SBAS Independent Assessment

EGNOS Workshop

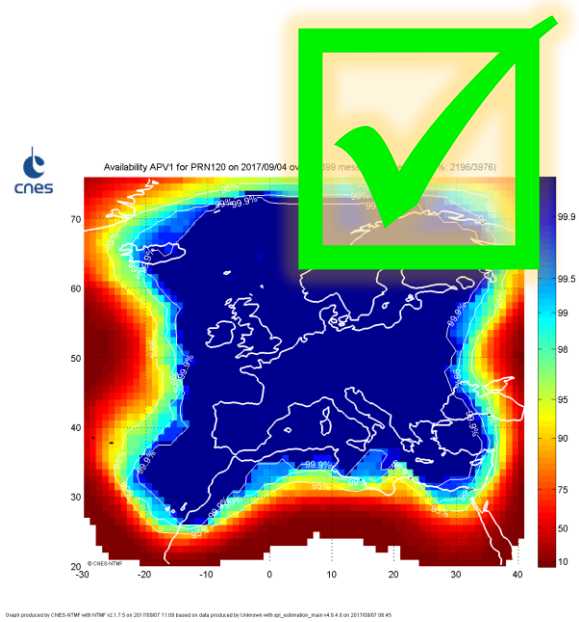
03/10/2017

SPMS

European GNSS Agency

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

SBAS Independent Assessment



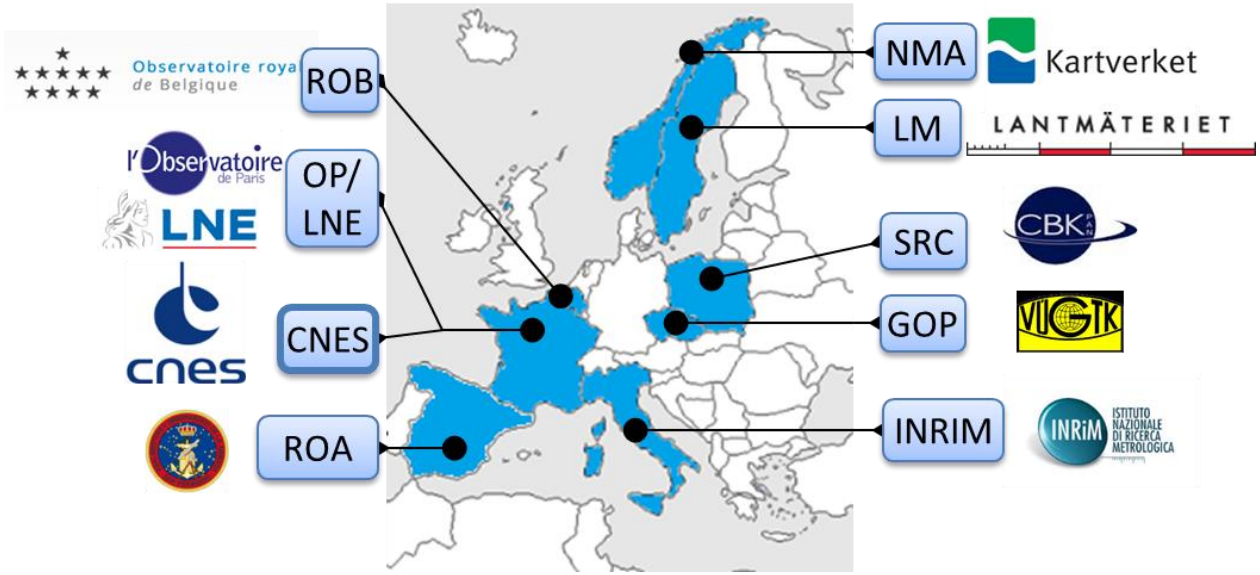
- SPMS Partnership
- EGNOS Time
- EGNOS Data Access Service
- Other SBAS performance assessment

EGNOS Service Performance Monitoring Support to GSA

SPMS ⇔ European Global Navigation Satellite Systems Agency

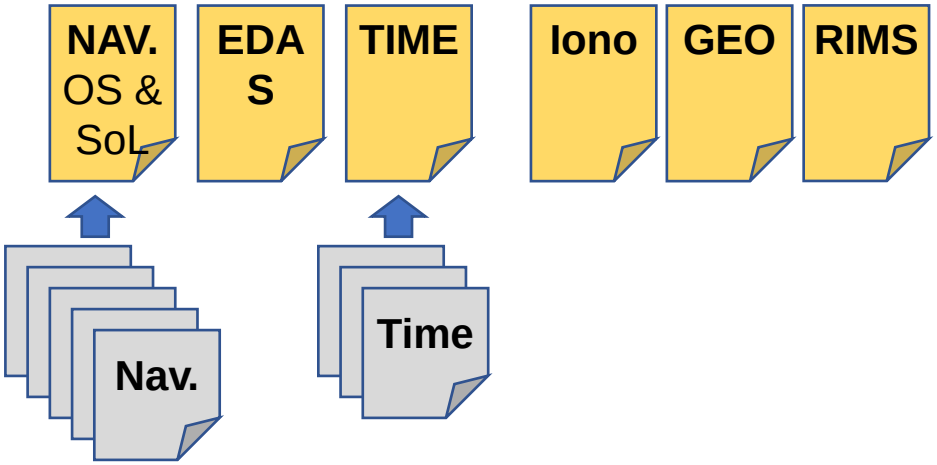
Independent consortium

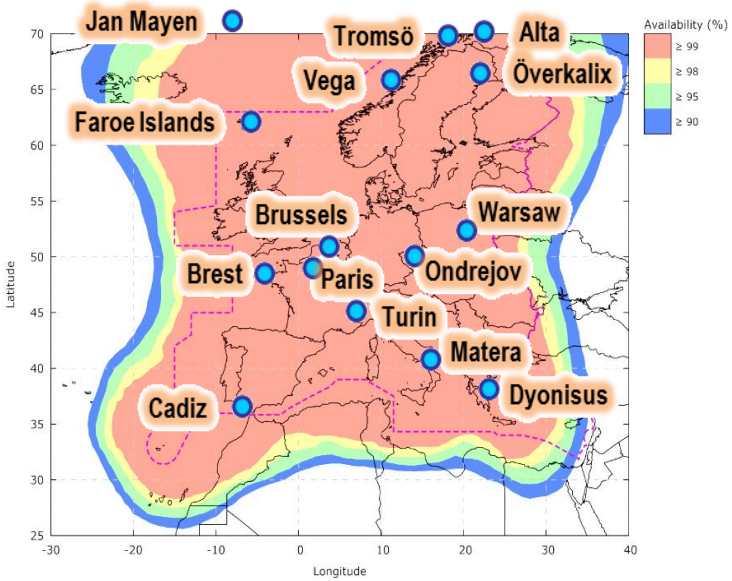
- 10 public entities
- CNES coordinator



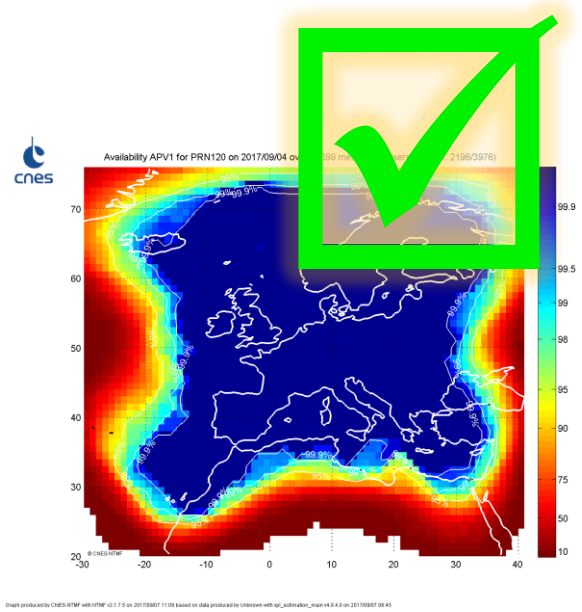
SPMS : Independent means and reports

- 13 GNSS stations + 3 GNSS time receivers
- Independent performance analysis tools
- Quarterly reports to GSA
  Access to performance data servers for GSA





SBAS Independent Assessment



SPMS Partnership

EGNOS Time

EGNOS Data Access Service

Other SBAS performance assessment

SPMS: EGNOS Time performance assessment

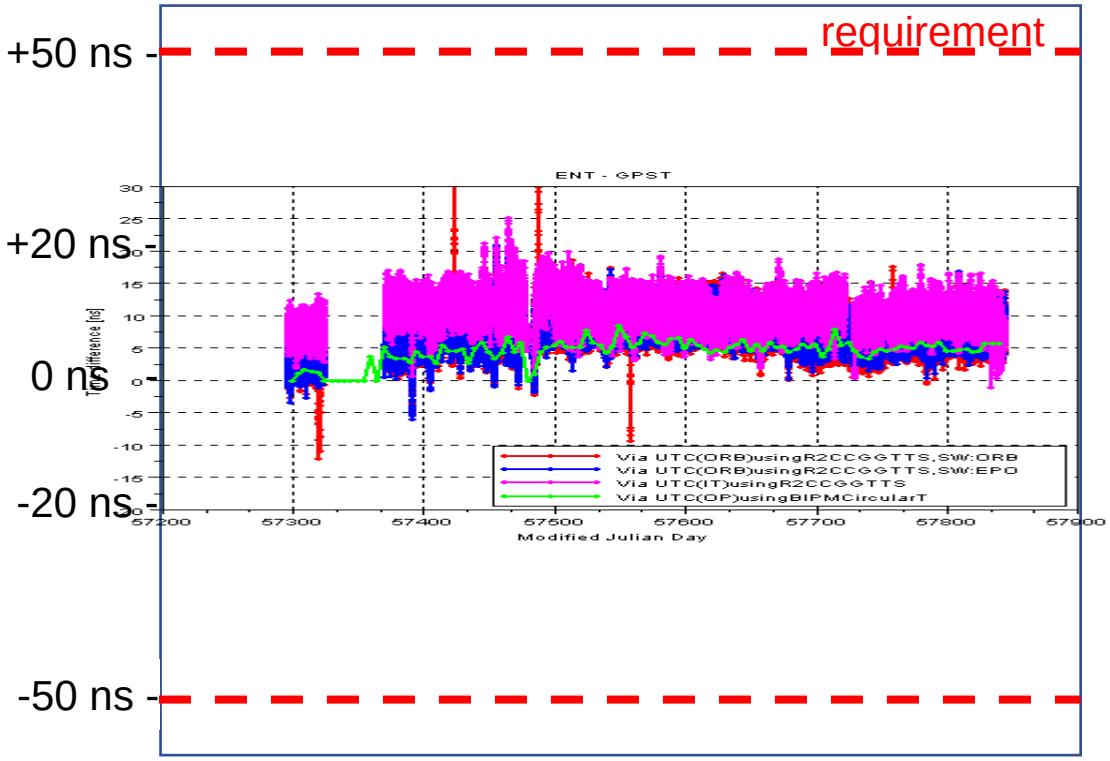
- 3 time calibrated GPS receivers referenced to UTC(OP), UTC(ORB), UTC(IT)
- 2 independent tools from ORB and CNES implementing 2 different methods (ionosphere corrections from EGNOS model or dual-frequency measurements)
- Use of different time transfer techniques (PPP, TWSTFT) to consolidate the analysis

- Good convergence of results from different tools
- Good performance of EGNOS Time and realization of UTC

EGNOS Time performance: SPMS results (1/3)

EGNOS Time offset to GPS Time

OK ☑



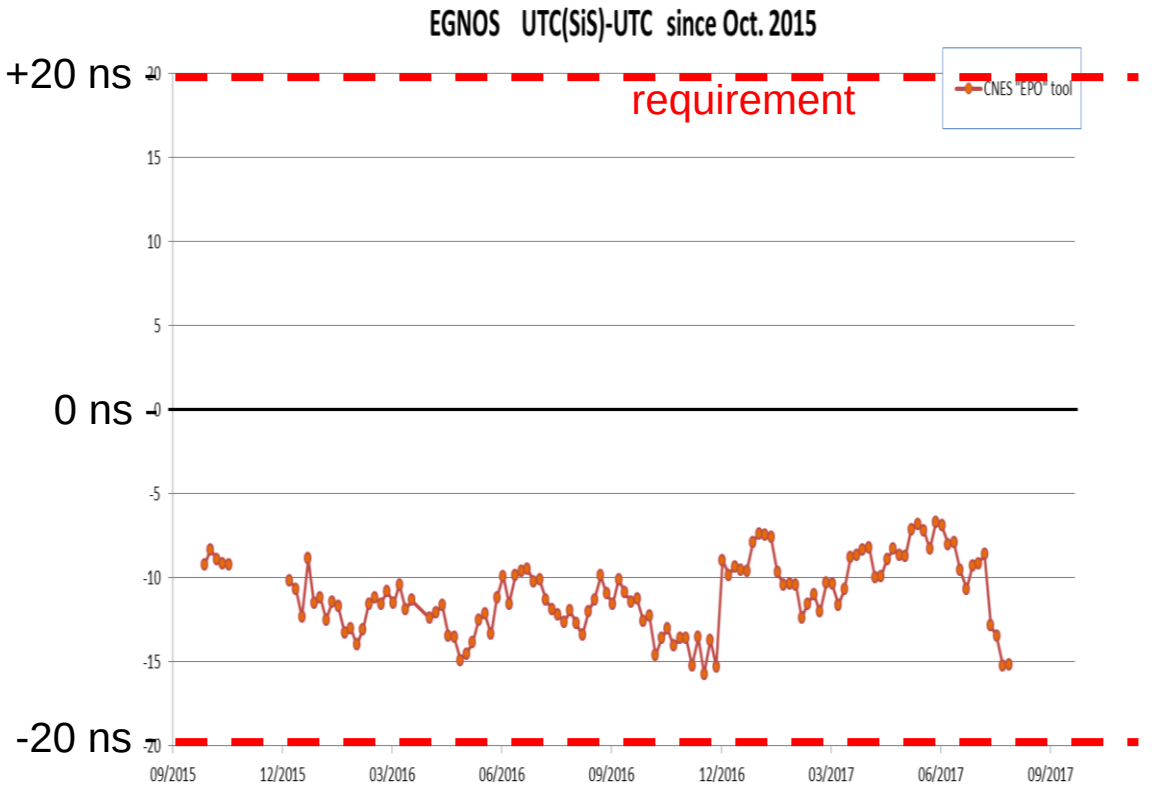
EGNOS Time – GPS Time
(Oct.2015 to Mar.2017)

EGNOS Time performance: SPMS results (2/3)

EGNOS transmits parameters to compute a realization of UTC at EGNOS user level.

This UTC realization is named in the graph "UTC(SiS)".

OK ☑



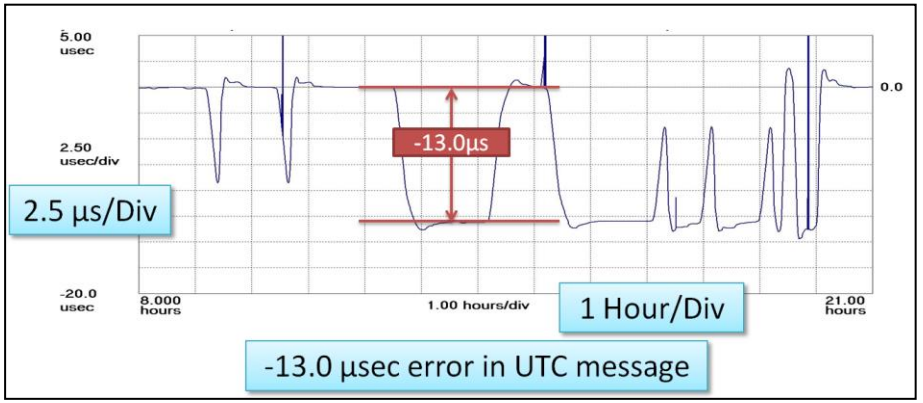
PRN120 UTC(SiS) – UTC
(Oct.2015 to Jul.2017)

EGNOS Time performance: SPMS results (3/3)

On 26 January 2016, during 13 hours,

15 GPS satellites broadcast UTC parameters with an error of 13 microseconds.

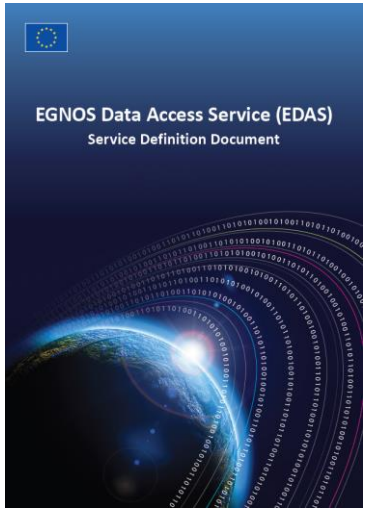
UTC realization from
a GPS time receiver →



Source : Prof Charles Curry, BEng, CEng, FIET, FRIN *Chronos Technology Ltd*

➢ EGNOS Time remained stable and **EGNOS UTC parameters were not affected** ☑

EGNOS Data Access Service (EDAS): SPMS assessment

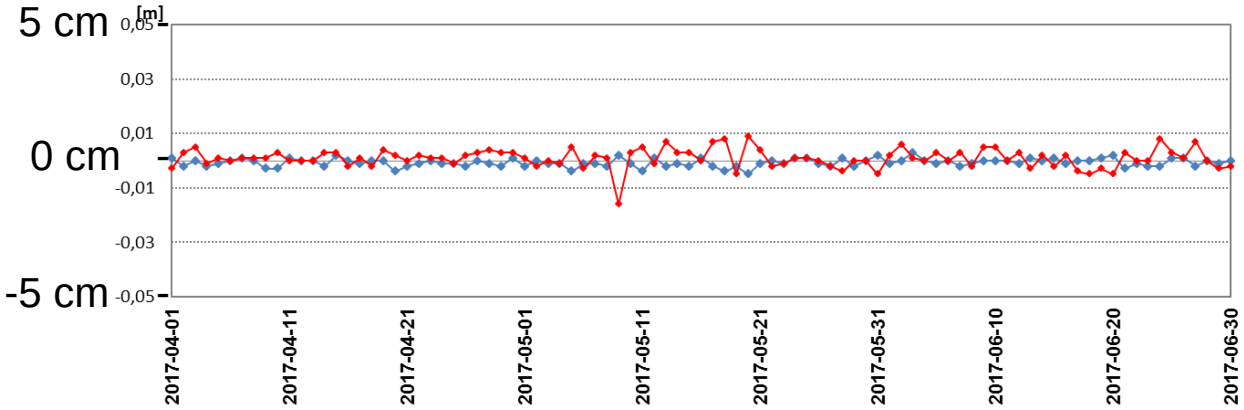


- EDAS Server performance assessment
  (Geodetic Observatory of Pecny/Technical University of Prague)

- Assessment of EDAS corrections against Signal-in-Space corrections

EGNOS Data Access Service (EDAS): SPMS assessment

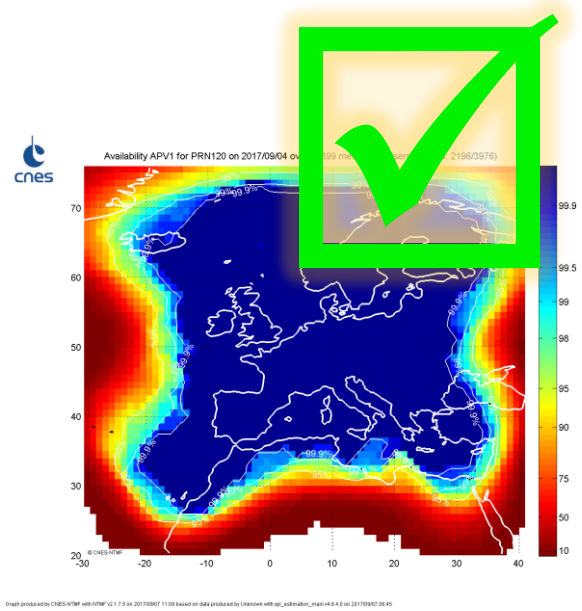
- Comparison of station coordinates computed with:
  - EGNOS corrections from Signal-in-Space, and
  - EGNOS corrections from EDAS.



Delta of Warsaw station coordinates [SiS PVT – EDAS PVT]
(Apr. 2017 to Jun. 2017) (horizontal ---, vertical ---)

SPACE RESEARCH CENTRE
of the Polish Academy of Sciences

SBAS Independent Assessment



SPMS Partnership

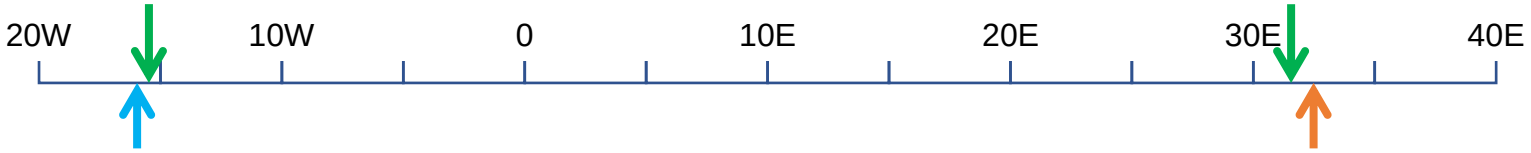
EGNOS Time

EGNOS Data Access Service

Other SBAS performance assessment

- Collocated SBAS satellites
- Ionosphere events

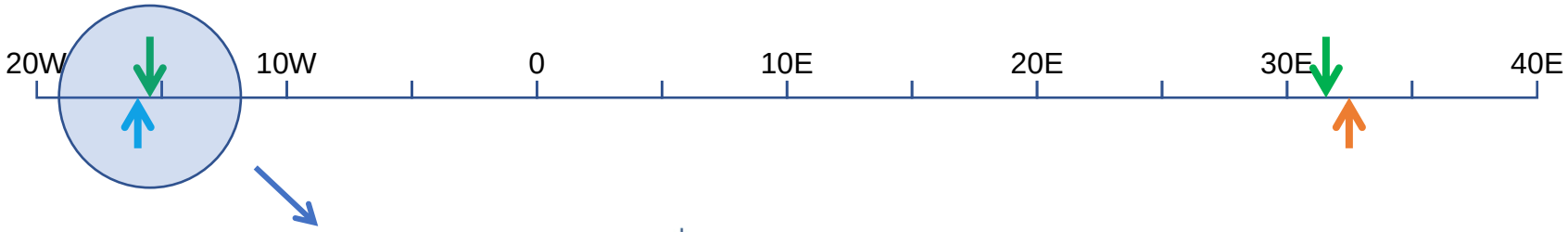
EGNOS and other GNSS : collocated GEO satellites survey



- 2 pairs of quasi-collocated SBAS satellites
  - EGNOS PRN120 (Inmarsat-IIIF2) / SDCM PRN125 (Luch-5b) ➔ longitude separation 0.5°, L1-band
  - EGNOS PRN123 (Astra-5B) / NAVIC PRN106 (IRNSS-1F) ➔ longitude separation 1°, L5-band
- Survey of the absence of impact on user performance and EGNOS system (*)
  - Compliance to signal power commitments
  - Compliance to minimum satellite longitude separation commitments
  - No expected impact on the EGNOS uplink station
- Monitoring of several parameters
  - Satellite longitudes
  - Angular separation from EGNOS uplink station
  - Relative signal power, spectrum, correlation loss (CNES large dish L-band antenna)

(*) Luch-5b position and characteristics of broadcast have been modified by Russia following negotiations between ESSP and SDCM operator to minimize the impact on PRN120.

EGNOS and other GNSS : collocated GEO satellites survey

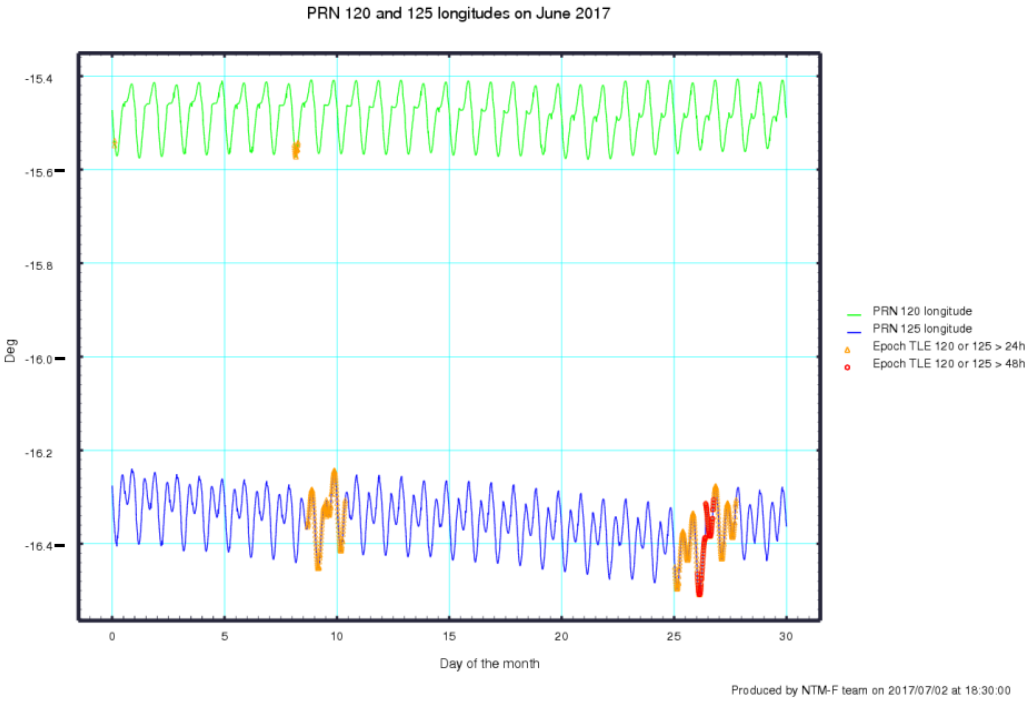


EGNOS PRN120 and **SDCM PRN125**
Satellite longitude
(June 2017)

15,6°W

16°W

16,4°W



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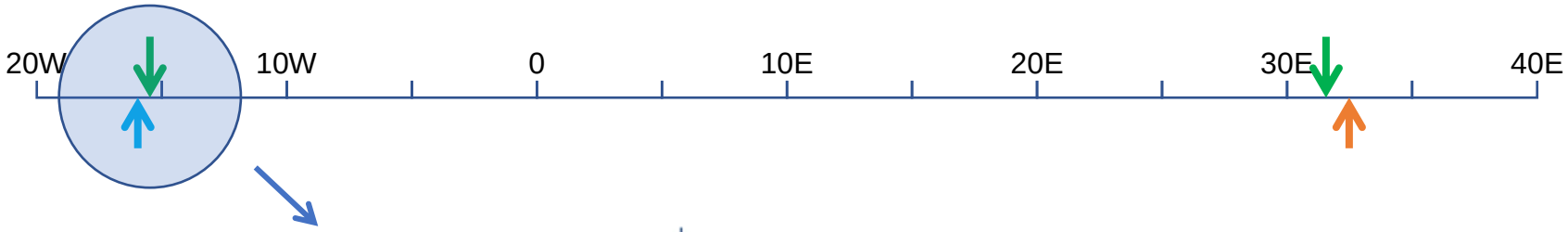
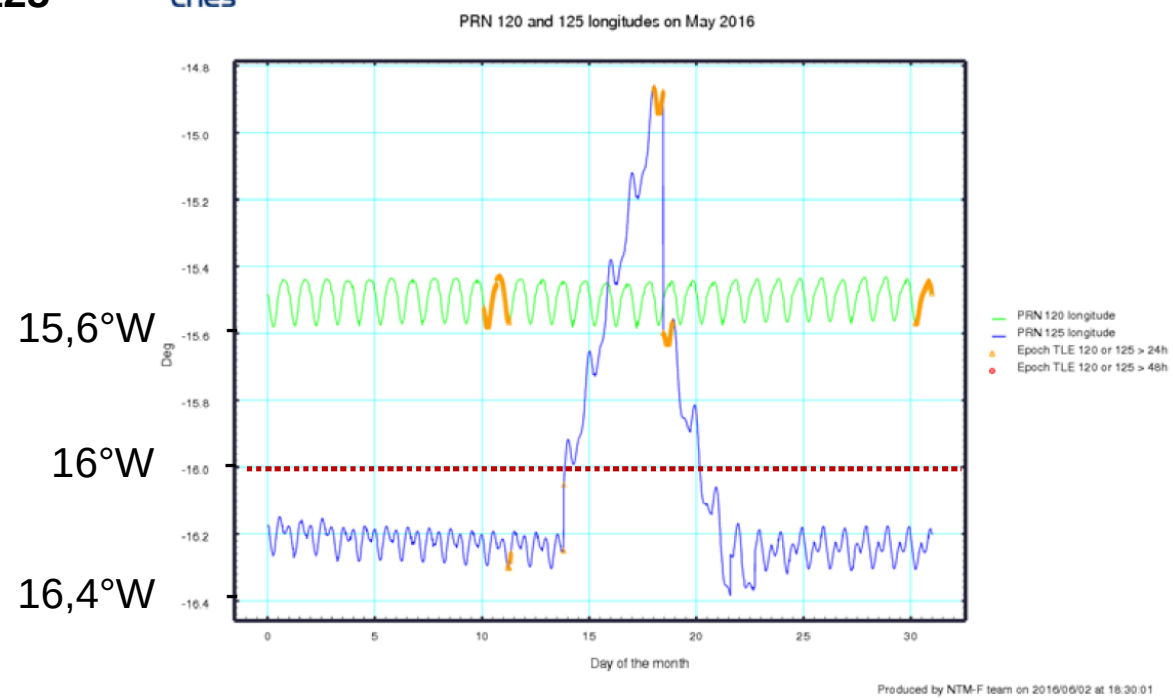
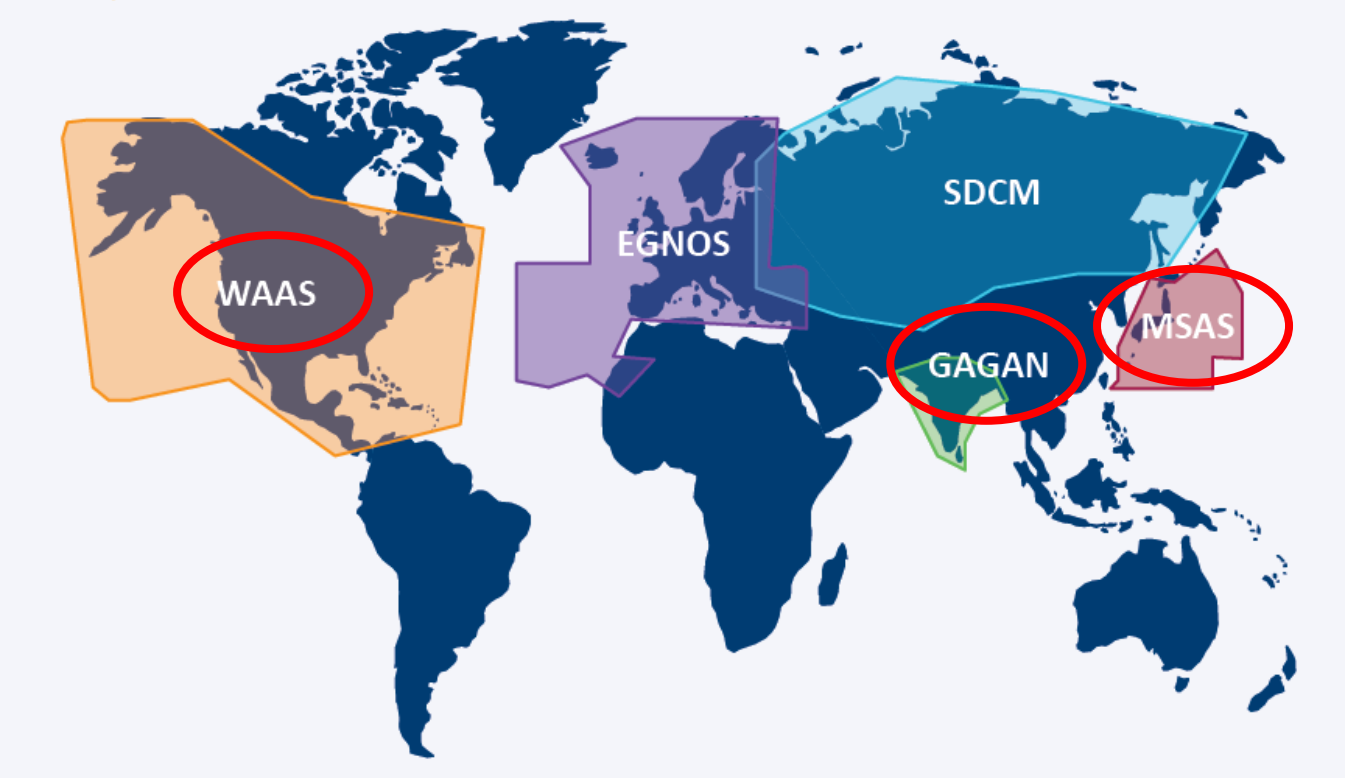


EGNOS PRN120 and **SDCM PRN125**
Satellite longitude
(Mai 2016)



Assessment of other operational SBAS

- SPMS also monitors the other SBAS providing an operational Safety of Life service



Source: GSA EGNOS SoL SDD 3.1

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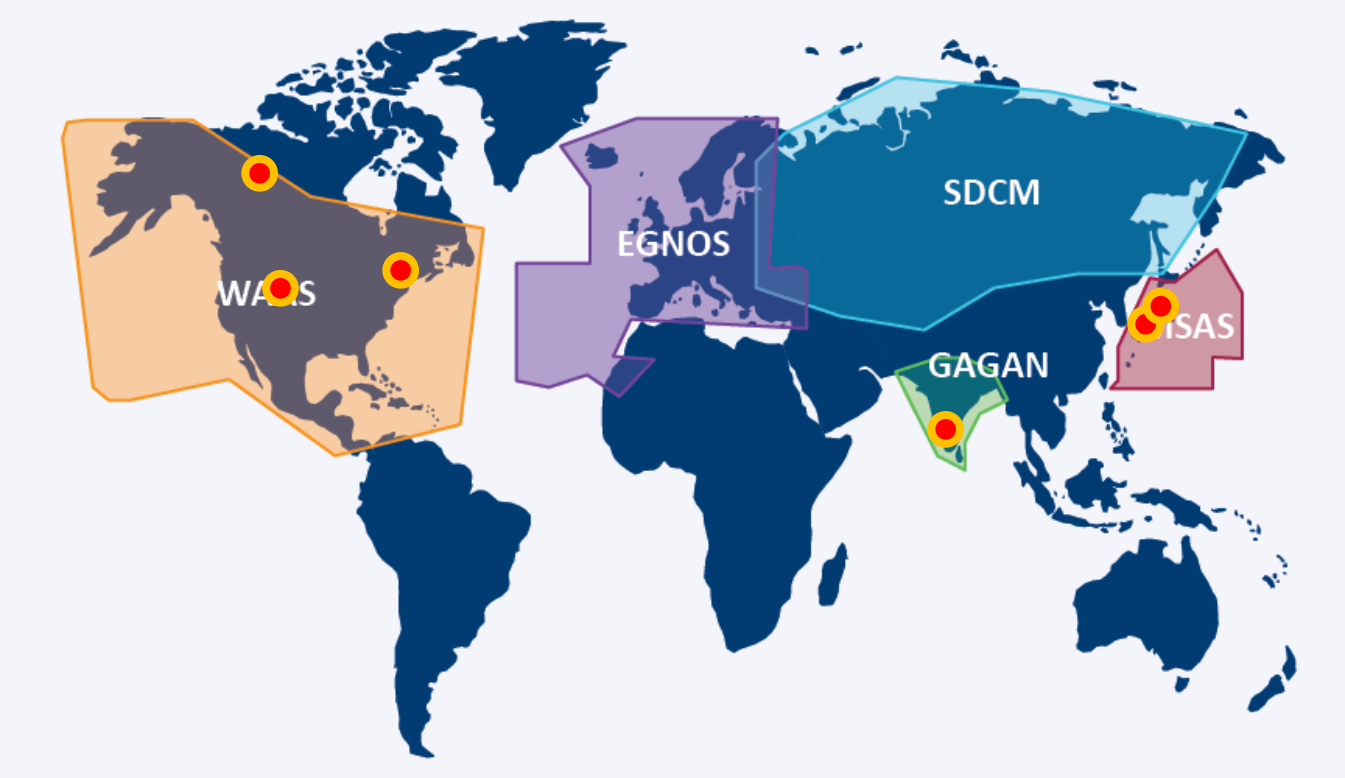
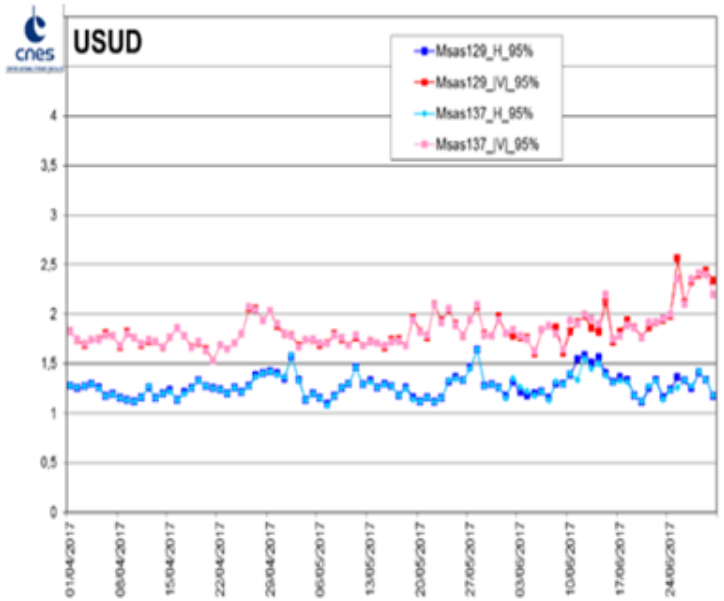


Other SBAS: data collected, analysis and performance indicators

- Use of CNES RINEX-B files (= broadcast SBAS messages): https://ntmf.cnes.fr
- One or several IGS stations are monitored in each SBAS service area
- KPIs:
  - **Accuracy of the positioning service**

MSAS, Mar. Jun. 2017
Usada station - horiz. & vert. accuracy



Usuda (xPE 95%)

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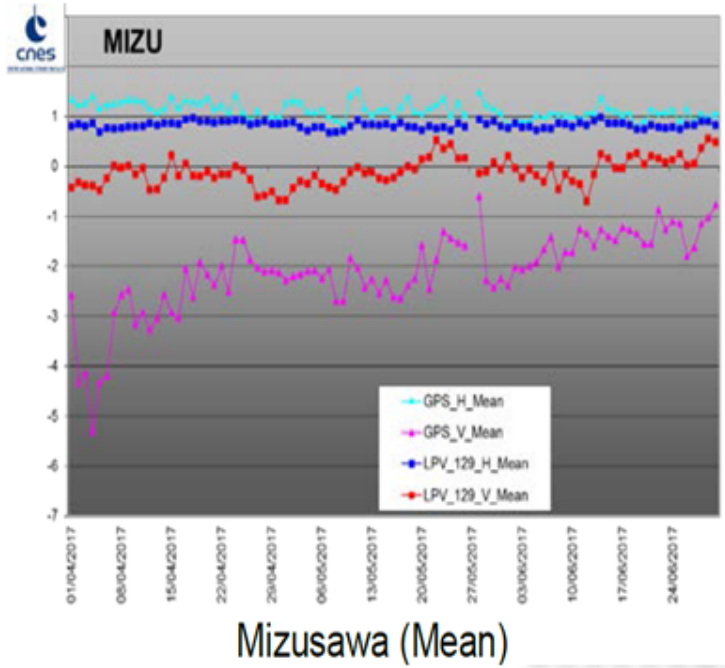
  - **Accuracy of LPV200 and comparison to GPS**

MSAS, Mar. Jun. 2017
Mizusawa station – LPV200 vs. GPS accuracy



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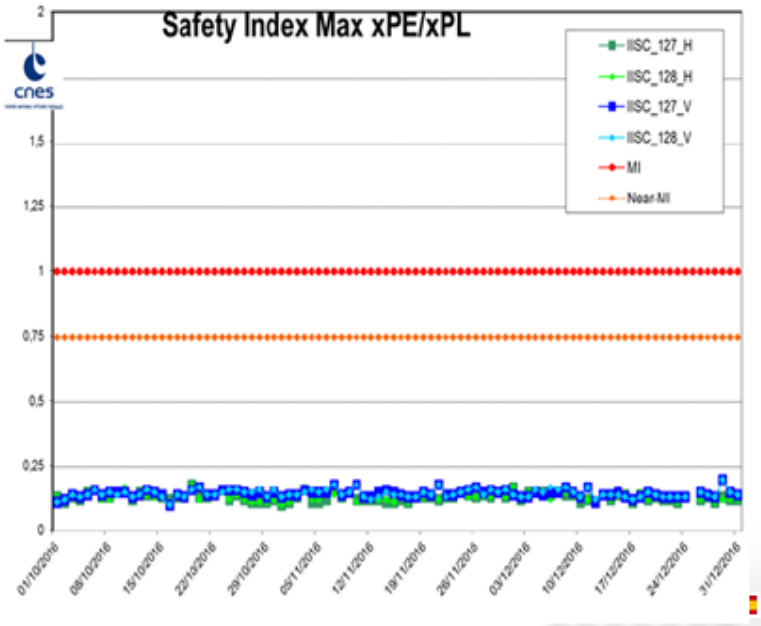
  - **Accuracy of the positioning service**
  - **Accuracy of LPV200 and comparison to GPS**
  - **Integrity**

GAGAN, Oct. Dec. 2016
Bengalore station – Integrity check



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- KPIs:
  - **Accuracy of the positioning service**
  - **Accuracy of LPV200 and comparison to GPS**
  - **Integrity**
  - **Availability of positioning, APV1 and LPV200 services**
  - **Continuity of APV1 and LPV200 services, SoL service interruptions**
  - **Analysis of service degradations and ionosphere events**

Other SBAS: example of Ionosphere monitoring

Independent ionosphere monitoring approach in SPMS (Norwegian Mapping Authority)

- Northern Europe ionosphere monitored with NMA stations
  - Estimation of rate of TEC Index for Northern, Middle and Southern Norway
  - Comparison with other sources of ionosphere data (NOAA)
- Monitoring of EGNOS broadcast ionosphere bounds (GIVE average, max)
- Comparison between EGNOS Vertical-TEC and observed Vertical-TEC (Total Electon Content)

Determination of the origin of events observed in the EGNOS ionosphere grid:

- Due to the ionosphere, or
- Due to a system event (mostly a RIMS data collection event: network, RIMS maintenance, …).

Impact of ionosphere events on EGNOS and WAAS

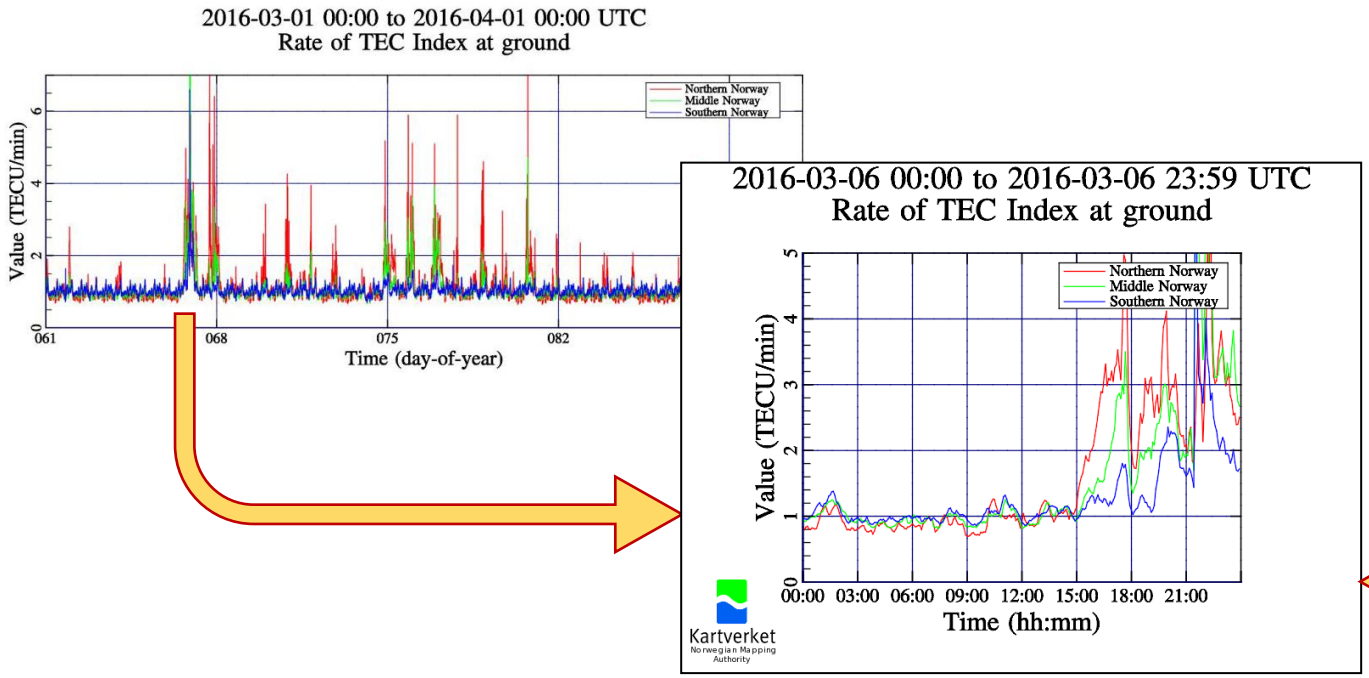
- WAAS performance is crosschecked in case of ionosphere event impacting EGNOS service.
- Example: major event of 6/7 March 2016.

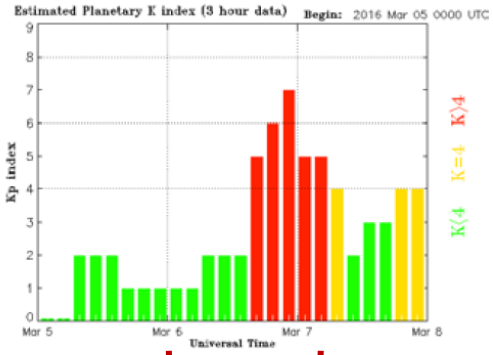
Common SBAS Ionosphere event: 6/7 March 2016

❖ Total Electron Content Index:

TEC measurements from 10 Norwegian stations
March 2016 / zoom on 06/03

NOAA – Planetary K index
5, 6 & 7 March 2016

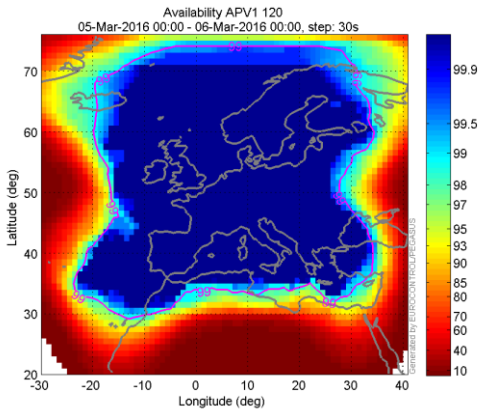


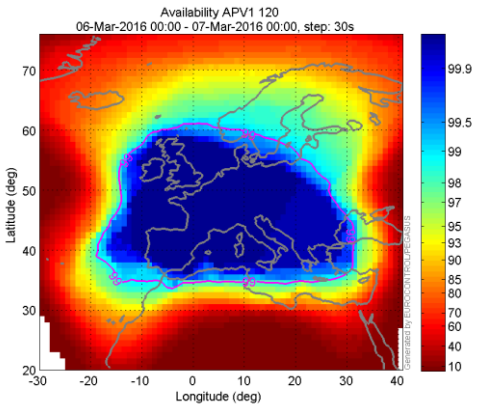


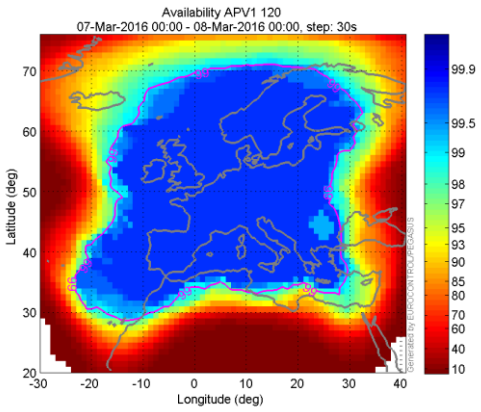
6/7 March 2016: WAAS and EGNOS APV1 availability

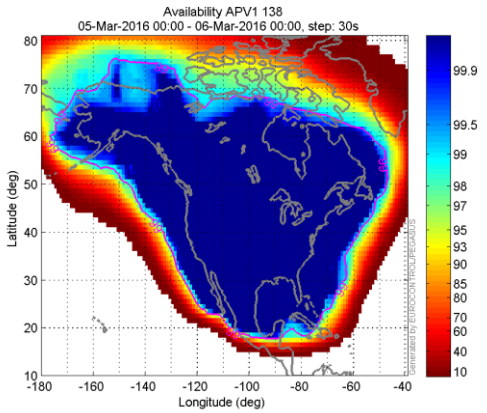
EGNOS

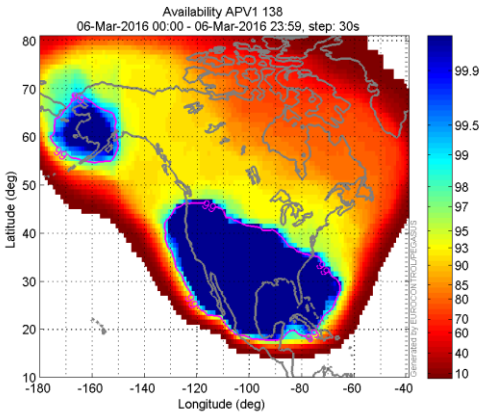
WAAS

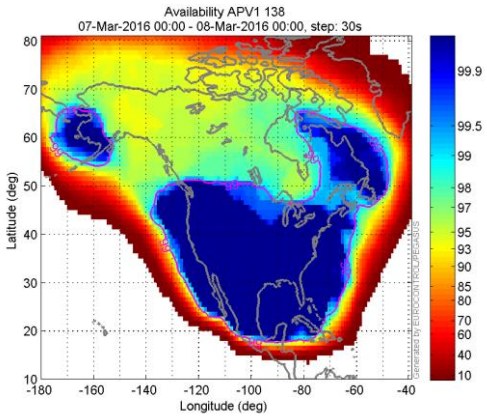












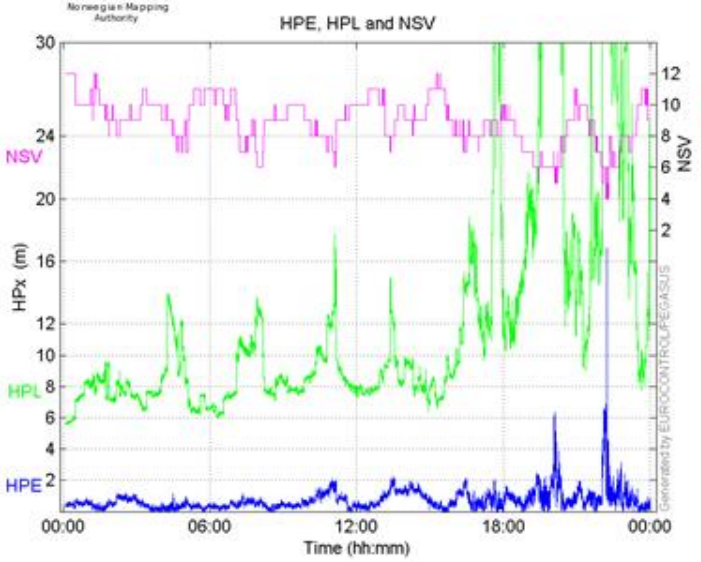
5 March 2016

6 March 2016

7 March 2016

6/7 March 2016: EGNOS and WAAS stations results

Scale 0m – 30m

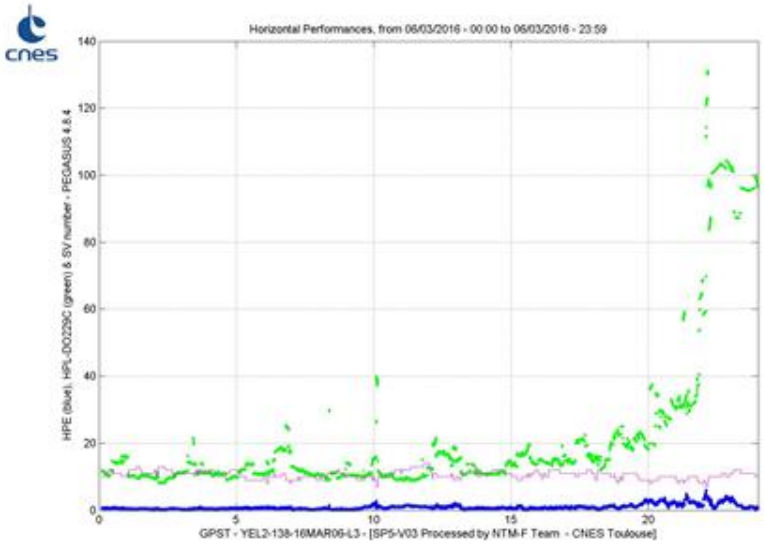


NB Sat.

Hor. Protec. Level.

Hor. Pos. Error.

Scale 0m – 140m



EGNOS
Överkalix
(North-East of Sweden)

6 March 2016

WAAS
Yellowknife
(Central-West of Canada)

6/7 March 2016: EGNOS and WAAS stations results

Kartverket
Norwegian Mapping Authority

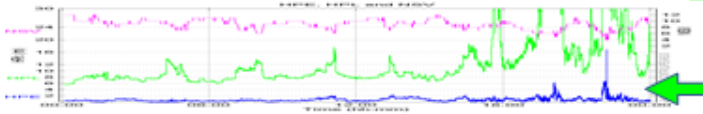
Scale 0m – 30m

Scale 0m – 140m

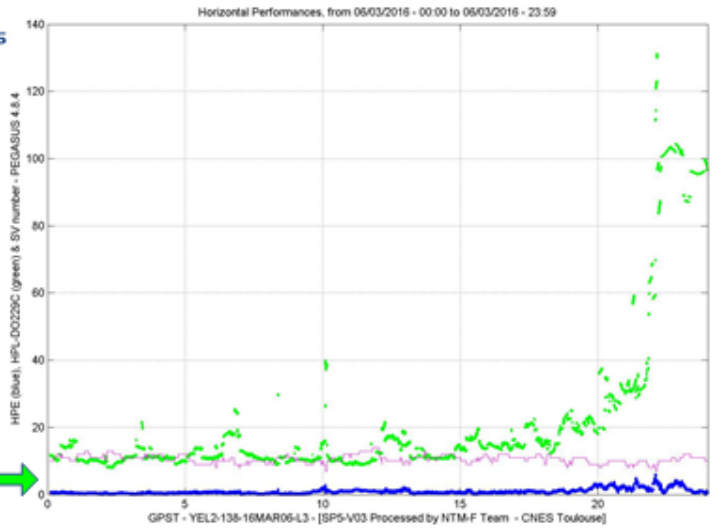
NB Sat.

Hor. Protec. Level.

Hor. Pos. Error.



Integrity always OK

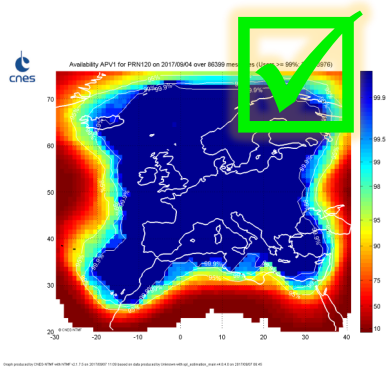


EGNOS
Överkalix
(North-East of Sweden)

6 March 2016

WAAS
Yellowknife
(Central-West of Canada)

- Thank you for your attention.
- Questions ?



European Global Navigation Satellite Systems Agency