Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Timing Services Based on European GNSS

Session 3: Timing Security, Resilience and GNSS Issues

Wednesday, May 20, 2020
10:00 a.m. - 12:00 p.m. ET

Sponsored by: MEINBERG

Andreas Bauch, WG Time Dissemination

Timing Services Based on European GNSS

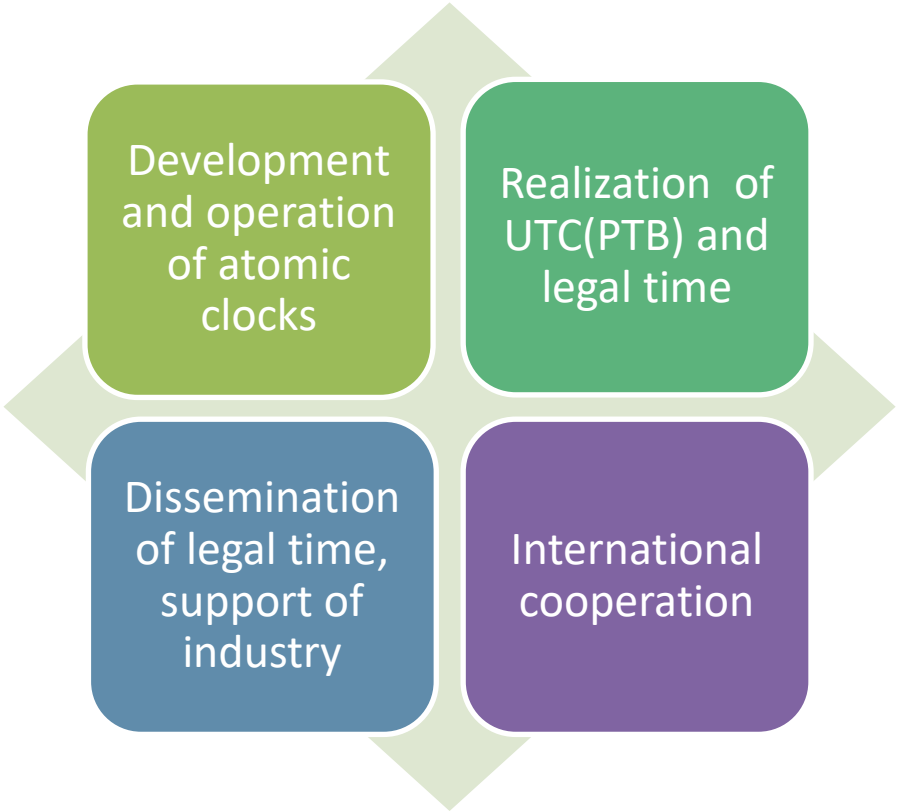
- Introduction
- Motivation
- EU project EGALITE
- Conclusions

Andreas Bauch (*1957)
Physicist, PhD

In PTB since 1983, today Head, Time Dissemination WG; Involved in Galileo projects with ESA, EU, GSA since 2002

PTB : its role and its involvement in T&F

- National Metrology Institute, since 1887
- Headquarter in Braunschweig, roots in Berlin where a second site still exists.
- Federal Ministry for Economy and Energy
- 1850 staff, 180 Mio. € budget



Motivation

Many applications require assured >*access*< to accurate >*time*<

?? time unit (frequency), 1PPS epoch or Time-of-Day, ??

for making measurements or for date/time stamping
traceable to international or/and legal standards.

GNSS reception is predominant in many fields, but is it
assured ?
accurate ?
sufficient to obtain traceability ?

Motivation

Many applications require assured >*access*< to accurate >*time*<

GNSS reception is predominant in many fields, but is it
assured ? (safe, secured, trustworthy,…) is not my topic

Motivation

Many applications require assured >*access*< to accurate >*time*<

GNSS reception is predominant in many fields, but is it

accurate ? revolutionized time-keeping decades ago, still „technically“ better than many user requirements

Motivation

Many applications require assured >*access*< to accurate >*time*<

GNSS reception is predominant in many fields, but is it

sufficient to obtain traceability ?

This is where rules of metrology come into play.

Motivation

Traceability is relevant for both, making measurements and for time/date stamping, defined in the VIM* as

„property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations ((comparisons)), each contributing to the measurement uncertainty.”

Each of the highlighted words would deserve a detailed discussion.

In short: The metrological community feels confident that reception and processing of GNSS signals alone does not provide traceability as defined above (Matsakis et al.*, Piester et al.*).

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* References given on last slide

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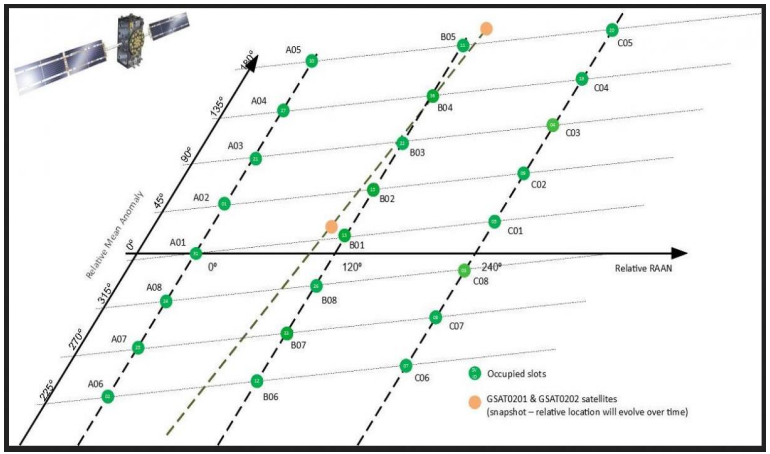
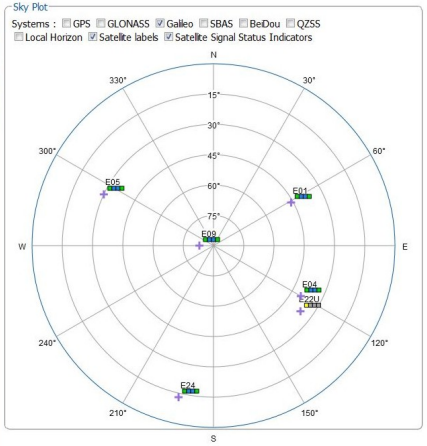
The use of European GNSS



Galileo – the European GNSS

- Initial Services officially announced December 2016
- Minimum Performance Level (MPL) according to OS Service Definition Document* (OS SDD 2019)

- EU and GSA interested in the optimal exploitation of the Galileo services for European users

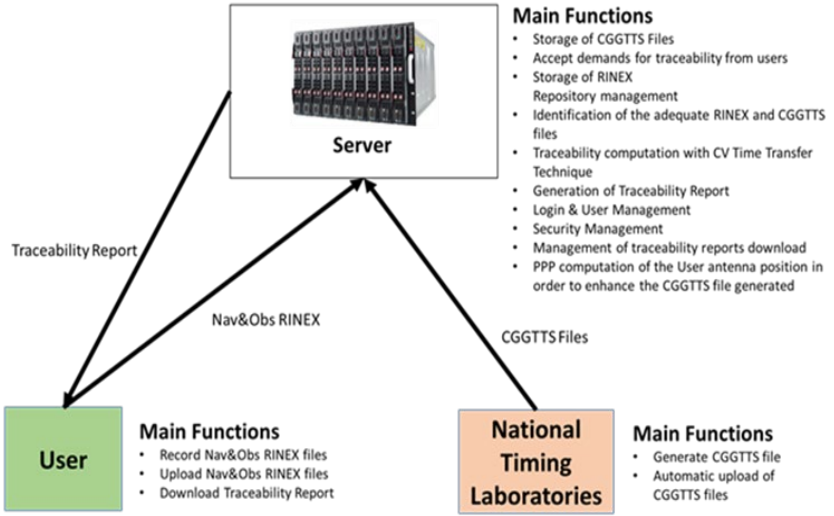


EGNOS and Galileo Timing Service Extension and Consolidation

Funding by EC under H2020 framework program
Studied the feasibility of dedicated **Timing Services** based on **Galileo**

EU project EGALITE

* **proposal 1**: Service to obtain legal traceability



- CGGTTS files provided periodically by the NMIs in EU in an automatic way.
- GNSS raw data (in RINEX format) provided by the users of the Service.
- Traceability reports would be disseminated to the users and stored in the Server.

- The service is proposed for both GPS and Galileo users with low cost timing receivers with either Dual or Single Frequency equipment
- Similar to service offered by NIST .

- No decision for its implementation in the short term

EU project EGALITE

Second proposed Timing Service:

- Based on **Timing Integrity Monitoring Stations**
  Measurements processed by a Timing Service Processing Facility which would disseminate **timing flags** to the users in the Galileo Signal-In-Space for indicating Use/Not Use Galileo satellites for timing applications
- Additional measures at receiver level are proposed such as **T-RAIM**, **Holdover**, and calibration, etc.

➢ TS would provide **end-to-end committed performances** to the users; Timing receivers to be developed according to dedicated standard.

EU project EGALITE

Result of questionaire 2018/2019 among EU members:

- In all European Union de facto time is obeyed as
  UTC, UTC+1h, UTC+2h or UTC+3h, respectively, including daylight saving time.
- In some countries, legal time is defined but
  - no institute is given the task to realize it,
  - no institute has a legal mandate to disseminate legal time.

- Practically all European institutes that pursue a T+F-activity disseminate time-of-day information (i. e. UTC) via the public Internet using the protocol NTP.

- Technical means of dissemination are not mentioned in any legal document, in particular GNSS (or GPS) is not mentioned anywhere.

EU project EGALITE

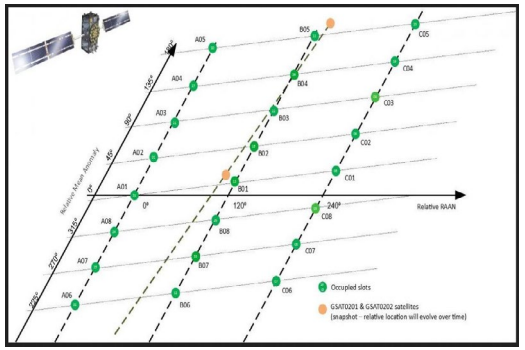
Result of questionaire 2018/2019 among EU members:

- Reception of GPS is used in countless applications for access to (legal) time - irrespective of existing laws:
- i. e. TOD in UTC through Week Number, Seconds of Week, Leap Second count.

  Galileo is “known”, but not yet widely used.
- EGNOS is of minor relevance in the T+F community.

The use of European GNSS

It is widely accepted not to use GNSS system times, but the predictions
GST – UTC (for Galileo) or GPStime – UTC(USNO),
which are broadcast in the respective navigation messages.



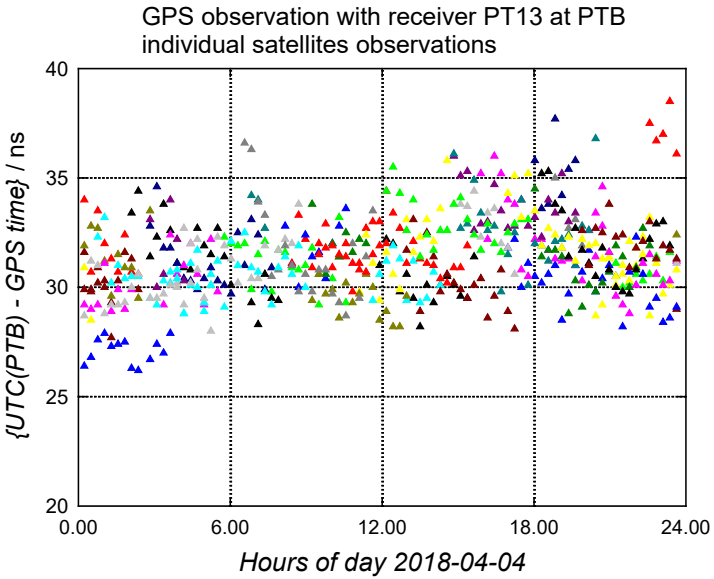
But

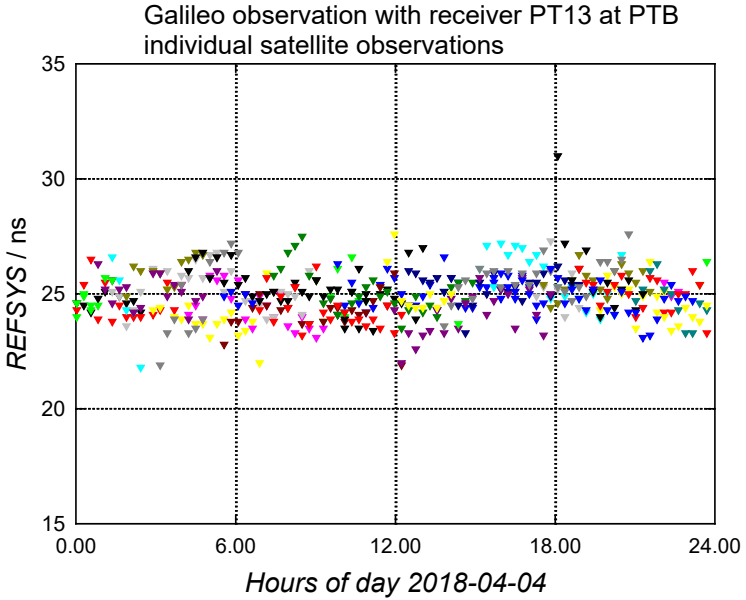
OS SDD Table 11 provides MPL for GST – UTC prediction

- ❖ Missing traceability: how is GST constructed, how is the prediction made?
- OS SDD Table 18 implicitly fixes MPL for clock model SV-GST to an almost negligible value (??)
- ❖ Missing traceability: algorithm? description?
- Proposals made to improve documentation for facilitating traceability

- Work to be continued in CCTF Task force on GNSS traceability, starting 2020

The use of European GNSS… brings advantages!





Better clock and orbit predicition,
Improved „NeQuick“ ionosphere model* for single frequency users..

Timing Services Based on European GNSS

Conclusions regarding professional applications of (legal) time:

a) Make a clear distinction between

- ♦ Time interval / frequency (unit of time)
- ♦ mutual synchronization within a network / system
- ♦ synchronization with respect to UTC
- ♦ Time of Day (TOD) according to legal time

b) Clearly differentiate between

- ♦ legal prescription (as German TeleKommunikationsGesetz)
- ♦ prescription due to EU regulations (like MIFID / RTS25)
- ♦ technical requirements in critical infrastructure applications

Timing Services Based on European GNSS

Conclusions regarding professional applications of (legal) time:

- There are ways to make measurement results traceable in the sense of the VIM:
- Recommendation to retrieve and analyze GNSS signal monitoring results from NMIs or other resources.
  Example: PTB public data repository and Time Service Bulletin*
- Recommendation to get signal delays in the receiver calibrated whenever epoch (accurate time synchronization) matters.

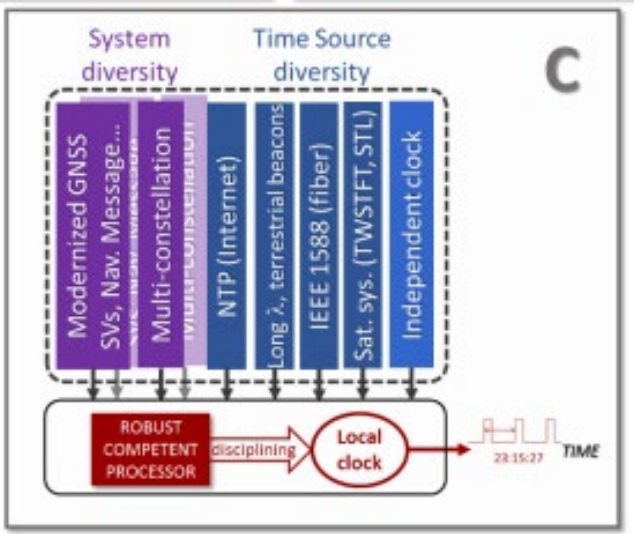
Timing Services Based on European GNSS

Conclusions regarding professional applications of (legal) time:

Final Recommendations:

- No <u>single</u> source of timing should be recommended for use in critical infrastructures.
- Promote use of redundant timing information, delivered via diverse routes, i.e.
- Integrate
  - fiber-based signals via public or private network (NTP, PTP, WR),
  - radio-signals, good clocks for hold-over

  in exacting timing systems.



Schematics of the competent processor, source NIST

Timing Services Based on European GNSS

Feel free to contact me at andreas.bauch@ptb.de
See our website at www.ptb.de/time

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List of references

Joint Committee for Guides in Metrology, “International vocabulary of metrology – Basic and general concepts and associated terms (VIM), 3rd Edition”, JCGM 200:2012, JCGM, 2012.

D. Matsakis, J. Levine, and M. A. Lombardi, “Metrological and legal traceability of time signals “, Proc. 2018 ION PTTI, Reston, Virginia, pp. 59-71

D. Piester et al., „Disciplined Oscillators for Traceable Frequency and Time in Metrology and Financial Sectors”, Navigation, vol. 66, 2019, pp. 661-671.

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European GNSS (Galileo) Open Service Service Definition Document (OS SDD) 05/2019

D. Piester et al., “PTB’s Time and Frequency Services 2018 – 2019”, Proc. 2020 ION PTTI, San Diego, CA

J. Fidalgo et al., “Proposal for the Definition of a European GNSS Timing Service”, Proc. ION 2019

European GNSS (Galileo) Open Service: Ionospheric Correction Algorithm for Galileo Single Frequency Users, European Commission, 2015

Links:

https://www.gsc-europa.eu/system-service-status/orbital-and-technical-parameters

ftp://ftp.ptb.de/pub/time/GNSS