



HORIZON 2020



www.demetratime.eu

This project has received funding from the **European GNSS Agency** under the **European Union's Horizon 2020** research and innovation programme under grant agreement No 640658.

DEMETRA

A Time Service Demonstrator

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on behalf of DEMETRA consortium





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Galileo is disseminating time

GALILEO STARTS TO TELL UTC, THE WORLD'S TIME



Galileo for timing

25 April 2013 Europe's four Galileo satellites are now working as clocks accurate to a few billionths of a second, disseminating the exact time through their signals expressed as the UTC Universal Coordinated Time global standard.

"A billionth of a second equals a nanosecond, a time interval far beyond our own human capacity of appreciation," explains Marco Falcone, ESA's Galileo System Manager.

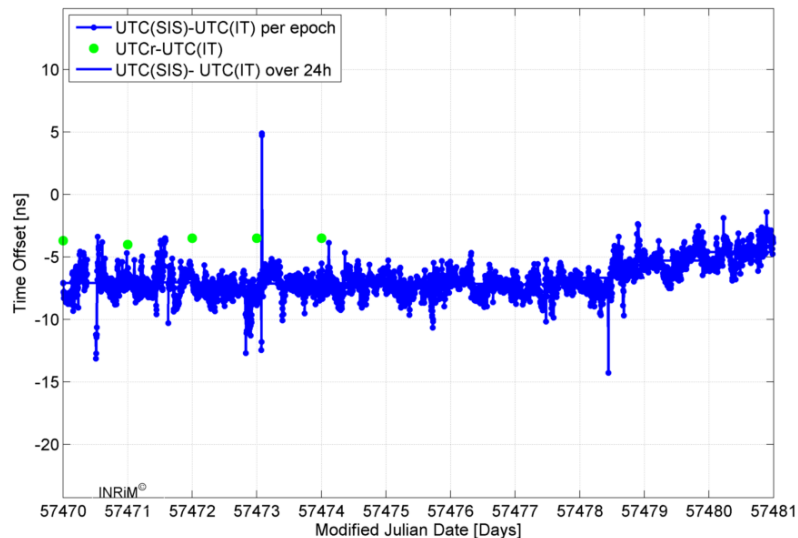
"A single lightning flash across the sky during a thunderstorm lasts about ten milliseconds, which is already 10 000 000 nanoseconds. But for high-tech applications, as well as navigation services, nanosecond accuracy is essential."



ESA press release
April 25, 2013
In Orbit Validation
Test campaign

ities/N
ill UTC

UTC(SIS)-UTC(k) Time Offset median over the constellation
from 2016-03-23 to 2016-04-02



JTC is part of all our daily lives: it is the timing used for

User can get UTC from Galileo
with about 10 nanosecond accuracy

What else is needed?

h Technische
ory in the UK,
de Paris in
Spain and



Galileo Control Centre in Fucino

time scales
estimated and provided to the Galileo
satellites for transmission in the

ue available to the user via Galileo is
e last two months it was even better,
five nanoseconds."



Time measurements in power grids

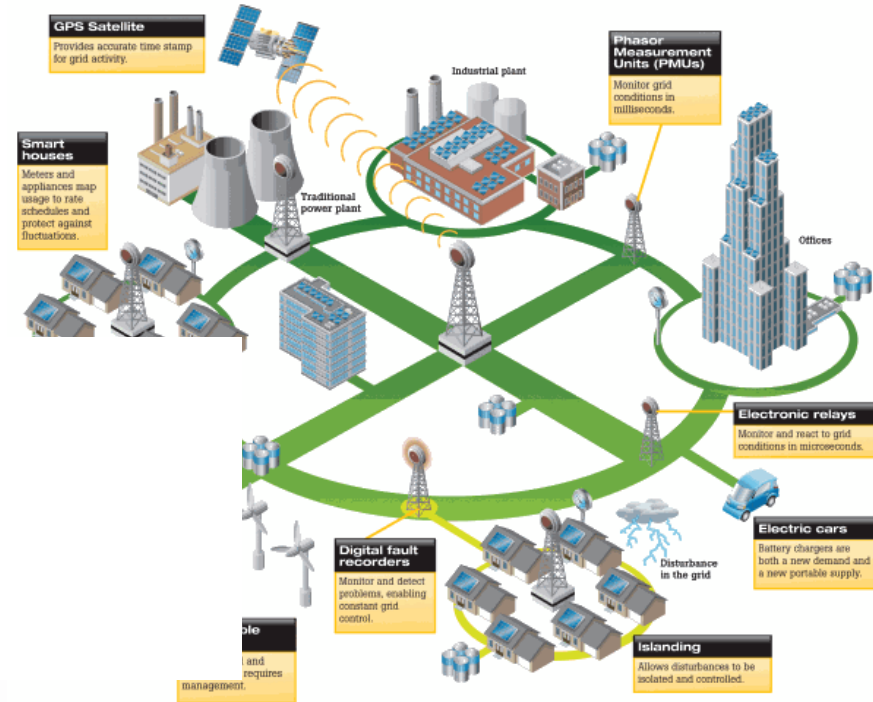


Wide area monitoring, fault location, grid real-time state information and control (Smart Grids) asks for synchronous measures.

Present timing accuracy: **1 μ s**



What is needed?
Network synchronisation
Robust resilient timing signal



Speed meters

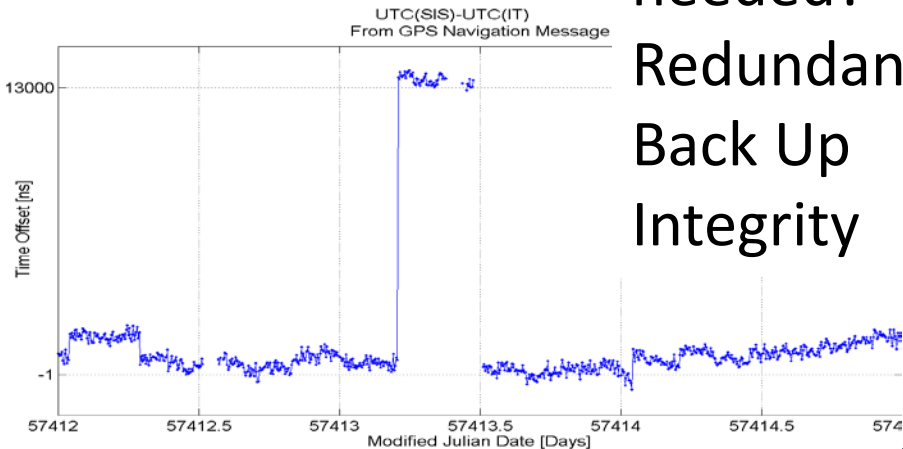
Often fines are contested as the time stamping is not proved to be correct

What is
needed?
Low accuracy
Certification
Liability



GNSS services can fail

On Jan 26, 2016 GPS transmitted a wrong time information:
13 microsec error



What is
needed?
Redundancy
Back Up
Integrity

InsideGNSS

Engineering Solutions from the Global Navigation Satellite System Community



INSIDE GNSS NEWS

GPS Glitch Caused Outages, Fueled Arguments for Backup

Latest News

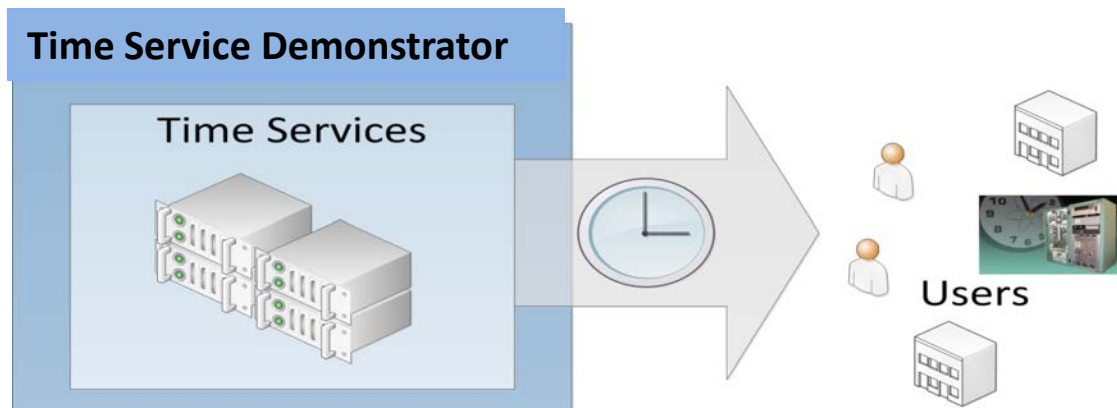
16

lashdot Technorati Twitter

nth after Europe switched off most of its Loran problem with GPS satellite timing signal is across the continent and caused an unknown ages, including the disruption of some features structure.



The DEMETRA project: a Time Service Demonstrator based on European GNSS



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accuracy

non-repudiation

resilience

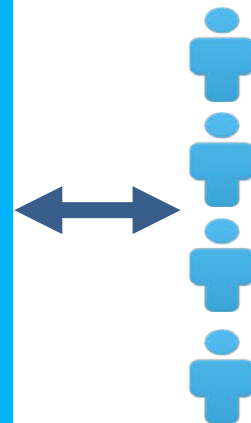
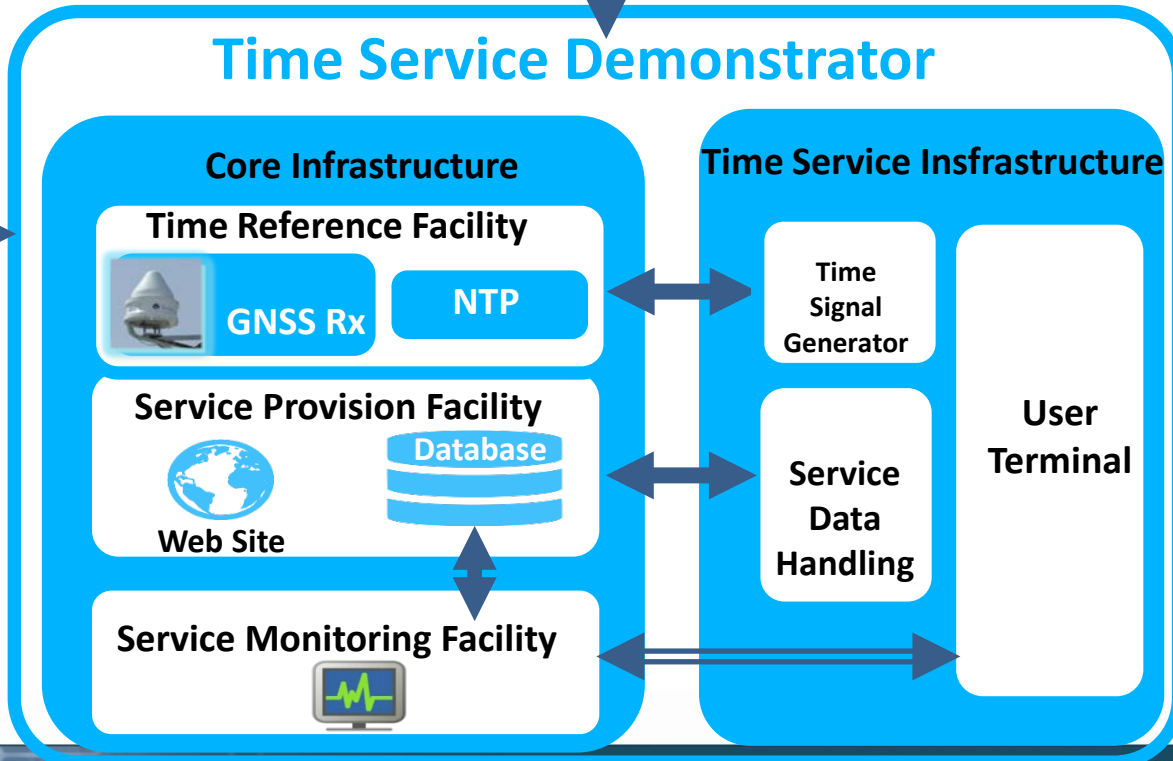
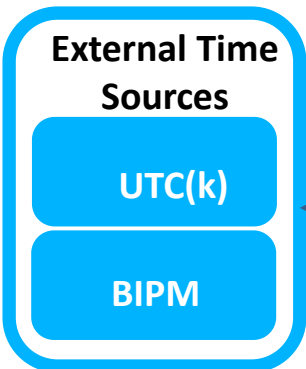
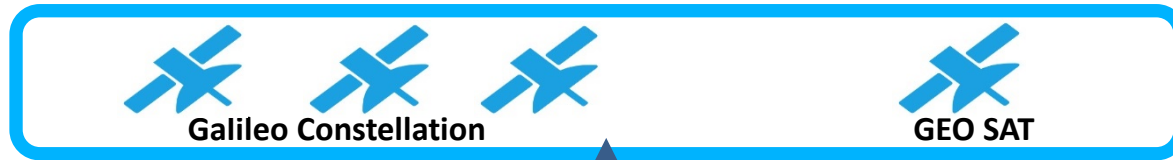
certification

steering

integrity

security

Started in
Jan 2015



Logical Link

Physical Link

Legend for link types: a single blue line represents a 'Logical Link' and a double blue line represents a 'Physical Link'.

The Time Service Demonstrator



DEMETRA is a demonstrator capable to prove time services from 'end to end', from the European GNSS to end user



DEMETRA Opening Lab
in March 4th, 2016



Demonstrator Development



- ❖ The demonstrator successfully passed the **Assembling, Integration and Validation phase** (Nov. 2015-Feb. 2016) at INRIM premises in Turin, Italy.

- ❖ Two experimentation campaign were carried out:
 - ✓ **Closed Loop Test (March-May 2016):** the User Terminal (UT) is placed in the same location of the Reference Time Generator.
 - ✓ **End to End Test (July-October 2016):** the UT is located in a real user environment to test the real advantages and feasibility of the new time services.

DEMETRA Timing Services



1

Time broadcasting over TV/Radio links

2

Certified Trusted Time Distribution using NTP

3

Time and Frequency Distribution over Optical link

4

Time and Frequency Distribution via GEO Satellite

**Alternative
back up links**

5

User GNSS Receiver Calibration

6

Certified Time Steering

7

Time Monitoring and Steering

8

Time Integrity

9

All-in-one Time Synchronization Solution

**Galileo
based**



SERVICE 01: Time Broadcasting over TV/Radio links



The service disseminates time coded information via European Radio and TV signals

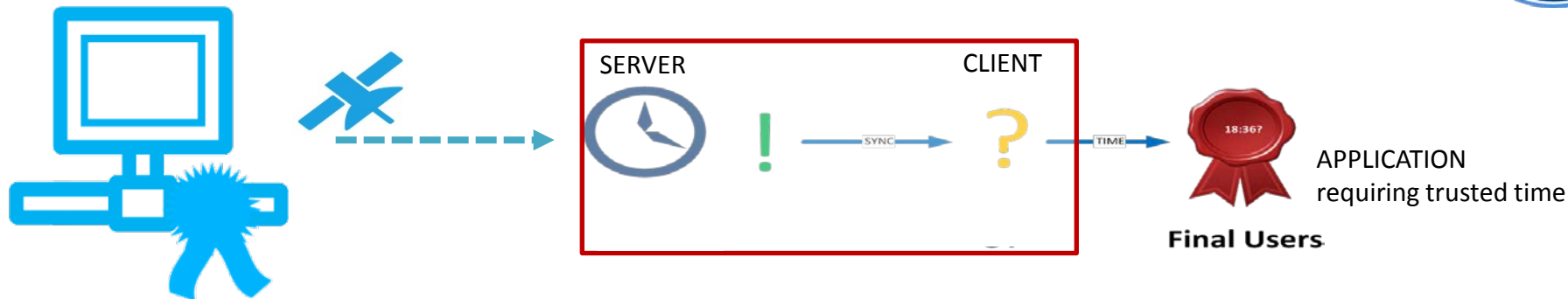
goals:

- ✓ precision of 1ms
- ✓ Standardized code time dissemination through Europe, using Digital Audio Broadcasting and Digital Video Broadcasting transmissions standards

SERVICE 01: Time Broadcasting over TV/Radio links



SERVICE 02: Certified Trusted Time Distribution using NTP



The service disseminates time with NTP protocol through the network and validates user clock performance providing a certified time service.

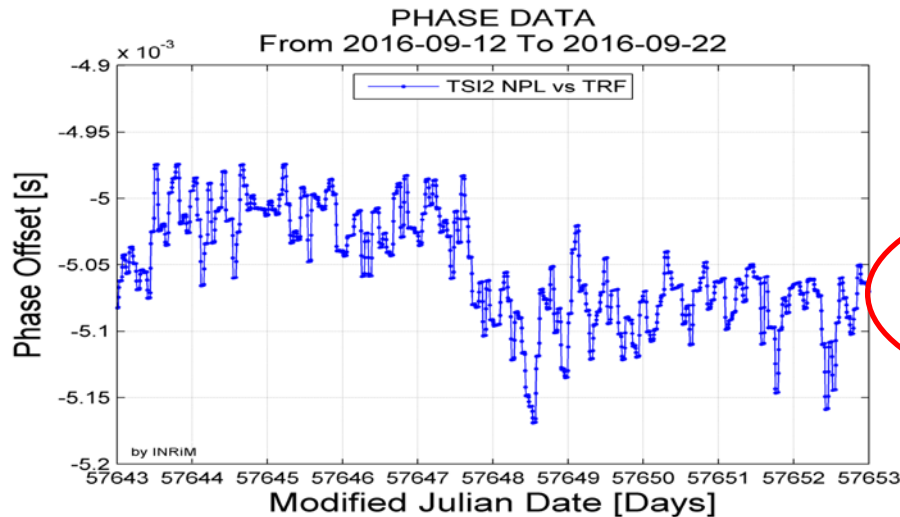
goals:

- ✓ Accuracy below 10 ms over the Internet.
- ✓ Two-way time transfer system. One-way distribution and two-way dedicated for backward time auditing, monitoring, validation and certification of UTC time at user level.
- ✓ Single source can deliver validated reference time

SERVICE 02: Certified Trusted Time Distribution using NTP



Difference between the reference time and the time received at User level



Currently under test in
Polish and Britain
metrological laboratories

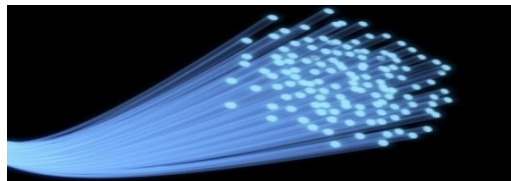
During the end-to-end campaign maximum offset error is below 7 ms.
Average value is about 5 ms.

the Service assumes to reach accuracy:

- * better than 1ms for LAN
- * better than 10ms for Internet



SERVICE 03: Time & Frequency Distribution over Optical link



High accuracy time and frequency transfer with Optical fiber with the White Rabbit method

goals:

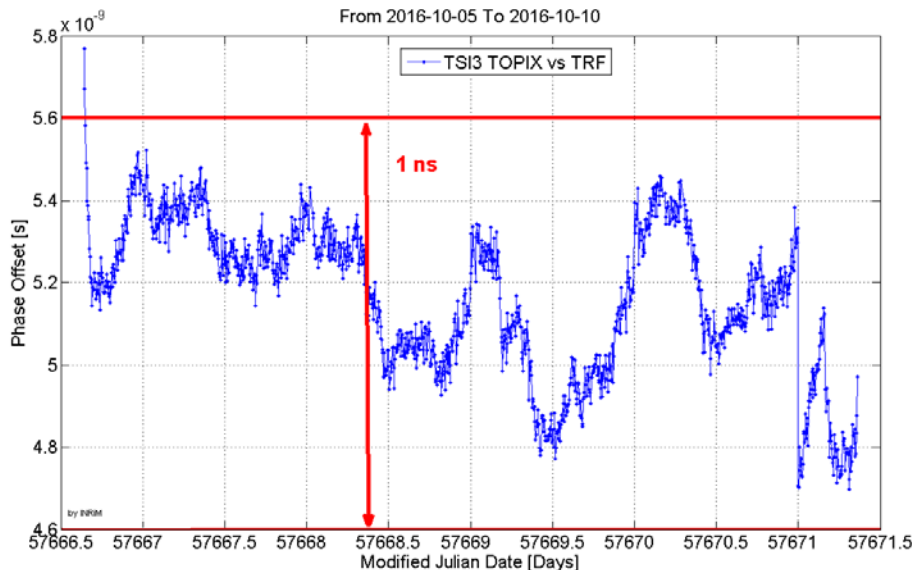
- ✓ To ensure a time accuracy below 10 ns at the user terminal.
- ✓ To provide a security enhancement as GNSS backup with anti-spoofing



SERVICE 03: Time & Frequency Distribution over Optical link



**Difference between the reference time and
the time received at User level**



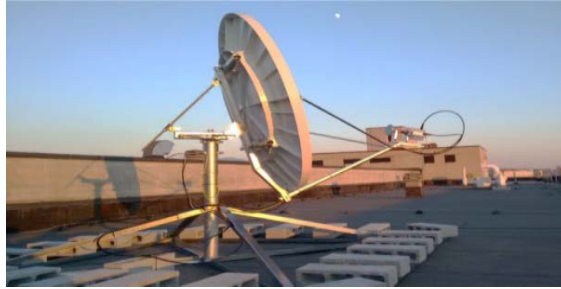
The White Rabbit time dissemination on optical fiber is tested proving the capacity of the system to disseminate time at sub-nanosecond level.

**Phase Offset between
disseminated and received time
less than 1 ns**

Currently under test in the
Italian financial district in
Milano



SERVICE 04: Time & Frequency Distribution via GEO Satellite

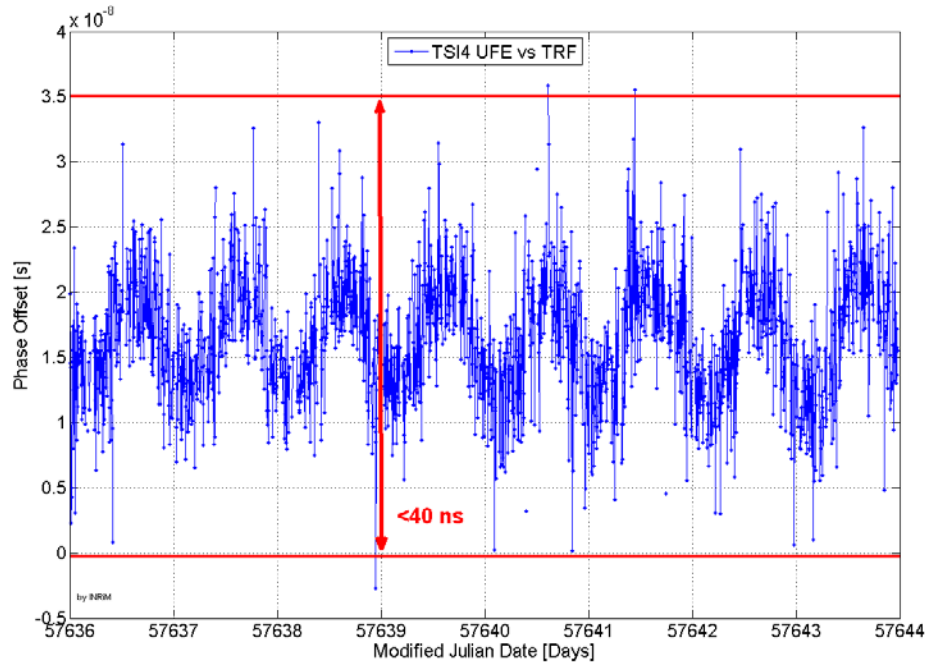


goals:

- ✓ Based on a geostationary satellite (any GEO is suitable, e.g. commercial sat) -> versatility
- ✓ Provides technological redundancy to GNSS systems -> increases robustness of Galileo
- ✓ Accuracy ~100ns
- ✓ UT equipment: 1 subrack and 1 rx antenna



SERVICE 04: Time & Frequency Distribution via GEO Satellite



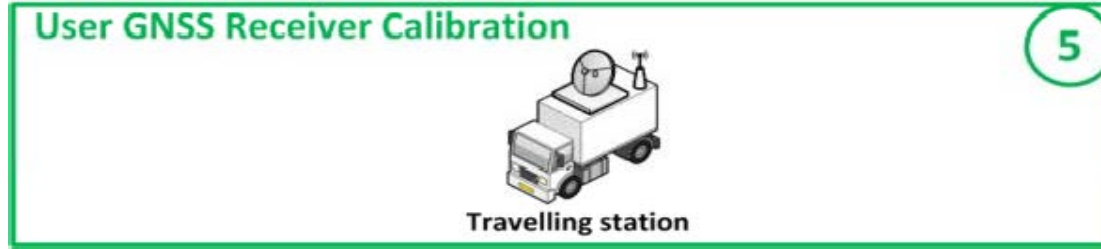
Difference between the reference time and the time received at User level after having travelled to a GEO satellite and down to the user

is within 40ns

Currently under test in the Italian RAI and Mediaset broadcasting companies



SERVICE 05: User GNSS Receiver Calibration



High accuracy European GNSS timing with "absolute" and "relative" receiver calibration providing the first calibration procedures for **Galileo receivers**

For both GPS and Galileo signals

Absolute calibration by CNES

Using a simulator of GNSS signals,
measuring the hardware delays

Uncertainty : 1 ns

Relative calibration by ORB

The user station and the reference
station are put in common-clock.

Uncertainty: 3 ns



SERVICE 06: Certified Time Steering



computer

oscillator

receiver

The service allows the traceability and steering to UTC of GNSS user clock, together with trusted health information about user terminal equipment.

Goals → **Real Time Certified Galileo Disciplined Oscillator**

- ✓ User oscillator remotely disciplined (in TIME and FREQUENCY) in real-time on the reference time
- ✓ Issue **certificate** with time and frequency offset of the user oscillator with respect to the reference
 - hence traceability to the Universal Time Coordinated (UTC).
- ✓ Based on processing of **Galileo** observations from the user and the reference



DEMETRA CALIBRATION CERTIFICATE (TSI#6-001/2015)

This certificated is issued:

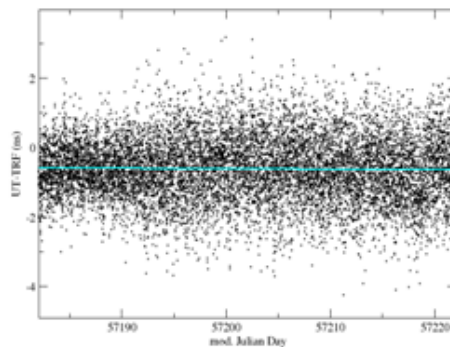
to XXXX, located in (to fill with the address)

by TSI#6 in the frame of the DEMETRA Time Service Demonstrator installed at INRIM premises, Strada delle Cacce 91, 10135, Torino;

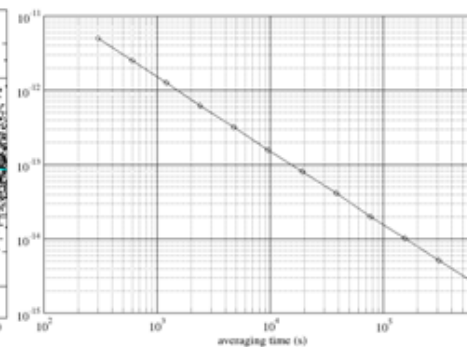
SERVICE 06: Certified Time Steering

With this documentation is certified that the oscillator XXXX (SN-XXXX) operated by XXXX on temperature controlled environment ($t=23 \pm 0.5$ °C) is steered on the DEMETRA TSD Reference Time applying a Common View Method [1] based on real-time common view of GNSS measurements, allowing the traceability to UTC(*).

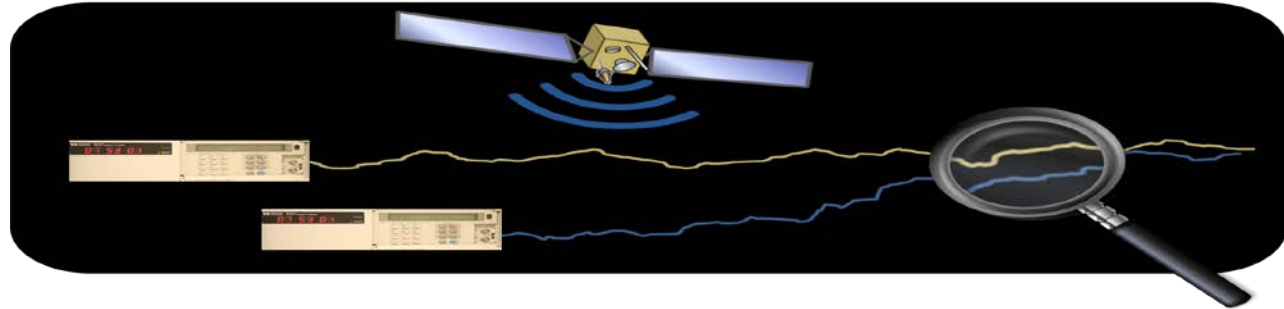
Synchronization Error



Allan Deviation



SERVICE 07: Time Monitoring and Steering

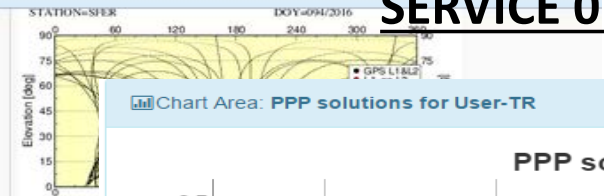


The service offers a near real time monitoring of remote clocks connected to a GNSS receiver. In addition the user receives information on the necessary steering corrections to keep the clock aligned to UTC

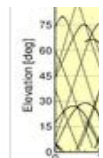
goals:

- ✓ Monitor in real-time the atomic clock of the user from GNSS data analysis
- ✓ Monitor the GNSS station of the user, provide Key Perfo Indicators
- ✓ Provide to the user steering parameters to keep its clock aligned on UTC
- ✓ Provide to the user the prediction of its (clock-UTC) in the following days

SERVICE 07: Time Monitoring and Steering



Satell



Sat

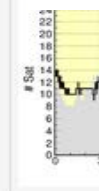
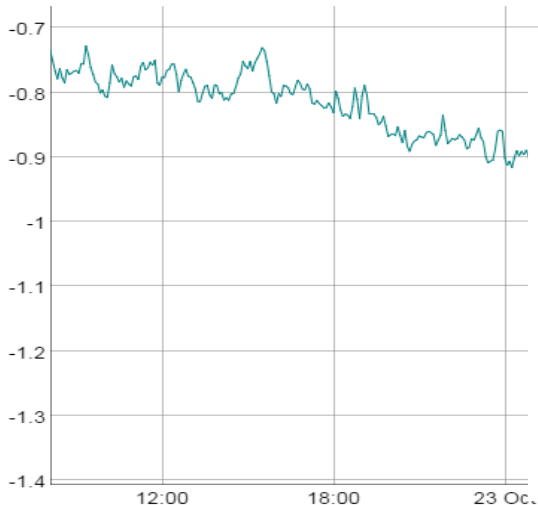


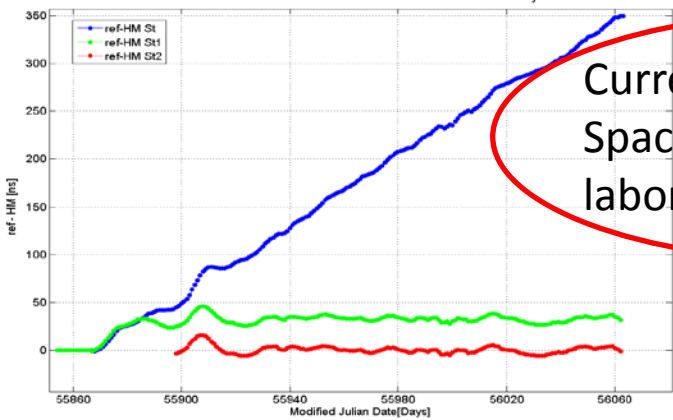
Chart Area: PPP solutions for User-TR

PPP solutions for User-TR [Nanoseconds]



Steering algorithm

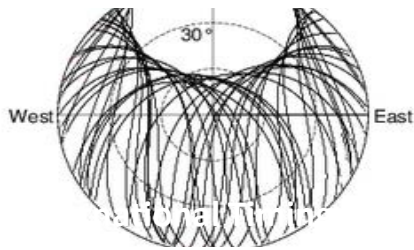
Simulation of INRIM HM steered from October 2011 to May 2012



Currently under test in EU Space Agencies, National laboratories

TI [Number of observed satellites](#)

al
e'



Clock PPP monitoring, steering correction and GNSS performance evaluation by a geodetic station performances



SERVICE 08: Time Integrity



The service provides to the GNSS user timing information, complementary to broadcast Navigation Message data, allowing user positioning and timing accuracy improvements

goals:

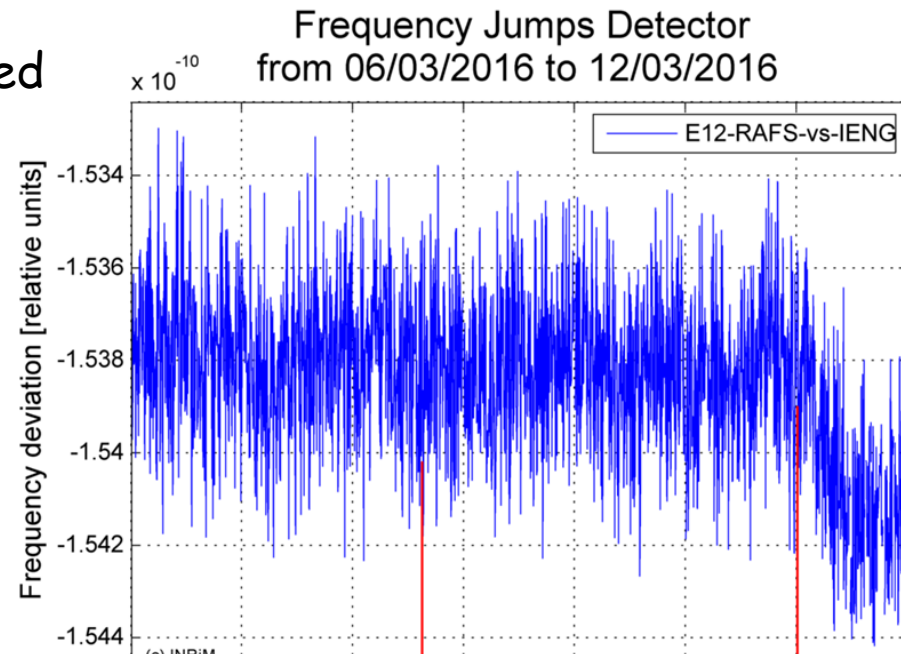
- ✓ Based on Galileo signals
- ✓ Aims to improve user positioning and timing accuracy
- ✓ First step testing a Galileo time integrity service



The Integrity service check for possible anomalies in the Galileo transmission of GGTO and UTC

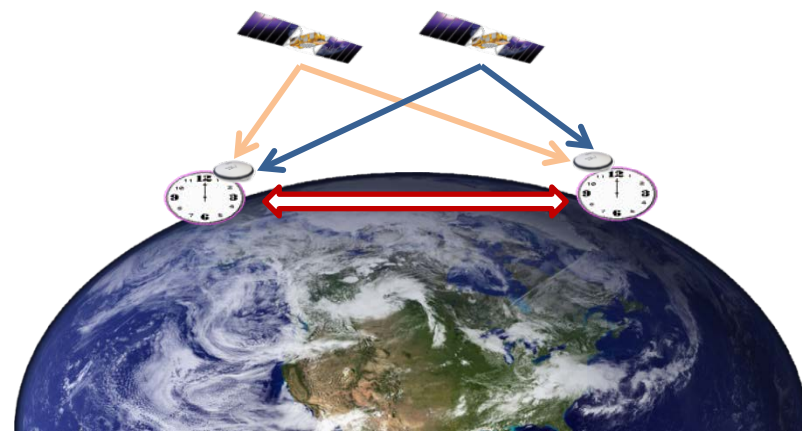
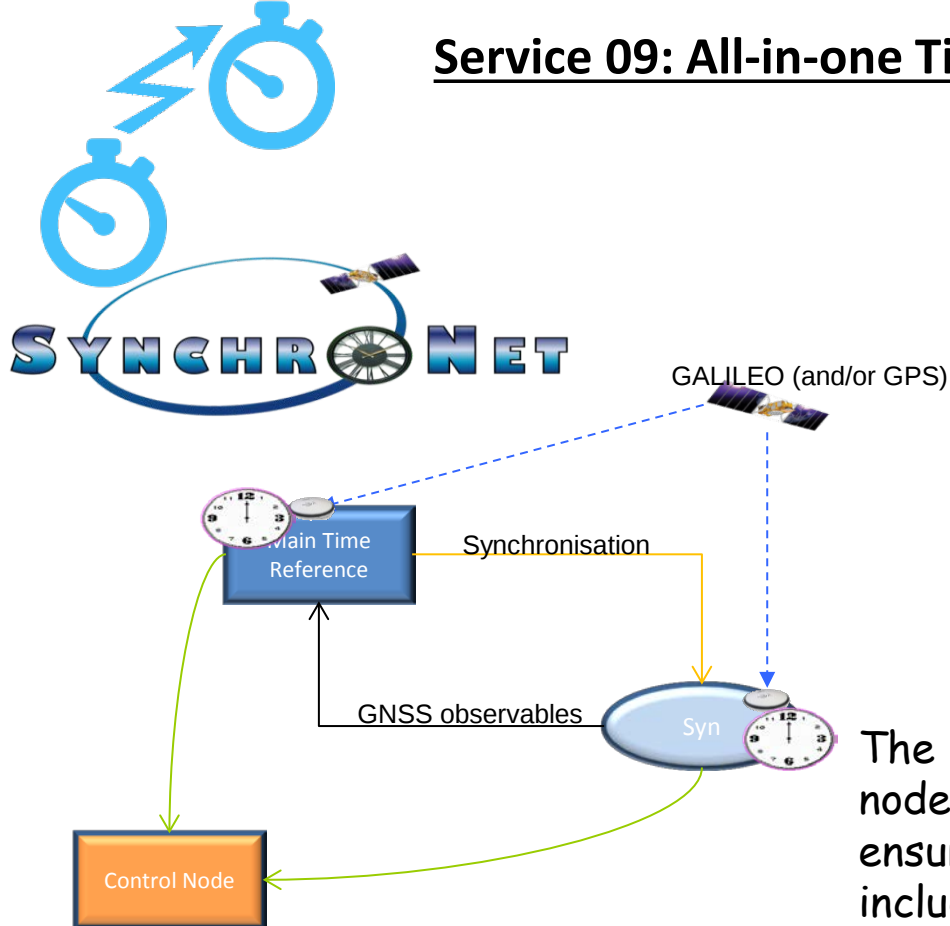
In case of discrepancy the user is alerted

A list of not usable satellite is produced in case of anomalies detected on space clocks



###SVN###	###MJD###	#####DATE#####	###AMPLITUDE###	###UNITS###	###DETECTED ANOMALY##
E12	57455.6285	2016-03-08 15:05:00	4.72e-13	[rel.units]	Frequency Jump
E12	57459.0035	2016-03-12 00:05:00	4.86e-13	[rel.units]	Frequency Jump
E19	57456.0000	2016-03-09 00:00:00	3.22e-09	[seconds]	Phase Jump

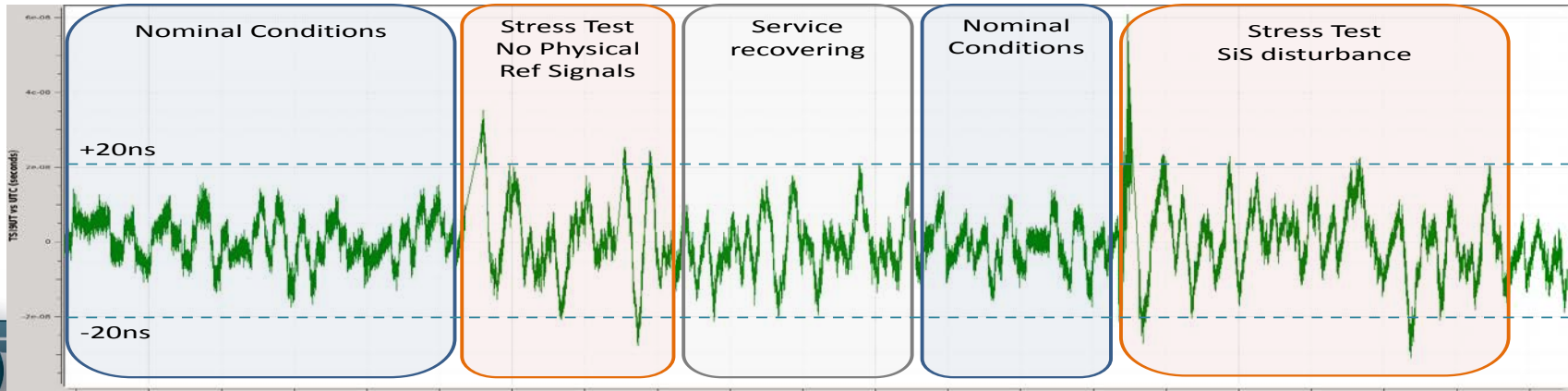
Service 09: All-in-one Time Synchronization Solution



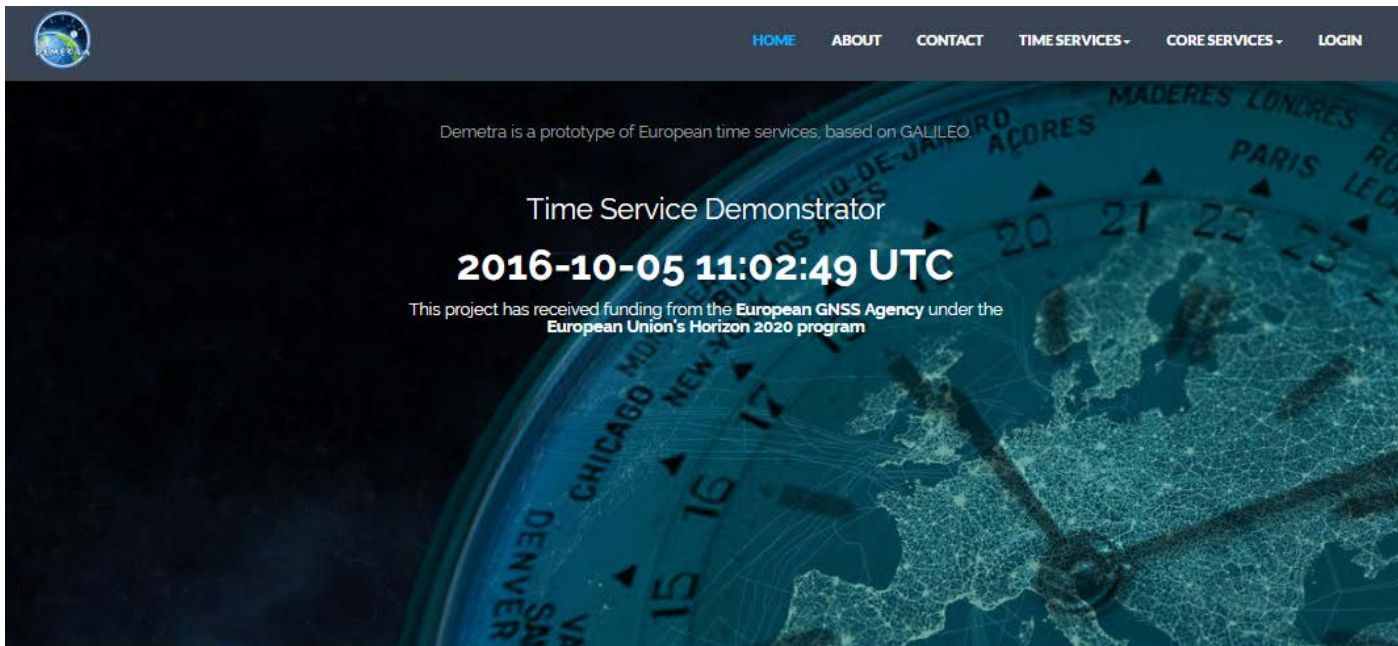
The service is designed for a scalable network of nodes based on GNSS (GPS and Galileo) receivers ensuring high performances, high availability and including integrity and overall status monitoring



- ✓ **Availability:** can compensate/mitigate effects of downtime of GNSS (also in case of jamming or spoofing) as well as of ground network used for data exchange
- ✓ **Accuracy:** below 10 ns with a predictive clock model
- ✓ **Stability:** up to $<10^{-14}$ ADEV @24h
- ✓ **Integrity and monitoring:** continuous monitoring of functions and performances
- ✓ **Integration and security:** All nodes communicate over encrypted tunnels that guarantee authenticity and secrecy. Integrity provided as additional layer



Demetra Webpage



The main parts are:

- Public site for general information.
- Private site for TS subscriber users.

<https://www.demetratime.eu>



App & Social Networks



*And find more on Android
with the DEMETRA application*



More info on demetratime.eu



***Come to see us at
the DEMETRA booth***

