EGNOS timing performances as evaluated by SPMS

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The views expressed in this presentation are those of the authors and do not necessarily reflect the official position of the GSA/EC

Outline

1. Introduction to EGNOS and ENT

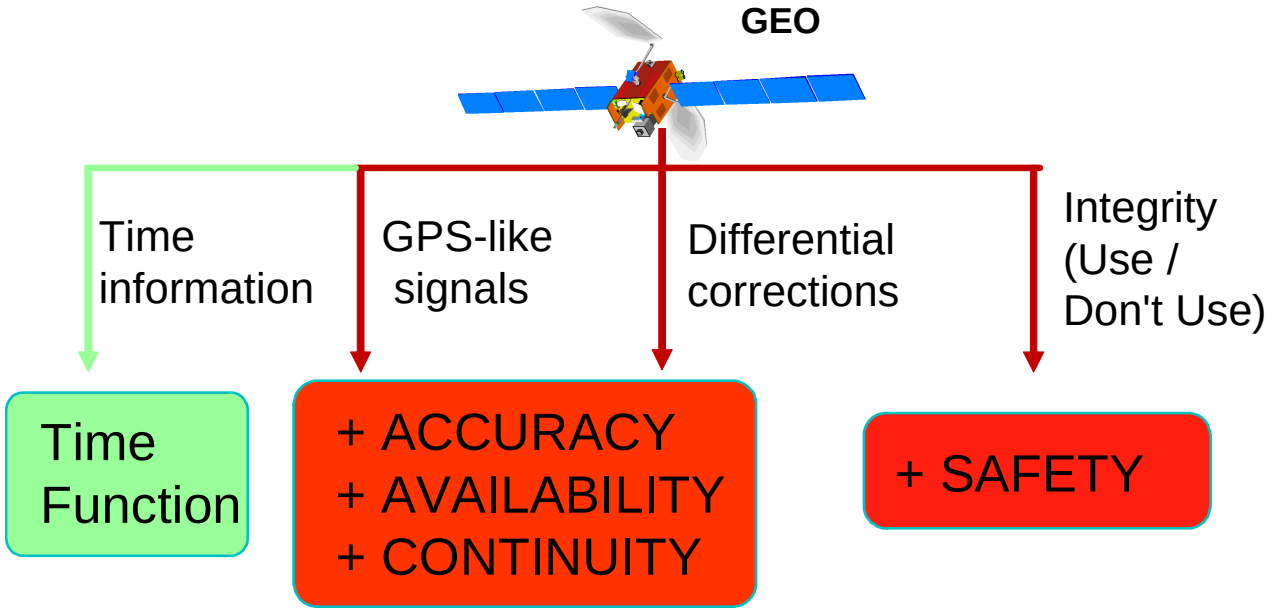
2. EGNOS timing performances

3. WAAS timing performances

4. Conclusions

EGNOS overview

EGNOS = European Geostationary Navigation Overlay Service
GPS SBAS over Western Europe



EGNOS services currently broadcast by 2 GEO :
PRN 120 and 136 (operational)
PRN 123 (to come)

EGNOS Open Service : October 2009
EGNOS Safety-Of-Life service : March 2011

EGNOS Network Time (ENT)

- EGNOS system time = ENT
- ENT is computed from differences between clocks in the EGNOS ground stations (obtained by GPS Common-View)
- ENT is steered to GPST

ENT – GPST < 50 ns (5 σ) – cf. EGNOS SRD

- ENT is described in the ICG WG-D timing template available on the ICG web site

ENT and UTC

Link between ENT and UTC in Message Type 12 (MT12)

- Offset between UTC [or one UTC(k)] and SBAS system time
- Max update time : 300 s
- Validity time : 86400 s

EGNOS requirement

ENT – UTC(OP) accuracy
< 10 ns (3 σ)

UTC identifier	
0	UTC(CRL)
1	UTC(NIST)
2	UTC(USNO)
3	UTC
4	European UTC(k)
5-6	Reserved for future use
7	Not provided

(see MOPS Annex A)

ENT and UTC(OP)

An EGNOS station at Observatoire de Paris

- Physically connected to UTC(OP)
- Time delays within this station
  - » calibrated in real time through the use of dedicated GPS-like signals
  - » transmitted to EGNOS system

ENT-UTC(OP) comes as output of the composite clock algorithm (but UTC(OP) is not used to form ENT)

MT12 is uploaded to the EGNOS satellites and broadcast in each EGNOS PRN navigation frame

The EGNOS user shall be aware that applying EGNOS corrections to its GPS measurements will turn its time reference from GPST to ENT and therefore to UTC(OP) if MT12 is used

SPMS

CNES awarded in 2015 by GSA of the **Service Performance Member State Support** (SPMS) grant :

- CNES leads a consortium of 8 state bodies from 7 countries
- Main objective = EGNOS performance monitoring

One WP is devoted to the **EGNOS time function monitoring.**

It involves :

- the Italian Istituto Nazionale di Ricerca Metrologica (INRIM)
- the laboratory Systèmes de Références Temps-Espace (LNE-SYRTE) of Observatoire de Paris
- the Royal Observatory of Belgium (ROB)
- CNES

ENT perfo monitoring

To monitor EGNOS timing function, these time offsets are computed :

- ENT – ENT_{user}
- ENT – UTC
- ENT – GPST

ENT_{user} is the time scale obtained when applying EGNOS corrections on the GPS measurements of a given receiver

The chosen approach is to have different computation methods and/or data with a view to :

- cross-checking results
- easing investigations in case of discrepancies

ENT – ENT_{user}

$ENT - ENT_{user} = ENT - UTC(OP) - ENT_{user} - UTC(OP)$

Broadcast in MT12

Computed by 3 different methods :

1. Applying EGNOS corrections to a calibrated GPS rx (OPMT) connected to UTC(OP)
2. $ENT_{user} - UTC(ORB) + UTC(ORB) - UTC(OP)$

   Applying EGNOS corrections on BRUX (ORB GPS calibrated receiver)

   Circular T
3. $ENT_{user} - UTC(IT) + UTC(IT) - UTC(OP)$

   Applying EGNOS corrections on IENG (INRIM GPS calibrated receiver)

   TWSTFT

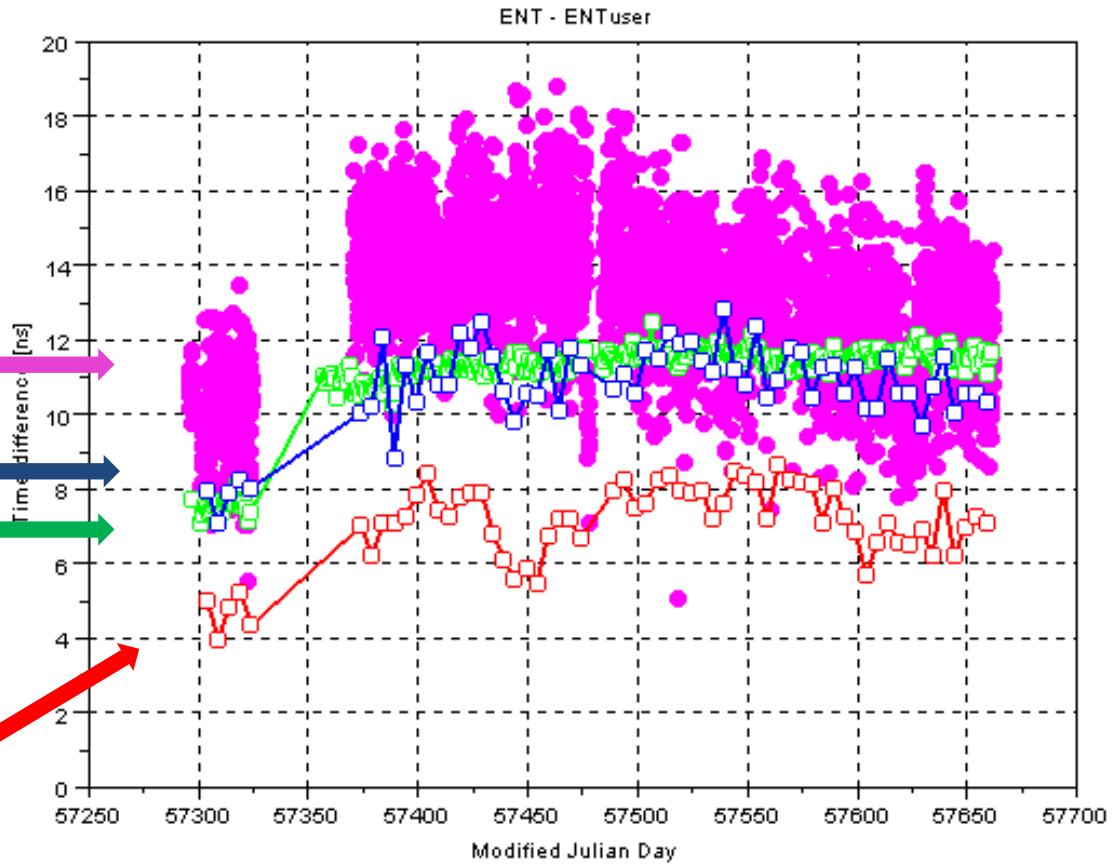
ENT – ENT_{user}

ENT – ENT_{user} via INRIM

ENT – ENT_{user} via ORB

ENT – ENT_{user} via OP

ENT – ENT_{user} via ORB
using P3 iono-free combination
(instead of C1 + iono corrections)

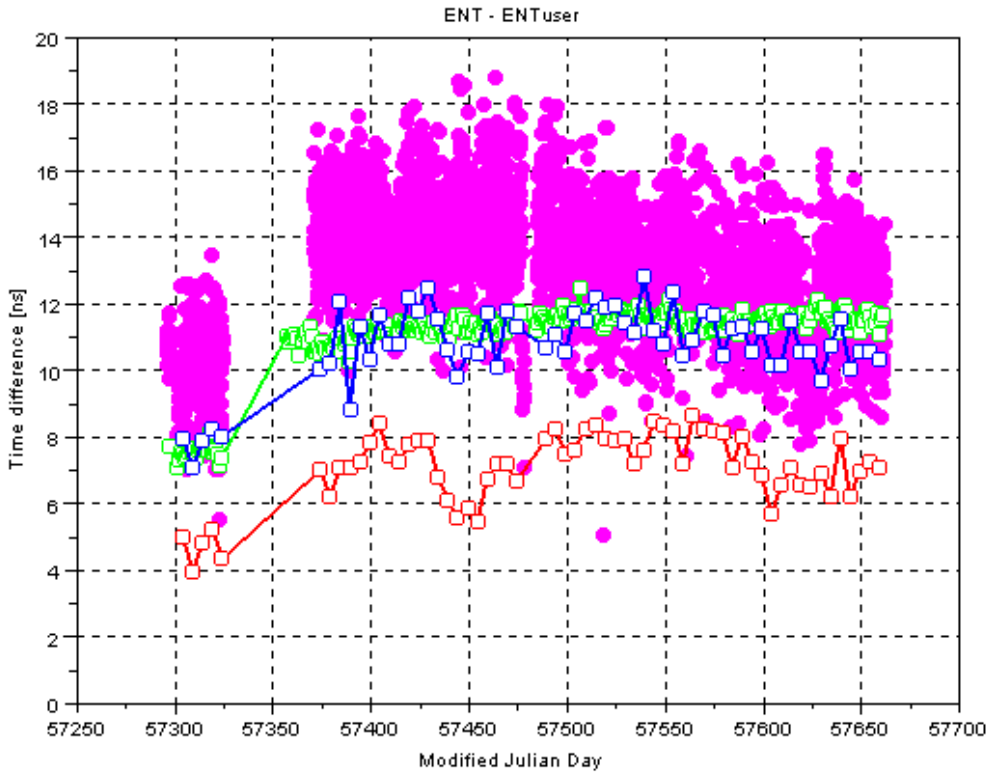


ENT – ENT_{user}

The different methods provide consistent results

Missing results are due to absence of MT12 (e.g. Nov 2015)

The bias between ENT and ENT_{user} increased from ~7 ns to ~11 ns following the interruption in Nov 2015



ENT – UTC

ENT – UTC = ENT – UTC(OP) + UTC(OP) – UTC

Broadcast in MT12

Computed by 3 different methods :

1. Circular T
2. = UTC(OP) – UTC(ORB) + UTC(ORB) – UTC

   PPP

   Circular T
3. = UTC(OP) – UTC(IT) + UTC(IT) – UTC

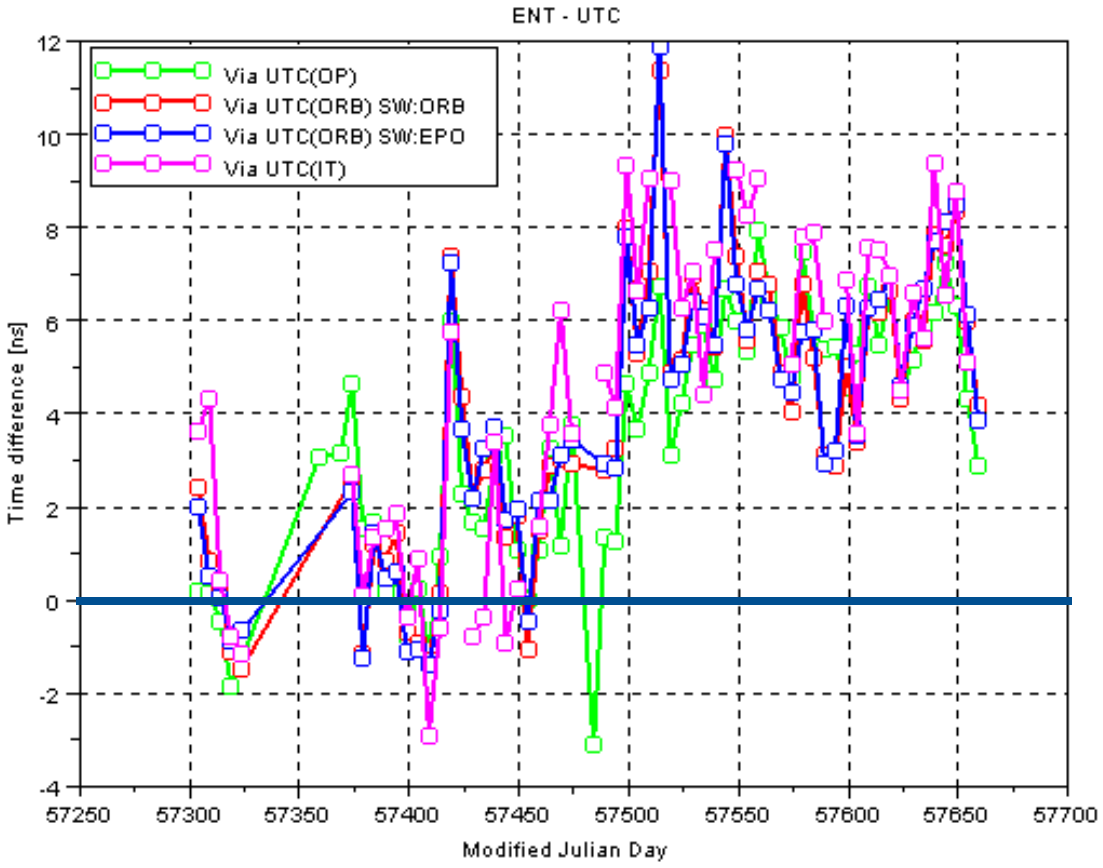
   TWSTFT

   Circular T

ENT – UTC

The different methods provide consistent results
Missing results are due to absence of MT12 (e.g. Nov 2015)

Same code color
as for ENT - ENT_{user}



ENT – GPST

ENT – GPST = ENT – UTC(OP) + UTC(OP) - GPST

Broadcast in MT12

Computed by 3 different methods :

1. = UTC(OP) - UTC + UTC - GPST

Circular T

2. = UTC(OP) – UTC(ORB) + UTC(ORB) – GPST

PPP

Using BRUX CGGTTS files

3. = UTC(OP) – UTC(IT) + UTC(IT) – GPST

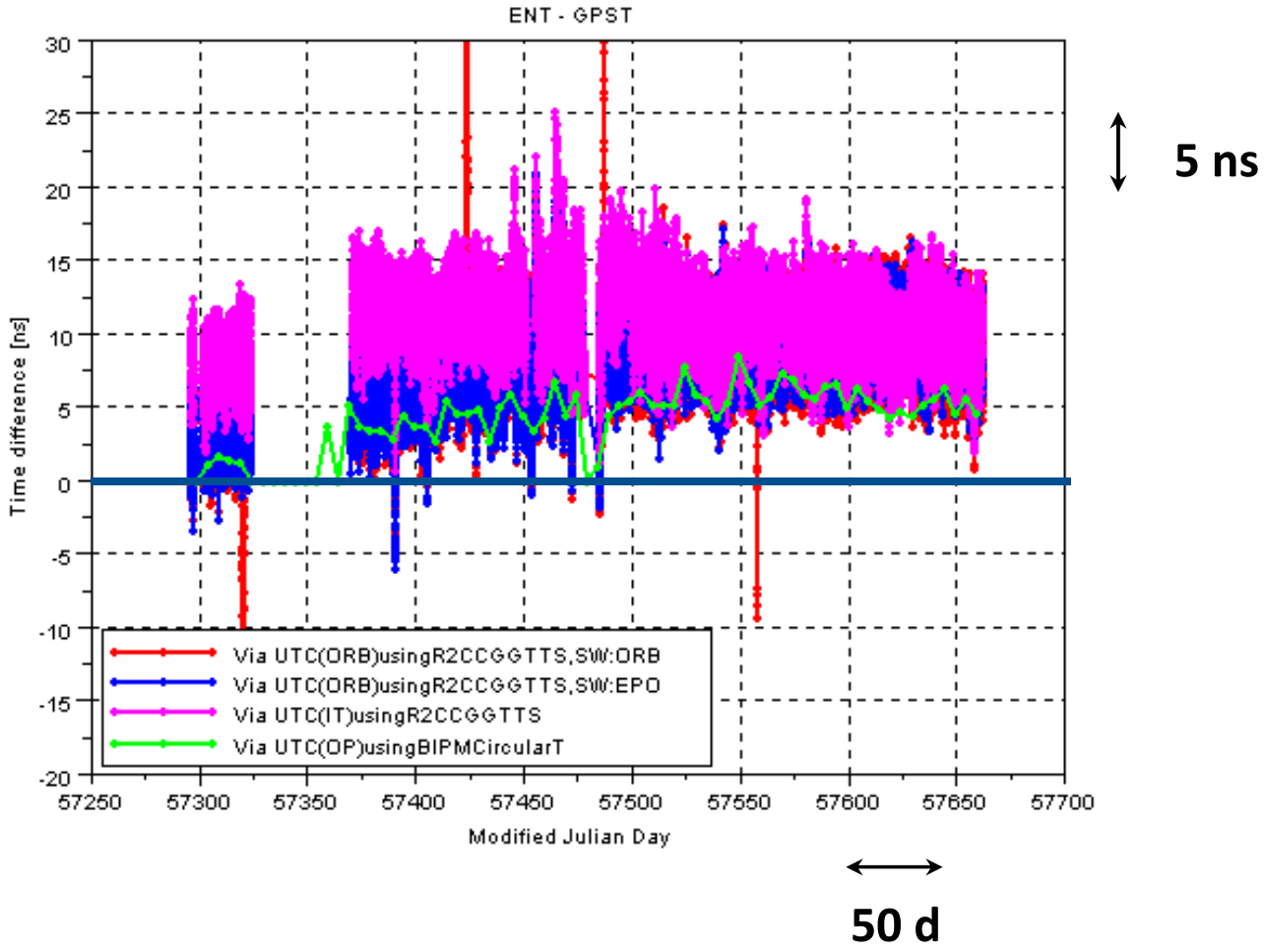
TWSTFT

Using IENG CGGTTS files

ENT – GPST

The different methods provide consistent results
Missing results are due to absence of MT12 (e.g. Nov 2015)

Same code color
as for ENT - ENT_{user}



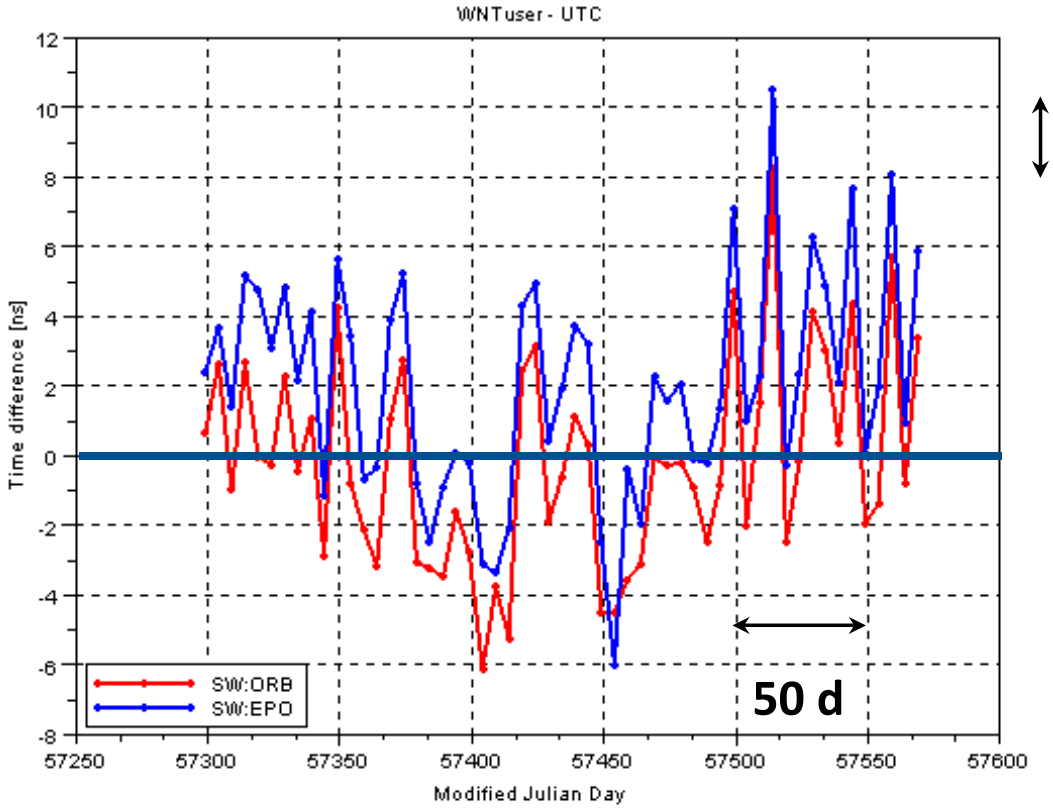
WNT_{user} – UTC

WAAS Network Time is also monitored using IGS station USN7

WNT_{user} – UTC = WNT_{user} – UTC(USNO) + UTC(USNO) – UTC

Applying WAAS corrections on USN7

Circular T

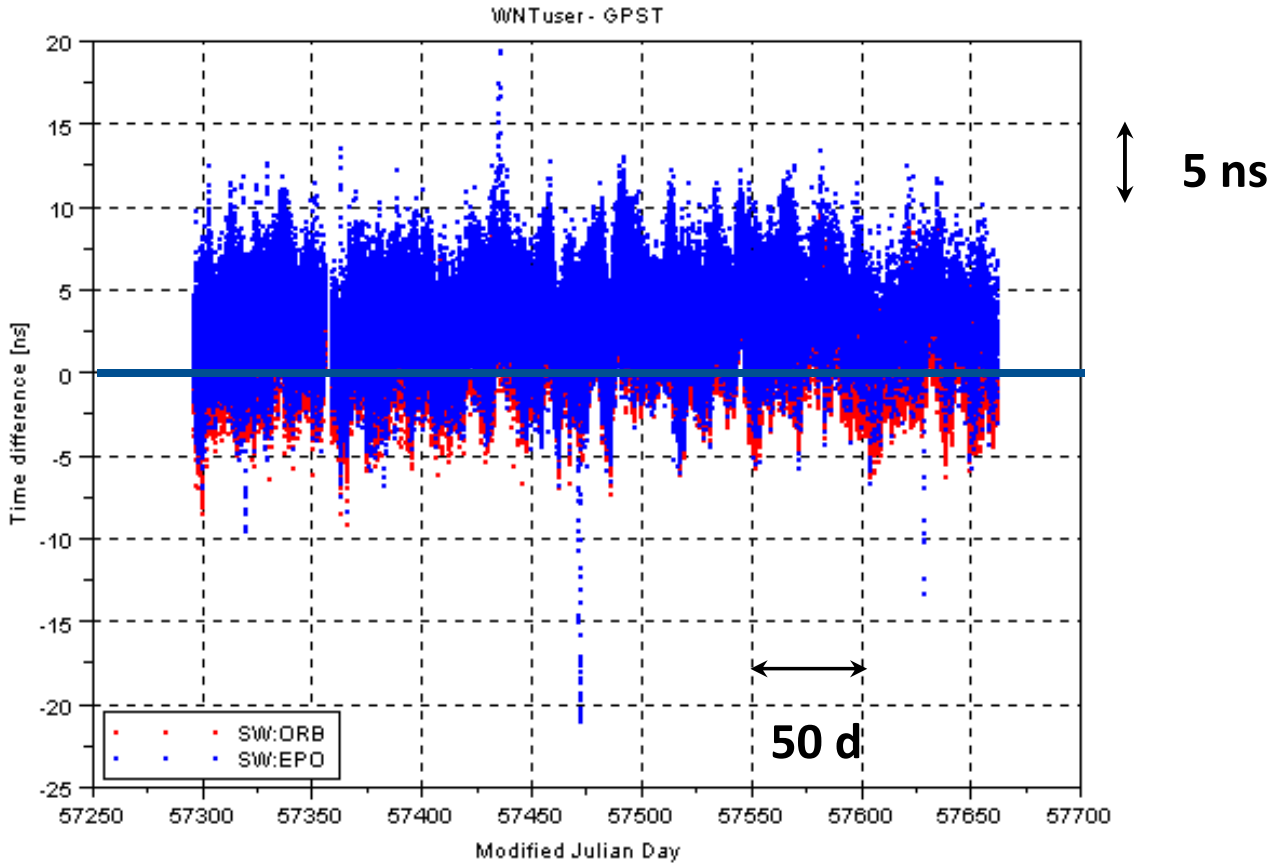


WNT_{user} – GPST

WNT_{user} – GPST = WNT_{user} – UTC(USNO) + UTC(USNO) – GPST

Applying WAAS corrections on USN7

Using USN7 CGGTTS files



Conclusions

The SPMS consortium provides an assessment of the EGNOS timing function

The MT12 (that contains ENT – UTC(OP)) has a small bias w.r.t. our estimations of ENT_{user} – UTC(OP) of ~11 ns as of now

ENT is close to UTC (and GPST) at the level of a few ns

This performance is comparable to WNT_{user}

Acknowledgments

Thanks to :

- Ester Armengou-Miret (GSA, SPMS technical officer)
- Jean Maréchal (CNES, SPMS consortium leader)

All these results have been obtained thanks to the timing team of the SPMS consortium :

- INRiM : Ilaria Sesia, Giovanna Signorile
- ORB : Pascale Defraigne, Huang Wei
- LNE-SYRTE : Pierre Uhrich
- CNES : Amale Kanj, Norbert Suard, Jérôme Delporte

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2017 Joint Conference of the EFTF & IEEE IFCS
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