Test methodology

DL 3: Selection of receivers to be tested (+rationale supporting the choice)
DL 4: Selection of Test scenarios + Test sites
DL 5: Presentation of the test procedure and test data to be gathered

"Assessment of EGNOS potential in the maritime and inland waterways transport sector"

Specific Contract No.3 under DG ENTR's Framework Contract ex TREN/G4/475-1-2009

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Reference Documents

Reference	Title	Release Date
RD1	u-blox 6 Receiver Description Including Protocol Specification, FW 7.03, GPS.G6-SW-10018-A	01.04.2011
RD2	Trimble SPSx51Modular GPS Receivers User Guide, Version 3.70, Revision A, August 2008	10/2008
RD3	EVK-6 u-blox Evaluation Kits User Guide, GPS.G6-EK-10040-1	2011
RD4	SBF Reference Guide, V.1.9.0	16.07.2010
RD5	Firmware User Manual, Rev.0	07.09.2010
RD6	Operators Manual GPS Navigator GP-150, OME-44400-C	18.02.2010
RD7	RTCA DO-229D	13.12.2006

Table of Content

1   Introduction

The purpose of this document is to provide a detailed test methodology for the test carried out under this specific contract for the European Commission, and therefore corresponds to the deliverable "DL 5: Presentation of the test procedure and test data to be gathered".

1.1   Interference sources

This section is not intended for a general discussion about GNSS/SBAS interference since there are multiple papers available discussing these issues. The interference sources on the ship identified are radar and radio, even though some of the ships probably do not have radar aboard. Sonar and other typical equipment present on ships are considered to have less influence.

The radar aboard ships depends very much on the ship type and its usage. The transmission power therefore varies from some milliwatt on private ships to kilo watts on high-sea ships. In order to avoid disturbance of the test equipment by radar, the antennas shall be placed as far away from the radar as possible. Preferably the navigation antennas are also placed on the highest point of the ship. With the mast detailed in section 2.1, this can easily be realized. Nevertheless the aim shall be to stay as low as possible to best reflect the real world scenario. This will be the case if the mast is not used but the antennas are mounted directly on structures available on the ship. It is important that the antennas are not place directly in the radar beam.

The boats to be used are intended to be similar as shown in Figure 1. This type of boats is considered to be representative for the private ship owner, since it is not too big but also not too small and allows the tests to be carried out with the equipment required and providing space for the personnel present.


Figure 1 Boat types

Since the tests shall reflect a likely usage scenario no active measures against interference are taken, expect from the antenna placement. This is considered a valid approach since it is thought to be what the private ship owner would do.

1.2   Handling of two antennas

The introduction of two antennas through the update of the task specification – as outlined in the proposal – leaves the difficulty of the exact determination of the position of the medium-end antenna. It requires the question to be clarified how the second antenna can be referred to the reference antenna, or in other words how the reference track can be compared to the track recorded through the second antenna. The only way to align the two tracks would be that the system provides heading information. Since not all receivers are available at the submission of this draft of the test methodology it cannot be stated whether this will be the case or not. At the time of writing it seems unlikely that a receiver would provide sufficiently accurate heading information, since heading is usually provided through duplicate antenna systems. Figure 2 shows the situation. What can be seen that by calculation the position of the medium antenna the missing angle information would lead to an error, indicated as red position marked "Wrong".
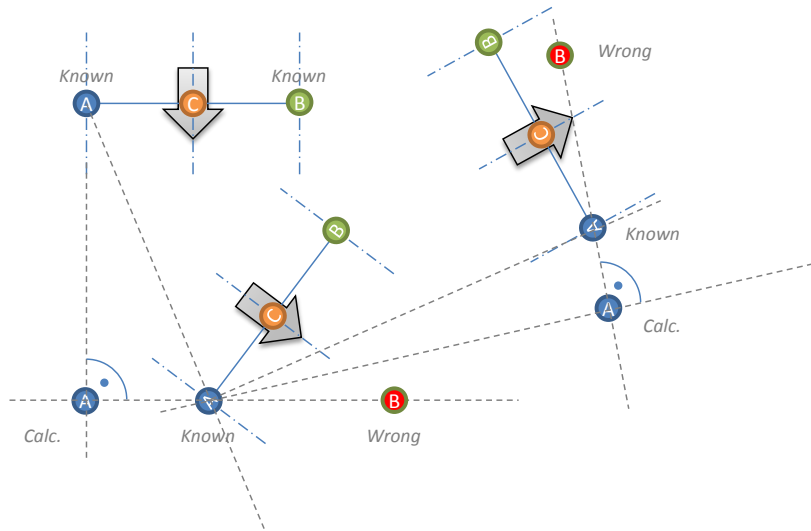
Figure 2 Medium-end antenna position determination

A way to calculate the position of the medium-end antenna is the course over ground. The quality of this computed "quasi" reference position will be assessed at the preliminary test.

In any case at the start of the measurement the antenna positions will be determined through the reference antenna. As shown in Figure 3 the antenna mast will be turned by 180° to determine the position of both antennas. The beacon antenna will be placed in the middle of the antenna array. The distances between the antennas are fixed. Therefore the measurement as a side effect also provides an assessment of the reference position accuracy, since the distance between the antennas is fixed being one meter.

A Reference antenna
B Medium-end antenna
C Beacon antenna
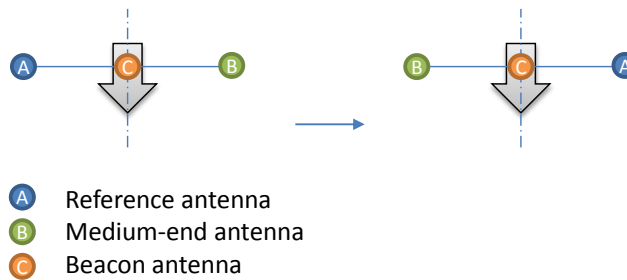
Figure 3 Antenna position determiation at start

The distance between the antennas on the structure used is chosen to be possible on a small ships mast like the ones shown, but also to avoid the antennas interfering with each other (in case they would be too close). Details for the antenna mounting are discussed in section 2.2.

The following section introduces the equipment used. The details on each receiver are entered only after the validation and test with the real receiver, the section shall not be a copy of the manuals.

1.3   Test route and timing

The test route chosen is a straight line from the departure point to the end-point selected with a distance of about 15km (~8.09 nautical miles). Depending on the speed of the boat available, the test route will be extended by the same straight line perpendicular to the first part of the test route, see Figure 4.

1,2,3,4	2,3 4,5	4,5,8,9 6,7,10,11
	1,6	1,2,3,12
7.5km 15km	15km 25km	12.5km 25km
5 km/h = 2.7 knots	15 km/h = 8.1 knots	25 km/h = 13.5 knots
Each indicated part ~ 90 min	Each indicated part ~ 60 min	Each indicated part ~ 30 min
Total 6 h	**Total 6 h**	**Total 6 h**
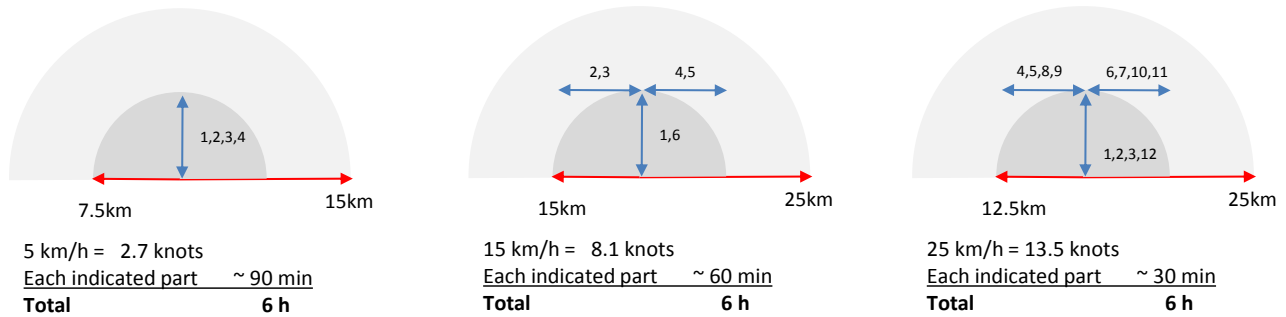
Figure 4 Route/test path

As shown in Figure 4 the route is depending on the speed of the boat. The basis is the part of the route always indicated as "1". For the maritime this part will in any case be repeated for all scenarios. In order to more efficiently use the time available on the test day, this basic scenario will be extended with the "vertical" tests indicated to vary the test route. Obviously on inland waterways the scenario cannot be like shown in Figure 4, but rather has to follow the path of the waterway. Therefore a straight line is intended to be followed if possible. In any case on the inland waterway the route will be repeated (following the same course) in order to create the repeated measurement data – nevertheless this can only be done if the traffic and rules allow for it.

The distance is a result of the boat type and the speed it provides along with the time available for a test. Table 1, Table 2 and Table 3 detail the planned timeline for tests on a full-day and an additional half-day test. The full-day test is guaranteed on each test site. The half-day test will be done if the test-site schedule allows for it. The timing is a general timing that is valid for the test sites. It can vary depending on circumstances such as delayed flights etc. and can be extended to increase the test time.

Time - start	Time - end	Duration	Activity
08:00			Arrival, Boat pick-up
08:15	08:45	00 h 30 min	Equipment set-up on the boat
09:00	09:45	00 h 45 min	Warm-up Phase Veripos service (~30min)
09:45	10:15	00 h 30 min	Static measurement phase (30 min)
10:30			Departure harbor / Kinematic test start
	16:30	06 h 00 min	Arrival harbor / Kinematic test end
16:30	17:00	00 h 30 min	Equipment packing
17:15			Departure, Return boat

Static test duration	**00 h 30 min**
Kinematic test duration	**06 h 00 min**

Table 1 Test day timing - full-day

Time - start	Time - end	Duration	Activity
08:00			Arrival, Boat pick-up
08:15	08:45	00 h 30 min	Equipment set-up on the boat
09:00	09:45	00 h 45 min	Warm-up Phase Veripos service (~30min)
09:45	10:15	00 h 30 min	Static measurement phase (30 min)
10:30			Departure harbor / Kinematic test start
	13:30	03 h 00 min	Arrival harbor / Kinematic test end
13:30	14:00	00 h 30 min	Equipment packing
14:15			Departure, Return boat

Static test duration	**00 h 30 min**
Kinematic test duration	**03 h 00 min**

Table 2 Test day timing - half-day morning

Time – start	Time - end	Duration	Activity
13:00			Arrival, Boat pick-up
13:15	13:45	00 h 30 min	Equipment set-up on the boat
14:00	14:45	00 h 45 min	Warm-up Phase Veripos service (~30min)
14:45	15:15	00 h 30 min	Static measurement phase (30 min)
15:30			Departure harbor / Kinematic test start
	18:30	03 h 00 min	Arrival harbor / Kinematic test end
18:30	19:00	00 h 30 min	Equipment packing
19:15			Departure, Return boat

Static test duration	**00 h 30 min**
Kinematic test duration	**03 h 00 min**

Table 3 Test day timing - half-day afternoon

The timing is put with some room in order to allow for a certain probability that the tests can be executed according to the schedule in case of any delays. The half-day test can be executed in the morning (plan see Table 2) or shifted to the afternoon in case of arrival in the morning (plan see Table 3).

The static test to be performed is to be carried out with the equipment mounted on the ship but before the ship leaves the harbor. This way the correct performance of the equipment can be checked. Also EGNOS can be validated to be working properly. The ESSP service site will be accessed at the day of testing to check for the current state of EGNOS. The exact assessment of the EGNOS performance cannot be done as is not a goal of the tests to be performed, it is an assessment of the usability of EGNOS and therefore it is interesting to understand the general availability of EGNOS on the test days. To assess that once the availability of EGNOS will be checked before the test and documented with Figure 5 and Figure 6. . In addition, the EGNOS Helpdesk will be contacted at least one week in advance in order to obtain a detailed view of the expected performances over the area during the selected dates. In case of any significant change occurs differing from the initial planning, it will be communicated by the EGNOS Helpdesk in order to take it into account during the trials. On the day after the test Figure 7 will be included in the test report to state the correct sending of EGNOS messages. Actual performances can be checked against the data recorded at the nearest RIMS provided by the EGNOS User Support website or requested directly at the EGNOS Helpdesk.
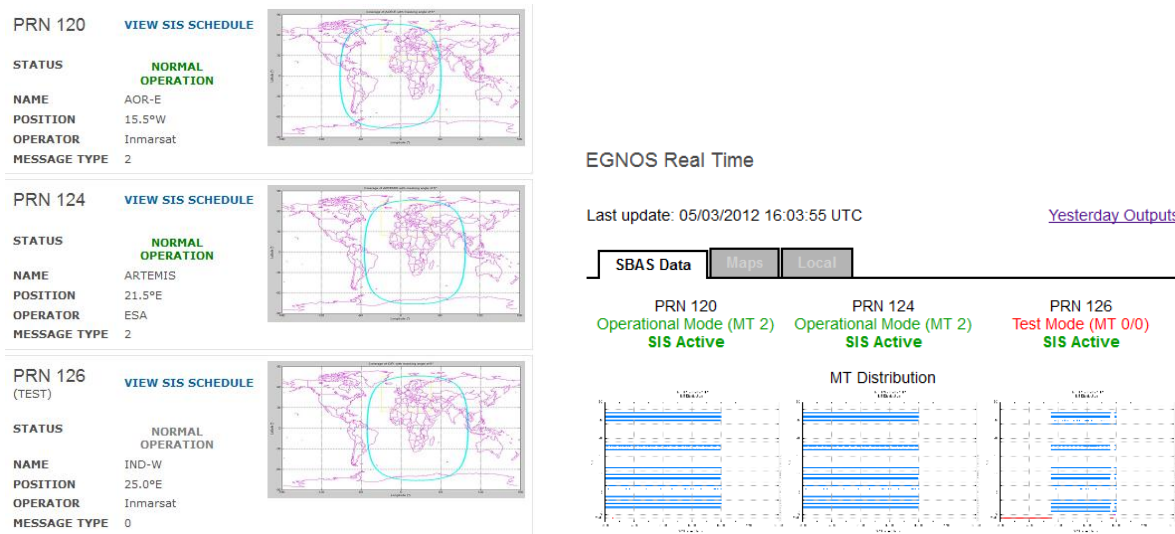
Figure 5 EGNOS satellite status before testing [Source: ESSP]

Figure 6 EGNOS SiS planned transmission [Source: ESSP]
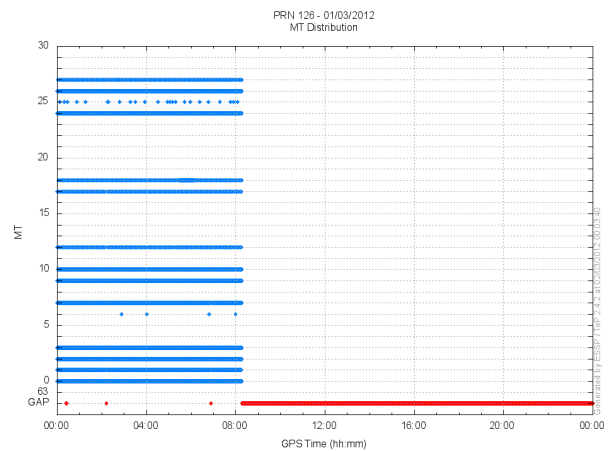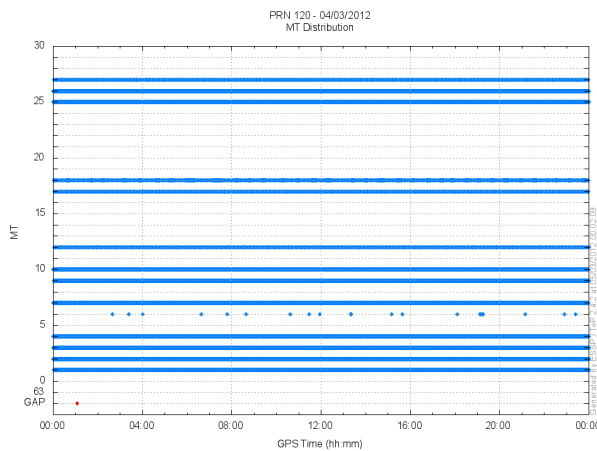
Figure 7 EGNOS sateliltes message type trasnmitted on day of testing [Source: ESSP]

The above figures shall be in line with the EGNOS messages received and logged by RX4. Therefore a check of the EGNOS messages logged and those sent on the EMS will be done, with the aim to indicate that the receiver was receiving the EGNOS messages correctly.

2 Equipment

The task specification page eight required to use six receivers to log GPS and EGNOS data as well as IALA beacon and reference position data. The receiver selected for the tests are listed in Table 4.

Receiver usage	Receiver name	Receiver ID
GPS receiver	uBlox EVK-6T	RX1
EGNOS low-end receiver	uBlox EVK-6T	RX2
EGNOS mid-end receiver	Furuno GP-150	RX3
EGNOS high-end receiver	Septentrio AsteRx2eL	RX4
IALA (MSK) beacon receiver	Trimble SPS 351	RX5
Reference receiver (Veripos service)	Septentrio AsteRx2eL	RX6

Table 4 Equipment – Receivers

The equipment was selected to reflect the requirements set by the task specification as well as to cover the possibility for the introduction of new equipment in the maritime market and include equipment certified by the International Maritime Organization (IMO) for the maritime usage. The equipment covers a wide price range. This distribution was chosen on purpose to reflect the scenarios from the private ship owner to the "expensive" receiver required to use the DGPS L-band frequency services used as reference position. Nevertheless the absolute high-end equipment in the price range of > 10T EUR is not covered by this test, since it was not included A) in the task specification and B) this price range is not consider relevant for the intended audience. The selection of the receivers was discussed with and agreed by the European Commission in the Kick-off meeting held for this specific contract.

> **The above is considered as the deliverable requested in the task specification on page eight as "DL3: Selection of receivers to be tested" with the receivers listed in Table 4.**

The receivers used operate in
- the GPS L1 (1575.42 MHz) and L2 (1227.6 MHz) frequencies
- the DGPS L-band frequency on which the VERIPOS data is transmitted, antenna input range 1525 MHz to 1559 MHz
- the IALA beacon frequency 283.5 kHz to 325.0 kHz

This frequency distribution in combination with the requirements from the task specification makes it necessary to include three antennas. Those comprise a medium-end and high-end GNSS/SBAS antenna as well as an IALA-beacon antenna. The two GNSS/SBAS antennas are to be split among the receivers. This is detailed in section 2.1. The distribution of one antenna signal between multiple receivers requires using active splitters, those would be filtering out the IALA beacon frequency, and therefore a separate antenna is used to receive the IALA signal.

The antennas and splitters are listed in Table 5 and Table 6.

Splitter	Splitter name	Splitter ID
Splitter I	GPS Networking ALDCBS 1X8	SP1
Splitter II	GPS Networking ALDCBS 1X8	SP2

Table 5 Equipmnet – Splitters

Antenna usage	Antenna name	Antenna ID
Medium-end antenna	PPM AT 575	ANT1
High-end antenna	Trimble GA 530	ANT2
IALA beacon antenna	CT A401223	ANT3

Table 6 Equipment - Antennas

The cables used to connect the antennas to the splitters and receivers are high quality cables especially produced for mobile usage, according to the distributor. The cables required are listed in Table 7.

Cable usage	Connector – (Adapter) – Cable type – Connector	Cable length	Cable ID
RX1 – SPx	SMA (m) – H2000F – TNC (m)	30 cm	C1
RX2 – SPx	SMA (m) – H2000F – TNC (m)	30 cm	C2
RX3 – SPx	TNC (m) – H2000F – TNC (m)	30 cm	C3
RX4 – SPx	TNC (m) – H2000F – TNC (m)	30 cm	C4
RX5 – ANT3	TNC (m) – H2000F – TNC (m)	15 m	C5
RX6 – SPx	TNC (m) – H2000F – TNC (m)	30 cm	C6
SP1 – ANT1	TNC (m) – H2000F – TNC (m)	15 m	C7
SP2 – ANT2	TNC (m) – H2000F – TNC (m)	15 m	C8

Table 7 Equipment - Cables & Connectors

The connection to the PC is done via the means provided by the receiver, see Table 8 for details.

Receiver	Receiver name	Receiver ID	PC connection
GPS receiver	uBlox EVK-6T	RX1	USB (also provides power)
EGNOS low-end receiver	uBlox EVK-6T	RX2	USB (also provides power), BT
EGNOS mid-end receiver	Furuno GP-150	RX3	RS-232 to USB
EGNOS high-end receiver	Septentrio AsteRx2eL	RX4	USB
IALA (MSK) beacon receiver	Trimble SPS 351	RX5	Ethernet
Reference receiver (Veripos service)	Septentrio AsteRx2eL	RX6	USB

Table 8 Connections - Receiver to PC

The recording of the respective data is done as detailed in Table 9.

Receiver	Data	Format	Recording
GPS receiver	GPS position	NMEA0183	Recording via HyperTerminal
EGNOS low-end receiver	EGNOS position	NMEA0183	Recording via HyperTerminal
EGNOS mid-end receiver	EGNOS position	NMEA0183	Recording via HyperTerminal
EGNOS high-end receiver	EGNOS position	SBF/NMEA0183	Septentrio software
IALA (MSK) beacon receiver	IALA position	NMEA0183	Recording via HyperTerminal
Reference receiver (Veripos service)	Reference position	SBF/NMEA0183	Septentrio software

Table 9 Position logging - Port, Format, Type

For the recording of the log file a software called HyperTerminal is used. This software was chosen due to its simplicity. In general any software can be used which allows for the capturing of a data stream on the serial ports (virtual serial ports).

All receivers will be transported and some of them mounted in a waterproof and shockproof box with dimensions 50.1 x 27.9 x 19.3 cm.

2.1   Splitting of the antenna signals

The splitters used are active splitters and therefore amplify the signal coming from the antenna. This is required since otherwise the signal strength would be reduced. The required theory behind this is not part of this methodology document. The splitters provide an average gain of 18.4dB. This high gain could cause problems on the low-end

receivers therefor 10dB attenuators are used to keep the "antenna gain" after the splitters at an acceptable level for all receivers.

Two splitters have to be used to account for the requirement of feeding one antenna signal to multiple receivers. This led to a consecutive requirement of using a separate IALA beacon antenna, even though the GA530 has an internal beacon antenna. This is based on the fact that the splitter filters out the IALA beacon signal. With a frequency of ~300kHz the beacon signal can be treated as quasi direct-current (DC). This on the other hand has the advantage that a TNC-Tee can be used to combine the GNSS signal from the splitter with the IALA beacon signal from the beacon antenna. The splitter outputs are in DC block mode and therefore are protected against the IALA beacon signal which would be fed to the splitter through the TNC-tee. An alternative option would be to use a diplexer. But the tee option is supported by the distributor of the receiver as well as the antenna. This would also be interesting if e.g. an existing system shall be enhanced with a better antenna the "tee-solution" would be something the end user would rather do than buying a diplexer.

Some of the antenna to receiver connections cannot be changed and therefore imply a certain connection diagram which is shown in Figure 8. The reference receiver RX6 must be connected through the splitter to the high-end antenna, since this is the only combination that enables the Veripos service (indicated as LBand). The second connection that cannot be changed is the connection of the IALA beacon receiver RX5 to the beacon antenna (indicated as MSK). The other connections are interchangeable.
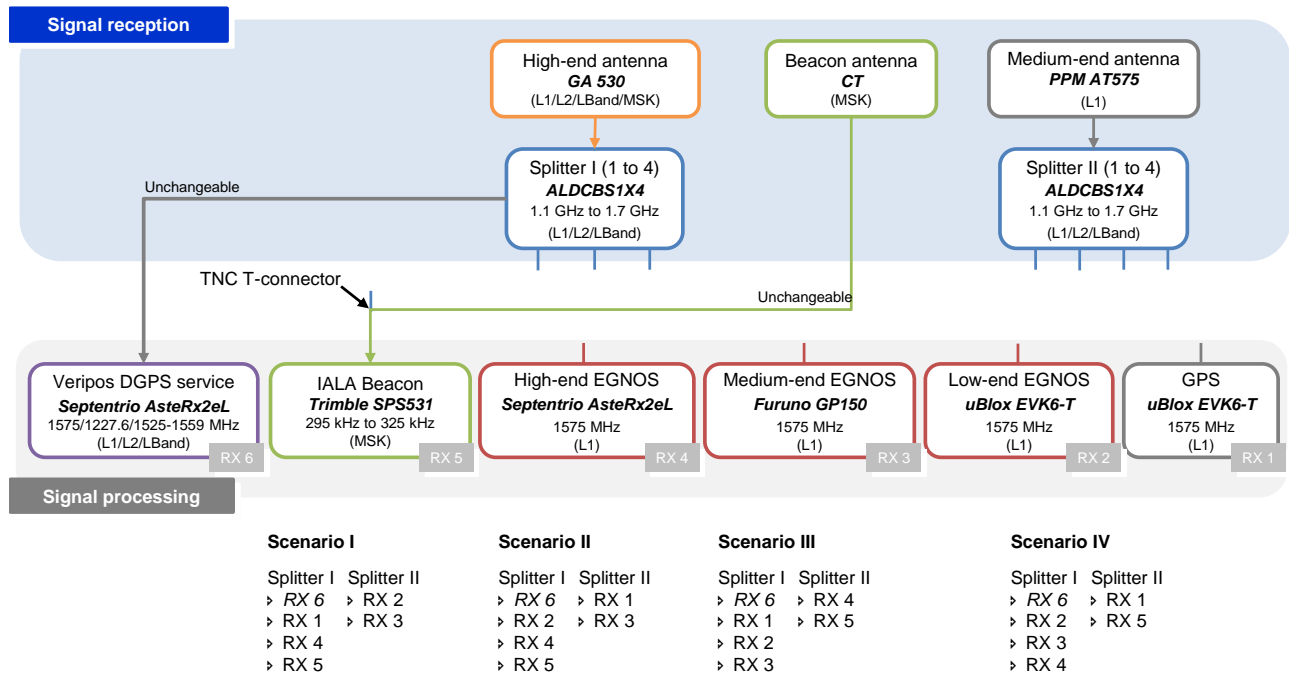
Figure 8 Antenna to receiver connections – unchangeable (colors are not indicational of conenctions)

Splitter I leave three connectors available allowing three additional receivers to be connected, since the RX6 receiver connection cannot be changed. Therefore the reference position can only be directly compared to three other receivers at the same time. Therefore scenarios are available to exchange the receivers and splitters. The scenarios used to switch between the receivers and antennas are shown in Figure 8. The idea is to have once the signals GPS, EGNOS and Beacon connected and compared to the reference position. Subsequently for example separate the two receivers recording the protection layers in order to see the influence by the antenna. As a positive side effect the order of the scenarios has the advantage of little cable changes (mainly two cables) required.

The scenarios are applied so that during

  ▷ a full test day providing six test hours (see Table 1) every two hours the scenario shall be exchanged (I->II->III)

▷ a short test day (see Table 2 and Table 3) providing three test hours, two scenarios will be used (I and II)
▷ Scenario IV is a backup in case a longer test duration would be possible at a test site

2.2 Signal conditioning

In order to make sure that the signals provided by the antenna and amplified through the splitters (or amplifiers) are not harming the equipment used during the tests, the signal level was checked.

Figure 9 Splitter used to connect antennas
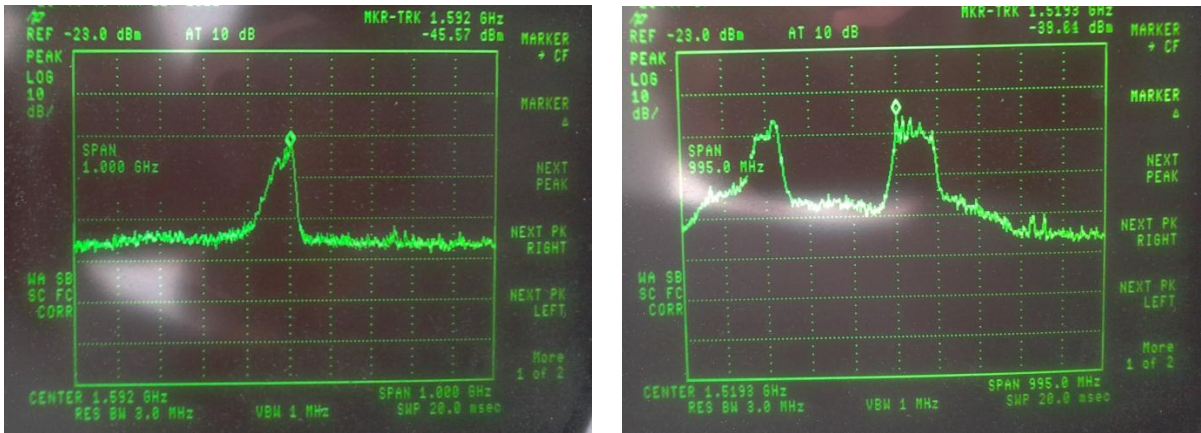
Figure 10 Low-end (left) and high-end (right) GPS antenna signals

What can be seen is that with the excellent conditions on the roof of the DKE Aerospace Germany Building where there is no obstruction anywhere close, the signal level is around -40dBm. This is below any critical signal level that could harm the equipment used. Therefore the usage of the splitter is considered justified.

From the theory it was assumed that the IALA beacon signal due to its frequency is relatively easy to receive. A preliminary test showed that at a distance of ~160km from an IALA beacon station it was difficult to receive the signal if the antenna was not placed on the roof of a building and even then with the signal received it is most of the time difficult to lock on a IALA station. As Figure 11 shows the signal level is very low and noisy. This will be especially interesting for the preliminary test at the Lake of Constance. Since the lake is located at the edge of the IALA coverage.
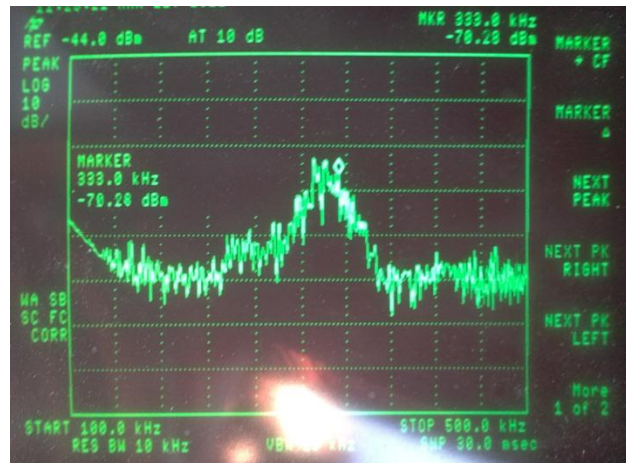
Figure 11 Beacon signal at the Lake of Constance

The beacon signal is well received getting closer to a beacon signal transmission station.

2.3 DKE antenna mast

The DKE Aerospace antenna mast is shown in Figure 12 (not containing the structure to hold the antenna).

Figure 12 DKE Aerospace antenna mast

The antenna mast provides the possibility to bring the antennas up to different heights. The theoretical maximum being ten meters, this case obviously is highly unlikely. Since the mast can be separated in elements, heights from 1.35m are possible. This shall allow the required flexibility to bring the antennas to a suitable and probable height, for example outside a radar beam.

The antennas are mounted at the top of the mast as shown in Figure 13.

Figure 13 DKE Aerospace antenna mast with antennas

As it can be seen in Figure 13 an additional ground plane is introduced right below the medium-end antenna (left in the picture) as well as below both antennas. This is considered realistic as the antennas used may either have an

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integrated ground plane or the antennas are mounted on the roof of the ship, which would then serve as ground plane.

The fixing of the mast on the ship shall be done either on the guard rail of the ship or another suitable structure, a collection of shells available shall provide enough flexibility in case the exact location cannot be determined beforehand. V2A U bolts and a set of V2A or aluminum profiles shall provide the necessary flexibility to mount the mast on the different ship types.

Since the antenna mast is used on a ship, the height of the antenna is also influenced by the possibilities to mount the mast on the ship.

If the mast cannot be used, the antennas will be mounted on the highest suitable point available on the ship using a similar structure as used to mount the antennas on the top of the mast.

The result of the difference in ships used during the tests results also in a different height of the antenna. This is assumed to be acceptable since providing a guideline to mount the antennas on a certain height would be unpractical for the end-user.

In any case the mast will only be extended to a height that would be available/possible on the ship. It is not intended to increase the signal reception by mounting the mast higher than necessary.

The two GPS antennas are mounted on the mast with a distance of roughly one meter. The beacon antenna is placed somewhere else on the ship not close to the GPS antennas. During the testing it turned out that the beacon antenna would have a negative effect on the GPS antennas (more on the low-/medium-end antenna than on the high-end antenna). The beacon signal reception shall not be influenced by the mounting of the beacon antenna. The position of the beacon antenna has no influence on the beacon enhanced position, since the beacon signal only provides enhancement data and not a position itself.

3   Receiver settings

A few settings have been suggested by different parties as for example a PVT elevation mask of 15° was suggested by the EC whereas Veripos suggested a 10° PVT elevation mask. Therefore a tradeoff has to be found for certain values.

The values the receivers shall be set to are
- 10° elevation mask
- SNR for satellites 28 dbHz to be used in PVT
- SBAS satellites to be used 120, 124 (or other EGNOS-PRNs according to the operational status)
- GPS smoothing – not used

Other settings vary between the receivers are discussed in the following sub-sections.

3.1   GPS position – RX1

The settings on RX1 need to be configured so that it does not incorporate SBAS or other enhancement data. The configuration is done via the software provided along with the receiver referred to as "uCenter". The uCenter software allows to configure the receiver through a graphical user interface.

Turning off the SBAS functionality can be done through disabling the SBAS functionality in the/via the UBX CFG-SBAS message, see Figure 14.
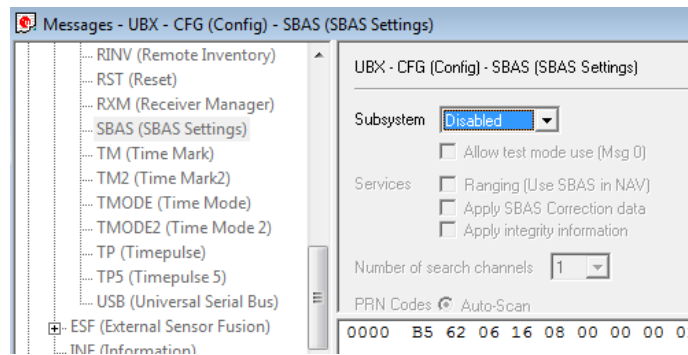
Figure 14 RX1 - Disable SBAS

To make sure this setting does not change the configuration is written into the non-volatile memory of the receiver, see Figure 15.
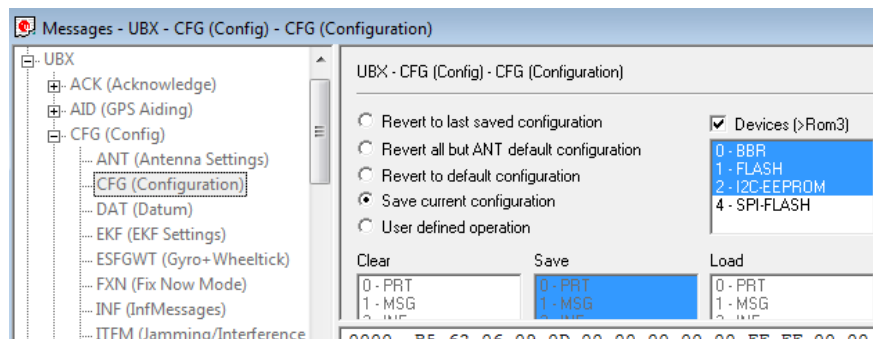
Figure 15 RX1 - Permanently save the configuration

u-blox maintains a world-wide network of GPS monitoring stations, collects measurements and distributes aiding information derived from these measurements over an Internet-connected Server. No registration is done for this

service and no connection to the internet will be available for the RX1 receiver. Therefore the u-blox AssistNow service will not be used by the receiver – this is important since it shall be a GPS position.

Since RX1 is to be used in maritime or inland water way scenarios, the platform settings will be set to sea. The description of this is detailed subsequently.

"u-blox positioning technology supports different dynamic platform models to adjust the navigation engine to the expected application environment. These platform settings can be changed dynamically without performing a power cycle or reset. The settings improve the receiver's interpretation of the measurements and thus provide a more accurate position output. Setting the receiver to an unsuitable platform model for the given application environment results in a loss of receiver performance and position accuracy." [Source: u-blox 6 Receiver Description Protocol Specification]

The platform setting "At-sea" is described as "Recommended for applications at sea, with zero vertical velocity. Zero vertical velocity assumed. Sea level assumed. MAX Altitude [m]: 500, MAX Velocity [m/s]: 25, MAX Vertical Velocity [m/s]: 5, Sanity check type: Altitude and Velocity, Max Position Deviation: Medium" [Source: u-blox 6 Receiver Description Protocol Specification]

The setting is made through the CFG-NAV5 message.

Any other corrections done to the GPS position such as for example Kalman filters designed specifically for certain scenarios are considered to be a valid position enhancement and will not be disabled (see the setting to "At-sea"). Internal position enhancement measures which are not documented in the publicly available and provided manuals cannot be influenced and therefore no attention can be paid to such measures.

Further settings in the NAV5 messages are the exclusion of satellites below the elevation in degrees specified in section 3. This shall allow for a good position performance.

3.2   Low-end receiver EGNOS position – RX2

The settings for RX2 are basically the same as for RX1, except that the SBAS usage is not as shown in Figure 14 but enabled. The further settings in SBAS are to disable the "Autoscan" for SBAS satellites and use only the relevant EGNOS operational PRNs.

3.3   Medium-end receiver EGNOS position – RX3

A very important setting is the enabling of EGNOS on RX3 through the menu as described in the manual (OME-44400-A) on page 8-10.

Note The Furuno GP-150 only talks about WAAS only when it means SBAS.

The other settings for RX3 are very straight forward since it only allows to enable or disable NMEA sentences through their respective output rate. This is explained in the manual (OME-44400-A) on page AP-2.

Further it is possible to set GPS smoothing and RAIM.

3.4   IALA beacon position – RX5

RX5 provides the possibility to be configured through a web interface or directly on the device. The web interface will be used as the main configuration option.

In order to set the values defined in section 3, the "Receiver Configuration" menu is used, see also RD2 page seven. The output through the Ethernet port is configured in the "I/O Configuration" menu, where the frequency for the specific NMEA sentences can be set. All NMEA sentences are output with 1 Hz.

3.5 High-end receiver EGNOS position (RX4)

RX4 needs to be configured to apply EGNOS corrections only. To configure the receiver a Septentrio software package called "RxControl" is used. To apply EGNOS corrections only and no other corrections "StandAlone" and "SBAS" is selected (see Figure 16-left). The reason to select both is that at least the GPS position shall be output in case EGNOS would not be included in the position. The usage can be determined in the analysis through the GSA message, where all satellites are shown which are used for the position computation.

The SBAS corrections are set through the "SBAS Corrections"-tab of the "RxControl" software, see Figure 16-center.

The DO 229 standard, which has its origin in aviation, makes a distinction between two positioning applications: en-route and precision approach. The choice between both applications influences the length of the interval during which the SBAS corrections are valid and the criteria to use a satellite in the PVT solution. During a precision approach the validity of the data is much shorter and a satellite is used in the PVT solution if only SBAS satellite and ionospheric corrections are available. Whereas during en-route, a satellite without SBAS ionospheric corrections can be used in the PVT solution, using greater of equal number of satellites with respect to precision approach. Since the scenario is not an aviation scenario the setting of choice is "EnRoute". The Version of the DO229 is left to automatic since there is no noticeable advantage in returning to DO-229C.

The last interesting tab is the "Differential Corrections"-tab; in which the used Veripos service is set to "ULTRA", see Figure 16-left. "ULTRA" is chosen over "APEX" since Veripos recommended the "ULTRA" service.
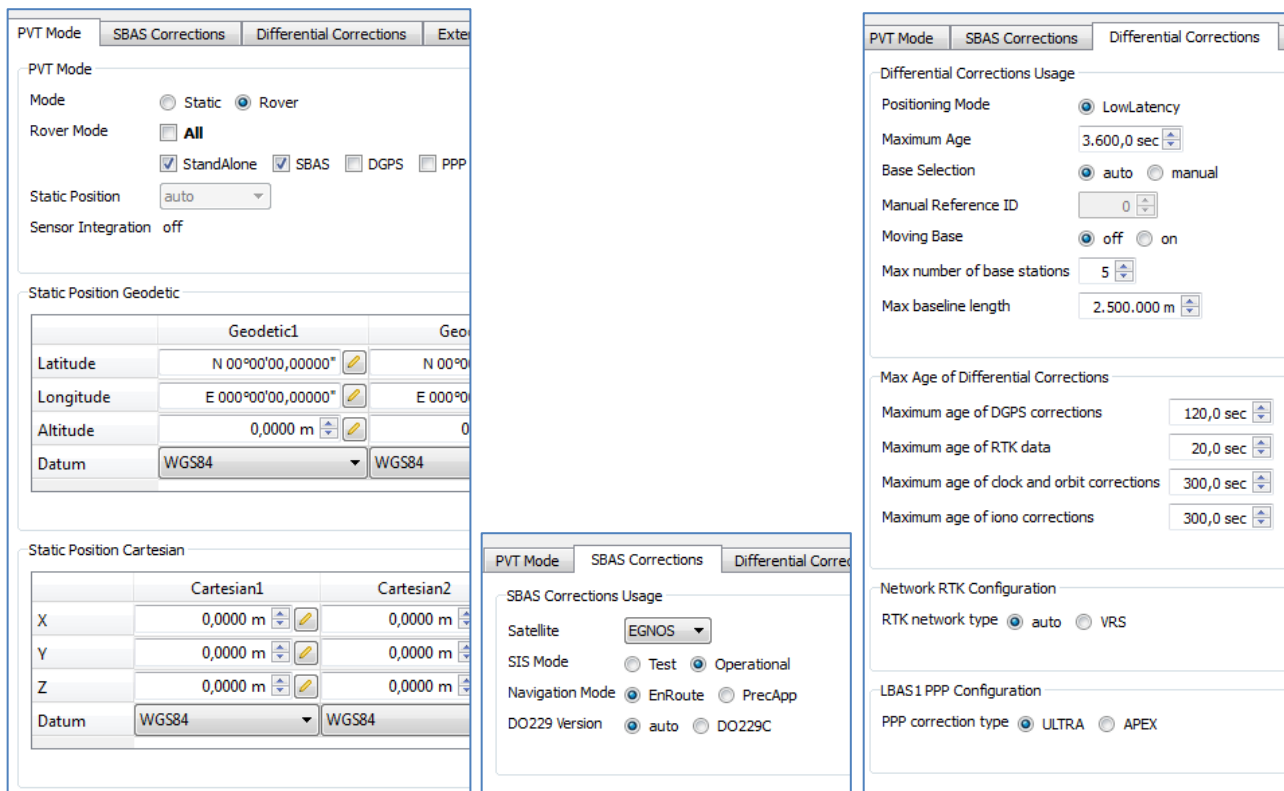

Figure 16 RX4 settings – "Positioning Mode"

The explanations given subsequently are mostly from the Septentrio user manual or help pages. The references to those are not provided each time for readability reasons. It is not intended to copy information or violate copy rights. Therefore this notice is provided.

Further the Navigation menu provides access to

- ▷ Receiver Operation
  - ▷ Tracking
    - ▷ Multipath Mitigation – *kept off*
    - ▷ Smoothing – *kept off*
  - ▷ Masks
    - ▷ Elevation Mask – *PVT = 10°, Tracking = 0°*
      Satellites under the PVT mask are not included in the PVT solution, though they still provide measurements and their navigation data is still decoded and used. The PVT elevation mask do apply to the SBAS satellites: the ranges to SBAS satellites under the elevation mask are not used in the PVT, but the SBAS corrections are still decoded and potentially used in the PVT.
    - ▷ Health Mask – *Tracking = On, PVT = On*
      If Mask is on for the Tracking engine, no measurements are generated for unhealthy signals, but these signals will remain internally tracked and their navigation data will be decoded and processed. This is to ensure immediate reaction in the event that the signal would become healthy again.
      If Mask is on for the PVT engine, measurements from unhealthy signals are not included in the PVT. Setting this mask to off must be done with caution: including a non-healthy signal in the PVT computation may lead to unpredictable behavior of the receiver.
    - ▷ C/N0 Mask - *For all satellites set to 28dB-Hz*
      The receiver does not generate measurements for those signals of which the C/N0 is under the specified mask, and does not include these signals in the PVT computation. However, it continues to track these signals and to decode and use the navigation data as long as possible, regardless of the C/N0 mask.
  - ▷ Position
    - ▷ Atmosphere
      - ▷ Ionosphere Model – *SBAS*, to be tested
      - ▷ Troposphere Model, Zenith Model – *MOPS*
      - ▷ Troposphere Model, Mapping Model – *MOPS*
      - ▷ Troposphere Parameters – *Default*
    - ▷ Motion
      - ▷ Acceleration and jerk levels – *Moderate*
      - ▷ Type of motion – *Pedestrian or Automotive*, to be tested.
    - ▷ Earth Models - to be tested
    - ▷ Integrity - to be tested
    - ▷ Ambiguities - *Default*
    - ▷ Datum - *Default*
  - ▷ Timing - *Default*
  - ▷ GPIO - *Default*
- ▷ Receiver Initialization
- ▷ Receiver Setup
- ▷ Advanced User Settings
  - ▷ Satellite Tracking, *see Figure 17-left*
  - ▷ Signal Tracking, *see Figure 17-right*

With the above setting possibilities the data can be set according to section 3. Additional setting influences will be tested.
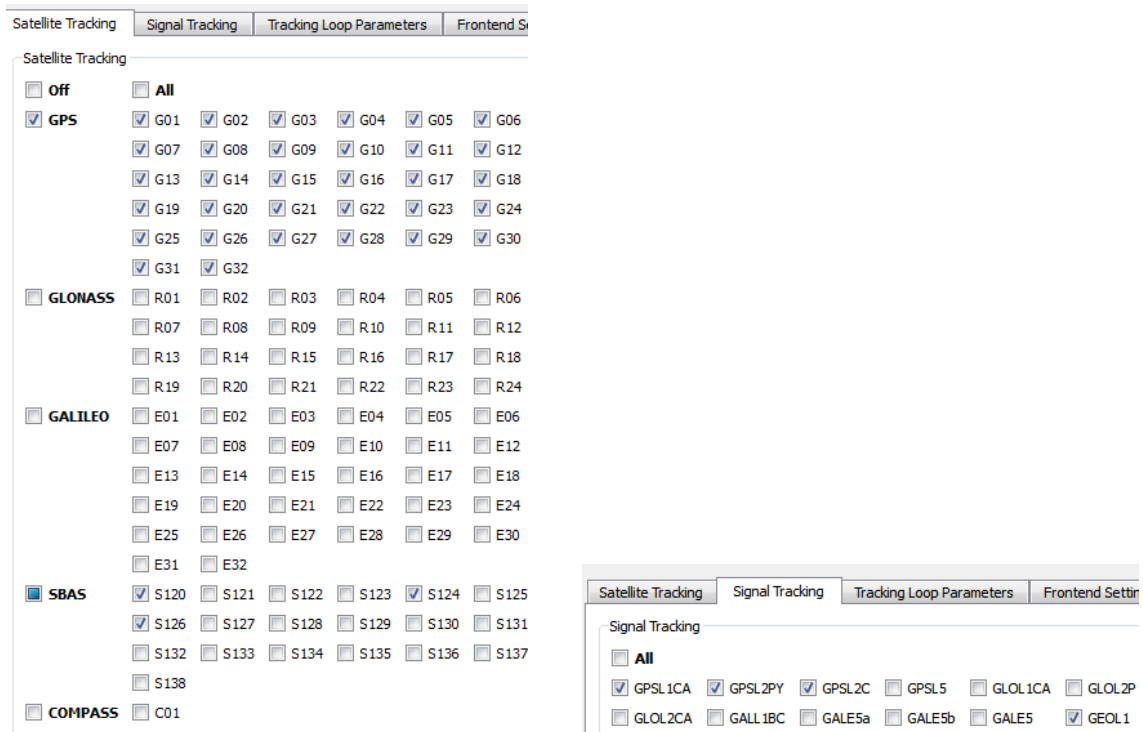
Figure 17 RX4 - Navigation-Advanced User Settings-Tracking

Note The enabled S126 in Figure 17 originates from a preliminary test and was disabled afterwards. Also the GPSL2C was only a test and will not remain enabled.

3.6 Reference position (RX6)

The reference position is chosen to be Veripos ULTRA and therefore in Figure 16-left, instead of SBAS the PPP option is chosen. The remaining settings in the "Positioning Mode" menu are not to be changed.

Veripos stated to set the maximum age to 120 s and the elevation mask for tracking to be set to 5°. It will be tested if the Veripos service is also working properly with the settings indicated in section 3.

Veripos provided a manual how to configure RX6 to DKE Aerospace. *It has to be checked whether the information from this document can be made publicly available or included in this document. Otherwise a reference will be provided. This was not answered by the time of submission of this report.*

4   Data logging

The data which needs to be recorded is

- GPS position from the GPS receiver (RX1)
- EGNOS position from the low-end EGNOS receiver (RX2)
- EGNOS position from the medium-end EGNOS receiver (RX3)
- EGNOS position from the high-end EGNOS receiver (RX4)
- DGPS (reference) position from the reference receiver (RX5)
- IALA beacon position from the beacon receiver (RX6)
- Raw GPS data from the high-end EGNOS receiver (RX4)
- Raw EGNOS data from the high-end EGNOS receiver (RX4)

For each receiver the minimum requirement to be logged are the NMEA sentences containing the position of the respective receiver computed with the respective GNSS position w/wo SBAS/DGPS/IALA enhancement. The NMEA sentences logged are:

- GGA – Global Positioning System Fix Data
- RMC – Recommended Minimum Specific GNSS Data
- VTG – Course Over Ground & Ground Speed
- ZDA – Time & Date

Additional NMEA sentences, which are not available on all receivers, are

- GSA – GNSS DOP and active satellites
- GSV – GNSS satellite in view
- GST – GNSS Pseudorange Error Statisitics
- GRS – GNSS Range Residuals

The selection of the NMEA sentences shall provide an indication of the quality of the position, the position itself and the timeframe of the test performed.

Additional recorded data is detailed in section 6.

The data recorded is to be stored on a separate encrypted SD card for backup reasons as well as to be sent to a DKE Aerospace server through a secured connection.

4.1   GPS position – RX1

The GPS only position is recorded on RX1.

The NMEA positions are recorded through the HyperTerminal application, which provides a visual output of the NMEA sentences received. The NMEA sentences to be received can be set in the uCenter software. In order to store the NMEA sentences for the analysis the HyperTerminal provides the possibility to write the NMEA sentences in a file through the option "Transfer" and "Capture Text…".

RX1 does not allow to store raw data in a human readable format and therefore this data cannot be used, since uBlox does not provide a parser for their log-files, but would only allow to replay it in uBlox. This is considered useless for the purpose of the tests to be done.

4.2   Low-end EGNOS position – RX2

The NMEA positions are recorded through the HyperTerminal the same way as for RX1, also RX2 does not allow to log raw data.

4.3 Medium-end receiver EGNOS position – RX3

A SBAS position is recorded on RX3.

The NMEA positions are recorded through the HyperTerminal application and stored in a file. The NMEA sentences to be received can be set on the receiver directly (see AP-2 in the manual ODE-44400-A.

RX3 does not allow to store raw data.

4.4 High-end receiver EGNOS position (RX4)

The position of the high-end EGNOs receiver is logged through NMEA sentences, similar to the other receivers. RX4 therefore creates a file with the NMEA sentences to be stored, for example RX6_0670.121. Which contains the NMEA sentences as shown in Table 10.

NMEA – RX4
$GPRMC,102307.10,A,4740.32125,N,00923.10343,E,0.0,,070312,0.0,W,D*00
$GPGGA,102307.10,4740.32125,N,00923.10343,E,2,10,0.8,419.35,M,48.00,M,2.4,0124*44
$GPVTG,,T,,M,0.0,N,0.0,K,D*26
$GPGSA,A,3,13,32,01,17,11,20,10,04,23,31,,,1.6,0.8,1.3*3F
$GPGRS,102307.10,1,0.3,0.2,-0.1,-0.9,0.4,-0.0,0.7,0.5,0.1,-0.4,,*42
$GPGSV,3,1,10,23,71,195,50,10,11,274,42,11,14,156,45,31,23,047,48*79

Table 10 NMEA data recording (RX4)

4.5 IALA beacon position – RX5

The IALA beacon position is recorded through the NMEA sentences output by RX5. In order to ensure that the output position is a IALA beacon position a second NMEA message is important "PTNL,GGK". It outputs the GPS Quality indicator which provides information about the current position, as indicated in Figure 19 in field eight by indicator 13. There would be further NMEA messages suitable for this purpose PTNL,PJK / PTNL,VGK / PTNL,VHD.

All NMEA messages available on RX5 are shown in Figure 18, it can be seen that the NMEA messages stated in the introduction of section 4 are provided by the receiver, except for GRS.

Message	Function
GGA	Time, position, and fix related data
GSA	GPS DOP and active satellites
GST	Position error statistics
GSV	Number of SVs in view, PRN, elevation, azimuth, and SNR
HDT	Heading from True North
PTNL,AVR	Time, yaw, tilt, range, mode, PDOP, and number of SVs for Moving Baseline RTK
PTNL, BPQ	Base station position and position quality indicator
PTNL,GGK	Time, position, position type and DOP values
PTNL,PJK	Local coordinate position output
PTNL,VGK	Time, locator vector, type and DOP values
PTNL,VHD	Heading Information
RMC	Position, Velocity, and Time
ROT	Rate of turn
VTG	Actual track made good and speed over ground
ZDA	UTC day, month, and year, and local time zone offset

Figure 18 RX5 - Available NMEA sentences [RD2]

Field	Meaning
0	Talker ID $PTNL
1	Message ID GGK
2	UTC time of position fix, in hhmmmss.ss format. Hours must be two numbers, so may be padded, for example, 7 is shown as 07.
3	UTC date of position fix, in ddmmyy format. Day must be two numbers, so may be padded, for example, 8 is shown as 08.
4	Latitude, in degrees and decimal minutes (dddmm.mmmmmmm)
5	Direction of latitude: N: North S: South
6	Longitude, in degrees and decimal minutes (dddmm.mmmmmmm). Should contain three digits of ddd.
7	Direction of longitude: E: East W: West
8	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK float or RTK location 3D Network solution 7: RTK fixed 3D Network solution 8: RTK float or RTK location 2D in a Network solution 9: RTK fixed 2D Network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution 12: Location RTK solution 13: Beacon DGPS
9	Number of satellites in fix
10	Ellipsoidal height of fix (antenna height above ellipsoid). Must start with EHT.
11	M: ellipsoidal height is measured in meters
12	The checksum data, always begins with *

Figure 19 PTNL,GGK message fields [RD2]

RX5 does not allow to log raw data.

4.6 Reference position (RX6)

The data to be recorded with RX6 and the Veripos service enabled is shown in Table 11. The data logging is enabled through the same process as described in section 6.1 except that additionally in the "SBF"-tab of the settings of the software "RXLogger" the L-band related data, see Table 11, is recorded through enabling the respective check marks.

Name	Content description
LBandTrackerStatus	Status of the L-band signal tracking
LBAS1DecoderStatus	Status of the LBAS1 L-band service
LBAS1Messages	LBAS1over-the-air message

Table 11 L-band data recording

Note It is important to store the log-files of RX4 and RX6 in different folders to avoid the files being overwritten.

5 Data analysis

The data analysis is to be separated dependent on the output of the receiver. The minimum information that can be expected to be output by each of the used receivers is the NMEA0183 RMC sentence. In this sentence the position is included and therefore a comparison of the different receivers is possible.

The raw data recording is not included in this section please refer to section 6 instead.

An example for the content of a NMEA0182 RMC sentence is shown in Figure 20.

$GPRMC	135849	A	4740,32106	N	923,10369	E	0,023	210212		D*70

Figure 20 Sample NMEA0183 RMC sentence

After the sentence identifier the GPS time of week is shown.

The important information is in fields four to seven since it contains the position. This position is converted into the UTC format (Northing and Easting) and from there the error of the respective receiver is calculated against the reference receiver (RX6) for those receivers connected to the same antenna as RX6.

Therefore the error is visualized against the reference position over the TOW as shown in Figure 21. *Please note that the reference receiver is not available at the time of writing this document, therefore only two receivers (GPS and EGNOS-low end) are shown in the figure and the EGNOS positions are used as reference positions.* By simulating a static situation other figures – well known from available GPS receiver comparisons – can be created. This will be done by removing the distance between the reference positions. The same distances will be removed from the other receiver points and therefore a static situation can be simulated, where the average of all reference positions would be the reference point.
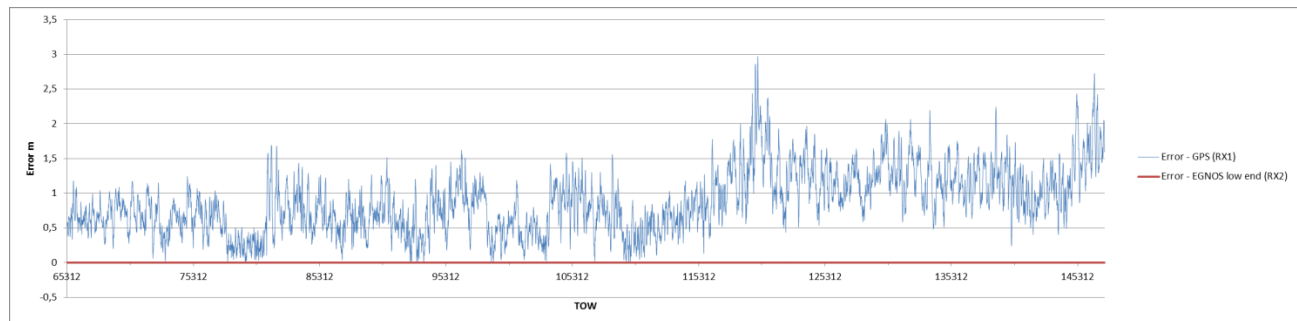

Figure 21 Error visualization

Further data analysis shall be done covering statements about the satellite constellation, which can be obtained through the NMEA sentences GSA and GSV, please refer to the NMEA0183 standard p.91f. These sentences provide the dilution of precision values, the signal-to-noise ratios for each satellite as well as for example the satellites elevation and azimuth. Therefore these values can be compared to each other through several combinations. The exact report will be provided after the first test at the Lake of Constance.

The analysis will also include the assessment of the protection layers computed by EGNOS through the values recorded (as detailed in section 6.2).

A detailed analysis of the EGNOS and GPS data recorded by RX4 and RX6 can be done by third parties also through post processing with the recorded raw data (see section 6) available in ASCII (which is called STF by the manufacturer of RX6) and RINEX format.

The analysis will be done similarly for both splitters meaning that the receivers connected to the respective splitters will be analysed. Obviously since the second splitter does not have a reference position, a "quasi" reference position is computed (taking into consideration what is detailed in section 1.2) and compare the receivers connected to SPII to this computed "quasi" reference position. In order to compute the "quasi" reference position the course over ground will be used (which is dependent on the speed). This will allow also a statement about the receivers connected to the second splitter. It is understood that there is a difference between the reference position and the "quasi" reference position. The preliminary test shall provide the possibility to analyse the quality of the "quasi" reference position and its influence on the analyses outlined.

The optimum to determine the position of the second antenna would be an INS integrated receiver, nevertheless this was not an option due to budget constraints. Further the boats might or might not have a compass and if it has a compass it can be a GPS COG (course-over-ground) information that is displayed; Therefore the only real option is to use the COG provided by the receivers, well knowing that it is speed dependent.

6 Raw data recording (RX4 or RX6)

The raw data is recorded for GPS as well as EGNOS satellites using RX4. The raw data is recorded in a proprietary format called SBF. In order to read the raw data it can be converted into different file formats including ASCII. The raw data is then represented as hexadecimal values for GPS, while for EGNOS raw data the messages are the EGNOS messages which can be parsed according to the EGNOS standard.

The raw data is stored via one serial port while the second serial port can be used to check the data live, such as for example the skyplot.

The RX4 provides the raw data for GPS as well as EGNOS, the messages logged are shown in Table 12. The data logged shall provide the sources required for postprocessing by any interested party after the tests were done.

Name	Content description
GPSRawCA	GPS CA navigation frame
GPSRawL2C	GPS L2C navigation frame
GEORawL1	SBAS L1 navigation message

Table 12 GPS and EGNOS data recording

For each type of raw data a separate file is created, which needs to be converted with the SBF converter. The filename for the raw data is created according to the IGS Convention as for example "RX4_0670.12_", where the file type is "12_". For details regarding the naming convention see the "RxControl v4.6.5" manual page 64. The files are placed in a directory created also according to IGS conventions as for example "12067" where "12" indicates the year and "067" the day of the year when the data was recorded.

When converting the file with the SBF converter the separate files are created according to the selection done for the raw data to be logged, for example "RX4_0670.12__GEORawL1_1.stf" for the GEORawL1 raw data and "RX4_0670.12__GPSRawCA_1.stf" for the GPSRawCA raw data. Samples of the respective messages are shown in Table 13 and Table 14.

GPSRawCA
1678,118800.000,1,,0,1,,8b10b4c89ab0d344a5bdc4ce409bdafd1d00c284338e436af6ef479a32ec7d2dede7ec007ef
1678,118800.000,20,,0,1,,8b0a384c9ab0deb4a5bdc4ce409bdafd1d00c284338e436af6ef479a32ec7d2dede7ec007ef
1678,118800.000,32,,0,1,,8b0a384c9ab0deb4a5bdc4ce409bdafd1e0086843389e36af6e5079a32c57d2ded43f0000d7
1678,118800.000,11,,0,1,,8b0a384c9ab0deb4a5be1a13809c7dfd1b004684339c636a7b48879a04c27c5cad2fec00763

Table 13 GPS raw data recording (RX4)

The EGNOS raw data is recorded for all satellites in view, an example is shown in Table 14. This data is input into the SBAS teacher to verify its readability, the result is shown in Figure 22.

| GEORawL1 |
|---|
| 1678,118800.000,126,,24,1,0,c60e0010000003fe8003ff3ff0000003fcc000000001bb979d7b97bba31b1640 |
| 1678,118800.000,120,,24,1,0,c60c400c000003fe4003ff0000000003fdc000000001bb979d7b97bb83aa1840 |
| 1678,118800.000,124,,24,1,0,c6110024000003fc3fe0000000000000000000001fb997b80000021e40000 |
| 1678,118801.000,126,,24,1,0,5360014000003fc7fe0001fb997880283c150601c0334402a010501a0e9ed7c0 |
| 1678,118801.000,120,,24,1,0,53104024000003fc3fe00000000000000000000001fb997b8000003dbe7880 |
| 1678,118801.000,124,,24,1,0,53093fe80000000080000000000000003fc3ff3fdd7bbbbbbbb955dbbed700 |

Table 14 EGNOS raw data recording (RX4)
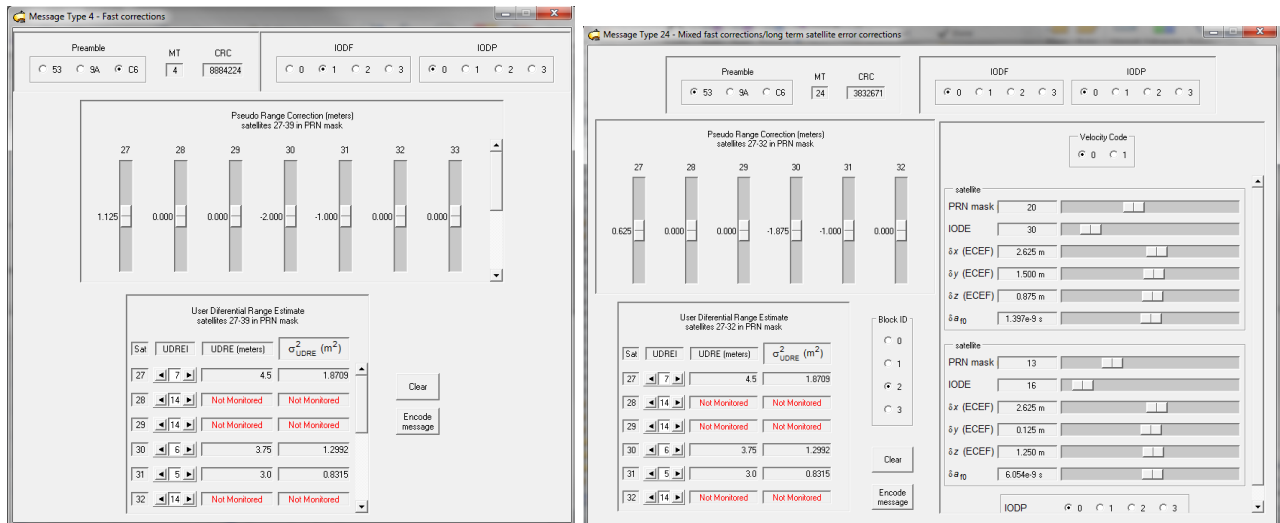
Figure 22 Decoded messages - SBAS teacher

The European Commission stated that the raw data should also be available in RINEX format. Since the software provides this possibility the requirement is fulfilled and it can be selected whether to convert the raw data to RINEX 2.3 / RINEX 3.0 or even both (subsequently), see Figure 23. The direct recording via the option shown in Figure 26-left will be used as well.
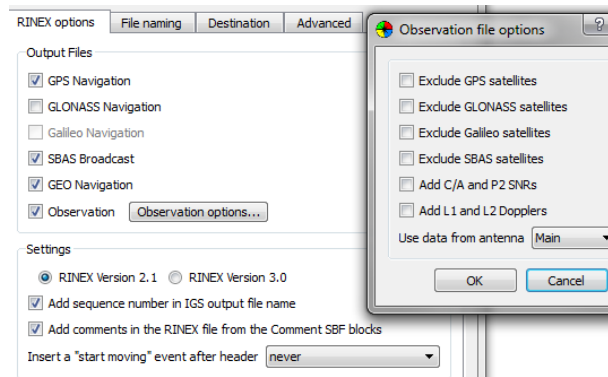

Figure 23 RINEX conversion options

To summarize the GPS raw data is provided through Rinex and the EGNOS messages through an ASCII text file in the format as stated.

6.1 Settings

This section details the configuration dialog of the software package used to log the raw data on RX4 or RX6. The software package comes with the receiver and is named "RXLogger". The first tab to be configured is called "Global".
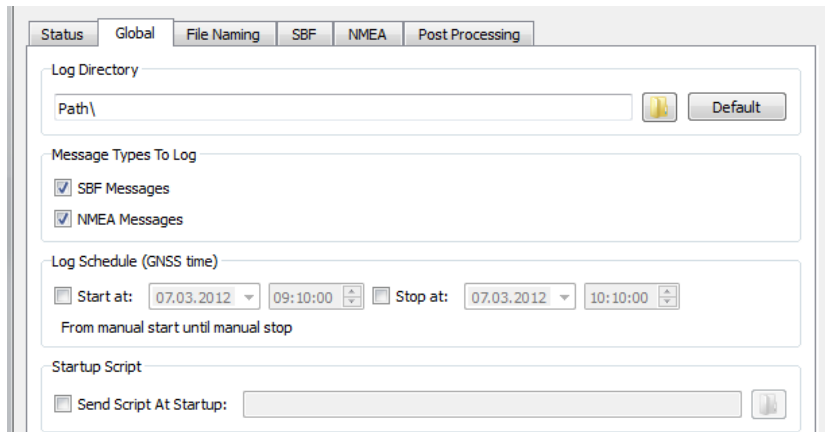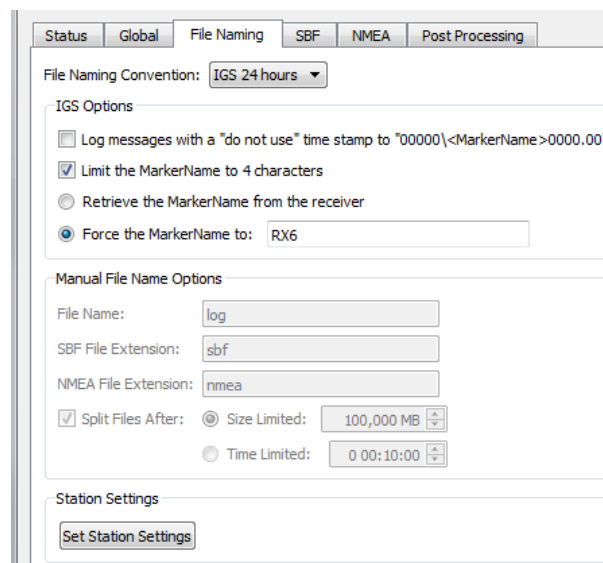
Figure 24 RX4/RX6 Settings – Global

In the global-tab, see Figure 24, the path were the raw data file and/or the NMEA data file shall be stored can be defined, as well as the messages to be logged. Both message types SBF and NMEA are going to be used in order to get the data required for the analysis described in section 5. This will create "*.xy_" file containing the raw data as well as the "*.xy1" file containing the NMEA data.

The other settings of the global-tab are not of importance for the tests to be done.

The file names are partially predefined by the receiver itself and also defined through the "File naming" tab, see Figure 25. The interval of data contained in one file can be set. For the tests to be done the exact interval is set to 24 hours. If the file size turns out to be too big to be handled by software used for the analysis, the interval will be decreased. In any case this has no major influence on the tests to be done. The "MarkerName" is the receiver identifier of the receiver used to create the log file.

Figure 25 RX4/RX6 Settings – File Naming

The "SBF"-tab provides the settings to log the raw data. Figure 26 shows the user interface where the raw data for GPS L1/L2 as well as the EGNOS satellites is selected (GEORawL1).
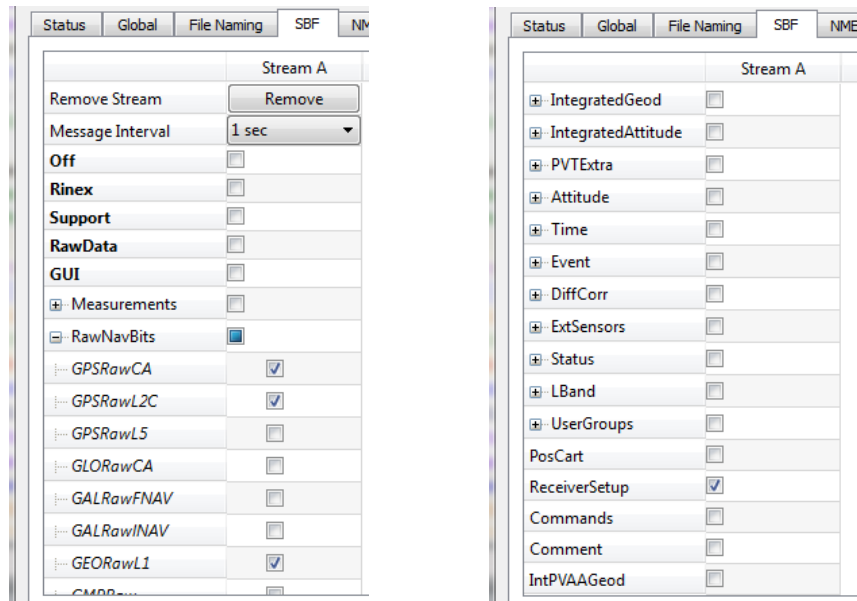

Figure 26 RX4/RX6 Settings – SBF

The last setting to be done in the "RXLogger" software is the configuration of the NMEA sentences to be stored. The "NMEA"-tab provides the required controls, as shown in Figure 27.
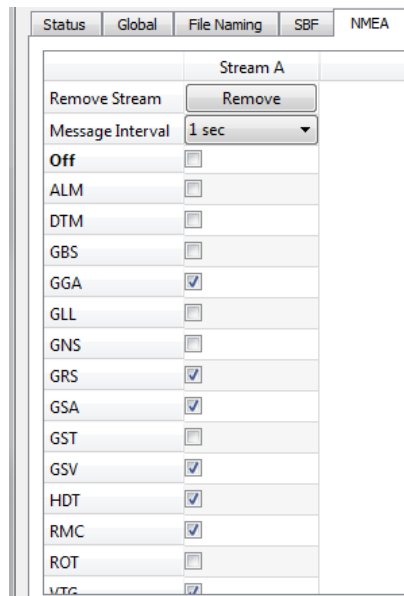

Figure 27 RX4/RX6 Settings – NMEA

6.2 Integrity recording

Since the integrity of EGNOS is an important aspect it shall be logged for each test site throughout the test. Two possibilities are available to record the integrity values – namely HPL and VPL (for aviation).

The EGNOS-SDK v1.0 allows for logging the horizontal and vertical protection levels for different k-factors determining the intended usage scenario. This means that the EGNOS-SDK will be taken into the maritime tests an additional mean to log the protection layer values. No additional receiver is required since the EGNOS-SDK will be connected to RX2.

The EGNOS-SDK currently implements the aviation k-factor ($K_{h,aviation} = 6.18$), the k-factor for maritime ($K_{h,maritime} = 5.6$) as well as a user defined value which is per default set to "Other (85%)" ($K_{h,user} = normcdf^{-1}(85\%) = 1.04$). Therefore setting the k-factor to maritime the HPL especially for maritime can be recorded. The value of the k-factor for maritime is based on the paper "EGNOS Terrestrial Regional Augmentation Networks Based on AIS for River Information Services" (M. Jandrisitis et al).

At the same time RX4 and RX6 allow to log the HPL/VPL values according to DO-229 ($K_{h,aviation} = 6.18$, $K_{v,aviation} = 5.33$). In order to do so, the "*DOP*" message in "PVTExtra" (compare Figure 26) of the SBF protocol is used.

With the above mentioned information a comparison between the HPL for both k-factors for aviation as well as maritime can be done for the test sites. This is considered particularly interesting. Also the maritime HPL can be computed by dividing the HPL of RX4 by the $K_{h,aviation}$ and multiplying the resulting value with the $K_{h,maritime}$.

7 Tests - per test site

The test sites were proposed by the European Commission in the task specification page seven. The rationale behind the selection shall provide a good coverage of the European Union including tests of EGNOS on the edges of the coverage zone (at the time of writing this document). The sites were able to be changed within a 200nm rage if requested by the test team. Subsequently the test sites are detailed and shown in Figure 28. The test sites are discussed with and agreed by the European Commission.
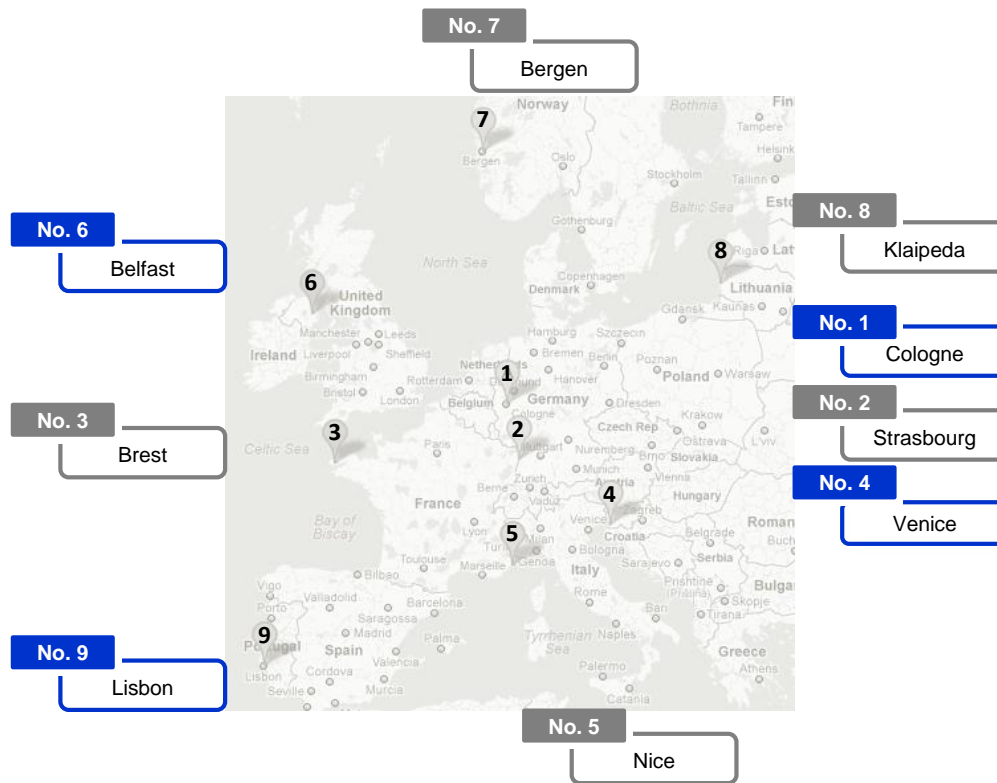

Figure 28 Test sites (excl. additional test at the Lake Of Constance)

> **This section shall provide the deliverable requested in the task specification on page eight "DL4: Selection of test scenarios + test sites".**

The tests on each site shall be done in the same way in order to have repeated test cases. Therefore the difference is to be made between inland waterway tests and the maritime tests as stated in previous sections. The inland waterway (IWW) tests will differ in such a way that the straight line that is followed in the maritime cases is not possible on the IWW due to natural the shape of the waterways. Other than that there shall be no difference in terms of equipment or setup to what is discussed in this document.

7.1 Lake of Constance – Preliminary test

The date for the test is indicated to be on March 17. This date was chosen since currently the boats are in their winter quarters and are not available yet. The boat will be provided by the DLRG a German organization. The boat foreseen is shown in Figure 29.

Figure 29 Boat - preliminary test

The preliminary test is considered very important since it is the dry-run for all upcoming tests. The timing shall also allow for a second test if required since the first real test is scheduled for 02 April 2012.

7.1.1 Timing

The timing for the test on the Lake of Constance will be the one shown in Table 2.

The timing is chosen rather loosely to provide enough time to set everything up carefully and see how much time is required. The maximization of the test time is not the most important for this test but rather the check of the tests themselves.

The DKE Aerospace team will intentionally not checkout the boat beforehand to have the same situation as for the other tests, where also only the statements of the skipper and maybe pictures to check for possibilities to mount the antennas and place the equipment are available.

7.1.2 Route
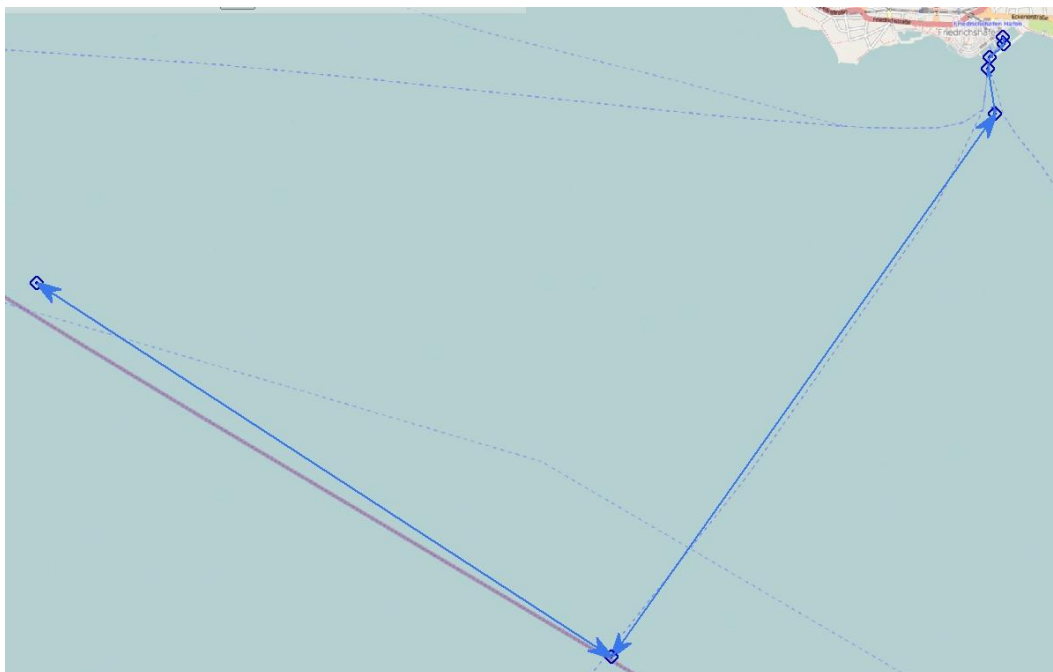
Figure 30 Lake of Constance test - Route

Properties

Name
Lake of Constance

Depart From	Destination
Harbour Friedrichshafen, Germany	Harbour Friedrichshafen, Germany

Total Distance	Plan speed (Kts)	Time Enroute	Departure Time (m/d/y h:m)
22.61	10.00	02 Hours 15 Minutes	

Times shown as
○ UTC ◉ Local @ PC ○ LMT @ Location   Color: Default color ▼

Waypoints

Leg	To Waypoint	Distance	Bearing	Latitude	Longitude	ETE	Speed (Kts)	Next tide event
---	001	4129.25 nm	078 Deg. T	047 39.0 N	009 29.1 E	Start	10.00	
1	002	0.04 nm	170 Deg. T	047 39.0 N	009 29.1 E	00 H 00 M	10.00	
2	003	0.11 nm	228 Deg. T	047 38.9 N	009 29.0 E	00 H 00 M	10.00	
3	004	0.06 nm	187 Deg. T	047 38.9 N	009 29.0 E	00 H 01 M	10.00	
4	005	0.25 nm	172 Deg. T	047 38.6 N	009 29.0 E	00 H 02 M	10.00	
5	006	3.58 nm	215 Deg. T	047 35.7 N	009 25.9 E	00 H 24 M	10.00	
6	005	3.58 nm	035 Deg. T	047 38.6 N	009 29.0 E	00 H 45 M	10.00	
7	006	3.58 nm	215 Deg. T	047 35.7 N	009 25.9 E	01 H 07 M	10.00	
8	009	3.70 nm	303 Deg. T	047 37.7 N	009 21.4 E	01 H 29 M	10.00	
9	006	3.70 nm	123 Deg. T	047 35.7 N	009 25.9 E	01 H 51 M	10.00	
10	005	3.58 nm	035 Deg. T	047 38.6 N	009 29.0 E	02 H 12 M	10.00	
11	004	0.25 nm	352 Deg. T	047 38.9 N	009 29.0 E	02 H 14 M	10.00	
12	003	0.06 nm	007 Deg. T	047 38.9 N	009 29.0 E	02 H 14 M	10.00	
13	002	0.11 nm	048 Deg. T	047 39.0 N	009 29.1 E	02 H 15 M	10.00	
14	001	0.04 nm	350 Deg. T	047 39.0 N	009 29.1 E	02 H 15 M	10.00	

Figure 31 Lake of Constance test - Route details