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ESTB SIS

USER INTERFACE DESCRIPTION

Prepared by :	Reviewed by :	Approved by :
N. Suard	H. Secretan	Ph. Michel

Centre Spatial de Toulouse - 18 Avenue Edouard Belin - 31401 Toulouse Cedex 4 - France
Tel. : +33 (0)561 282865 - Fax : +33 (0)561 282866

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DOCUMENT CHANGE RECORD

Issue	Revision	Date	Change Status	Origin
0	**0**	**20/03/00**	**Draft**	
0	**1**	**20/06/00**	**Updated Draft :** New ESTB modes (§3 & §4) New results (§5) Modifications in current restriction (§6.6) ESTB evolutions (§11) Schedule (§8, §11) Web address (§7.4)	

TABLE OF CONTENTS

1. SCOPE OF THIS DOCUMENT

After a brief description of the ESTB, this document describes the different sequences of messages broadcast by the ESTB towards users according to the running modes of the ESTB.

Additional information is provided about MOPS messages (contents, validity…), ESTB broadcast schedule and contacts point to know the ESTB status.

2. ESTB DESCRIPTION

2.1 Description of ESTB general functions

The ESTB is a complete prototype of the EGNOS system. It implements the main functions (ranging, GPS differential corrections and integrity) with real time elements enabling different user experiments or tests.

Of course, the ESTB functions complexity and performances are reduced to an order of magnitude from the EGNOS system, principally concerning the availability, the robustness and redundant facilities.

2.2 Description of ESTB implementation

The ESTB system is composed of (see figure 1):

- some Reference Stations (RS) gathering data for corrections and integrity messages purposes deployed over Europe in hosting sites,
- a Central Processing Facility (CPF) to compute on-line differential corrections and integrity data, based at Hönefoss in Norway (NMA premises),
- three Geostationary Ranging Station (GRS) implementing a wide triangular observation base for ranging purposes with the stations located in Aussaguel (France), Kourou (French Guyana) and Hartebeeshoeck (South Africa),
- a Mission Control Center (MCC) located in Toulouse (France, CNES premises) to compute ranging messages and prepare navigation messages to AORE payload,
- a Test Master Station (TMS) located at Fucino (Italy) to prepare navigation messages to IOR payload,
- two Navigation Land Earth Station (NLES) based on existing stations of the INMARSAT network, one located in Aussaguel (France) implementing the broadcast link to the AORE Navigation payload, the other located at Fucino (Italy) implementing the broadcast link to the IOR Navigation Payload. Each NLES is compliant with requirements from DA3 (SDM for INMARSAT Geostationary Navigation Overlay Service)
- a ground network composed of sub-networks to transmit data from RS to CPF, from GRS to MCC, from CPF to MCC or TMS, and MCC or TMS to the appropriate NLES.

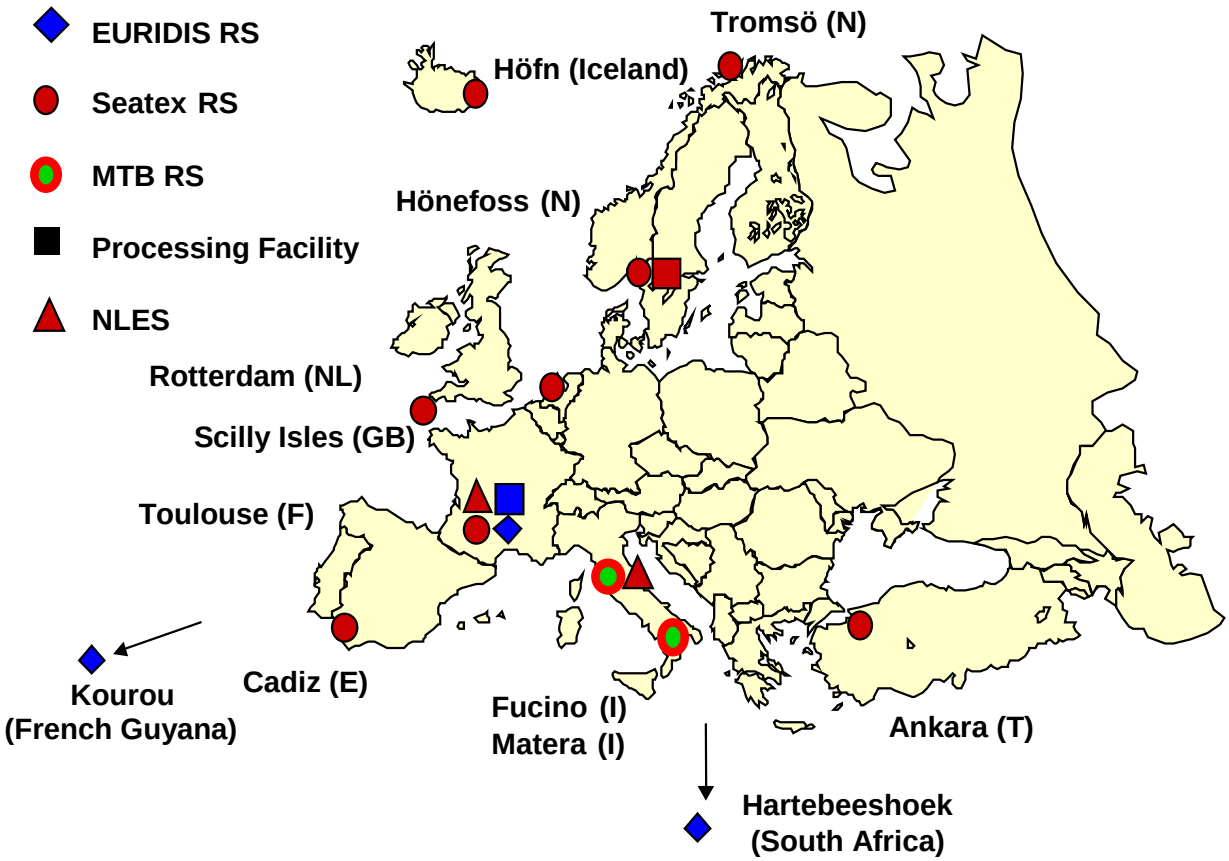

Figure 1 : ESTB components & locations

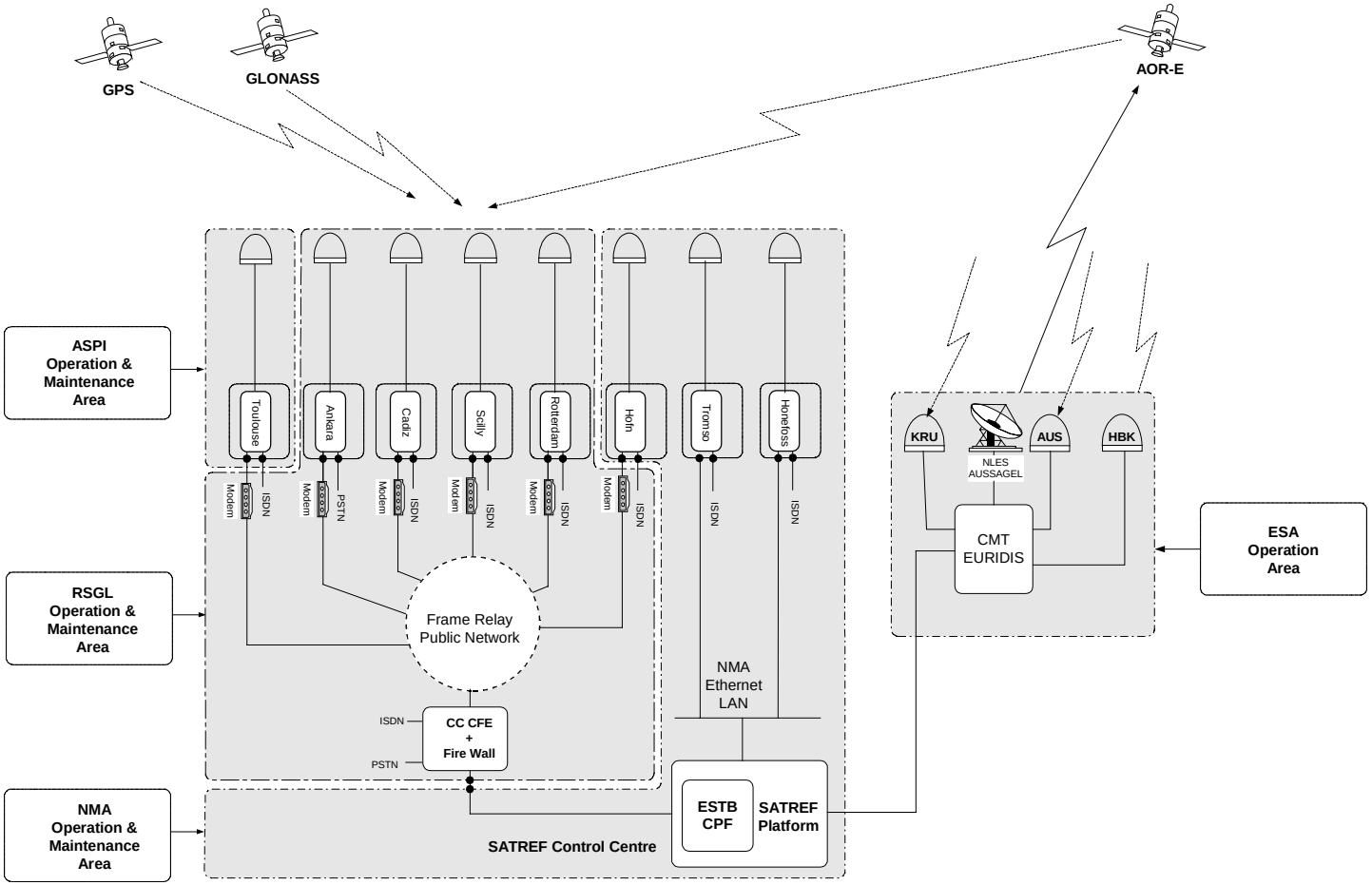

Figure 2 : ESTB V1 Overall Architecture

Note: some RS extensions are scheduled and MTB (Mediterranean Test Bed) facilities are not yet connected to the CPF (see chapter Schedule)

2.3 User equipment requirements

To be able to receive the ESTB signal and process ESTB messages, the user has to acquire a GNSS receiver in conformance

- with the RTCA/DO 229 standards (DA1), except of signification of the message type 0 (see warning hereafter)
- and with the GPS SPS Signal Specification dated June 2, 1995 (DA2).

In that case, the receiver has to track the Pseudo Range Number (PRN) set to ESTB signals :

- PRN 120 for AORE navigation payload
- PRN 131 for IOR navigation payload

in order to deliver pseudoranges on ESTB signals, ESTB broadcast messages and user positions including GPS/SPS and ESTB services.

Warning about message type 0 : In case of reception of this type of message, the receiver has to discard all the data messages from the PRN. If positions are delivered by the receiver, it is only for **test purposes** and using these positions for another matter is at the own risks of the user without any claim against the ESTB signal provider.

3. ESTB RUNNING MODES AND PROVIDED SERVICES

A set of modes has been defined for the ESTB according to the status of some ESTB components. In each mode, some information about test receiver deliveries is given regarding to the augmentation service per comparison with the GPS SPS basis.

The list of possible ESTB modes is :

"**internal test**" mode : in that case, the broadcast messages are only messages type test. The receiver is only able to deliver pseudoranges concerning the PRN navigation payload

"**only ranging**" mode : in that case, the broadcast messages enable to consider the navigation payload as a supplementary GPS like resources. The receiver is able to deliver pseudoranges concerning the PRN, and user positions mixing GPS and navigation resources. In that case, the RAIM is most efficient and the user position is smoother and a little more accurate than the GPS/SPS one. In case of PRN 120, note that the URE concerning this GPS like resource is less than 10 meters (DR1).

"**clock only corrections**" mode : in that case, the broadcast messages enable to correct GPS pseudoranges with differential corrections and integrity information compensating a large part of the GPS Selective Availability. The receiver is able to deliver pseudoranges concerning the PRN and the user position is more accurate than the GPS SPS one (few meters instead of roughly hundred meters with SA or twenty meters without SA).

"**clock corrections & ranging**" mode : in that case, please refer to "only ranging" mode plus "clock only corrections" mode features.

"**ionosphere only corrections**" mode : in that case, the broadcast messages enable to correct GPS pseudoranges with a grid of "near real time" ionosphere delays instead of the Klobuchar algorithm (cf. DA2) with the last broadcast set of the associated parameters. The receiver is able to deliver pseudoranges concerning the PRN and the user position is more accurate than the GPS SPS one (the gap is depending of the ionosphere activity and the last update of Klobuchar parameter set).

"**ionosphere corrections & ranging**" mode : in that case, please refer "ionosphere only corrections" mode plus "only ranging" mode features

"**No ionosphere corrections**" mode : in that case, the broadcast messages enable to correct GPS with differential corrections and integrity information compensating a large part of the GPS Selective Availability and a large part of the broadcast GPS ephemeris error. The receiver is able to deliver pseudoranges concerning the PRN and the user position is more accurate than the GPS SPS one (few meters instead of roughly hundred meters with SA or twenty meters without SA)

"**No orbit corrections & no ranging**" mode : in that case, please refer to "clock only corrections" mode plus "ionosphere only corrections" mode features

"**No orbit corrections**" mode : in that case, please refer to "clock only corrections" mode plus "ionosphere only corrections" mode plus "only ranging" mode features

"**GIC/WAD corrections**" mode : in that case, the broadcast messages enable to have "**No ionosphere corrections**" mode messages plus "**ionosphere only corrections**" mode messages. The receiver is able to deliver pseudoranges concerning the PRN and the user position is more accurate than the GPS SPS one (a 8m HNSE (Horizontal Navigation System Error) and a 10m VNSE (Vertical Navigation System Error) are specified, current values obtained during tests are better than specified). For more details on performances, please refer to the adequate chapter.

" **GIC/WAD corrections & ranging**" mode : this mode is really the demonstration of the future EGNOS service. It is the combination of the only ranging mode and of the GIC/WAD correction mode applied on GPS signals and GPS like signals.

Modes most used during ESTB operations are :

- **only ranging (default mode through AORE)**
- **clock only corrections**
- **clock corrections & ranging**
- **No orbit corrections**
- **GIC/WAD corrections**
- **GIC/WAD corrections & ranging**

4. LIST OF MESSAGES ACCORDING TO EACH MODE

The different types of messages broadcast by the ESTB are resumed in the following table. Content and use of each type of message is described in the RTCA DO 229 document (DA1).

ESTB mode		Types of broadcast messages	Availability through AORE (PRN 120)	Availability through IOR (PRN 131)
internal test	**Euridis**	0	Yes	
	MTB	63		Yes
only ranging		1, 9, 12, 17, 24, 63, (0)*	Yes	No
clock only corrections		0, 1, 2, 3, 4, 7, 25***, (63)**	Yes	Yes
clock corrections & ranging		0, 1, 2, 3, 4, 7, 9, 12, 25***, (63)**	Yes	No****
ionosphere only corrections		0, 1, 18, 26, (63)** (TBC)	Yes	Yes
No orbit corrections		0, 1, 2, 3, 4, 7, 9, 12, 18, 25***, 26, (63)**	Yes	No****
No orbit corrections and no ranging		0, 1, 2, 3, 4, 7, 18, 25***, 26, (63)**	Yes	Yes
No ionosphere corrections		0, 1, 2, 3, 4, 7, 25, (63)**	Yes	Yes
GIC/WAD corrections		0, 1, 2, 3, 4, 7, 18, 25, 26, (63)**	Yes	Yes
GIC/WAD corrections & ranging		0, 1, 2, 3, 4, 7, 9, 12, 18, 25, 26, (63)**	Yes	No****

* : depending on internal MCC status, not often used

** : depending on unavailability of ESTB message at the NLES for the current epoch, not often used, just in case of network disturbances concerning links CPF/MCC or MCC/NLES

*** : fields “slow corrections” except time filled with 0.

**** : if messages type 9 and 12 are received through this channel, they will be filled with null values

Warning : There is no standard ESTB sequence(s) of messages except in “only ranging” mode. The ESTB messages are only constrained to the maximum update interval defined for each type of message in DA1.

Warning about message type 0 : In case of reception of this type of message, the receiver has to discard all the data messages from the PRN. If positions are delivered by the receiver, it is only for **test purposes** and using these positions for another matter is at the own risks of the user without any claim against the ESTB signal provider.

5. PERFORMANCES

5.1 Expected navigation performances

5.1.1 With the 8 first ESTB Reference Stations

The expected (required) performances for the ESTB are :

- 8m HNSE (Horizontal Navigation System Error) - 95% over 12h
- 10m VNSE (Vertical Navigation System Error) - 95% over 12h

Examples of the expected error distributions over the ESTB area are given through the following figures

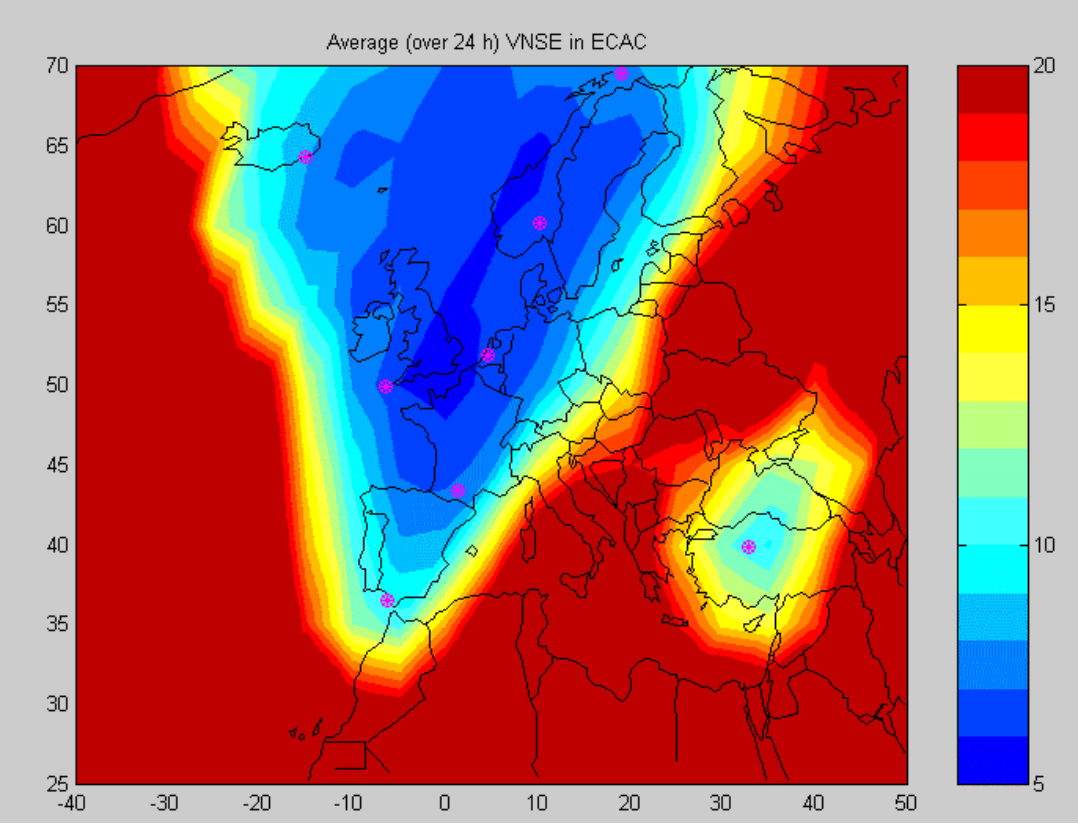

Figure 3 : expected VNSE 95 % with the 8 first RS

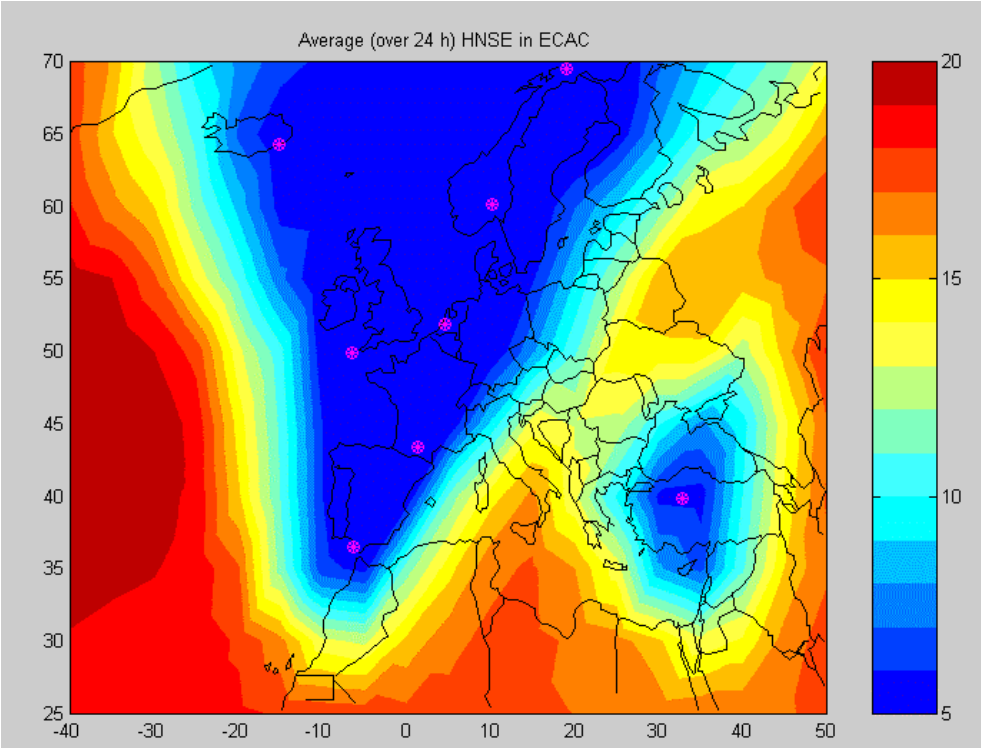

Figure 4 : expected HNSE 95% with the 8 first RS

5.1.2 With the 8 first RS and the 2 MTB RS connected to CPF

Examples of expected error distributions over the ESTB with the 2 MTB RS connected to the CPF are given hereafter.

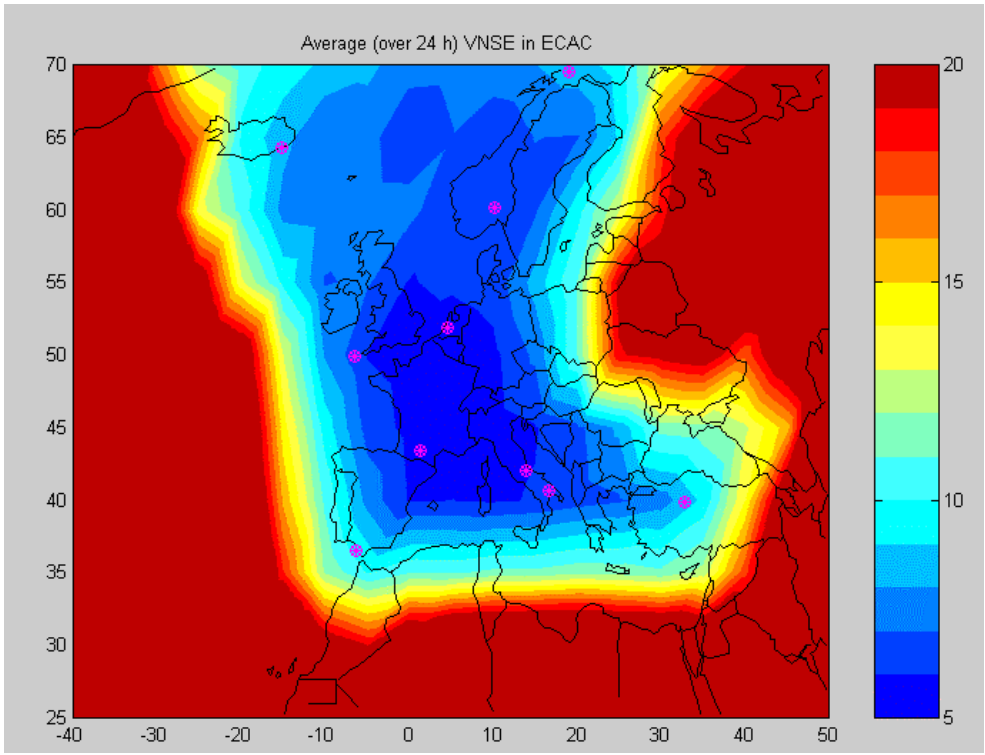

Figure 5 : expected VNSE 95% with the 8 first RS + 2 MTB RS

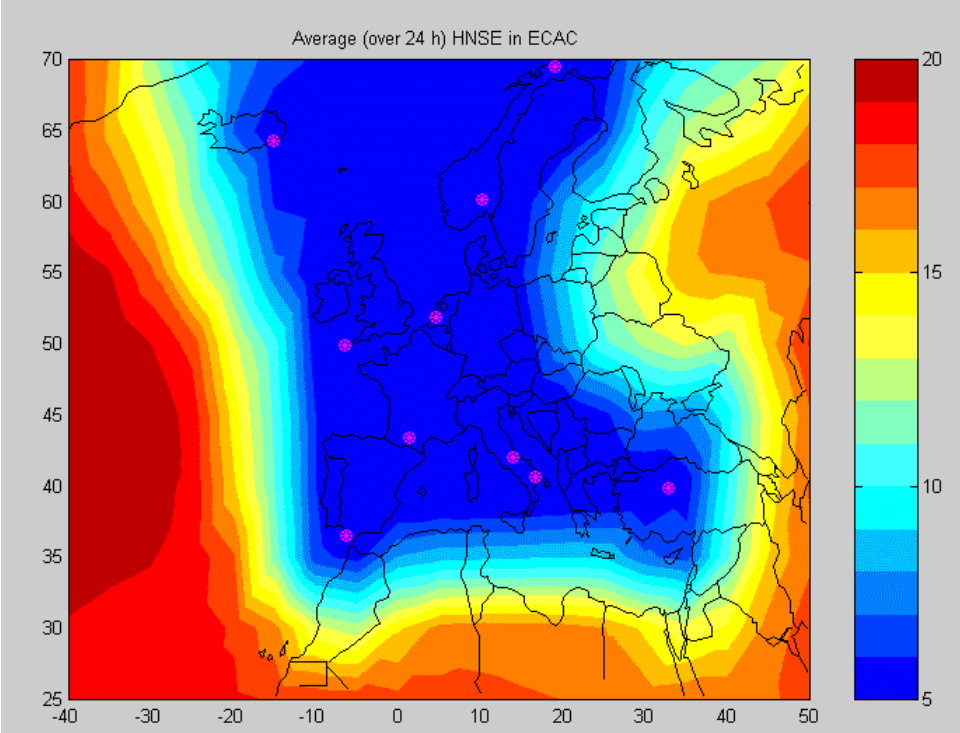

Figure 6 : expected HNSE 95 % with the 8 first RS + 2 MTB RS

5.2 Measured navigation performances : some examples

5.2.1 GPS system with SA

During the first test campaign in January 2000, in "all correction" ESTB mode with 8 reference stations, the following results are obtained (unit : meter) :

Place	VNSE 95% over 24h	HNSE 95% over 24h	VNSE 95% over 6h	HNSE 95% over 6h	VNSE 95% over 3h	HNSE 95% over 3h
Toulouse	11.3	6.3	6.4	3.6	N/A	N/A
Rotterdam	8.6	4.8	N/A	N/A	N/A	N/A
Cadiz	11.3	6.4	N/A	N/A	N/A	N/A
Tromsö	N/A	N/A	13.5	7.5	8.5	5.1

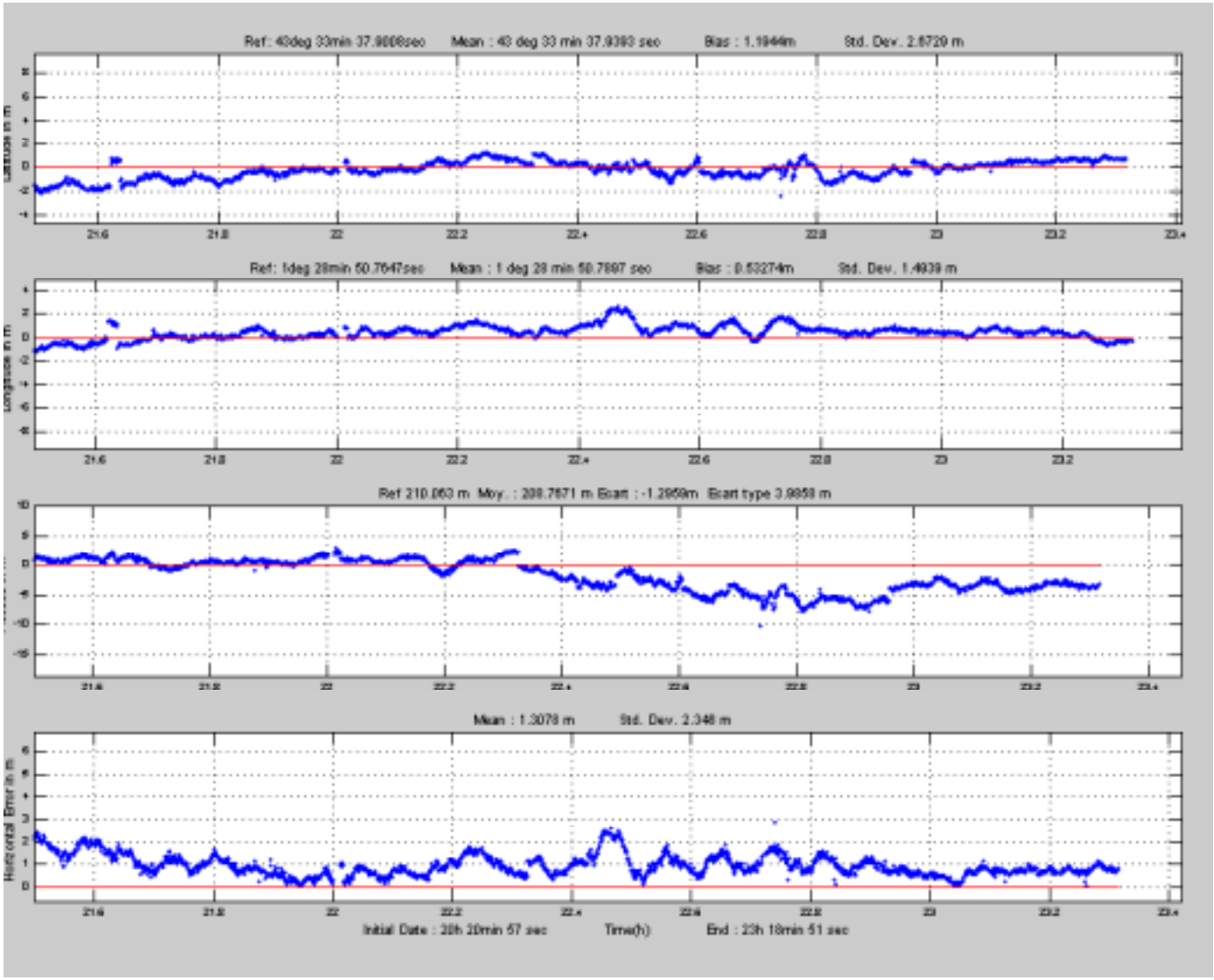

Figure 7 : comparison "user position" and fixed point at Toulouse

The figure 7 has been obtained by comparing the user position data delivered by the Aquarius receiver based at the Euridis MCC with the coordinates of this referenced point over 3h.

5.2.2 GPS system without SA

To be completed when available (lack of data from a receiver fully compliant with MOPS ionosphere delay algorithms and one of ESTB RS out of order since May)

5.3 Typical broadcast UDRE

Next figure depicts minimum, mean (black points) and maximum values computed for UDRE type over 10h for each satellite visibility. Mean UDRE value is around 2.3 m.

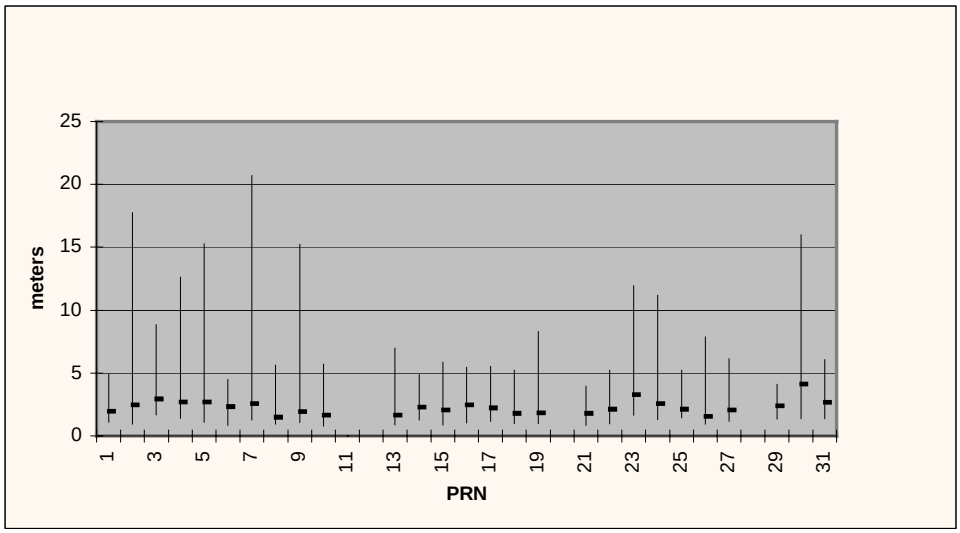

Figure 8 : Typical UDRE broadcast values

5.4 Time to alarm

The ESTB design is not compatible with minimizing the Time-to-Alarm in case of Don't Use SV_i occurrence due to the latency time (approximately 3s) introduced by the fact that CPF and MCC are not co-located.

Two tests were made by creating events causing Don't Use situation for several SV_i. Time difference results between time tag for the event and Time tag for Don't Use received by the receiver are :

Minimum : 8 seconds	Average : 10,1 seconds	Maximum : 12 seconds

5.5 Ionosphere delays and errors (GIVD & GIVE)

With the current 8 ESTB Reference Stations, a large part of the ECAC zone is covered, only some points of the grid near the border of this area have "don't use" GIVD and GIVE values due to the small number of stations (see figure 9).

A first set of comparisons was made between the 4 points of the grid around Toulouse and measurements obtained through EURIDIS data collection on the same location. Euridis ionosphere measurements are ionosphere delays towards the AORE satellite and represent roughly twice the vertical delay.

A second set of comparisons over 5 hours including a sunset (DR2) were made between GIVD broadcast data over a point of the grid (South of France) and batch TEC Grids (DR3) at the same location.

A third set of ionosphere delays determination were made with CNES algorithms (DR2) over the same period and compared to the ESTB GIVD.

These comparisons (DR2) show that broadcast GIVD (figure 10) are in the expected range.

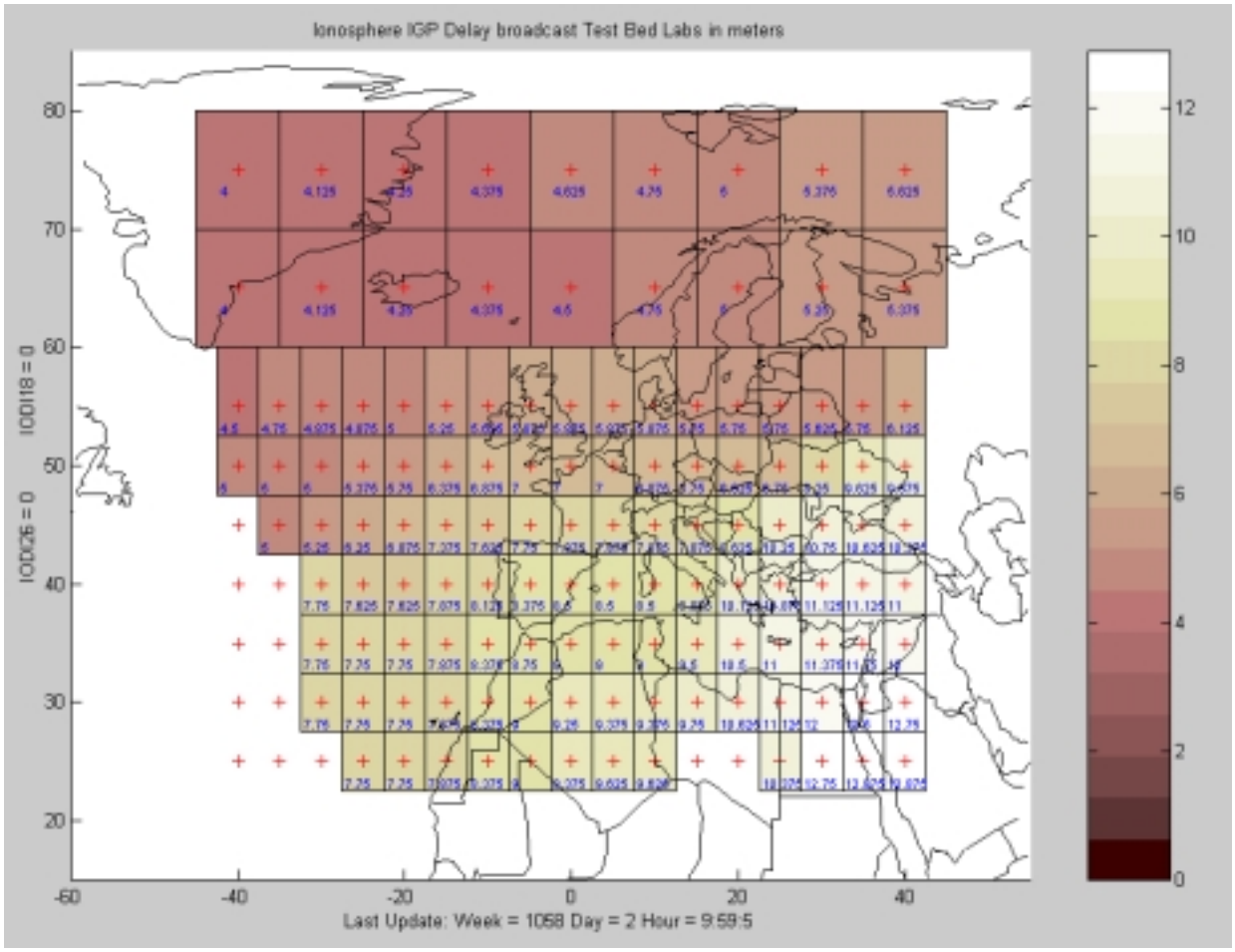

Figure 9 : Typical usable ESTB grid

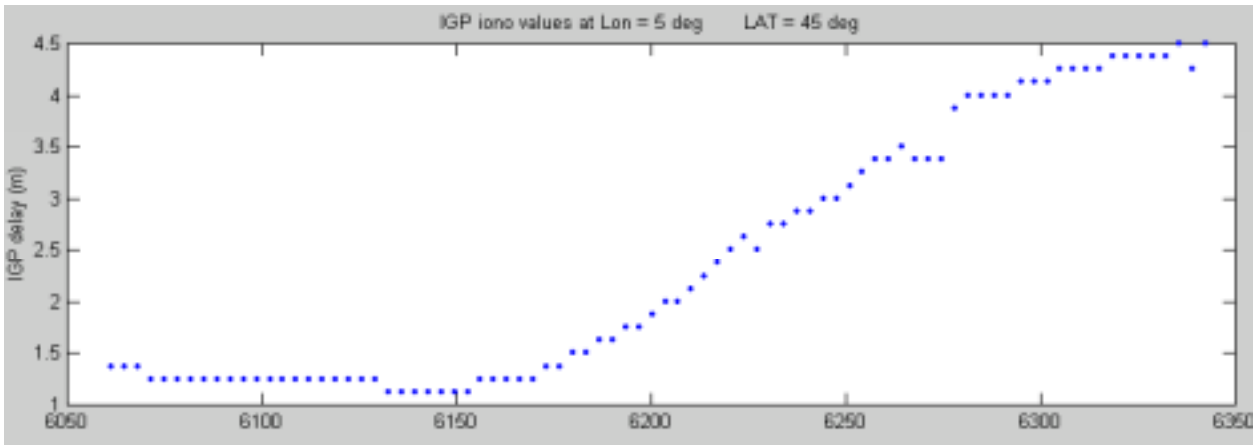

Figure 10 : GIVD broadcast by ESTB on the 20th of January, from 5h00 to 10h00

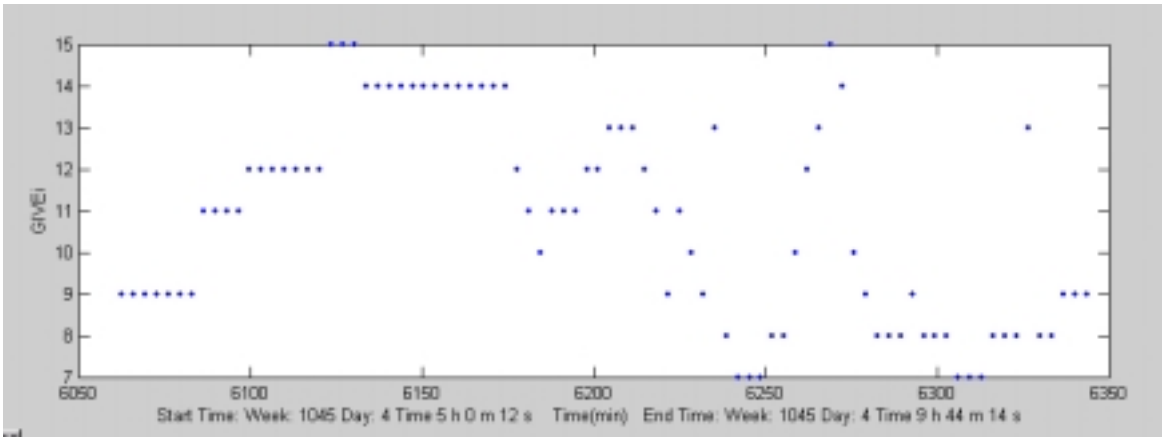

Figure 11 : GIVE indicators associated to previous GIVD

For example, these GIVE indicators are in a range of error (3 σ) from 2.4 meters to 45 meters according to tableA-16 of DA1. These GIVE (99.9% values) seem too high regarding to the broadcast GIVD and regarding to the other ionosphere delay determinations. In that last case, the difference between ESTB delay (GIVD) and each other batch determination is always **less than 1 meter** over the analysed period. So, expected max GIVE indicator should have been 10.
These high GIVE might be due to the fact that only 8 reference stations are available today and this configuration doesn't allow a better tuning of the ESTB algorithm without making an upgrade.

5.6 Protection levels

The Vertical and Horizontal Protection Levels have been computed for the Precision Approach flight phase. The results are shown on next figures. As an example, at Honefoss (Norway) the VPL is varying between 10m and 50m, and at Toulouse (France) between 15m and 60m. The VPL is mainly affected by the high values of GIVE.

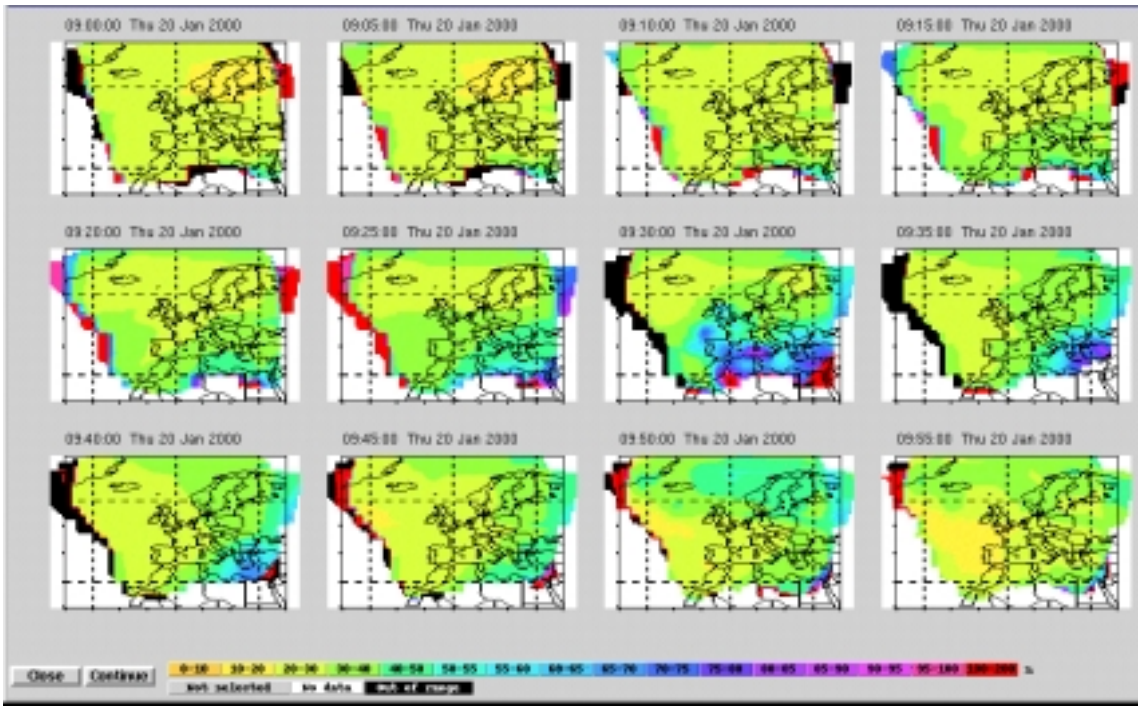

Figure 12 : VPL (PA, All Corrections), 20/01/00 from 9h00 to 10h00

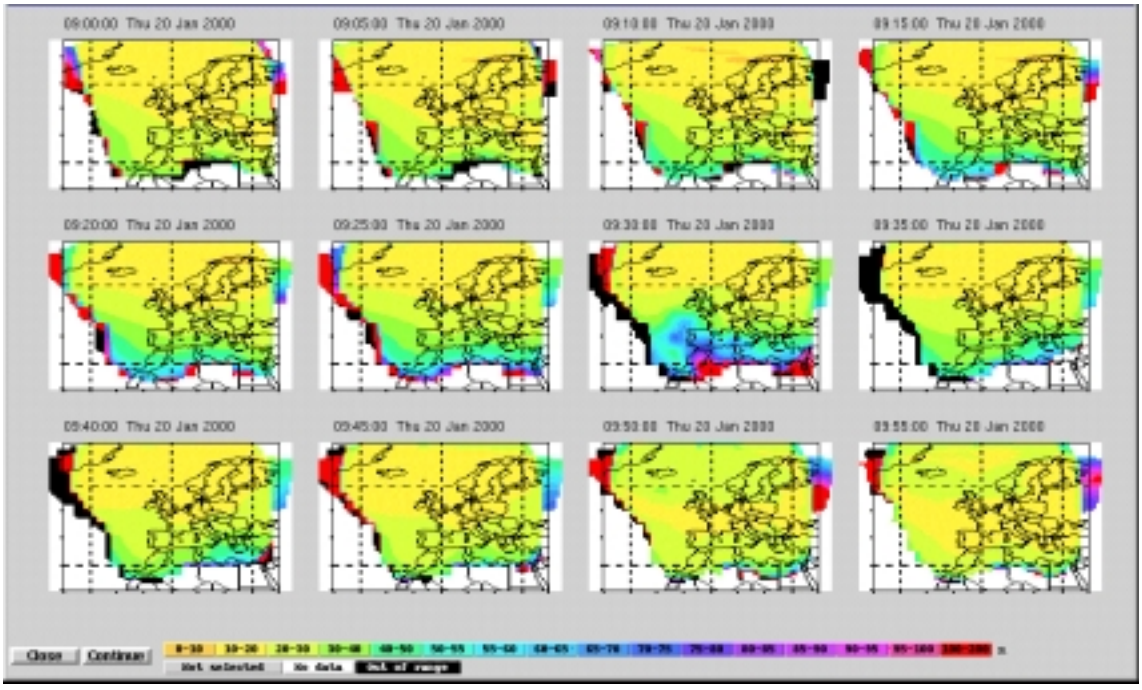

Figure 13 : HPL (PA, All corrections), 20/01/00 from 9h00 to 10h00

6. CURRENT RESTRICTIONS

6.1 Comparison

Warning : Be careful if you want to use directly some ESTB broadcast information to compare with an other source of data without making the comparison at an user navigation level.
In fact, the ESTB broadcast information are not potentially free of bias, but this bias, affecting each pseudorange, disappears if an user navigation solution is computed.

6.2 Mode tested by ESTB ESA operation team

"**ionosphere only corrections**" and "**No ionosphere corrections**" modes are not yet tested by ESA operations team within the real time data context.

6.3 Delays to establish expected ESTB mode

In order to have sufficient sets of gathered data or CPU time for computation, some delays exist to establish a transition from an ESTB mode to an another one. Some examples are given hereafter.
After some cases of MCC or NLES interruptions, some hours under "internal test" mode are needed to have the possibility to broadcast in "only ranging mode".
The duration of normal transition from "clock only corrections" mode to "GIC/WAD corrections" or "GIC/WAD corrections & ranging" mode is roughly 2 hours.
After some cases of CPF interruptions, one day under "clock only corrections" mode is needed to have the possibility to broadcast ionosphere corrections and three days to broadcast in "GIC/WAD corrections" or "GIC/WAD corrections & ranging" mode.

6.4 GIC/WAD + ranging mode

Even if all messages of this mode are broadcast, information inside messages type 2-4 do not enable yet the use of the GPS like resource in the computation of user navigation if there is more than 4 broadcast GPS differential corrections.

6.5 Message Type 17

This message is not broadcast as request by DA1, except in "only ranging" mode.

6.6 GIVE level

Due to a Software limitation with only 8 RS in the current CPF release, GIVE have often too high values for Precision Approach protection levels (HPL, VPL). Integrity flags on board has to be disabled for such flight phases.

6.7 DA1 Issue

ESTB broadcast messages (format and data) are currently compliant with the issue Change 1 of DA1, dated July 15, 1997, except in "only ranging mode" where they are compliant with the initial issue of DA1 (January 16, 1996).
Regarding the radio characteristics and convolutional encoding, ESTB broadcast messages are compliant with the issue Change 1 of DA1, dated July 15, 1997 and Change 3 of DA1, dated June 9, 1998.

7. CONTACTS

7.1 General ESTB technical information and utilization requests

For general technical information relevant to ESTB, please contact the ESA/ESTB Project Office :

- **Hugues Secretan**, ESTB Manager,
  ☎ (33) [0]5 61 28 29 02, fax (33) [0]5 61 28 28 66, email : Hugues.Secretan@cnes.fr
- **Norbert Suard**, ESTB system engineer,
  ☎ (33) [0]5 61 28 13 17, fax (33) [0]5 61 27 30 84, email : Norbert.Suard@cnes.fr

7.2 ESTB operational information

If you need information or explanations concerning past or current ESTB modes or operation status, please contact directly the ESTB/CNES operation team by one of the following means :

- fax : send your request to MCC at the fax number **(33) [0]5 61 28 14 20**
- email : send your request to **Christophe.Texier@cnes.fr** or **Thierry.Thuron@cnes.fr** or **Thierry.Beltan@cnes.fr**
- phone : call MCC operation team at **(33) [0]5 61 28 13 56** or **(33) [0]5 61 28 13 72**

The working hours of the operation team are each French working days from 8h00 to 18h00 (Central European time). Speaking languages are French and English.

7.3 Reception of ESTB information - Mailing list

You have the possibility to know the broadcast periods and the expected mode by receiving emails some hours or days in advance.
To be included in the email list, please send an email to **Christophe.Texier@cnes.fr** with email address(es) authorized in your company to receive this kind of information.

7.4 EGNOS/ESTB web site

The EGNOS/ESTB web site address is **http://www.esa.int/navigation/**.

8. ESTB SIGNAL AVAILIBILITY

Except during interruptions due to maintenance, failures, upgrade or technical investigations, the expected availability of the ESTB is 90% with the following features through the AORE:

- until the installation of the definitive network between CPF and MCC (expected date is third quarter of 2000), “clock corrections & ranging” mode or “GIC/WAD corrections & ranging” mode during working hours of the Operation Team and “only ranging” mode during nights and weekends. During this period, specific timetables could be offered on request for tests or demonstration purposes
- after the installation of the definitive network between CPF and MCC, “clock corrections + ranging” mode or “GIC/WAD corrections & ranging” mode, 24h per day, seven days per week.

9. ESTB SERVICES ACCESSIBILITY

The use of ESTB signal is **free of charges**, you have only to pay a provider for a GNSS test receiver.
Services described in chapter “Contacts” are also free of charges (except the network communication charges for your request).

10. OPERATIONS SCHEDULE

Services through AORE described in §7 and §8 are already available.

Note:
Exploitation of ESTB V1 is under ESA responsibility with contribution of:

- CNES for overall coordination of ESTB V1 and for Euridis subsystem operations
- NMA for GIC/WAD subsystem operations implemented on Satref platform

11. ESTB EVOLUTIONS

11.1 Extensions with additional RS already scheduled :

- 2 RS from the MTB, one in Fucino and one in Matera, connection date around June 2000
- 2 RS from AENA, one in Canaries Island and one in Baleares(Palma airport), connection date around October 2000 (To Be Confirmed by AENA)
- one or more RS (being transportable) and located outside ECAC will be connected to the ESTB CPF for demonstration purposes under EC responsibility. Date is not yet defined.

11.2 Services through IOR

The ESTB signal will be broadcast on IOR (with PRN 131) in third quarter of 2000 with Fucino NLES . This signal will include GIC and WAD MOPS messages without Ranging service.

11.3 Compliance with MOPS

ESTB signal with last release of DA1 (change 3, dated June 9, 1998) will be available in last quarter 2000. Main changes are:

- Implementation of MT10 with a priori values (configuration parameters)
- Computation of UDRE and GIVE according new table
- New troposphere model

Note:
MT27 will be implemented with some modifications for the interpretation in the receiver regarding to DA1. It will be documented in this document after test acceptance on this evolution.

12. BIBLIOGRAPHY

DR1 : Euridis System Test Measurement Station, Michel Brunet, Alain Lamy, N. Suard - CNES, ION GPS, September 1999.
DR2 : Training Report from A. Lhermite, ENAC/CNES, Study on ionosphere delays over Europe
DR3 : **ftp://igs.ensg.ign.fr/pub/igs/iono** ftp server with TEC grids from several Labs
DA1 : RTCA/DO 229 MOPS standards
DA2 : GPS SPS Signal Specification dated June 2, 1995
DA3 : SDM for INMARSAT Geostationary Navigation Overlay Service

Most of result figures are issued from analysis tools developed by J.C. De Mateo, ESA trainee.

13. ACRONYMS

AORE : Atlantic Ocean Region - East
CNES : Centre National d'Etudes Spatiales
CPF : Central Processing Facility
ENAC : Ecole Nationale de l'Aviation Civile (France)
ESTB : EGNOS System Test Bed
GIC : GNSS Integrity Channel
GNSS : Global Navigation Satellite System
GPS/SPS : GPS Standard Positioning Service
GRS : Geostationary Ranging Station
HNSE : Horizontal Navigation System Error
IOR : Indian Ocean Region
MCC : Mission Control Center (French acronym CMT)
MOPS : Minimum Operational Performance Standards
MTB : Mediterranean Test Bed
NLES : Navigation Land Earth Station
NMA : Norwegian Mapping Authority
PRN : Pseudo Random Noise
RS : Reference Station
TMS : Test Master Station
URE : User Range Error
VNSE : Vertical Navigation System Error
WAD : Wide Area Differential