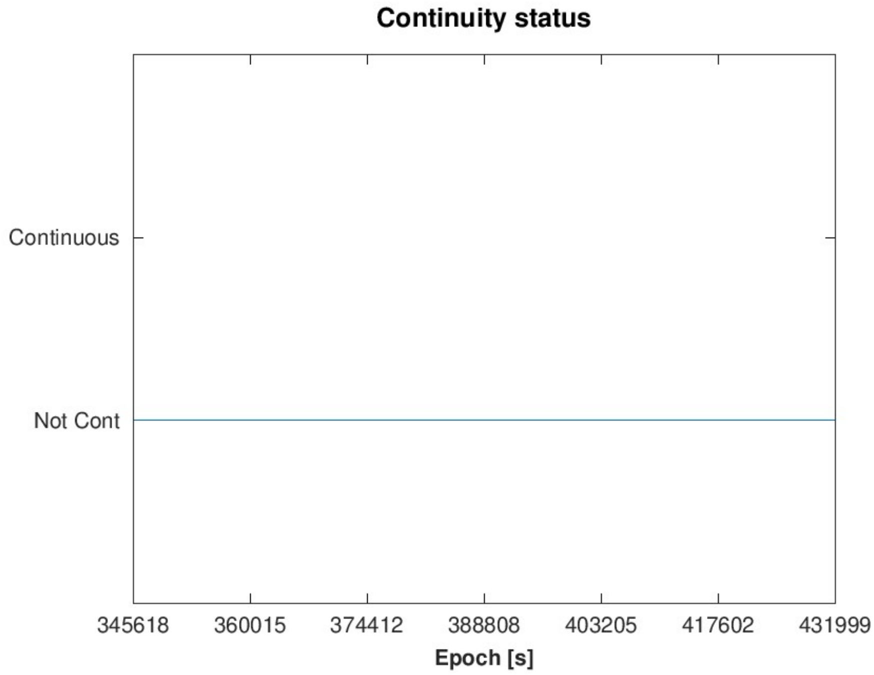


The tool provides an output of traffic light for the whole scenario. Considering that the Alert Limit is 25 meters in coastal navigation, the following results are obtained.

	 The tool decodes, processes the information, and provides satellite visibility across the scenario.  The tool decodes, processes the information HDOP and GDOP.

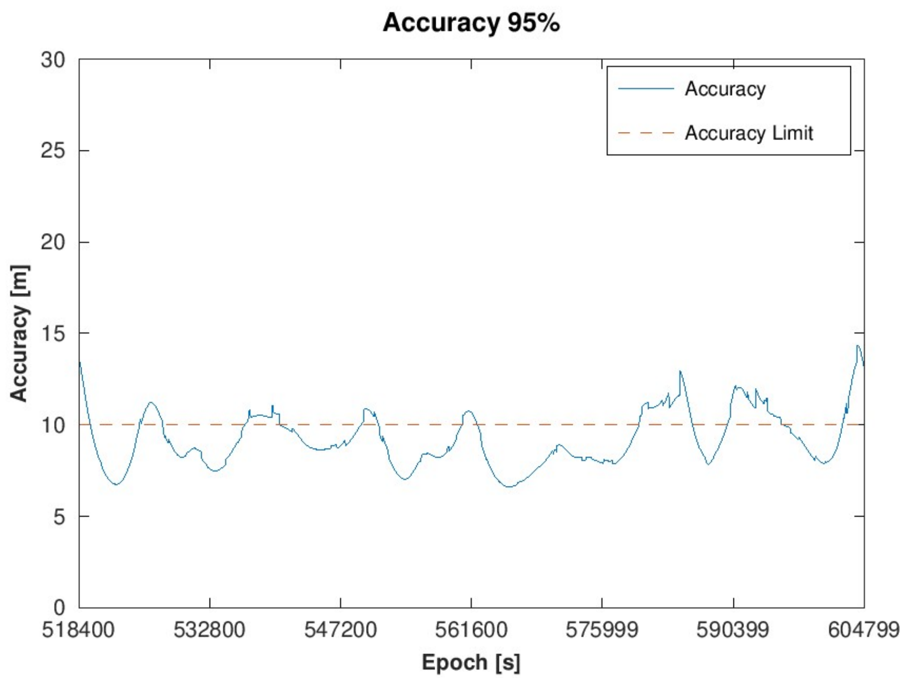


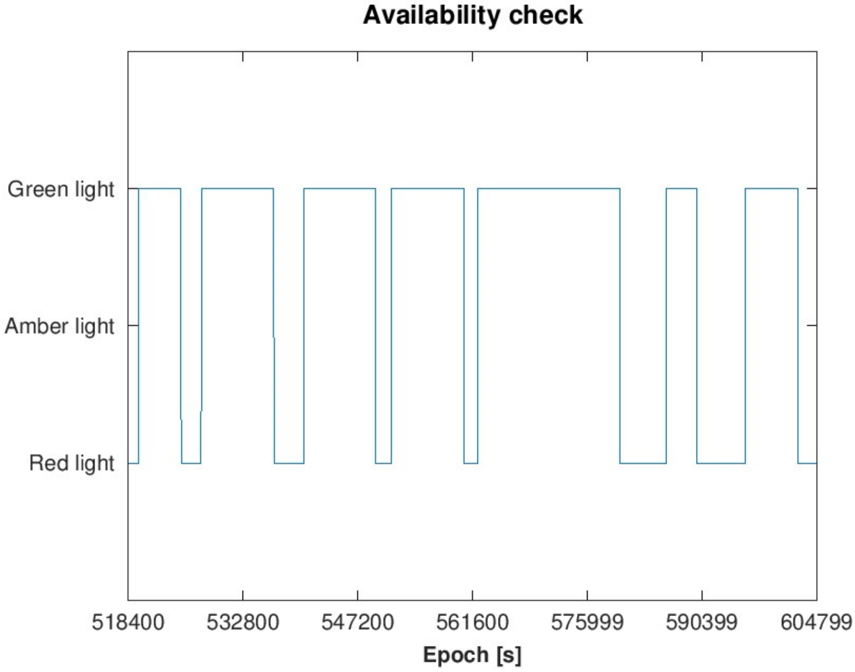
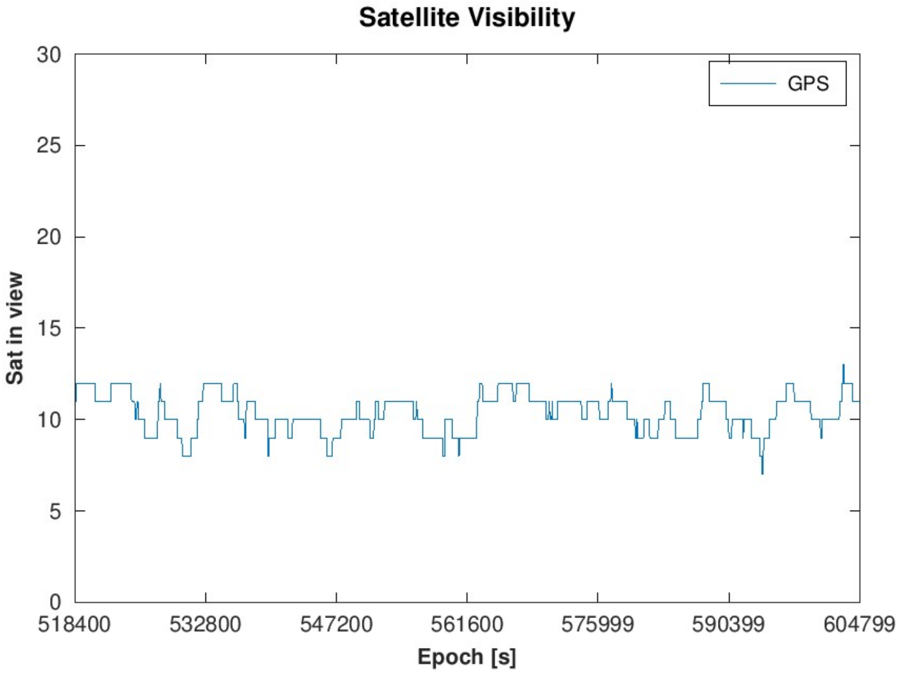
The tool decodes, processes the information, and provides system continuity status across the scenario.

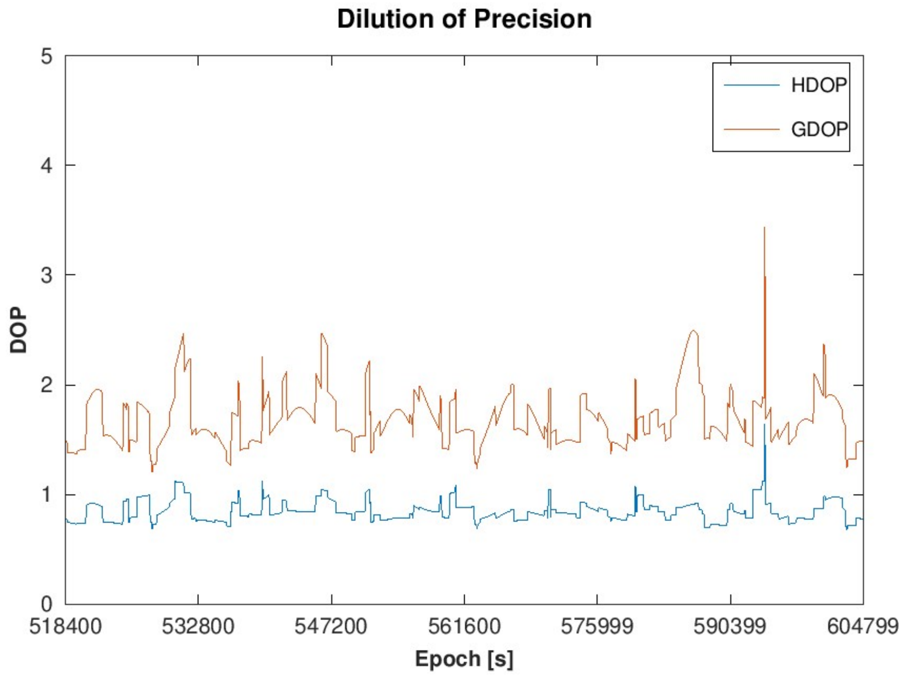
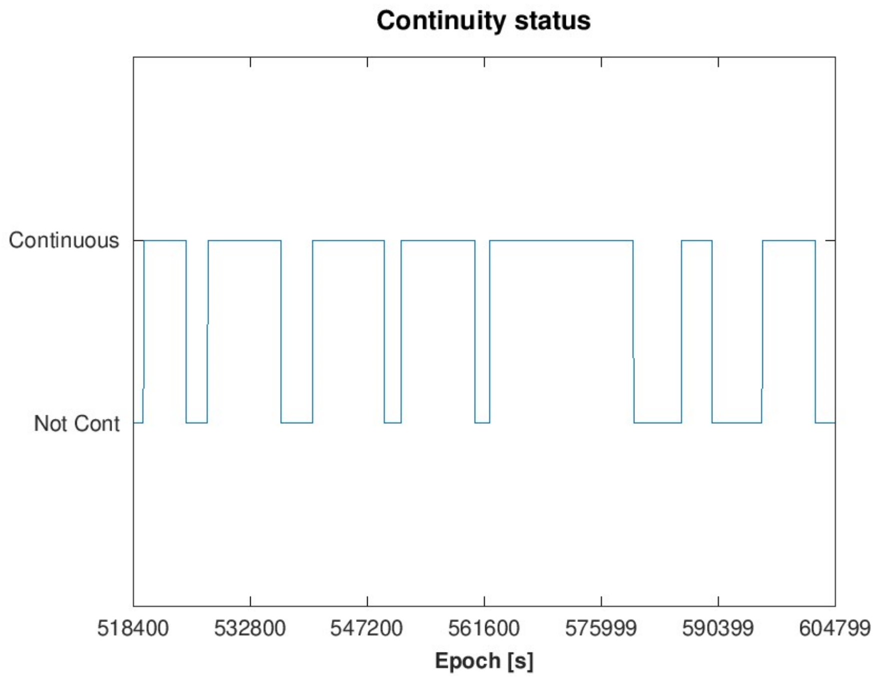


The tool provides the outputs in plain text mode:

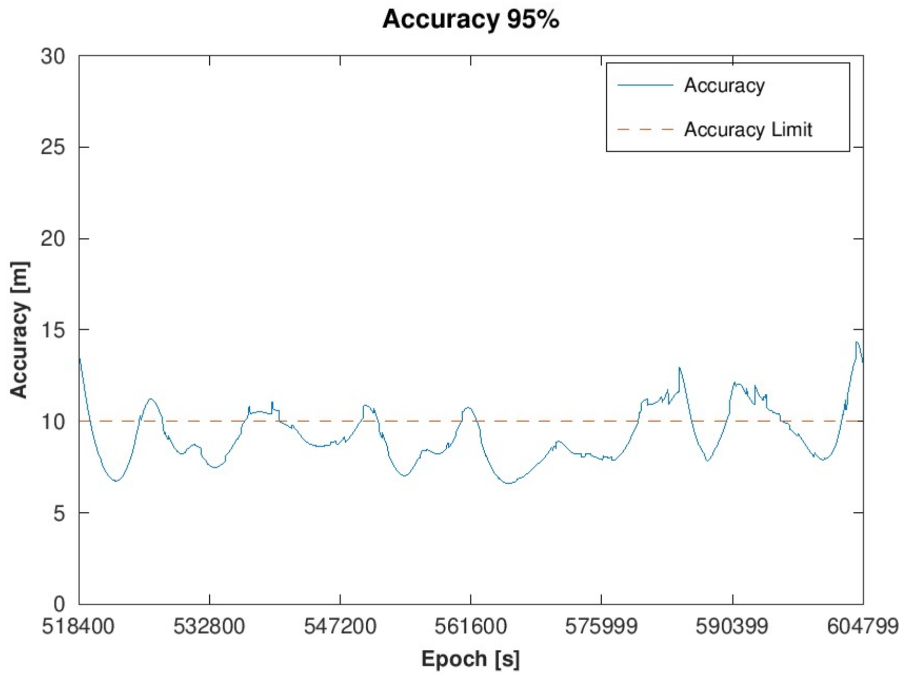
5.10 TC.MPT.010

Test Code	TC.MPT.010 MGRAIM		
Test Objective	To check that files are read, and a solution using MGRAIM is generated as expected for a single location for a 24 h period. Double Frequency single constellation (GPS only) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS		
Duration Time	The execution: 50 s time step Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	GPS ephemerides		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MGRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 18/09/2023 from 00:00:00 - 23:59:59 ■ GPS ■ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ■ Coastal navigation: Accuracy threshold = 10 m		
Outcome criteria	■ The tool shall decode, process the information, and provide accuracy 95% results in the range of [5-20]m for the configuration selected ■ The tool shall decode, process the information, and provide traffic light status along the scenario ■ The tool shall decode, process the information, and provide satellite visibility along the scenario ■ The tool shall decode, process the information, and provide Dilution of precision along the scenario ■ The tool shall decode, process the information, and provide continuity status along the scenario ■ The tool shall provide the outputs in plain text mode		
Outcome (Pass/Fail) **Results**	**PASS** The tool decodes and processes the information, giving Accuracy 95% values in the range previous mentioned. 		

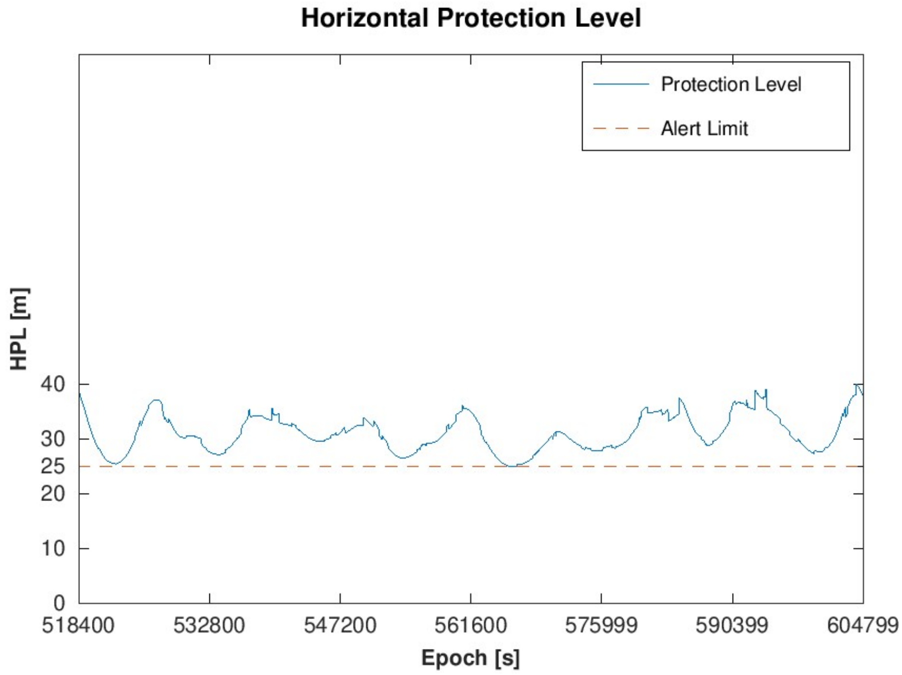
	The tool decodes, processes the information, and provides traffic light along the scenario.  The tool decodes, processes the information, and provides satellite visibility along the scenario.  The tool decodes, processes the information, and provides Dilution of precision along the scenario.

	 The tool decodes, processes the information, and provides continuity status along the scenario.  The tool provides results in a text plain mode. 

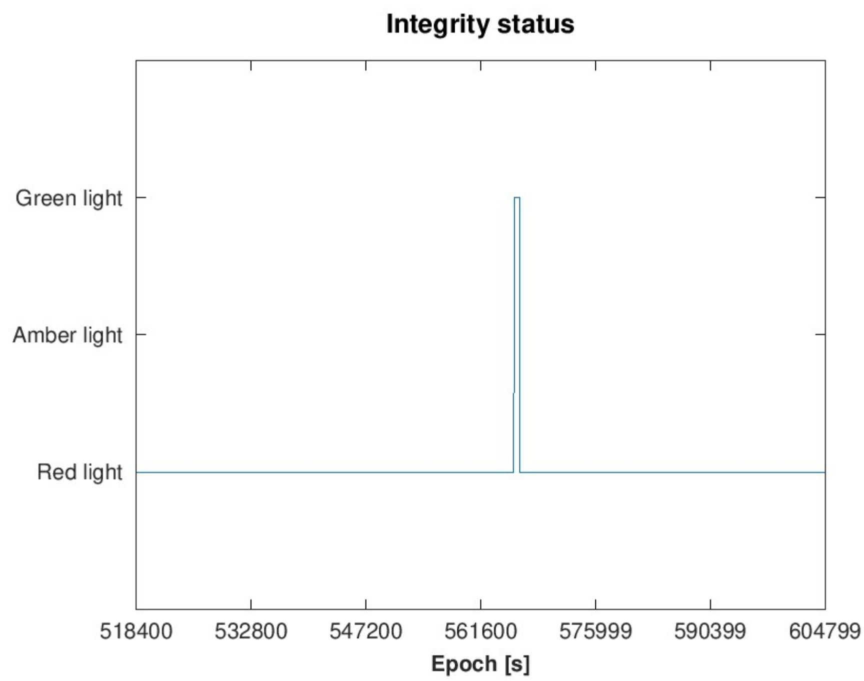
Test Code	TC.MPT.010 MRAIM		
Test Objective	To check that files are read, and a solution using MRAIM is generated as expected for a single location for a 24 h period. Single Frequency single constellation (GPS only) scenario studied for Coastal navigation		
Test Experiment Location	GMV Laboratory	**Test Experiment Equipment**	PC or laptop running Windows OS
Dependence SW	Octave 6.1.0		
Constellation used	GPS		
Duration Time	The execution: 50 s time step Period studied 24h, forecast for 23/09/2023 from 00:00:00 - 23:59:59		
Input Data	GPS ephemerides		
Processing	Execution of the Performance Prediction Prototype tool using a nominal configuration which includes: ■ MRAIM algorithm selection ■ Single user selection [Lat: 52.95175, Lon: -1.18215, h: 92.4800] ■ Forecast for 23/09/2023 from 00:00:00 - 23:59:59 ■ GPS ■ Nominal error models configurable. *Dual Frequency error model applied [RD.2]* ■ Coastal navigation: Accuracy threshold = 10 m; Integrity Alert Limit = 25 m		
Outcome criteria	■ The tool shall decode, process the information, and provide Accuracy 95% results in the range of [9-20]m for the configuration selected. These results shall be higher than TC.MPT.001 results ■ The tool shall decode, process the information, and provide HPL results in the range of [19+]m for the configuration selected. These results shall be higher than TC.MPT.001 results ■ The tool shall decode, process the information, and provide traffic light status along the scenario. This availability shall be reduced with respect to TC.MPT.001 results ■ The tool shall decode, process the information, and provide satellite visibility along the scenario. These results shall be lower than the TC.MPT.001 results as a single constellation is considered but the same number of GPS satellites should be considered ■ The tool shall decode, process the information, and provide dilution of precision along the scenario. These results shall be higher than the TC.MPT.001 results ■ The tool shall decode, process the information, and provide continuity status along the scenario. ■ The tool shall provide the outputs in plain text mode		
	PASS		
Outcome (Pass/Fail) Results	The tool decodes and processes the information, giving Accuracy values in the range previous mentioned.		



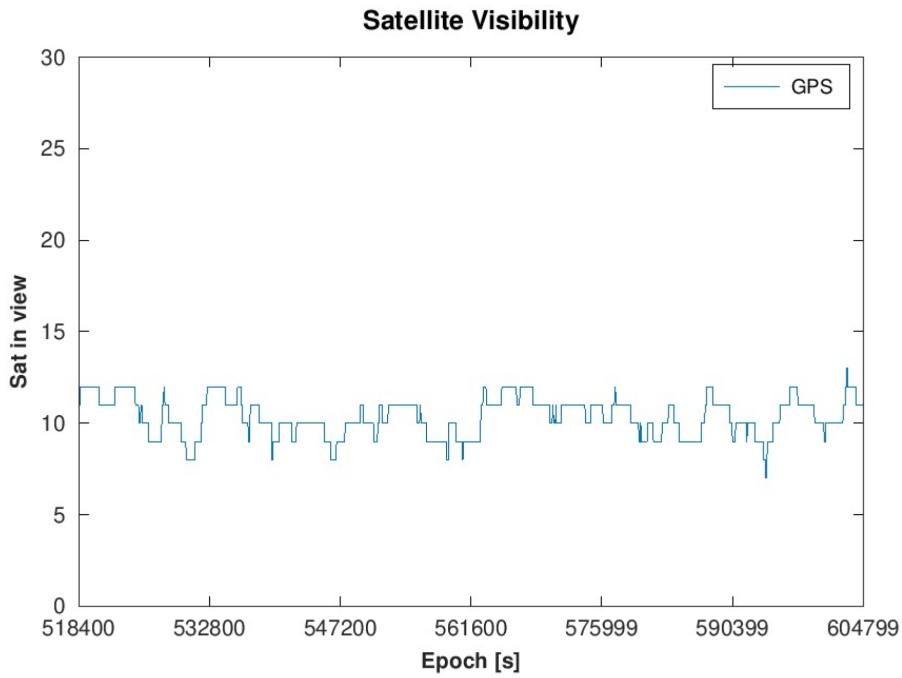
The tool decodes and processes the information, giving Protection Level values in the range previous mentioned. The tool decodes, processes the information, and provides the Horizontal Protection Level illustrating the Alert Limit of 25m.



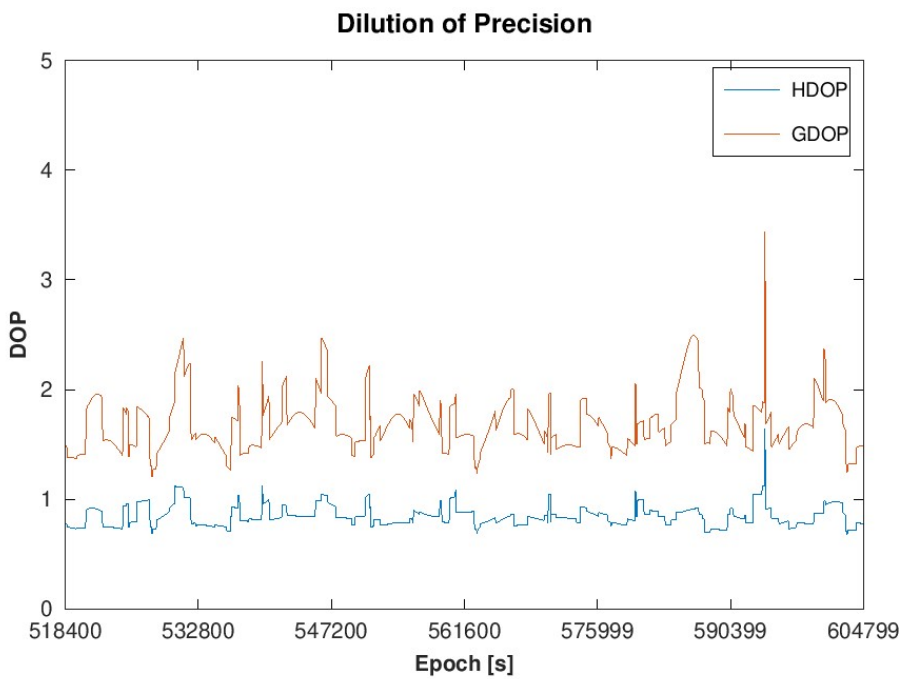
The tool provides an output of traffic light for the whole scenario. More alarms can be seen compared to TC.MPT.001.



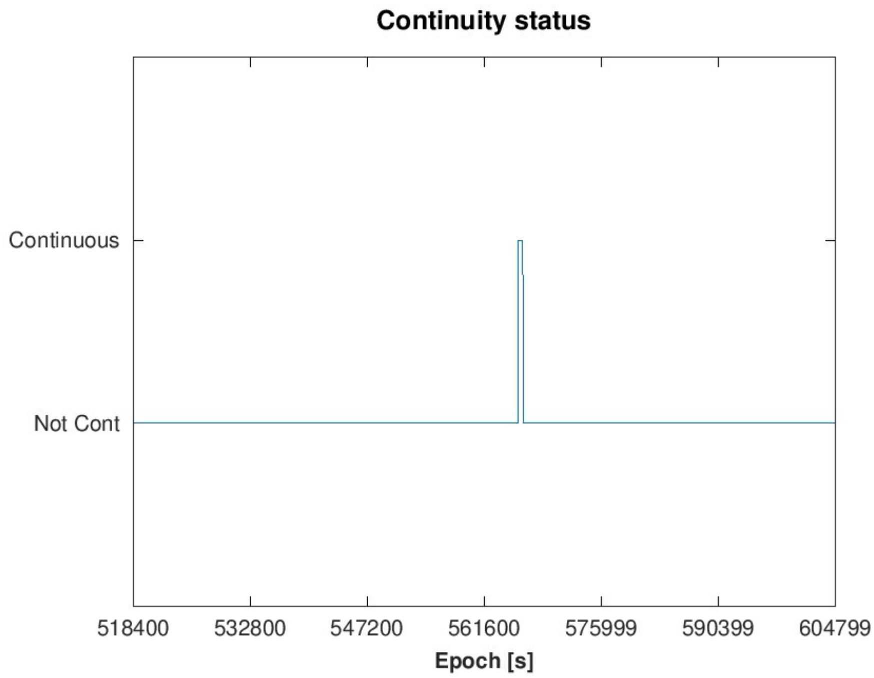
The tool decodes, processes the information, and provides satellite visibility across the scenario. Same number of GPS satellites can be seen as the minimum elevation angle considered for satellite rejection is 5 degrees.



The tool decodes, processes the information, and provides for the HDOP and GDOP across the scenario.



The tool decodes, processes the information, and provides system continuity status for the studied period.



The tool provides the outputs in plain text mode:

simulation_data_

6 USER MANUAL FOR THE TOOL

This section provides a brief overview of the main prototype features and detailed instructions on how to use the tool.

6.1 INSPIRe UK EGNOS Performance Coverage Prototype General Description

The INSPIRe UK EGNOS Performance Coverage software developed in Octave 6.1 for Windows. It is composed of several scripts organized in folders and therefore it requires no installation. The INSPIRe UK EGNOS Performance Coverage software has no further dependencies than the standard installed with Octave.

The tool is developed according to section 3.2to provide user performances for a single or a grid of users using MGRAIM or MRAIM algorithm according to a given configuration. Detailed tool description is contained in section 4.1.

Inside the inspire-svs folder, the following subfolders/files can be found:

- **data_WP5\ddmmyy**: Contains the ephemeris data of the studied constellations with the following names for Galileo and GPS respectively.
  - GAL_ddmmyy
  - GPS_ddmmyy

  The layout of the file is briefly explained later in Section 6.2.1.1.1

  And it also contains the SBAS files for L1 and DFMC L5 with the following names respectively.
  - \SBAS_DFMC_ ddmmyy\
    - EGNOS_ ddmmyy.csv
  - \SBAS_Legacy_ddmmyy\
    - UKSBAS_ ddmmyy.csv

  Where ddmmyy corresponds to dd: day, mm: month, and yy:year.
- **Simulations**: This folder contains the scenario folders with the configuration functions needed to generate the configuration files, and the function to generate them.

  Within this folder, there are several **'SIM_X' folders**: is the scenario used in the service volume, can be copied and changed in order to obtain the desired results. Each of them contains:
  - Input: contains
    - The function to set a configuration file is under the name: < create_TCINSPIReSVS_"subcase".m>, where subcase has to be set up
    - The function to create a configuration file is under the name: < run_create_config.m>

    A new folder called TCINSPIReSVS is generated when the tool is launched. This will contain the different subcases folders wanted with the configuration files.
  - Output: contains the outputs of the tool in an internal folder under the name TCINSPIReSVS in which the desired output plots as well as the files with information in plain text mode can be found.
- **src**: contains the source code of the tool, including the functions used to plot the results.
- **RAIM_SVS_main**: is the main function of the tool.

- **run_TC**: This is the tool executable from which the INSPIRe-svs interface is launched.

The folder structure is depicted in diagram in Figure 6-1.

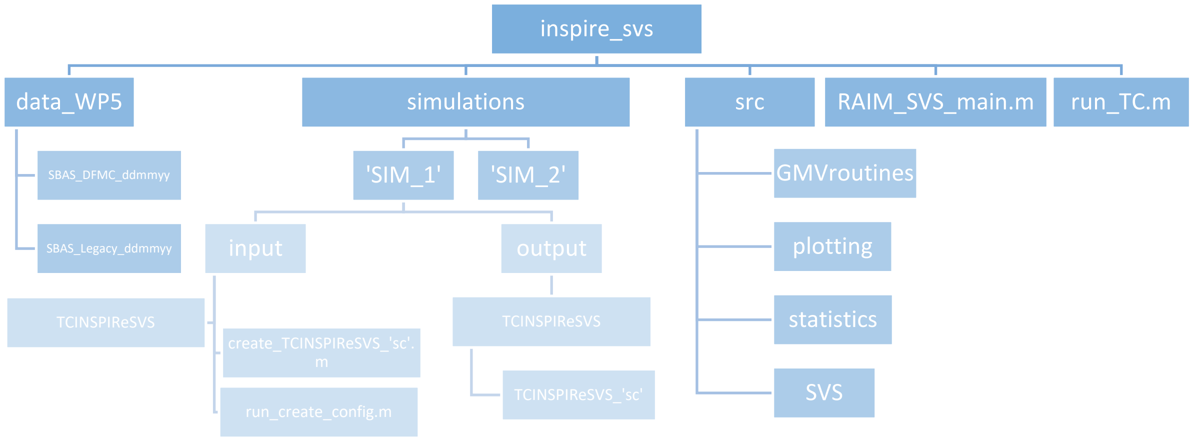


Figure 6-1. M(G)RAIM Performance Prediction prototype. Tool Directory Structure

6.2 INSPIRE UK EGNOS Performance Coverage Prototype Usage

This section provides essential information on how to use the INSPIRe UK EGNOS Performance Coverage tool, including detailed descriptions of the inputs and outputs, as well as instructions on how to run the tool.

6.2.1 Input and Output Files

6.2.1.1 Input files

The inspire_svs software requires two input files to work properly, which correspond to the constellation ephemeris and the scenario configuration. Description and structure of these files can be found next.

6.2.1.1.1 CONSTELLATION EPHEMERIS

Constellation ephemeris file (Figure 6-2) must be stored in the data_WP5 folder under the name <ConstellationName>.mat in a MATLAB structure format.

Each constellation ephemeris is input into inspire_svs as a matrix which includes the following columns per satellite introduced:

- Satellite ID (PRN)
- Mean anomaly at reference time of ephemeris (rad)
- Eccentricity (unitless)
- Semi-major axis (m)
- Right ascension of ascending node at TOE (rad)
- Rate of right ascension of ascending node (rad)
- Inclination (rad)
- Argument of perigee (rad)
- Reference time of ephemeris (s).

```
# name: eph
# type: matrix
# rows: 24
# columns: 9
 1 4.1807616901999998 0 26559800.001129892 3.2827025235999998 -8.1206679437000001e-09 0.95993108859999998 0 0
 2 2.3247785636999998 0 26559800.001129892 3.2827025235999998 -8.1206679437000001e-09 0.95993108859999998 0 0
 3 5.9880501306999996 0 26559800.001129892 3.2827025235999998 -8.1206679437000001e-09 0.95993108859999998 0 0
 4 0.23073252711 0 26559800.001129892 3.2827025235999998 -8.1206679437000001e-09 0.95993108859999998 0 0
 5 0.91402892927000001 0 26559800.001129892 4.3299000748000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 6 2.5263640923000001 0 26559800.001129892 4.3299000748000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 7 4.9111819821999996 0 26559800.001129892 4.3299000748000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 8 3.0681142921000002 0 26559800.001129892 4.3299000748000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 9 1.4536847340000001 0 26559800.001129892 5.3770976260000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 10 5.9901445257999999 0 26559800.001129892 5.3770976260000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 11 5.4293702370999997 0 26559800.001129892 5.3770976260000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 12 3.7170277079999998 0 26559800.001129892 5.3770976260000003 -8.1206679437000001e-09 0.95993108859999998 0 0
 13 1.8612191143000001 0 26559800.001129892 0.14110987002 -8.1206679437000001e-09 0.95993108859999998 0 0
 14 4.1339868662999999 0 26559800.001129892 0.14110987002 -8.1206679437000001e-09 0.95993108859999998 0 0
 15 0.11466813185999999 0 26559800.001129892 0.14110987002 -8.1206679437000001e-09 0.95993108859999998 0 0
 16 2.4219934030000001 0 26559800.001129892 0.14110987002 -8.1206679437000001e-09 0.95993108859999998 0 0
 17 2.9401816579000002 0 26559800.001129892 1.1883074212 -8.1206679437000001e-09 0.95993108859999998 0 0
 18 4.7823766833999999 0 26559800.001129892 1.1883074212 -8.1206679437000001e-09 0.95993108859999998 0 0
 19 0.65414940364999996 0 26559800.001129892 1.1883074212 -8.1206679437000001e-09 0.95993108859999998 0 0
 20 5.3249995478000001 0 26559800.001129892 1.1883074212 -8.1206679437000001e-09 0.95993108859999998 0 0
 21 3.6704274169 0 26559800.001129892 2.2355049723999998 -8.1206679437000001e-09 0.95993108859999998 0 0
 22 5.5264105434999999 0 26559800.001129892 2.2355049723999998 -8.1206679437000001e-09 0.95993108859999998 0 0
 23 1.3372712729 0 26559800.001129892 2.2355049723999998 -8.1206679437000001e-09 0.95993108859999998 0 0
 24 1.8633135094 0 26559800.001129892 2.2355049723999998 -8.1206679437000001e-09 0.95993108859999998 0 0
```

Figure 6-2. Input file. Constellation ephemeris

6.2.1.1.2 SCENARIO CONFIGURATION DEFINITION

This file must be in the scenario input folder under the name < TCINSPIReSVS_'sc' >.m

The scenario configuration definition is input into inspire_svs as '.m' file in a MATLAB structure format. Here all the configuration parameters must be modified depending on the scenario to be simulated, among others:

- Epoch studied: any time range can be simulated, taking into account a time step to suit the desired one, as well as the date of the simulation.
- Mode in which the tool can be launched: MRAIM or MGRAIM.
- User mode: selection of single point study or mapping study at any part of the Earth's surface.
- The number of constellations: suitable for Galileo and GPS.
- Satellite elevation angle: minimum elevation angle required to calculate the solution.
- Error modelling: all error models can be modified.
- SBAS selection: solution selection, SPP, DFMC, SBAS L1, DFMC SBAS L5.
- M(G)RAIM configuration parameters, among others:
  - DOP thresholds (for MGRAIM only)
  - Satellite fault probabilities (for MRAIM only)
  - Constellation fault probabilities (for MRAIM only)
  - Maximum nominal biases (for MRAIM only)
  - Mean fault duration (for MRAIM only)
- Navigation phase requirements
  - Accuracy threshold (for MGRAIM only)
  - False Alarm rate
  - Integrity Risk required (for MRAIM only)
  - Alarm Limit (for MRAIM only)
- Satellite exclusion: to emulate real constellation health.

- Service Level: To select the service level studied.

6.2.1.2 Output Files

The inspire_svs output files correspond to the files that are generated after the tool execution; those correspond to the scenario file generated.

Once the scenario file has been processed, the configuration file <sim_config_TCINSPIReSVS_'sc'> will be automatically generated in a folder, inside the input folder, named TCINSPIReSVS_'sc'. A structure of said file can be found in Figure 6-3.

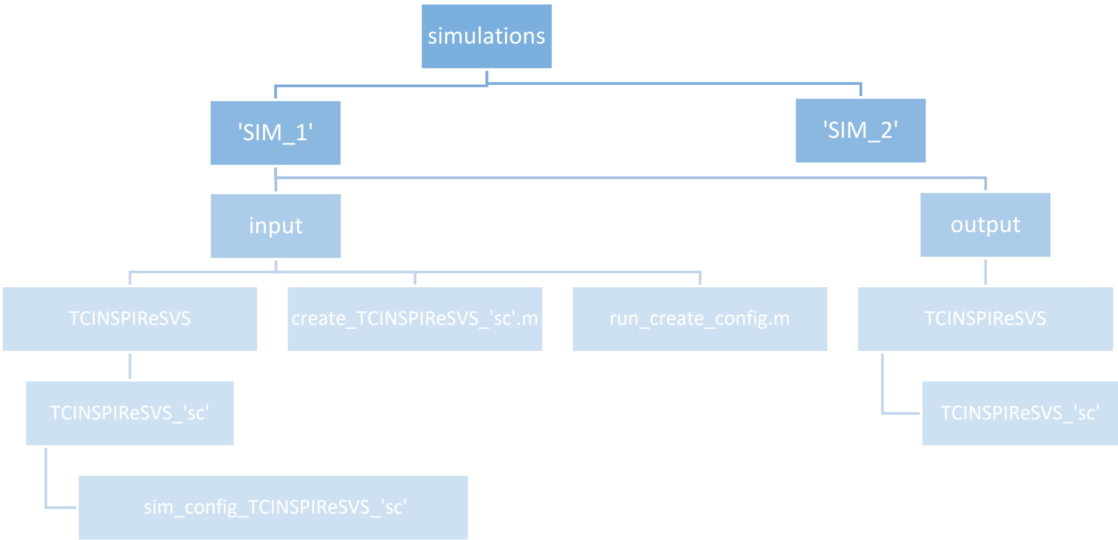


Figure 6-3. M(G)RAIM Performance Prediction prototype. Simulations Directory Structure

Depending on the plot mode selected the tool will generate a folder called ModeRAIM_Points or ModeRAIM_Maps, and the solution will automatically save file information in plain text mode under the name <simulation_data_'SIM_X'> as well as the plots generated.

6.2.1.2.1 Plain text file

The INSPIRE UK EGNOS Performance Coverage prototype tool provides two or three text files, depending on the execution mode

- **simulation_data_XXXX**: this is a plain text with the Matlab structures more relevant for the simulation. It contains the configuration structure together with several intermediate outcomes and the main M(G)RAIM output structure. This structure changes with the algorithm selected but it contains:
  - Integrity flags per user and epoch
  - Accuracy/HPL value in meters per user and per epoch
  - Number of satellites per constellation per user and epoch
  - Number of faults monitors (only in MRAIM mode)
- **simulation_data_XXXX_HPL_vec/matrix**: these are .csv files with the information about HPL value in a vector or matrix (for user grid mode) per user and epoch. Please note that in MGRAIM mode these files are fulfilled with 0 since no PL is computed.

6.2.1.2.2 Single user mode

When the tool is configured in a single user mode, giving a specific location on the Earth's surface, the tool provides the following plots in addition to the plain text file.

The tool depicts the estimated accuracy at 95% of confidence for the given user epoch by epoch for the MGRAIM mode. This accuracy takes into account the estimated GNSS constellation geometry, the integrity information and the error models to estimate which would be the expected performances along the time window introduced.

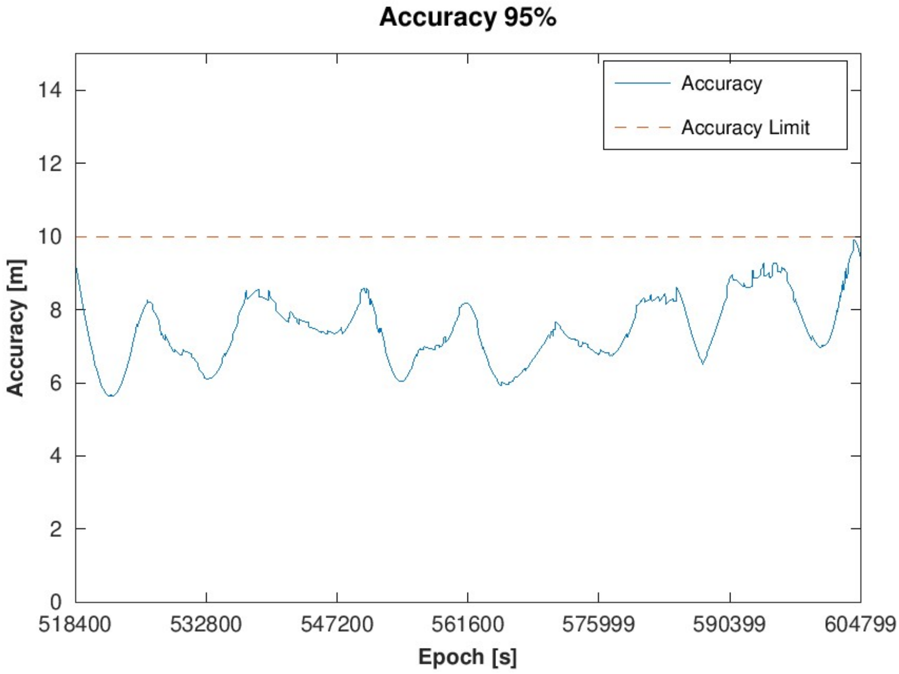


Figure 6-4. M(G)RAIM Performance Prediction prototype. Example of ACC95 along time

This figure parametrization is:

- Horizontal axis depicts to the epoch elapsed in seconds since the beginning of the simulation.
- Vertical axis depicts the Accuracy at 95% estimated by the algorithm

The tool depicts the HPL for the given user epoch by epoch for the MRAIM mode. This accuracy takes into account the estimated GNSS constellation geometry, the integrity information and the error models to estimate which would be the expected performances along the time window introduced.

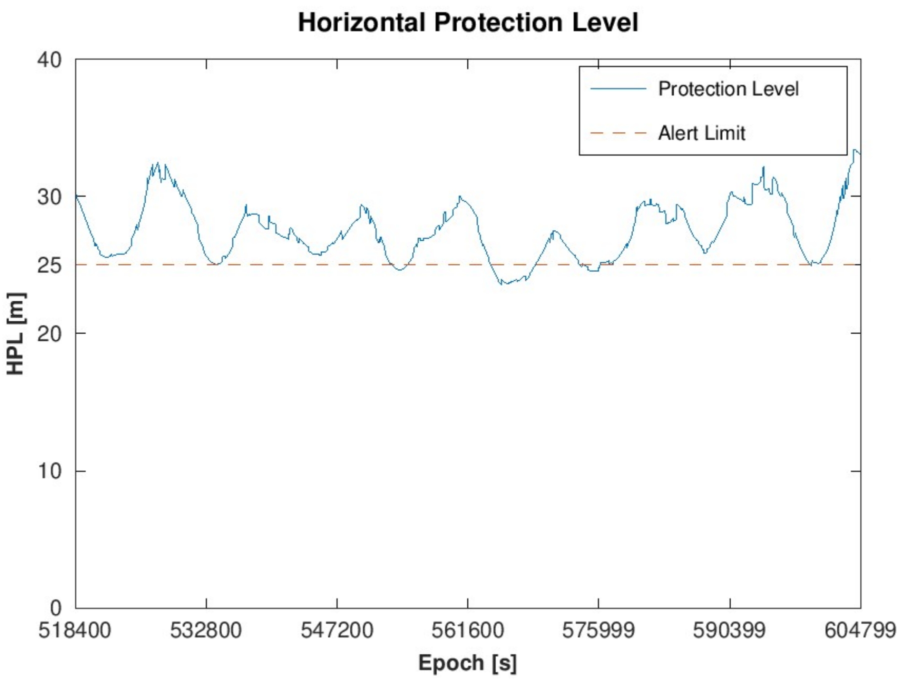


Figure 6-5. M(G)RAIM Performance Prediction prototype. Example of HPL along time

This figure parametrization is:

- Horizontal axis depicts to the epoch elapsed since the beginning of the simulation in seconds.
- Vertical axis depicts the HPL estimated by the algorithm according to the configuration.

The tool depicts the estimated integrity status for the given user epoch by epoch. This integrity status takes into account the estimated GNSS constellation geometry, the integrity information and the error models to estimate if any alarm will be risen during the operation.

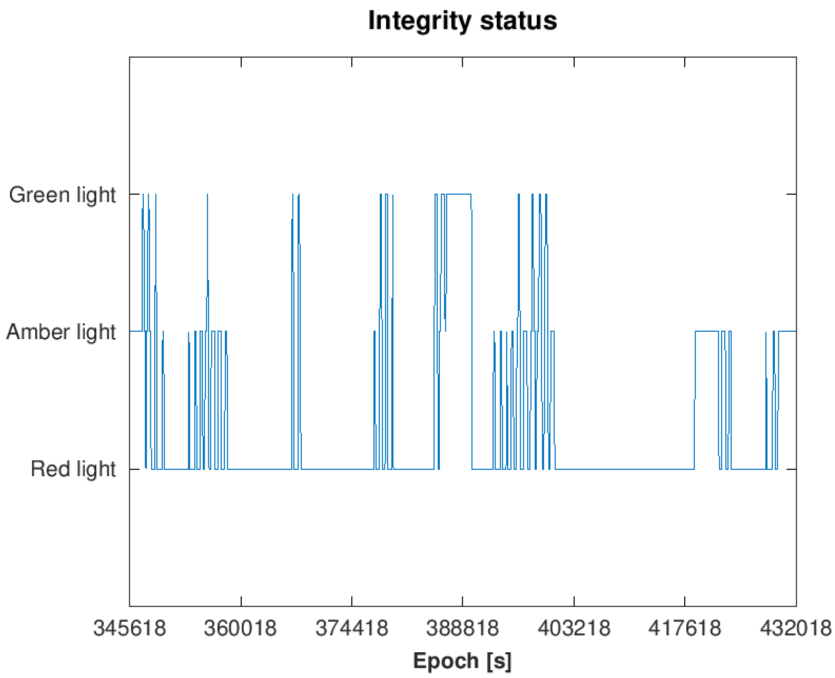


Figure 6-6. M(G)RAIM Performance Prediction prototype. Example of test SOL along time

This figure parametrization is:

- Horizontal axis depicts to the epoch elapsed since the beginning of the simulation in seconds.

- Vertical axis depicts the integrity status given by the traffic light concept where:
  - 2 corresponds to “green light”
  - 1 corresponds to “amber light”
  - 0 corresponds to “red light”

The tool depicts the estimated number of satellites available for the positioning solution for the given user epoch by epoch. This number of satellites takes into account the estimated GNSS constellation geometry and the integrity information to perform the estimation.

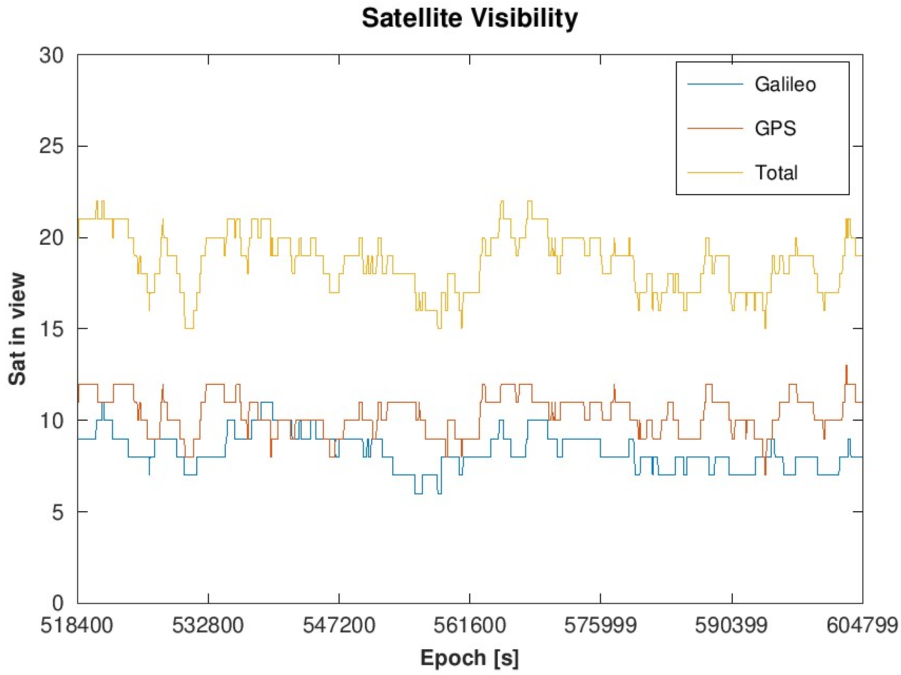


Figure 6-7. M(G)RAIM Performance Prediction prototype. Example of number of estimated satellites along time

This figure parametrization is:

- Horizontal axis depicts to the epoch elapsed since the beginning of the simulation in seconds.
- Vertical axis depicts the number of available satellites according to the depicted legend, which includes GPS/Galileo satellites and the total number.

The tool depicts the estimated dilution of precision for the positioning solution for the given user epoch by epoch. This dilution of precision takes into account the estimated GNSS constellation geometry to perform the estimation.

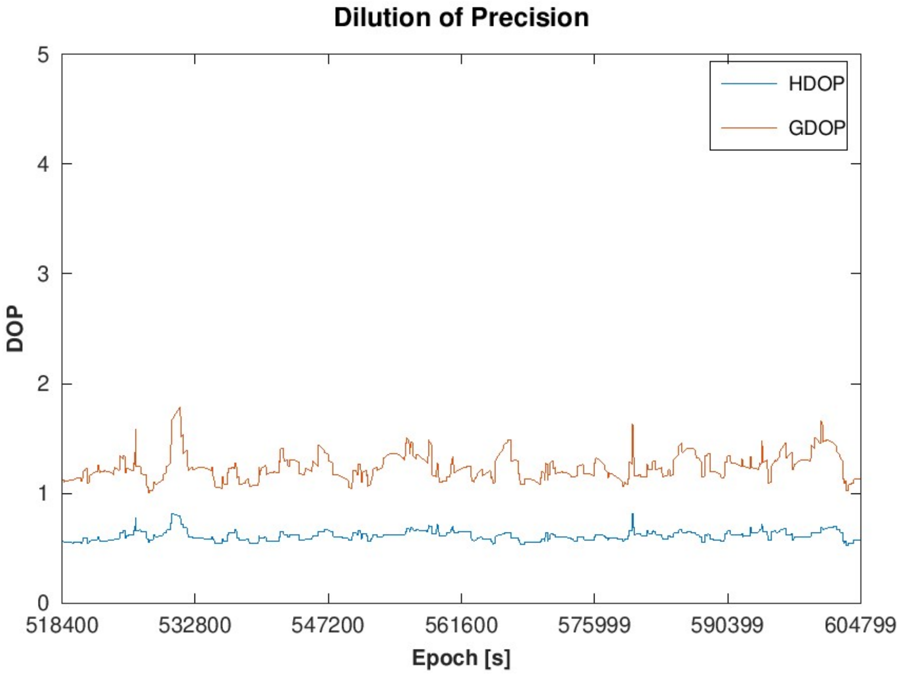


Figure 6-8. M(G)RAIM Performance Prediction prototype. Example of dilution of precision along time

This figure parametrization is:

- Horizontal axis depicts to the epoch elapsed since the beginning of the simulation in seconds.
- Vertical axis depicts the dilution of precision according to the depicted legend, which includes horizontal DOP and Geometric DOP.

Finally, the tool depicts the estimated continuity status for the positioning solution for the given user epoch by epoch. This continuity status considers the estimated GNSS constellation geometry and the integrity information to perform the estimation.

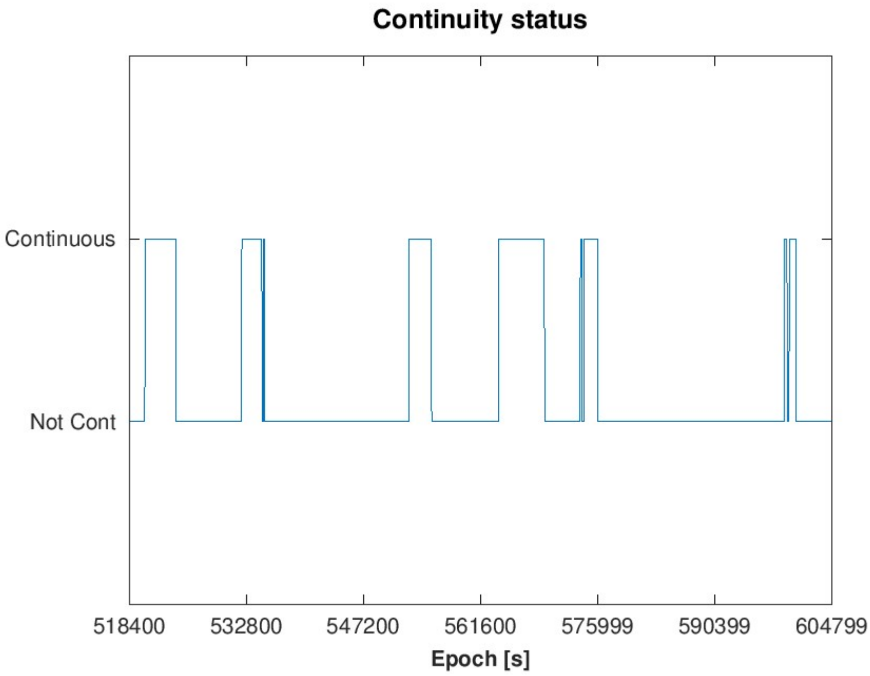


Figure 6-9. M(G)RAIM Performance Prediction prototype. Example continuity status along time

This figure parametrization is:

- Horizontal axis depicts to the epoch elapsed since the beginning of the simulation in seconds.
- Vertical axis depicts the continuity status that can be continuous or not continuous.It shows ‘not continuous’ when the integrity flag is 0 or 1, and continuous when the integrity flag is 2.

6.2.1.2.3 Grid user mode

Finally, in user grid mode the tool depicts similar information in a map format in addition to the plain text files. However, in this case the information cannot be provided for a long time and one statistical value for the distribution of each user has to be selected.

The tool depicts the estimated 95 percentile of the Accuracy at 95% of confidence for the grid of users for the MGRAIM mode. This accuracy considers the estimated GNSS constellation geometry, the integrity information, and the error models to estimate which would be the expected performances along the time window introduced.

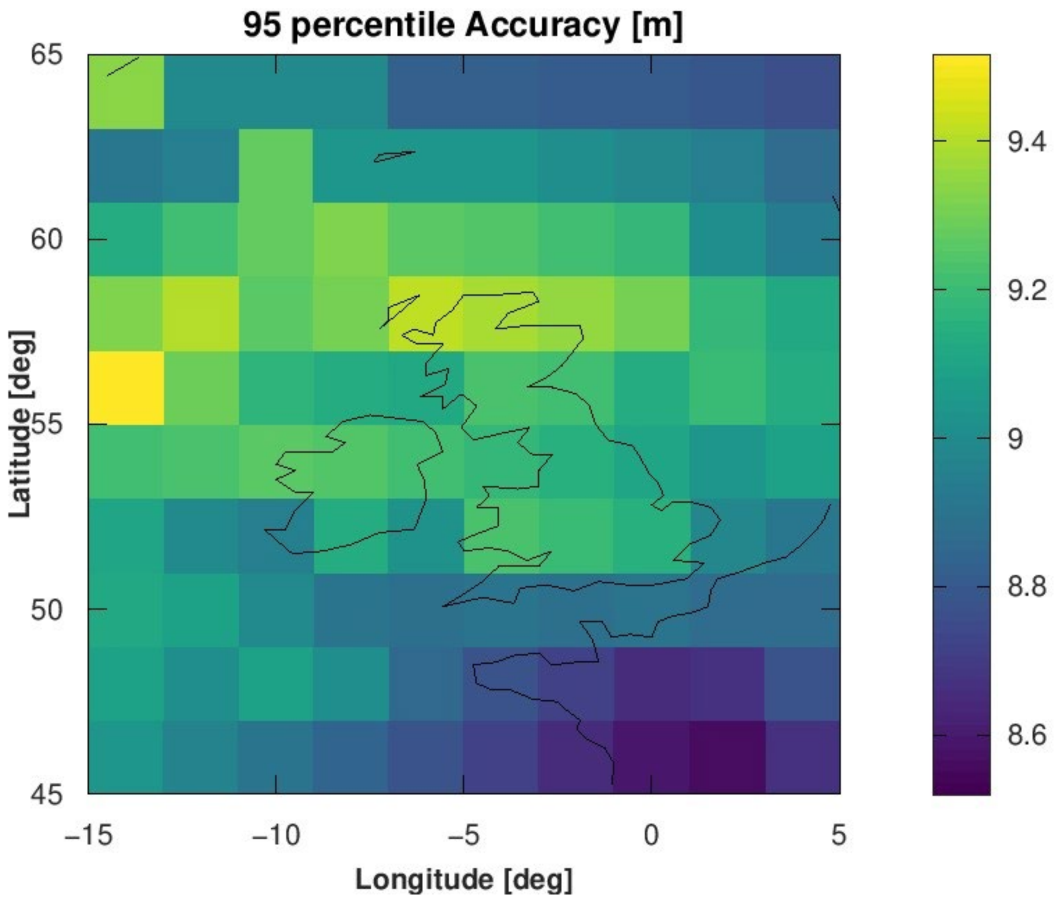


Figure 6-10. M(G)RAIM Performance Prediction prototype. Example of 95 percentile for the Acc95 over Europe

This figure parametrization is:

- Horizontal axis depicts the longitude of the user.
- Vertical axis depicts latitude of the user.
- Colour code depicts the 95 percentile of the Accuracy 95% for each user

The tool depicts the estimated 99.8 percentile of the HPL for the grid of users for the MRAIM mode. The percentile 99.8 has been selected to assess the HPL at the availability requirement for all the navigation phases. This HPL considers the estimated GNSS constellation geometry, the integrity information, and the error models to estimate which would be the expected performances along the time window introduced.

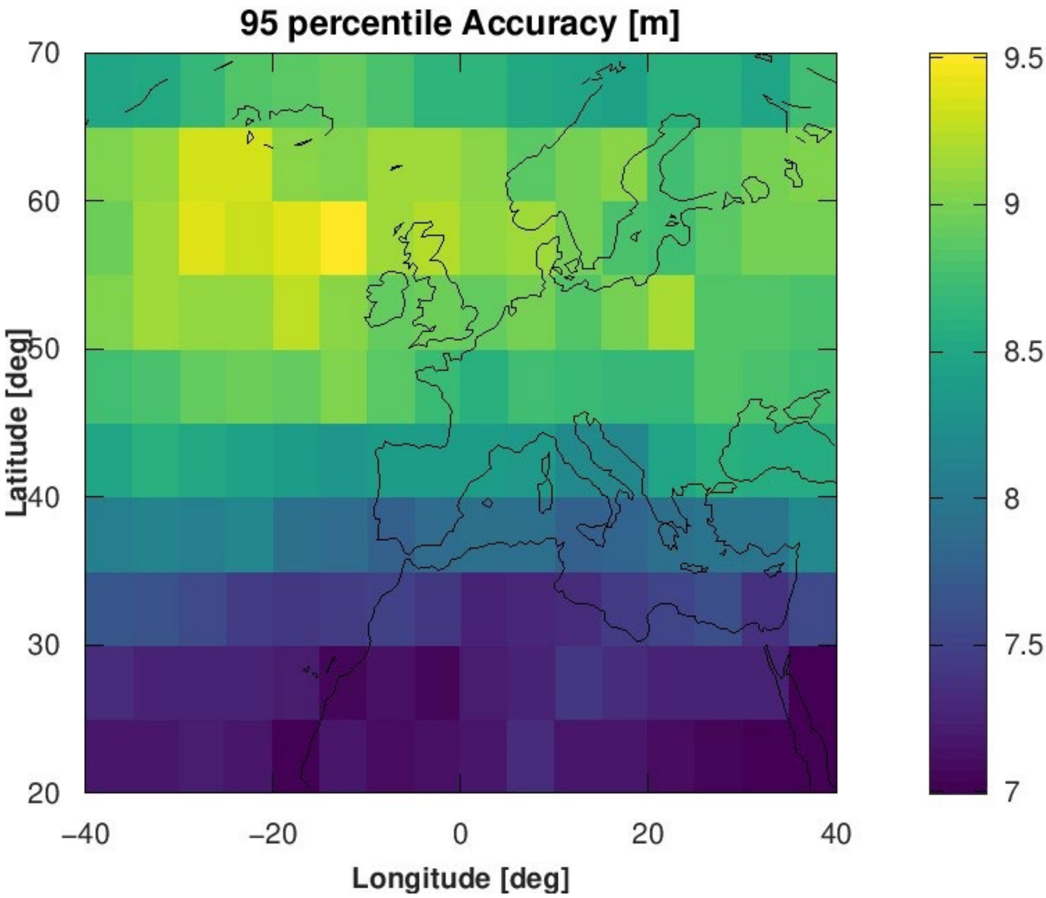


Figure 6-11. M(G)RAIM Performance Prediction prototype. Example of 99.8 percentile for the HPL over Europe

This figure parametrization is:

- Horizontal axis depicts the longitude of the user.
- Vertical axis depicts latitude of the user.
- Colour code depicts the 99.8 percentile of the HPL for each user

The tool depicts the availability for the grid of users for the MRAIM mode. This availability considers the estimated HPL and the integrity flags and compare them against the requirements of the navigation phase to provide an indication of the percentage of epochs that navigation will be available with the performance required.

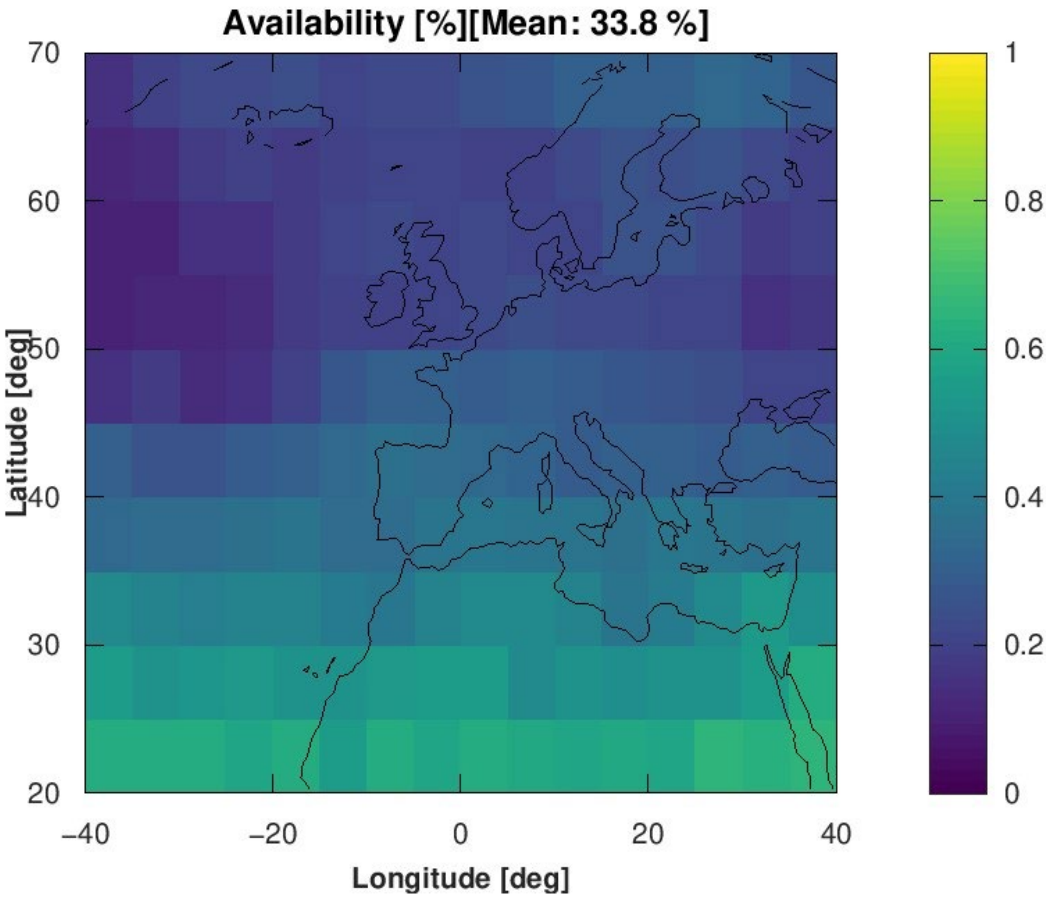


Figure 6-12. M(G)RAIM Performance Prediction prototype. Example of availability over Europe

This figure parametrization is:

- Horizontal axis depicts the longitude of the user.
- Vertical axis depicts latitude of the user.
- Colour code depicts the availability percentage for each user

The tool depicts the satellite visibility for the grid of users for the MRAIM mode.

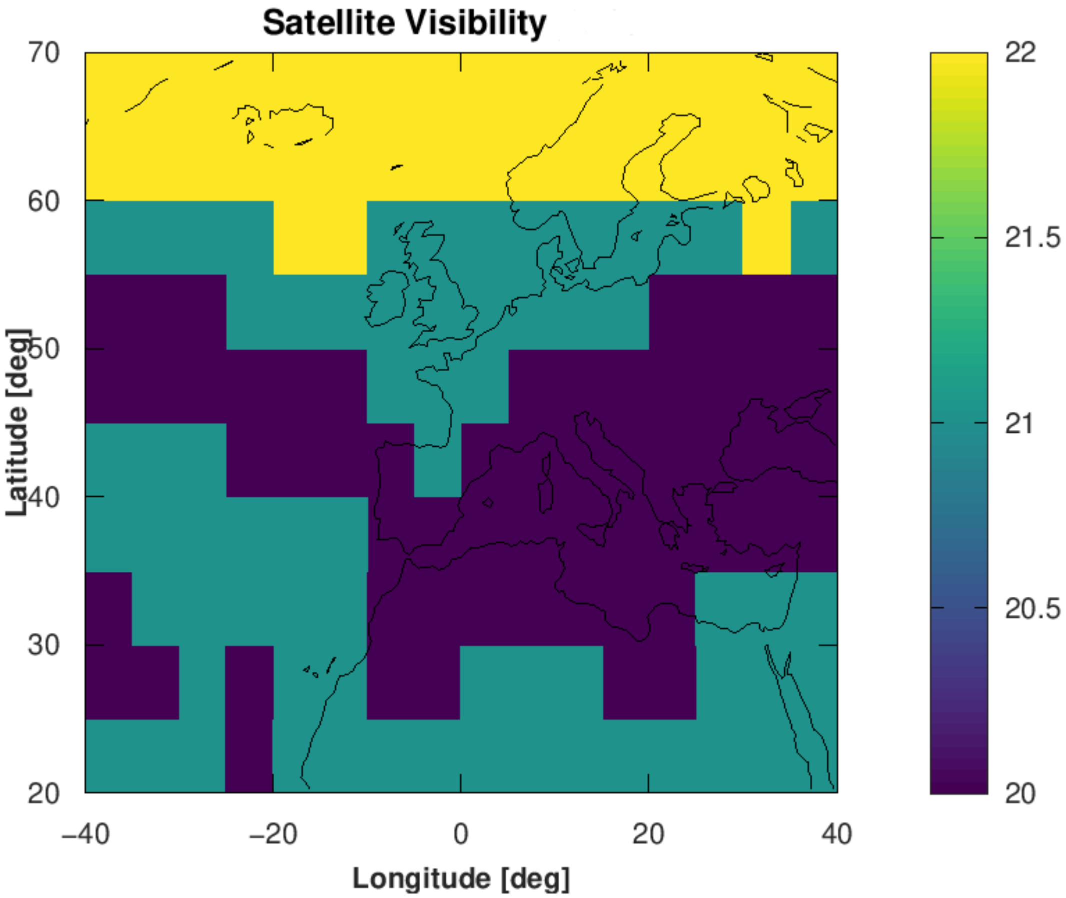


Figure 6-13. M(G)RAIM Performance Prediction prototype. Example of Satellite visibility over Europe

This figure parametrization is:

- Horizontal axis depicts the longitude of the user.
- Vertical axis depicts latitude of the user.
- Colour code depicts the satellite visibility for each user

The tool depicts the integrity status for the grid of users for the MRAIM mode. This integrity status considers the integrity flags.

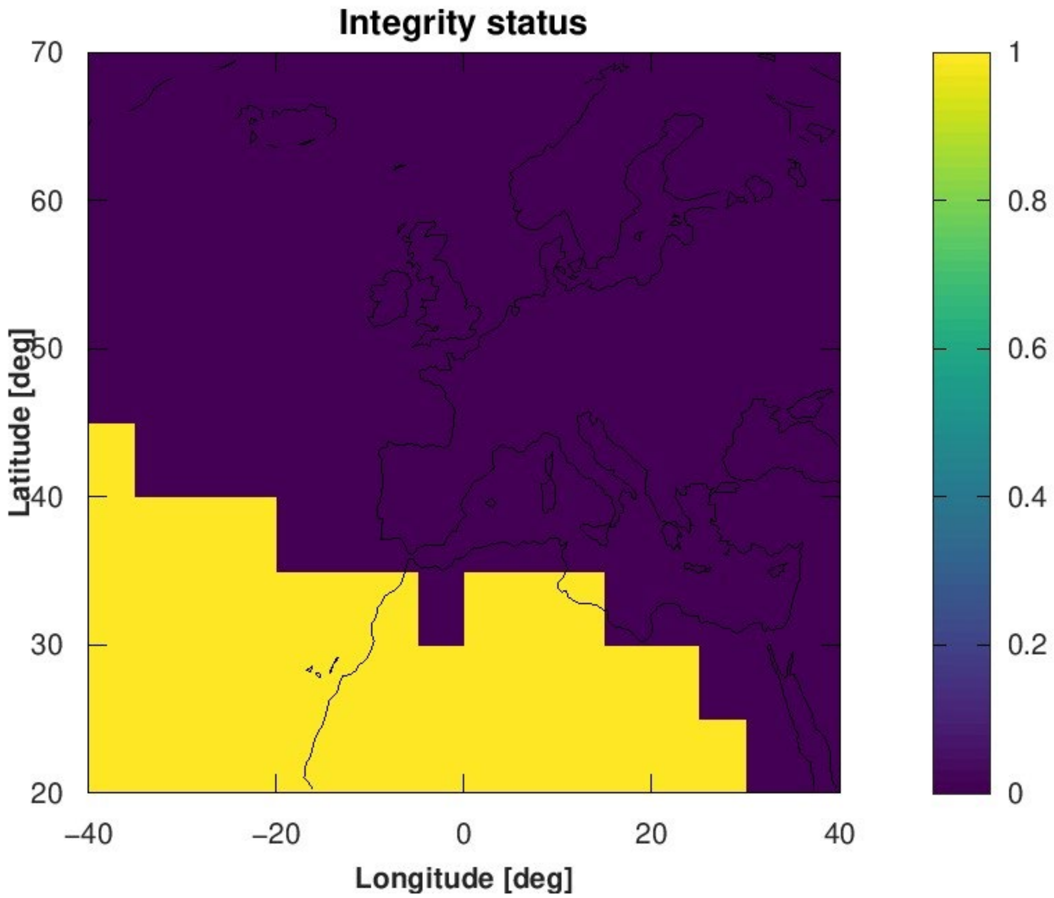


Figure 6-14. M(G)RAIM Performance Prediction prototype. Example of integrity flag over Europe

This figure parametrization is:

- Horizontal axis depicts the longitude of the user.
- Vertical axis depicts latitude of the user.
- Colour code depicts the integrity flag for each user
  - 0: red flag
  - 1: amber flag
  - 2: green flag

The tool depicts the continuity status for the grid of users for the MRAIM mode. This continuity status considers the availability status.

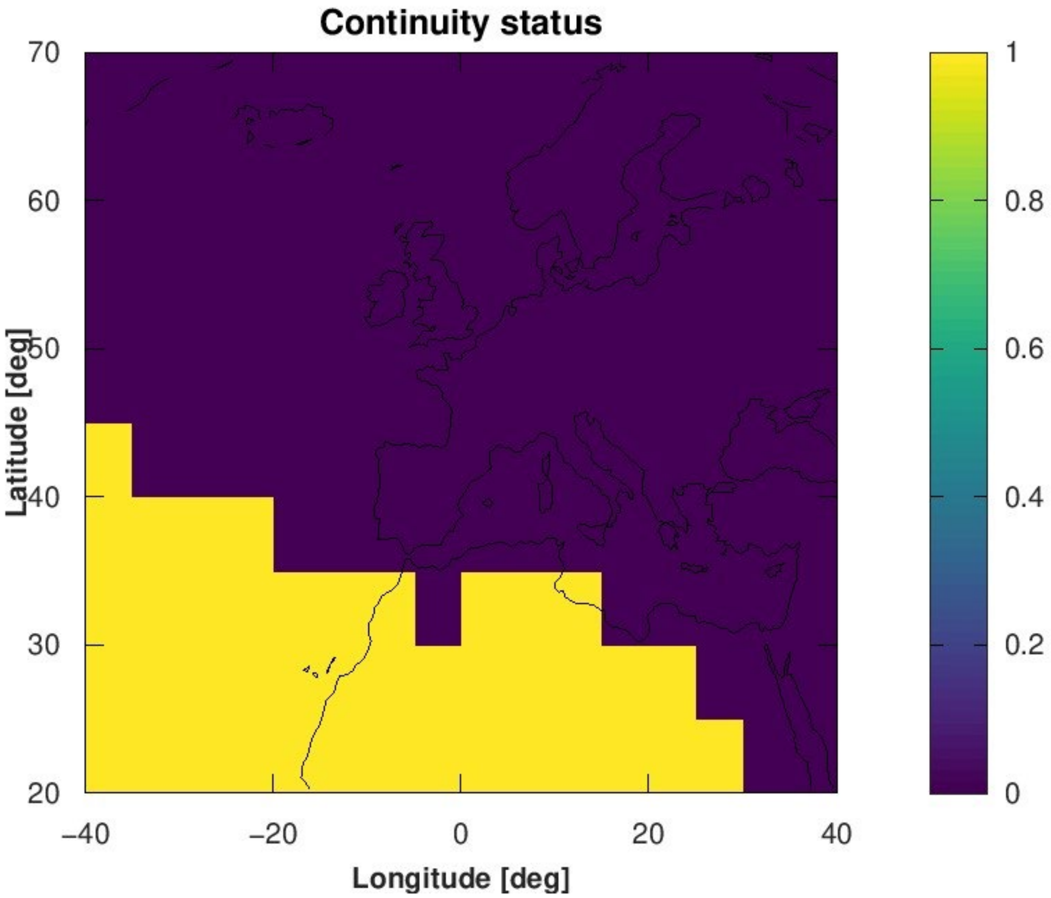


Figure 6-15. M(G)RAIM Performance Prediction prototype. Example of continuity status over Europe

This figure parametrization is:

- Horizontal axis depicts the longitude of the user.
- Vertical axis depicts latitude of the user.
- Colour code depicts the continuity status for each user
  - 0: Not continuous
  - 1: Continuous

6.2.2 Running the Tool

To run the tool, access the main folder (inspire_svs) and from there the “RAIM_SVS_main.m” shall be executed. This function takes the following input parameters in this order:

- Simulation path: Absolute path to the path where the configuration input file is contained
- Execution mode: Integer from 1 to 4 to indicate the kind of processing desired.
  - 1 for M(G)RAIM processing for one single scenario
  - 2 for PVT processing only without integrity algorithm for a single scenario
  - 3 for M(G)RAIM processing for one single scenario but making a sensitivity analysis for a single parameter
  - 4 for M(G)RAIM processing for several Test Cases and Subcases
- Simulation Configuration: Absolute path to the simulation configuration file
- Test subcase indicator

- Ephemeris filex2: Absolute or relative path to the input ephemeris file required, one per constellation and Galileo first if double constellation is used.

However, creating the simulation config files, store them in one folder each and run the main script with the input parameters could be very time consuming for those situations where several cases want to be executed.

To simplify the execution of these cases, two scripts have been created to provide a user interface for running multiple cases in batch mode.

To launch the application, it is first necessary to configure the configuration files to be analysed. To do this, the user must access the simulations folder, select the desired scenario, and go to input, where the configuration functions are located as mentioned above. An image of this configuration file can be seen in Figure 6-16.

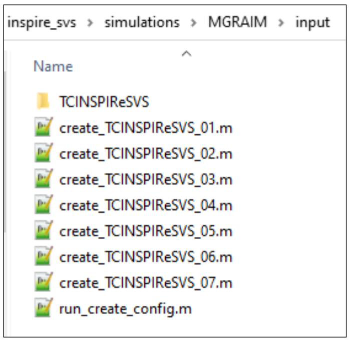


Figure 6-16. inspire_svs input configuration files location

By opening the scenario configuration file under the name <create_TCINSPIReSVS_‘sc’>.m in Octave, this can be modified. If more scenarios want to be generated the user has to copy the file and paste it in the same folder with a different ‘sc’ number and modify the variables to obtain the desired scenario, an example is shown in Figure 6-17. Please note that test case is identified as the text after the first “-“ character and subcases identifier are always the string after the first “_” character.

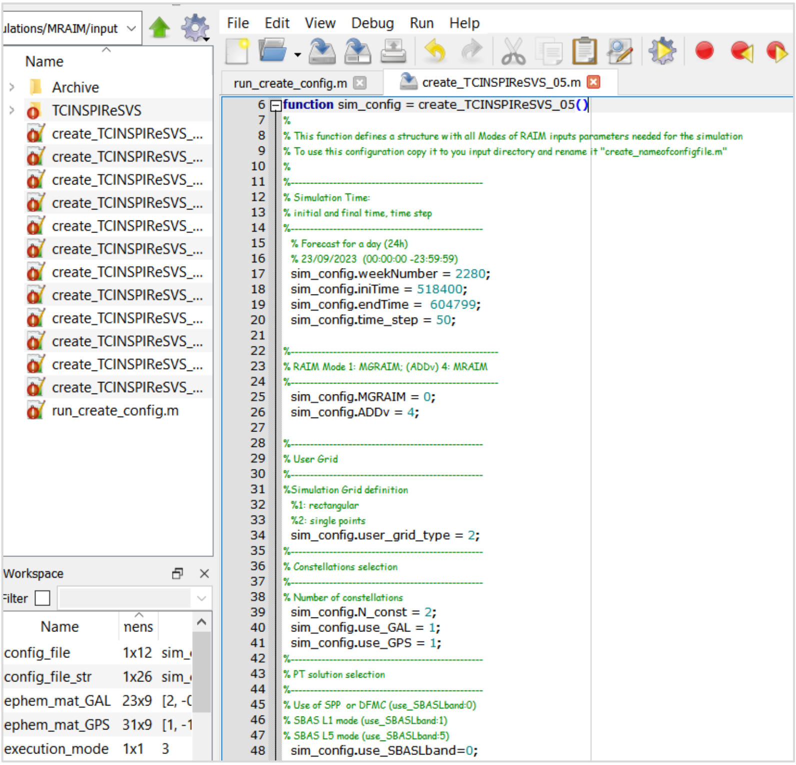


Figure 6-17. Configuration file

To create the scenarios in the desired format, the function run_create_config.m must be used, and the scenario must be added in the file. The part of the code that should be copied and paste is shown in Figure 6-18, by changing the names of the test case and the scenario, several scenarios can be launched at the same time.

As an example, the following variables:

- tc = 'TCINSPIReSVS_'sc' ';
- sim_config = create_TCINSPIReSVS_' sc' ();
- configuration_file = strcat('.\','simulations\','SIM_1\','input\',test,'\', tc);

```
%%%%%%%%%%%%%%%%%%% create_TC-INSPIRe-01 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Case 1, Diferenciate subcases with delim = "-"
tc = 'TCINSPIReSVS_01';
[test,subcase] = strtok(tc,"_")
disp(tc)

sim_config = create_TCINSPIReSVS_01();

configuration_file = strcat('.\','simulations\','MRAIM\','input\',test,'\', tc);

if exist(configuration_file)~= 7
  mkdir(configuration_file);
end
configuration_file = strcat(configuration_file, '\sim_config_', tc);
save(configuration_file, 'sim_config');
```

Figure 6-18. run_create_config file

The function “run_create_config.m” will be launched from the main folder of the inspire_svs tool. To do this, the first thing to do is to add to path the selected directories and subdirectories as shown in Figure 6-19.

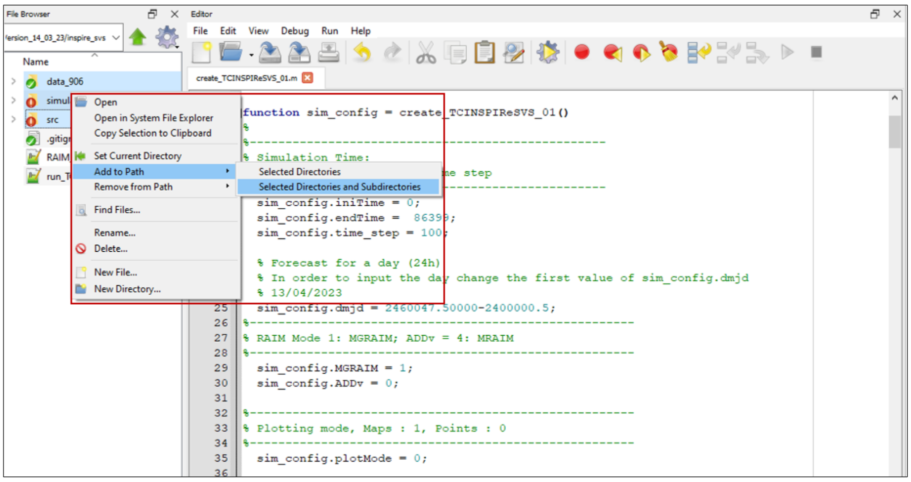


Figure 6-19. inspire_svs add to Path Directories

Then, to run several cases in a batch mode the user may open the executable run_TC on Octave. In this function the variable 'simulation_location' must be modified with the name of the folder of the scenario to be evaluated, as well as the scenarios evaluated in the variables 'tests.TC.name and 'tests.TC.cases' shown in Figure 6-20.

As an example, the following variables:

- simulation_location = '.\simulations\SIM_1\';
- tests.TC.name = ‘TCINSPIReSVS’
- tests.TC.cases = {' TCINSPIReSVS_'sc' ';' TCINSPIReSVS_'sc' '}

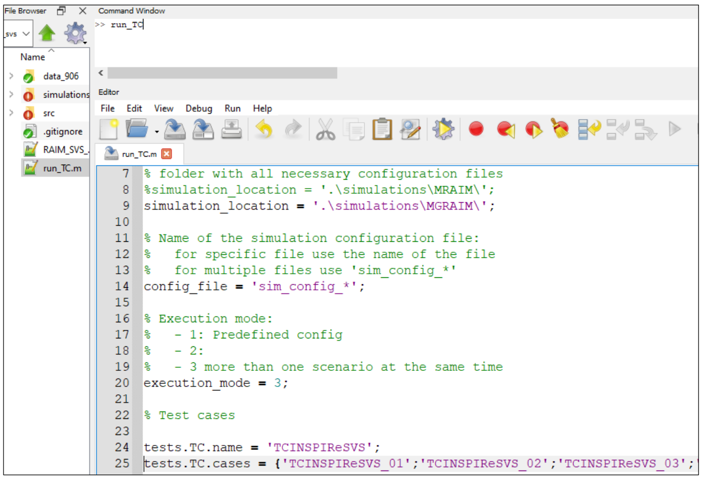


Figure 6-20. run_TC function

The desired results can be found in the output folder as mentioned in the beginning of the user manual.

7 IDENTIFICATION OF STEPS AND TIMESCALES FOR DEVELOPMENT AND IMPLEMENTATION OF AN OPERATIONAL TOOL

This section details the roadmap for the development of an operational UK EGNOS Performance Coverage Prototype tool.

Taking into account the M(G)RAIM algorithm design [RD.1][RD.2] and the requirements identified for the operational Performance Coverage Prototype Tool in section3.2. following sections details the activities that should be performed in order to put in place an operational tool and their timescale.

Please note that T0 will be in this section the kick-off of the service development. development for each stage. Please note that Performance Coverage Prototype will be developed in two stages:

1) Upgrade the prototype tool developed in this project to a functional, online, service that anyone can access. Its purpose would be mainly educational, to raise awareness of integrity at sea, and to inform today's mariners of the capability that their receiver is likely to provide.
2) Develop the Provision Scheme for an operational prediction service, along with the IALA / IMO process to get changes made to maritime equipment. This second stage will take into account the final implementation of the M(G)RAIM algorithms if they are finally incorporated into maritime receivers.

7.1 Operational Performance Coverage Prototype Tool Activities

This chapter contains the main actions identified to implement an operational Performance Coverage Prototype Tool from the prototype already developed.

7.1.1 Action #1. Incorporation of M(G)RAIM proposed solution

Objective: The objective of this action is to foster the incorporation of the M(G)RAIM proposed solution into maritime receivers.

Justification: It could be obvious to mention, but the usability of a potential Performance Coverage Prototype Tool for maritime users is linked directly with the penetration of the proposed M(G)RAIM algorithms designed in INSPIRe project [RD.1][RD.2].

Performances are given, both in terms of availability and size of protection level, for the proposed maritime on-board solution, assuming among other features, the implementation of one of the two algorithms analysed in this project. Therefore, maritime users shall implement these algorithms to find the Performance Coverage Prototype Tool useful.

In order to do so, it should be promoted the penetration of the M(G)RAIM proposed solution into maritime receivers via IEC standardisation, IALA guidelines or any other maritime regulatory material that could help this penetration. Afterwards, it should be assessed if the development of an operational Performance Coverage Prototype Tool, the second stage of the development, makes sense or the scope should be readapted to include the existing algorithms, regardless they are M(G)RAIM ones or any others.

In this action should be distinguished the two algorithms proposed. MGRAIM algorithm is a simpler algorithm where most of the checks are already implemented by the receivers and the geometry screening is the additional feature that should be included. Therefore, its penetration is expected much easier and the auxiliary tool could help to foster its usage.

However, the MRAIM implies a different integrity concept and would imply significant changes in the maritime integrity approach. For this algorithm is where has to be evaluated if an operational tool may make sense.

Action type: Promotion and Standardisation activity.

Owner: This work should be done by the maritime authorities and the INSPIRe consortium.

Criticality: The criticality of this action is classified as high because after its completion a go/no-go decision should be taken.

Timeframe: This activity shall be carried out before the service development and will last for at least ten years, starting at T0_ stage1 and ending at T0_stage1 +10yrs.

Recommendation: Promotion of M(G)RAIM solution should start as soon as possible since the time scope for maritime regulatory material modification or development is usually long and take not less than 2 years. In addition, manufacturers would not implement the M(G)RAIM solution unless clear advantages are observed or regulation imposes it.

7.1.2 Action #2. Service Provision Analysis

Objective: The objective of this action is analysing the service provision scheme for the Performance Coverage Prototype Tool, including the stakeholders involved in the service provision, the liabilities, and the interface among them.

Justification: This activity aims to analyse the service provision of a safety Maritime Performance Prediction service for the algorithm designed in INSPIRe project [RD.1][RD.2].

M(G)RAIM algorithms are designed for safety purposes in the context of maritime navigation, and therefore, their implementation is subject to some verification control that would assess if a receiver equipped with that algorithm is safe for maritime navigation. Taking this into account, this activity should assess and define the role of a Maritime Performance Prediction service and the most suitable scheme for its provision.

Depending on the outcomes of this analysis, the Performance Coverage Prototype Tool could be used to evaluate the compliance with the navigation requirements of certain operations, in certain areas over a specific time. Mariners will have an indication of the expected performances with a certain level of confidence. In this case, then it should be analysed if there were some kind of liabilities in the provision of such as performance forecast, that would allow maritime users to claim in case wrong prediction.

Action type: Service definition activity.

Owner: This work should be done by the maritime authorities that should define the specific role of this service considering the integrity concept in maritime domain.

Criticality: The criticality of this action is classified as high because the liabilities may impose additional requirements to the tool development.

Timeframe: The end of this activity will set the starting point of the second stage service development (i.e., T0_ stage2) and will last for a year, ending at T0_ stage2+12m.

Recommendation: The outcomes of this activity shall be, above all, the role of this tool in the maritime navigation procedures. In case this tool is provided only as an auxiliary tool to estimate approximately the performance of M(G)RAIM requirements will be much more relaxed.

7.1.3 Action #3. Prediction Tool Core Processing Development

Objective: The objective of this action is upgrade the current developed prototype into an operational tool, following the coding standards required.

Justification: Currently, M(G)RAIM prediction tools is developed as a prototype. In order to provide an operational tool, the core forecast module should be coded according to the requirements defined by Action #2. Service provision analysis.

This action will develop and implement all the requirements detailed in section 3.2.2 following the prototype design in section 4.1 and the appropriate coding standards, without taking into account interface requirements. Current protype implementation simplifies some of the processing and interfaces but the high-level scheme, the input and outputs will remain the same for an operational tool.

These interfaces may change along the Prediction Tool operation, for example due to a change of the message format, and therefore the development of the core processing should be a separated activity.

In addition, the auxiliary tool developed in the first stage will be evolved to become an operational tool with the latest changes considered when M(G)RAIM are implemented in maritime receivers.

Action type: Technical software development activity.

Owner: This work should be done by the service developers

Criticality: The criticality of this action is classified as high since is the core activity for the Performance Coverage Prototype Tool development.

Timeframe: This activity may be performed in 6 months starting at T0_ stage1 for the first stage and T0_ stage2 for the operational tool.

Recommendation: It is recommended to wait until high level provision scheme is defined in Action #2. Service provision analysis in order to develop the core tool function according to the most suitable standards. Otherwise, reengineering may be needed.

7.1.4 Action #4. Development of Performance Coverage Prototype Tool Interfaces

Objective: The objective of this action is to develop all the interfaces required to comply with section 3.2.2 requirements.

Justification: Currently, M(G)RAIM prediction tools is developed as a prototype that takes all input parameters in a file format. However, section 3.2.2 requirements and functional requirements of section 3.2.1 require different interface than static files.

In particular, there should be defined two different groups of interfaces, the one available to the mariner user to introduce its desired configuration and obtain the performance forecast, and the GNSS healthy related interfaces. In particular, the following interfaces should be developed:

- **GNSS healthy interfaces,** please note that these interfaces could take place between the stakeholders identified in Action #2. Service provision analysis:
  - **GNSS Navigation interface**: Tool requires the closest available GNSS constellation ephemeris to the configured date. These ephemerides should be obtained from a network of receivers decoding real data for the forecast, and from historical data for “past forecast” mode (i.e. Navigation RINEX).
  - **GNSS Health Status:** The operational tool should take as input the NANUs, NAGUs or equivalent messages that provide information about the GNSS constellation and satellite health status. In addition, this interface should consider as inputs augmentation system information, if used, about GNSS health information. These messages should be decoded in real-time for the forecast, and from historical data for “past forecast” mode (i.e. NANUs/NAGUs historical data or ftp servers)
  - **Error models:** These models could be provided by a user configuration or taken from augmentation system signal error estimations, making assumptions for the

propagation of the model in the future. For "past forecast" mode augmentation messages shall be read from historical data, (i.e. ftp servers).

- **User interfaces**: The tool shall consider at least the following configuration parameters to be developed aligned with Action #2. Service provision analysis outcomes: User location / User grid definition; Date and expected time window; Constellation(s) to be used; Satellites to be used; M(G)RAIM configuration parameters and navigation phase requirements. It is expected that these configuration parameters will be provided via web GUI (Graphical User Interface), where also the output information can be displayed in the form of plots and maps. In addition, this interface should consider the automatic processing of reports in the form of PDFs or other text format.

These interfaces may change along the Prediction Tool operation, for example due to a change of the message format, and therefore the development of the core processing should be a separated activity.

Action type: Technical software development activity.

Owner: This work should be done by the service developers.

Criticality: The criticality of this action is classified as high since is the core activity for the Performance Coverage Prototype Tool development.

Timeframe: This activity may be performed in 6 months starting at T0_stage1.

Recommendation: It is recommended to wait until high level provision scheme is defined in Action #1. Incorporation of M(G)RAIM proposed solution

Objective: The objective of this action is foster the incorporation of the M(G)RAIM proposed solution into maritime receivers.

Justification: It could be obvious to mention, but the usability of a potential Performance Coverage Prototype Tool for maritime users is linked directly with the penetration of the proposed M(G)RAIM algorithms designed in INSPIRe project [RD.1][RD.2].

Performances are given, both in terms of availability and size of protection level, for the proposed maritime on-board solution, assuming among other features, the implementation of one of the two algorithms analysed in this project. Therefore, maritime users shall implement these algorithms to find the Performance Coverage Prototype Tool useful.

In order to do so, it should be promoted the penetration of the M(G)RAIM proposed solution into maritime receivers via IEC standardisation, IALA guidelines or any other maritime regulatory material that could help this penetration. Afterwards, it should be assessed if the development of an operational Performance Coverage Prototype Tool, the second stage of the development, makes sense or the scope should be readapted to include the existing algorithms, regardless they are M(G)RAIM ones or any others.

In this action should be distinguished the two algorithms proposed. MGRAIM algorithm is a simpler algorithm where most of the checks are already implemented by the receivers and the geometry screening is the additional feature that should be included. Therefore, its penetration is expected much easier and the auxiliary tool could help to foster its usage.

However, the MRAIM implies a different integrity concept and would imply significant changes in the maritime integrity approach. For this algorithm is where has to be evaluated if an operational tool may makes sense.

Action type: Promotion and Standardisation activity.

Owner: This work should be done by the maritime authorities and the INSPIRe consortium.

Criticality: The criticality of this action is classified as high because after its completion a go/no-go decision should be taken.

Timeframe: This activity shall be carried out before the service development and will last for at least ten years, starting at T0_ stage1 and ending at T0_stage1 +10yrs.

Recommendation: Promotion of M(G)RAIM solution should start as soon as possible since the time scope for maritime regulatory material modification or development is usually long and take not less than 2 years. In addition, manufacturers would not implement the M(G)RAIM solution unless clear advantages are observed or regulation imposes it.

Action #2. Service provision analysis in order to develop the core tool function according to the most suitable standards. Otherwise, reengineering may be needed.

7.1.5 Action #5. Deployment of monitoring network stations (Optional)

Objective: The objective of this action is to develop an additional module that could monitor the real performances and compare it against the forecasted ones, in order to fine tuning and refine the used error models.

Justification: Currently, M(G)RAIM prediction tools is developed as a prototype that takes all input parameters in a file format. Maritime error models are provided from pre-computed models or are extrapolated from real time information from augmentation systems, if used.

An additional module could be developed to monitor the real performances and compare it against the forecasted ones, in order to fine tuning and refine the used error models. This module will help then to improve the configured models without augmentation and also will improve the extrapolation models from augmentation messages information.

In addition to the refine function, the interfaces of this module may be also defined if this monitoring station network is deployed (or reused) with M(G)RAIM enabled receivers. These network station could also provide recorded information and the monitoring module could post-process the algorithm. Finally, this activity should define how previous models are overwritten with the outcome of the refinements since it should be noted that reference stations may not provide a representative enough error from the maritime environment.

Action type: Technical software/hardware development activity.

Owner: This work should be done by the service developers.

Criticality: The criticality of this action is classified as low since the refinement of the error models could be performed by many other approaches, and also could be configured by the user.

Timeframe: This activity may be performed in 6 months starting at T0_stage1+6m.

Recommendation: It is recommended to develop this activity once the service has started its Testing phase, since it is an optional module that requires the system already in place, at least in an EOP.

7.1.6 Action #6. Performance Coverage Prototype Tool Test Bed

Objective: Finally, the objective of this action is to develop a Test Bed to assess the functioning of the tool prior to its operational phase.

Justification: Similar to any operational service related to the safety of navigation, the Performance Coverage Prototype Tool shall be assessed by a Test Bed in order to analyse its functioning under the operational environment.

This activity is key to solving any undetected problem in the development phase before making any commitment, if any.

Action type: Technical software/hardware development activity.

Owner: This work should be done performed as defined in Action #2. Service provision analysis by the entity that is going to host the service.

Criticality: The criticality of this action is classified as high since it is the previous step before the service becomes operational where everything is tested.

Timeframe: This activity may be performed in 12 months starting at T T0_stage1+6m.

Recommendation: It is recommended to develop this activity considering the same stakeholders that are going to develop the operational system according to Action #1. Incorporation of M(G)RAIM proposed solution

Objective: The objective of this action is foster the incorporation of the M(G)RAIM proposed solution into maritime receivers.

Justification: It could be obvious to mention, but the usability of a potential Performance Coverage Prototype Tool for maritime users is linked directly with the penetration of the proposed M(G)RAIM algorithms designed in INSPIRe project [RD.1][RD.2].

Performances are given, both in terms of availability and size of protection level, for the proposed maritime on-board solution, assuming among other features, the implementation of one of the two algorithms analysed in this project. Therefore, maritime users shall implement these algorithms to find the Performance Coverage Prototype Tool useful.

In order to do so, it should be promoted the penetration of the M(G)RAIM proposed solution into maritime receivers via IEC standardisation, IALA guidelines or any other maritime regulatory material that could help this penetration. Afterwards, it should be assessed if the development of an operational Performance Coverage Prototype Tool, the second stage of the development, makes sense or the scope should be readapted to include the existing algorithms, regardless they are M(G)RAIM ones or any others.

In this action should be distinguished the two algorithms proposed. MGRAIM algorithm is a simpler algorithm where most of the checks are already implemented by the receivers and the geometry screening is the additional feature that should be included. Therefore, its penetration is expected much easier and the auxiliary tool could help to foster its usage.

However, the MRAIM implies a different integrity concept and would imply significant changes in the maritime integrity approach. For this algorithm is where has to be evaluated if an operational tool may make sense.

Action type: Promotion and Standardisation activity.

Owner: This work should be done by the maritime authorities and the INSPIRe consortium.

Criticality: The criticality of this action is classified as high because after its completion a go/no-go decision should be taken.

Timeframe: This activity shall be carried out before the service development and will last for at least ten years, starting at T0_ stage1 and ending at T0_stage1 +10yrs.

Recommendation: Promotion of M(G)RAIM solution should start as soon as possible since the time scope for maritime regulatory material modification or development is usually long and take not less than 2 years. In addition, manufacturers would not implement the M(G)RAIM solution unless clear advantages are observed or regulation imposes it.

Action #2. Service provision analysis to exploit synergies.

7.1.7 Action #7. Maritime User Engagement

Objective: The objective of this action is to promote the Performance Coverage Prototype Tool service for maritime users

Justification: After the Performance Coverage Prototype Tool service is developed for maritime users, mariners will need to realise the benefits of the tool. It is expected that usage of the tool would not be mandatory prior to any operation, and therefore benefits of the tool should be highlighted to mariners.

The main advantage of such a tool for mariners is the forecast capability to assess the level of performance for intended operation, in the given location, at the expected time window, increasing the safety of the operations since mariners would have an indication of how much they can trust in the positioning provided by GNSS. This would facilitate the operation since mariners will not set off unless they are sure they can perform the full operation without any risk. Obviously, these advantages are strictly related to Action #2. Service provision analysis since the mandatory grade of these algorithms will drive the added value in the eyes of the mariners.

Action type: Promotion activity

Owner: This work should be done by the maritime authorities and the INSPIRe consortium.

Criticality: The criticality of this action is classified as medium because it is not a key activity for service development, but it is for its usage and usefulness.

Timeframe: This activity may be performed in at least 18 months starting at T0_ stage 1.

Recommendation: It is recommended to keep in mind this activity for the whole development of the Performance Coverage Prototype Tool service to get mariner's feedback as soon as possible and engage them at the first operational stages.

7.2 Operational Performance Coverage Prototype Tool Roadmap

Finally, the last stage of this identification is the development of a roadmap based on the aforementioned information. The expected development roadmap is detailed in the following figure.

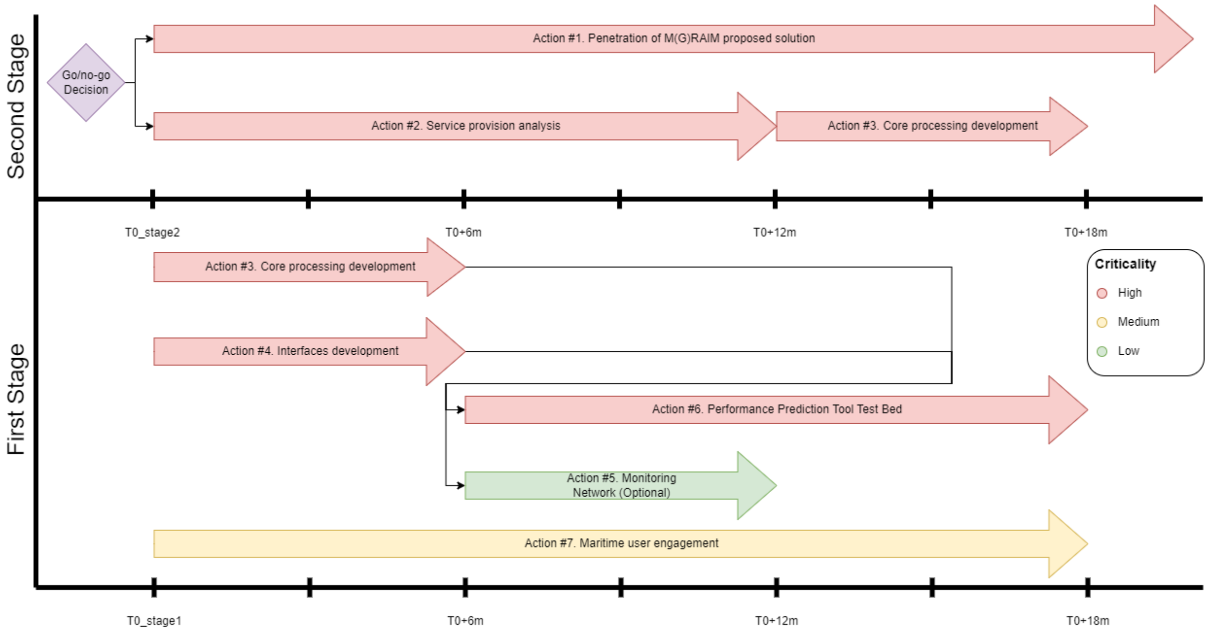


Figure 7-1. Operational Performance Coverage Prototype Tool Roadmap.

Actions have been classified by their criticality, indicating the relationship among the actions and the expected timeframe.

8 HIGH LEVEL ESTIMATED COST REPORT

This section provides a high-level estimated cost for an operational M(G)RAIM Performance Coverage Prototype Tool

including the development, implementation, and operations, highlighting assumptions and data sources.

Table 8-1, shows the high-level estimation for the development of the prototype tool based on the main actions identified to implement an operational Performance Coverage Prototype Tool described in Section 7 above. Be advised that the figures contained in this table are estimated considering the current proposal of Performance Coverage Prototype Tool development and are aligned with the hypothesis that this tool is provided as an auxiliary tool. In case of significant change in the development approach, the estimated cost shall be re-estimated.

Table 8-1 High-level estimate cost

Task	Estimated cost	Justification
Action #1. Incorporation of M(G)RAIM proposed solution	£300k+hardware	This action aims to develop technical analysis and dissemination activities to foster the penetration of the M(G)RAIM algorithms.
Action #2. Service provision analysis	£150k	This action only analyses the liabilities and service provision scheme for the Performance Coverage Prototype Tool Estimated cost for one-year desk research project
Action #3. Prediction Tool core processing development	£150k + validation	This action is for the upgrade from the prototype for the operational core tool. The level of validation required will increase the cost
Action #4. Development of Performance Coverage Prototype Tool interfaces	£200k	Interfaces include receiving the GNSS signal/messages in real-time and user/web interfaces
Action #5. Deployment of monitoring network stations (Optional)	£50k/station £100k (central facility)	This includes the deployment of stations to compare real performances against forecasted ones to refine the tool and error models
Action #6. Performance Coverage Prototype Tool Test Bed	£100k deployment +£50k per year	Test Bed cost has been estimated with the cost of the previous operational Test Bed deployed by GMV
Action #7. Maritime user engagement	£30k per person and a year of effort	This includes dissemination and maritime engagement activities to engage users in the usage of the Prediction tool

The operational cost of the tool, once developed, would depend on the service provision approach. If the tool is provided as it is then the operational cost is negligible. However, in case any commitment is made to the quality of the service, then operational costs will increase for the maintenance effort, the provision of periodic performance reports, the implementation of a user help desk, etc.

End of Document