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Space — SBAS receivers performances for maritime applications — MARESS Test report

National foreword

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Rue de la Science 23, B-1040 Brussels

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European foreword

This document (CEN/TR 18104:2024) has been prepared by Technical Committee CEN/JTC 5 “Space”, the secretariat of which is held by BNAE.

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Introduction

This technical document MARESS D2.2 has been prepared by European Satellite Services Provider (ESSP) in the scope of MARitime Receiver SBAS Standardization (MARESS) project to support International Standard IEC 61108-7 for SBAS receiver equipment. The purpose of this document is to present it in CEN/CENELEC JTC5/WG8 working group to support standardization process within IEC technical committee 80: Maritime navigation and radiocommunication equipment and systems.

Note at the time of the Publication: The outcome of this report has been already considered in the development of the IEC 61108-7 standard. This implies that these results are obsolete since in the current version of the IEC 61108-7 some requirements and tests have been updated.

1 Scope

The objective of this document is to present the results of the tests defined in the IEC 61108-7 draft [1] performed with a maritime receiver updated based on the SBAS maritime guidelines [2] and other GNSS SBAS receivers.

The list of test scenarios prepared, the receiver analysed, the configuration used and procedures are included in Clause 4. In Clause 5, graphical and numerical results for each of the test performed are presented, including if the tests are passed or failed. Annex A provides additional information on the test case setup.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp/>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Test scenarios

4.1 General

The test scenarios implemented in MARESS project have been based on the MARESS deliverable D2.1 Methods of testing and required results [1].

In this Clause, all the tests performed are listed including the respective configuration used. All the tests have been prepared to process GPS L1 and SBAS L1.

The following information can be found for each of the tests executed:

- start date: indicate the start date of the scenario under test;
- duration: indicate the duration of the test;
- signal source: specify if the receiver was connected to real signals with a GNSS antenna in ESSP roof (Madrid) or if the GNSS simulator has been used to generate the GNSS and SBAS signals;
- data source: indicate if real data has been used as input (GPS RINEX and EGNOS EMS files); or the data has been automatically generated by the GNSS simulator (synthetic data);
- receiver position: provides the position of the receiver (real or simulated);
- specific configuration related with the objective of the test;
- outputs to be analysed: list of parameters to be retrieved from the receiver under test to check if the test is passed/failed.

4.2 Test cases

4.2.1 Test case #1: static accuracy and availability

The objective of this test is to check the static accuracy and availability of the receiver when providing SBAS PVT solution.

Table 1 provides specific information on the test characteristics and configuration:

Table 1 — Test case #1 — Scenario configuration

Start date	N/A (variable)
Duration	> 86 400 epochs
Signal source	Real RF L1 Signal
Data source	Real Data
Receiver position	Lat = 40.472° Lon = -3.452° Height = 661,1 m
Specific configuration	NMEA output rate: 1 Hz Static receiver
Outputs	Epoch PVT solution mode Position

All the outputs from the receivers are obtained through NMEA messages.

The start date is variable since it depends on when the receiver was connected to the antenna located in the roof of ESSP premises in Madrid.

The results of this test are included in subclause 5.2.1.

4.2.2 Test case #2: static accuracy with angular movement

The objective of this test is to check the static accuracy and availability of the receiver providing SBAS PVT solution when the antenna is performing an angular displacement of 22.5°, simulating roll, in a period of 8 s during the duration of the test.

Table 2 provides specific information on the test characteristics and configuration.

Table 2 — Test case #2 — Scenario configuration

Start date	02-Apr-2021 23:50:00
Duration	87 000 epochs
Signal source	GNSS simulator
Data source	Synthetic data
Receiver position	Lat = 40.467° Lon = -3.45° Height = 661,28 m
Specific configuration	NMEA output rate: 1 Hz Static receiver Antenna with angular movement ($\pm 22.5^\circ$ during 8 seconds).
Outputs	Epoch PVT solution mode Position

Figure 1 shows a snapshot of the antenna movement configured in the GNSS simulator.



Figure 1 — Snapshot of GNSS simulator for antenna movement

Errors have not been introduced in the GPS signals and so, the position error is expected to be more accurate compared to a real scenario. However, the objective of the test is to check that the error is not increased when the antenna performs the angular movements in comparison with a nominal static scenario.

All the outputs from the receivers are obtained through NMEA messages.

The results of this test are included in subclause 5.2.2.

4.2.3 Test case #3: dynamic accuracy

4.2.3.1 General

The objective of this test is to check the dynamic accuracy of the receiver providing SBAS PVT solution.

Table 3 provides specific information on the test characteristics and configuration.

Table 3 — Test case #3 — Scenario configuration

Start date	03-Apr-2021 00:00:00
Duration	86 400 epochs
Signal source	GNSS simulator
Data source	Synthetic data
Receiver position	Dynamic position (refer to Table 4)
Specific configuration	NMEA output rate: 1 Hz Receiver in movement (refer to Table 4)
Outputs	Epoch PVT solution mode Position Truth position (from GNSS simulator)

The minimum requirement for the receiver movement described in D2.1 [1] is:

1. A fully locked and settled EUT travelling in a straight line at $48 \text{ kn} \pm 2 \text{ kn}$ for a minimum of 1,2 minutes which is reduced to 0 kn in the same straight line in 5 s.

In order to comply with this, the receiver in the GNSS simulator has been configured to perform the following movements:

Table 4 — Test case #3 — Ship movement configuration

	Ship dynamics	Period of time
Start position (step 0)	Lat = 41.517° Lon = 3.65° Height = 300 m	N/A
Step 1	Ship in halt	300 s
Step 2	Ship accelerating (max speed 25 m/s)	60 s
Step 3	Ship at constant speed (25 m/s)	120 s
Step 4	Ship reduce velocity until it stops (0 m/s)	5 s
Step 5	Ship in halt	120 s
Step 6	Repeat steps 2, 3, 4 and 5 consecutively.	

It is clarified that the ship movement configured is only at horizontal level.

In addition, the latitude of the receiver position is maintained during the whole scenario, the movement described in previous table only implies changes in the longitude.

Figure 2 shows a snapshot of the ship trajectory configured in the GNSS simulator.

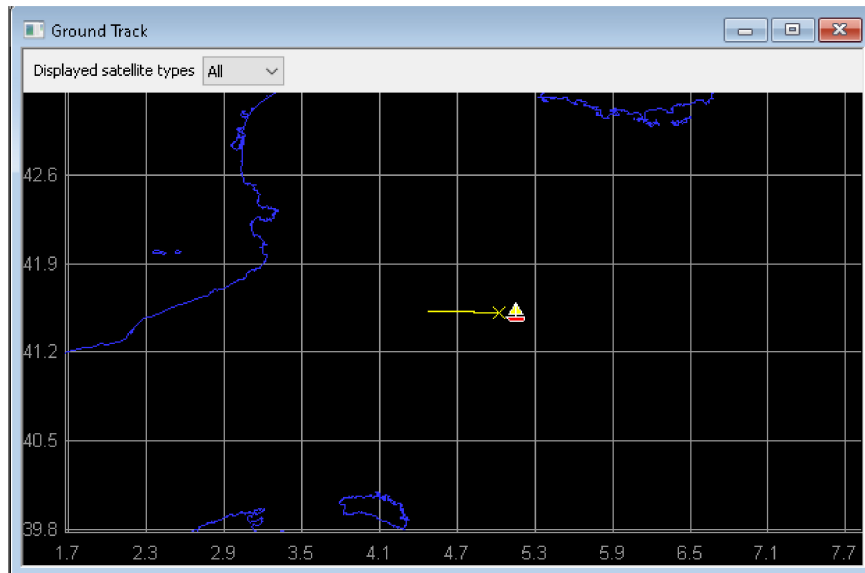


Figure 2 — Snapshot of ship trajectory for dynamic movement scenario

Errors have not been introduced in the GPS signals and so, the position error is expected to be more accurate compared to a real scenario. However, the objective of the test is to check that the receiver follows the dynamics of the ship. Nevertheless, in order to ensure that the receiver will correctly pass the test under a more realistic scenario. A Test case #3b was prepared (refer to subclause 4.2.3.1).

All the outputs from the receivers are obtained through NMEA messages. In this case, the GNSS simulator has been configured to provide also the truth position (through NMEA) during the whole scenario.

The results of this test are included in subclause 5.2.2.

4.2.3.2 Test case #3b: dynamic accuracy with input files

This test case was performed in order to check if the receiver correctly follows the ship dynamics when GPS RINEX and EGNOS EMS real data are used as input files in the GNSS simulator.

However, during the scenario executions, a limitation was found on the GNSS simulator. If real data are used as input, the GNSS simulator uses the GPS RINEX files for two purposes:

1. include the RINEX content into the GPS navigation messages;
2. generate the real GPS orbits.

Since the GNSS simulator uses the GPS RINEX, where the GPS messages have ephemeris/clock errors that SBAS will correct, to generate the real GPS orbits in the simulation, the SBAS corrections are not needed. Indeed, SBAS corrections increase the error in the position since SBAS is correcting errors that do not exist in the simulation. The same situation it occurs with the ionosphere, since the ionosphere generated by the simulator does not match with the ionospheric corrections delivered by SBAS. The GNSS simulator manufacturer was contacted to correct this issue, but it is confirmed that this is a limitation from the GNSS simulator.

In any case, this can be considered as a worst-case scenario, and so, it can be used to validate the test under analysis.

Table 5 provides specific information on the test characteristics and configuration:

Table 5 — Test case #3b — Scenario configuration

Start date	03-Apr-2021 00:00:00
Duration	86 400 epochs
Signal source	GNSS simulator
Data source	Real data
Receiver position	Dynamic position (refer to Table 4)
Specific configuration	NMEA output rate: 1 Hz Receiver in movement (refer to Table 4)
Outputs	Epoch PVT solution mode Position Truth position (from GNSS simulator)

All the outputs from the receivers are obtained through NMEA messages. In this case, the GNSS simulator has been configured to provide also the truth position (through NMEA) during the whole scenario.

The results of this test are included in subclause 5.2.3.1.

4.2.4 Test case #4: acquisition

The objective of this test is to check the acquisition time required by the receiver to provide SBAS PVT solution.

Table 6 provides specific information on the test characteristics and configuration.

Table 6 — Test case #4 — Scenario configuration

Start date	N/A (variable)
Duration	> 86 400 epochs
Signal source	Real RF L1 Signals
Data source	Real data
Receiver position	Lat = 40.472° Lon = -3.452° Height = 661,1 m
Specific configuration	NMEA output rate: 1 Hz Static receiver
Outputs	Epoch PVT solution mode Position

Since the requirement included in D2.1 [1] refers to acquisition time when there is valid almanac, the test has been done based on the following steps:

1. wait for the receiver to provide SBAS PVT solution;
2. remove connection to the antenna between 24 and 25 hours;
3. connect again the antenna to the receiver under test;
4. check the time required from connection to provide SBAS PVT solution.

All the outputs from the receivers are obtained through NMEA messages.

The start date is variable since it depends on when the receiver was connected to the antenna located in the roof of ESSP premises in Madrid.

The results of this test are included in subclause 5.2.4.

4.2.5 Test case #5: dynamic range

This test is aimed at checking that the receiver is able to track the SBAS signal between the maximum and minimum power levels indicated in D2.1 [1].

Table 7 provides specific information on the test characteristics and configuration.

Table 7 — Test case #5 — Scenario configuration

Start date	03-Apr-2021 00:00:00
Duration	1 800 epochs
Signal source	GNSS simulator
Data source	Synthetic data
Receiver position	Lat = 40.467° Lon = -3.45° Height = 661,28 m
Specific configuration	NMEA output rate: 1 Hz Static receiver 2 SBAS PRNs Signal power modified during scenario (refer to Table 8)
Outputs	Epoch PVT solution mode C/N ₀

In this scenario, two SBAS PRNs have been configured: PRN 123 and PRN 136 (corresponding to EGNOS SBAS). In order to ensure that the receiver complies with the requirement, the signal power of the SBAS satellites has been modified during the execution. The test has been done based on the following steps:

Table 8 — Test case #5 — SBAS signal power modifications

	PRN 123	PRN 136
Start - 00:00:00	-120 dBm	-130 dBm
Step 1 - 00:10:00	-123 dBm	-133 dBm
Step 2 - 00:12:00	-130 dBm	-120 dBm
Step 3 - 00:14:00	-133 dBm	-133 dBm

All the outputs from the receivers are obtained through NMEA messages.

The results of this test are included in subclause 5.2.5.

4.2.6 Test case #6: position update

4.2.6.1 General

The objective of this test is to check that receiver provides SBAS PVT solution at the required rate.

Two different sub test cases are identified to check the position update requirement, one related with low-speed crafts and other one for high-speed crafts.

4.2.6.2 Test case #6a: low-speed crafts

Table 9 provides specific information on the test characteristics and configuration.

Table 9 — Test case #6a — Scenario configuration

Start date	03-Apr-2021 00:00:00
Duration	1 101 epochs
Signal source	GNSS simulator
Data source	Synthetic data
Receiver position	Dynamic position (refer to Table 10)
Specific configuration	NMEA output rate: 1 Hz Receiver in movement (refer to Table 10)
Outputs	Epoch PVT solution mode Position

In D2.1 [1] is required to perform the test with a receiver travelling in a straight line at $5 \text{ kn} \pm 1 \text{ knot}$. In order to comply with this, the receiver in the GNSS simulator has been configured to perform the following movements:

Table 10 — Test case #6a — Low ship movement

	Ship dynamics	Period of time
Step 1	Ship in halt	300 s
Step 2	Ship accelerating (max speed 2'5 m/s)	1 s
Step 3	Ship at constant speed (2'5 m/s)	800 s

It is clarified that the ship movement configured is only at horizontal level.

In addition, the latitude of the receiver position is maintained during the whole scenario, the movement described in previous table only implies changes in the longitude.

All the outputs from the receivers are obtained through NMEA messages.

The results of this test are included in subclause 5.2.6.1.

4.2.6.3 Test case #6b: high-speed crafts

Table 11 provides specific information on the test characteristics and configuration.

Table 11 — Test case #6b — Scenario configuration

Start date	03-Apr-2021 00:18:21
Duration	1 101 epochs
Signal source	GNSS simulator
Data source	Synthetic data
Receiver position	Dynamic position (refer to Table 12)
Specific configuration	NMEA output rate: 1 Hz Receiver in movement (refer to Table 12)
Outputs	Epoch PVT solution mode Position

In D2.1 [1] is required to perform the test with a receiver travelling in a straight line at 50 knots $\pm$ 5 knots. In order to comply with this, the receiver in the GNSS simulator has been configured to perform the following movements:

Table 12 — Test case #6b — High ship movement

	Ship dynamics	Period of time
Step 1	Ship in halt	300 s
Step 2	Ship accelerating (max speed 25 m/s)	1 s
Step 3	Ship at constant speed (25 m/s)	800 s

It is clarified that the ship movement configured is only at horizontal level.

In addition, the latitude of the receiver position is maintained during the whole scenario, the movement described in previous table only implies changes in the longitude.

All the outputs from the receivers are obtained through NMEA messages.

The results of this test are included in subclause 5.2.6.2.

4.2.7 Test case #7: SBAS processing

The aim of this test is to check that the receiver correctly processes the SBAS data and messages according with the requirements stated in D2.1 [1].

Table 13 provides specific information on the test characteristics and configuration.

Table 13 — Test case #7 — Scenario configuration

Start date	03-Apr-2021 00:00:00
Duration	4 500 epochs
Signal source	GNSS simulator
Data source	Real data
Receiver position	Lat = 40.467° Lon = -3.45° Height = 661,28 m
Specific configuration	NMEA output rate: 1 Hz EGNOS messages modified (refer to Table 14)
Outputs	Epoch PVT solution mode Position

In order to follow all the steps identified in subclause 6.6.12 from D2.1 [1], the EGNOS EMS file used as input to feed the GNSS simulator was modified. Table 14 identifies all the steps performed in the EGNOS messages and signals transmitted by the GNSS simulator.

Table 14 — Test case #7 — Signal types configuration

	Signal type	Comment
Step 1 - 00:00:00	N/A	GPS signals on (HDOP < 4)
Step 2 - 00:05:00	Signal A	SBAS signal on
Step 3 - 00:10:01	Signal D	MT0 is transmitted by SBAS
Step 4 - 00:10:22	Signal A	Nominal signal
Step 5 - 00:16:27	Signal I	IODP not match
Step 6 - 00:16:50	Signal A	Nominal signal
Step 7 - 00:23:01	Signal L	Fast Corrections set to 255'875 m
Step 8 - 00:23:18	Signal A	Nominal signal
Step 9 - 00:24:59	Signal E	All UDREI set to 12

	Signal type	Comment
Step 10 – 00:25:18	Signal A	Nominal signal
Step 11 – 00:30:30	Signal J	Some IOD not match
Step 12 – 00:37:11	Signal A	Nominal signal
Step 13 – 00:42:42	Signal K	Ship outside MT27 area
Step 14 – 00:45:58	Signal A	Nominal signal
Step 15 – 00:48:02	Signal M	IODI not match
Step 16 – 01:00:00	Signal A	Nominal signal
Step 17 – 01:05:01	Signal N	Fast Corrections Update Interval set to 60 s
Step 18 – 01:06:00	Signal O	Fast corrections update interval set to 60 s and fast corrections degradation factor (a_i) set to 0
Step 19 – 01:07:04	Signal A	Nominal signal
Step 20 – 01:12:01	Signal P	MT6 messages with all UDREI set to 14 but IODFs do not match

For further information on the modifications performed within the EGNOS message content, including the epochs affected, etc. Please refer to Annex A.1.

All the outputs from the maritime receivers are obtained through NMEA messages. In the case of certified aviation receivers, the outputs are received in ARINC 429 format.

The results of this test are included in subclause 5.2.7.

4.2.8 Test case #8: SBAS satellite selection

4.2.8.1 General

This test is aimed at checking that the receiver is capable of tracking and processing two SBAS data streams if they are available, as well as switching from one stream to another to maximize the continuity of the service.

In order to check that the receiver can comply with the requirement, two different sub test cases are created, one related with two SBAS satellites belonging to the same service provider and other one with two SBAS satellites belonging to different service providers.

4.2.8.2 Test case #8a: Same service provider

Table 15 provides specific information on the test characteristics and configuration:

Table 15 — Test case #8a — Scenario configuration

Start date	03-Apr-2021 00:00:00
Duration	1 800 epochs
Signal source	GNSS simulator
Data source	Synthetic data
Receiver position	Lat = 40.467° Lon = -3.45° Height = 661,28 m
Specific configuration	NMEA output rate: 1 Hz Static receiver 2 SBAS PRNs from same SP Signal power modified during scenario (refer to Table 16)
Outputs	Epoch PVT solution mode C/N ₀

In this scenario, two SBAS PRNs have been configured: PRN 123 and PRN 136, both corresponding to EGNOS SBAS satellites. The receiver under test use in the PVT solution the PRN 136, so, in order to ensure that the receiver complies with the requirement; the signal of the SBAS satellite with PRN 136 was removed during a specific period of time. The test has been done based on the following steps:

Table 16 — Test case #8a — SBAS signals

	PRN 123	PRN 136
Start - 00:00:00	Signal On	Signal On
Step 1 - 00:10:00	Signal On	Signal Off
Step 2 - 00:15:00	Signal On	Signal On

All the outputs from the maritime receivers are obtained through NMEA messages. In the case of certified aviation receivers, the outputs are received in ARINC 429 format.

The results of this test are included in subclause 5.2.8.1.

4.2.8.3 Test Case #8b: Different service provider

Table 17 provides specific information on the test characteristics and configuration.

Table 17 — Test case #8b — Scenario configuration

Start date	03-Apr-2021 00:00:00
Duration	73 800 epochs
Signal source	GNSS simulator
Data source	Synthetic data
Receiver position	Lat = 50° Lon = 15° Height = 41,87 m
Specific configuration	NMEA output rate: 1 Hz Static receiver 2 SBAS PRNs from different SP Signal power modified during scenario (refer to Table 18)
Outputs	Epoch PVT solution mode C/N ₀

In this scenario, two SBAS PRNs have been configured: PRN 136 and PRN 125, corresponding to an EGNOS satellite and a SDCM satellite respectively. It is clarified that synthetic data have been used in this test case and so, PRN 125 is not transmitting the MT0.

The test has been performed based on the following steps:

Table 18 — Test case #8b — SBAS signals

	PRN 136	PRN 125
Start - 00:00:00	Signal On	Signal On
Step 1 - 12:00:00	Signal Off	Signal On
Step 2 - 12:20:00	Signal On	Signal On
Step 3 - 13:00:00	Signal On	Signal Off
Step 4 - 13:20:00	Signal On	Signal On

All the outputs from the maritime receivers are obtained through NMEA messages. In the case of certified aviation receivers, the outputs are received in ARINC 429 format.

The results of this test are included in subclause 5.2.8.2.

4.2.9 Test case #9: SBAS status indication

This test is intended to check that SBAS status indicators are provided according with the requirements from D2.1 [1].

Table 19 provides specific information on the test characteristics and configuration.

Table 19 — Test case #9 — Scenario configuration

Start date	03-Apr-2021 01:30:00
Duration	3 600 epochs
Signal source	GNSS simulator
Data source	Real data
Receiver position	Lat = 40.467° Lon = -3.45° Height = 661,28 m
Specific configuration	NMEA output rate: 1 Hz EGNOS messages modified (refer to Table 20)
Outputs	Epoch PVT solution mode Position

As per the test case #7, in this test case, the EGNOS EMS file used as input to feed the GNSS simulator was modified. Table 20 identifies all the steps performed in the EGNOS messages and signals transmitted by the GNSS simulator (indeed, to reduce time of execution, this scenario has been used as the continuation of test case #7 execution).

Table 20 — Test case #9 — Signal types configuration

	Signal Type	Comment
Step 1 - 01:30:00	Signal A	Nominal signal
Step 2 - 01:59:59	Signal C	Invalid CRC
Step 3 - 02:00:09	Signal A	Nominal signal
Step 4 - 02:04:59	Signal D	MT0
Step 5 - 02:05:05	Signal A	Nominal signal
Step 6 - 02:10:00	Signal F	All UDREI set to 14
Step 7 - 02:10:11	Signal A	Nominal signal
Step 8 - 02:14:59	Signal G	Alerts with UDREI set to 15
Step 9 - 02:15:08	Signal A	Nominal signal
Step 10 - 02:19:59	Signal H	All GIVEI set to 15 and vertical delay set to 63'875 m
Step 11 - 02:20:39	Signal A	Nominal signal

For further information on the modifications performed within the EGNOS message content, including the epochs affected, etc. Please refer to Annex A.2.

All the outputs from the maritime receivers are obtained through NMEA messages. In the case of certified aviation receivers, the outputs are received in ARINC format.

The results of this test are included in subclause 5.2.9.

4.2.10 Test case #10: integrity with RAIM

4.2.10.1 General

The objective of this test is to check if the EUT correctly performs RAIM computation providing the corresponding integrity status.

As defined in D2.1 [1], there are three status for integrity status: Safe, Caution and Unsafe. In order to test all the cases, two sub test cases have been prepared, one to check transitions from safe to caution and another one to test transition from safe to unsafe.

4.2.10.2 Test case #10a: RAIM caution flag

Table 21 provides specific information on the test characteristics and configuration.

Table 21 — Test case #10a — Scenario configuration

Start date	03-Apr-2021 01:05:00
Duration	1 800 epochs
Signal source	GNSS simulator
Data source	Real data
Receiver position	Lat = 40.467° Lon = -3.45° Height = 661,28 m
Specific configuration	NMEA output rate: 1 Hz Some signals from GPS are removed (refer to Table 22) GPS monitored by SBAS are reduced (refer to Table 22)
Outputs	Epoch PVT solution mode Number of SV used in PVT RAIM status

In order to test that the EUT correctly provides the RAIM caution flag, on one side, some signals from GPS satellites provided by the GNSS simulator are removed, on the other side, since the receiver uses the integrity information provided by SBAS for RAIM SBAS-based position, GPS satellites monitored by SBAS are reduced (this is done modifying the EGNOS EMS file). Table 22 provides the steps that have been performed for this test.

Table 22 — Test case #10a — Signal types configuration

	Modification
Step 1 - 01:10:00	GPS signals from all satellites are removed but GPS PRN 2, 3, 9 and 19.
Step 2 - 01:14:00	GPS PRN 4 restarts transmission

	Modification
Step 3 – 01:14:20	GPS PRN 6 restarts transmission
Step 4 – 01:14:40	Rest of GPS satellites restart transmission
Step 5 – 01:20:00	GPS satellites monitored by EGNOS are reduced to four
Step 6 – 01:25:00	GPS satellites monitored by EGNOS are recovered to nominal value

All the outputs from the receivers are obtained through NMEA messages.

The results of this test are included in subclause 5.2.10.1.

4.2.10.3 Test case #10b: RAIM unsafe flag

Table 23 provides specific information on the test characteristics and configuration.

Table 23 — Test case #10b — Scenario configuration

Start date	03-Apr-2021 02:30:00
Duration	5 700 epochs
Signal source	GNSS simulator
Data source	Real data
Receiver position	Lat = 40.467° Lon = -3.45° Height = 661,28 m
Specific configuration	NMEA output rate: 1 Hz Accuracy level set to 10 m Some clock errors in GPS are introduced (refer to Table 24) Some SBAS clock corrections error are introduced (refer to Table 24)
Outputs	Epoch PVT solution mode RAIM status Position

In order to test that the EUT correctly provides the RAIM unsafe flag, an error in the estimated position bigger than 10 meters needs to be introduced. For that purpose, on one side, some clock errors are introduced in the GPS satellites provided by the GNSS simulator, on the other side, since the receiver uses the pseudo-range corrections provided by SBAS for RAIM SBAS-based position, clock correction errors are introduced in SBAS messages (this is done modifying the EGNOS EMS file). Table 24 provides the steps that have been performed for this test:

Table 24 — Test case #10b — Signal types configuration

	Modification
Step 1 - 03:00:00	Errors in SBAS clock corrections for GPS satellites 2, 4, 5, 6, 7 and 9 are introduced.
Step 2 - 03:05:00	SBAS clock corrections are back to nominal values
Step 3 - 04:00:00	GPS clock errors are introduced in GPS navigation messages for satellites 2, 3, 5, 7, 9, 13, 14.

All the outputs from the receivers are obtained through NMEA messages.

The results of this test are included in subclause 5.2.10.1.

4.3 Receivers under test

A NAMELESS-1 receiver (RC01) upgraded according to the SBAS guidelines [2] was agreed to be used in MARESS project.

Unfortunately, some issues were identified in the behaviour of the NAMELESS-1 receiver that prevented the correct test execution and validation. In order to not block the project and the test implementation, it was decided to use, in addition to the NAMELESS-1 receiver, another maritime receiver (RC02) capable of processing SBAS.

Considering that the other GNSS maritime receiver was not developed based on the SBAS L1 maritime guidelines [2], some tests are expected to fail. It is clarified that having test failed do not imply that the test is not correctly described/implemented, but that at the time of writing the standard, there were no receivers compliant with these new requirements.

Since some SBAS tests are expected to fail with the RC02 receiver, a third receiver was used in order to ensure that the SBAS tests were correctly defined. In this case, a certified aviation receiver (RC03) was used. This aviation receiver is compliant with RTCA MOPS DO-229 [3]. Note that only the tests related with the SBAS satellite selection and SBAS processing are executed for this receiver, since these are the tests that are not expected to be passed by RC02.

Table 25 includes a summary of the GNSS receivers used in the test execution.

Table 25 — Receivers under test

RC01	RC02	RC03
Maritime receiver (GPS L1 + SBAS L1) upgraded based on maritime SBAS L1 guidelines	Maritime receiver (GPS L1 + SBAS L1) not updated based on maritime SBAS L1 guidelines	Aviation receiver (GPS L1 + SBAS L1) compliant with RTCA MOPS DO-229

5 Test results

5.1 General

In this Clause, the results obtained during the test implementation are presented. First a summary table with the test status is presented (PASSED/FAILED). Then, the corresponding outputs for each of the test performed are presented and the test status is described based on results obtained.

5.2 Summary

5.2.1 General

Table 26 includes a summary of the test results for each of the test cases and receivers used.

Table 26 — Summary test results

Test case	Title	RC01	RC02	RC03
1	Static accuracy and availability	Failed	Passed	N/A
2	Static accuracy with angular movement	Failed	Passed	N/A
3	Dynamic accuracy	Failed	Passed	N/A
3b	Dynamic accuracy with input files	Failed	Passed	N/A
4	Acquisition	Failed	Passed	N/A
5	Dynamic range	Failed	Passed	N/A
6a	Position update for low-speed craft	Failed	Passed	N/A
6b	Position update for high-speed craft	Failed	Passed	N/A
7	SBAS processing	Failed	Failed	Passed with clarification
8a	SBAS satellite selection with same SP	Failed	Failed	Passed
8b	SBAS satellite selection with diff SP	Failed	Failed	Failed with clarification
9	SBAS status indication	Failed	Failed	Passed with clarification
10a	Integrity with RAIM – Caution flag	Failed	Passed with clarification	N/A
10b	Integrity with RAIM – Unsafe flag	Failed	Passed with clarification	N/A

5.2.2 Test results #1: static accuracy and availability

In this test, two outputs are gathered from the receiver in order to check if the test is passed or failed: the estimated position compared with the true position and the availability of the PVT solution.

It is clarified that the test is not performed from the moment the receiver is connected to the antenna. The first minutes of execution are not included in the analysis to let the receiver track the satellites and the algorithms to converge in order to provide PVT solution.

The objective of the test is then twofold: