Certification of EGNSS Timing Receivers and Services

Roland Bauernfeind, NavCert

5th of April 2017

Project: Advanced Mission Concepts: R&D for robust EGNSS Timing Services

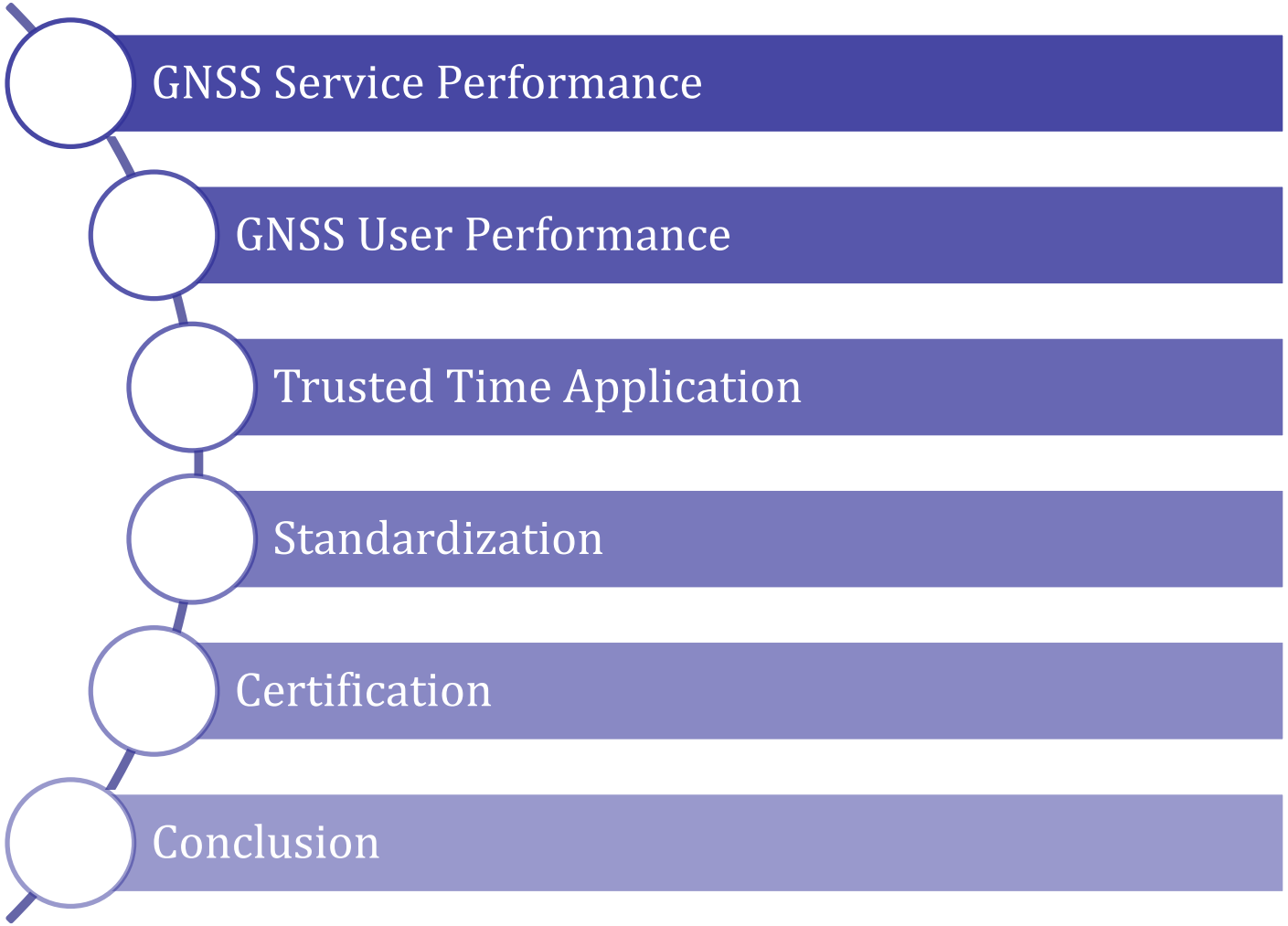
Funded by the European Union

Robust EGNSS Timing Services Project

- **Netherlands Aerospace Centre (NLR)**
  Consortium lead
- **Finnish Geospatial Research Institute (FGI)**
  Concept development, testing environment
- **Dutch Metrology Institute (VSL)**
  Synchronisation service, business case
- **VTT MIKES Metrology**
  Synchronisation service, testing, timing receivers, business case
- **NavCert GmbH**
  Standardisation and Certification
  - Development of standardization roadmap
  - Definition of possible certification schemes based on analysis of stakeholder's opinions

➢ Funding: European Commission – DG GROW

Content



GNSS Service Performance

- The levels of technical performance that users can expect from GPS is specified within
  - GPS Standard Positioning Service (SPS) Performance Standard
  - GPS Wide Area Augmentation System (WAAS) Performance Standard
  - GPS Civil Monitoring Performance Specification
- Galileo services performance is specified within Galileo Service Definition Documents

- Unified standards for GNSS open services performance parameter standards (PPS) are under development, originating from GPS Performance Standard & Specification Documents (ICG WG A)

- Ongoing definition of Features as additional Services like the GNSS Space Service Volume

➢ **Goal to establishing a specific Galileo and EGNOS Timing Service (TS) with associated performance requirements**
  - Todays accuracy is more than sufficient for the majority of the current timing applications
  - Focus on providing robustness and trust

GNSS Service Performance

- GNSS time determination capability is a feature of current positioning portfolio of services, e.g.
  - **Galileo**
    - Open Service (OS)
    - Commercial Service – High Accuracy (CS-HA)
  - **EGNOS**
    - Open Service (OS)
    - Safety of Life (SoL) Service

➢ Performance specifications only for the **Galileo Signal in Space (SiS) UTC Time/Frequency Dissemination Accuracy**, not for the user receiver time solution

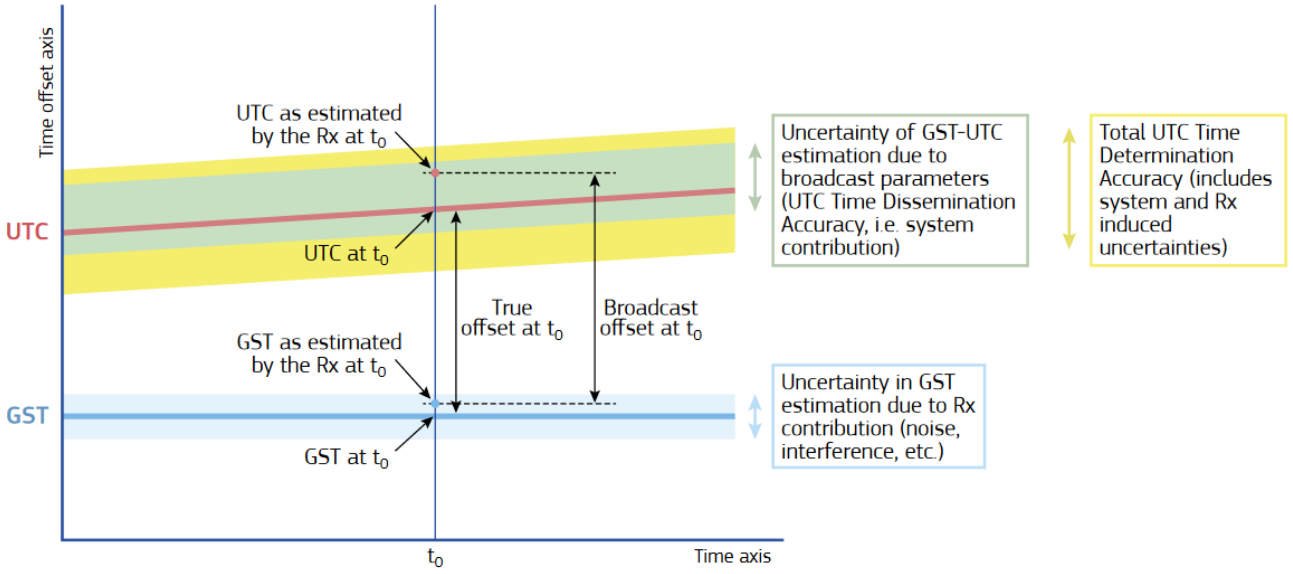


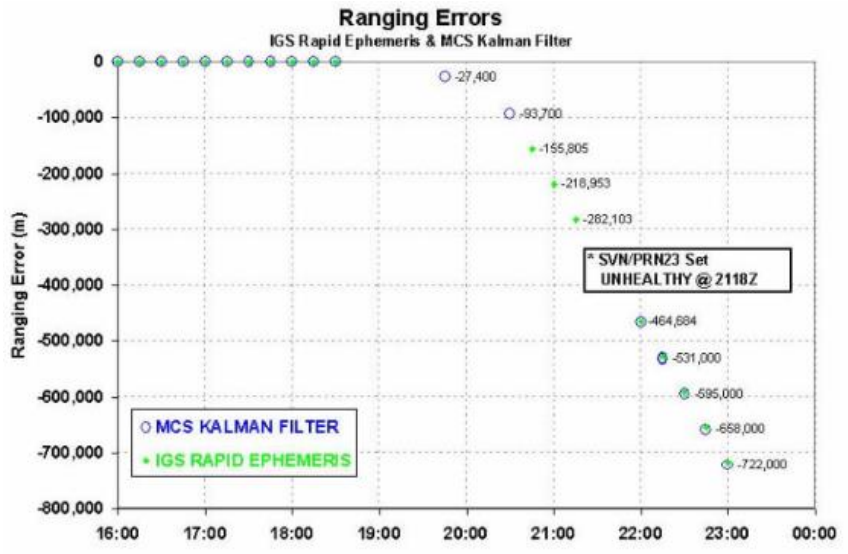
Figure: Graphical representation of the various components of the UTC time determination Accuracy.

Source: Galileo Initial Services, Open Service, Service Definition Document

GNSS Service Performance

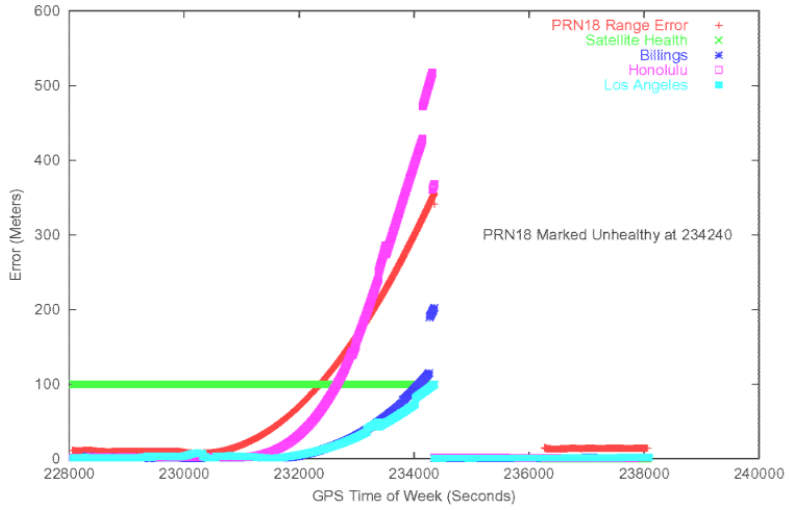
- GPS history shows high dependability, however signal-in-space integrity failures may occur, e.g.
  - PRN 23 Clock Failure, 1st of January 2004
  - PRN 18 Satellite manoeuver without navigation message flag, 10th of April 2007
  - PRN 32 (SVN 23) UTC time glitch, 26th of January 2016

PRN 23:



Source: Anne-Laure Vogel et. al. „Effect of a GPS Anomaly on Different GNSS Receivers“

PRN 18:



Source: Nathan Vary „WAAS Technical Report DR# 55 “

➢ Integrity Framework can protect applications from these Faults

GNSS Service Performance

- Aviation developed a very challenging integrity framework, augmentation of GPS C/A service
  - ICAO Standards and Recommended Practices (SARPS) Annex10 Volume I (Radio Navigation Aids)
    - Appendix B Detailed Technical Specifications for the Global Navigation Satellite System (GNSS)

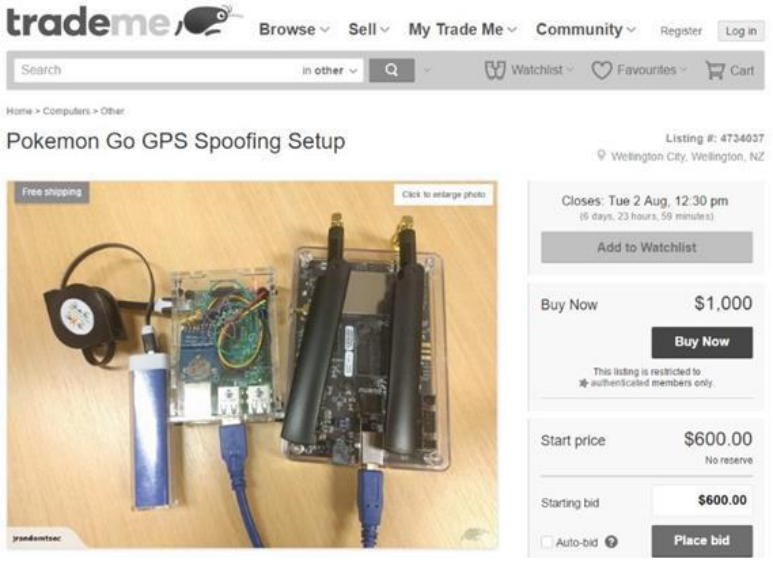
- EGNOS, initially 33 Ranging and Integrity Monitoring Stations (RIMS) in Europe
- LPV-200, decision height of 200 feet (61 m), Vertical Alert Limit = 35 m
  - GSA declared the EGNOS LPV-200 service operational on 29 September 2015
  - First LPV-200 approaches were implemented at Paris Charles de Gaulle Airport (LFPG) on 3 May 2016

Source: www.gsa.europa.eu/news/first-egnos-lpv-200-approach-implemented-charles-de-gaulle-airport

GNSS User Performance

- Robustness against local Effects
  - Multipath
  - Interference

- Detection of fake signals
  - Meaconing, record & playback attack
  - Spoofing, e.g. open source GPS signal simulator “gps-sdr-sim” generated streams
    - University of Texas at Austin (2012), demonstration by capturing an Unmanned Aerial Vehicle
    - DEFCON 23 (2015), low cost SDR spoofer by Huang and Yuang
    - Pokemon Go (2016), Public interest



GNSS User Performance

Features of GNSS Modules (based on product data sheets from corporate webpage)

- **ublox NEO/LEA-M8T**
  - Active continuous wave (CW) detection and removal
  - T-RAIM
- **FURUNO GT-87**
  - Active Anti-Jamming
  - Advanced Multipath Mitigation
  - T-RAIM
- **Trimble RES SMT 360**
  - T-RAIM
- **Telit SL869-T**
  - Jammer rejection
  - T-RAIM

➢ Standardization of **Signal Processing and/versus Test Specifications**

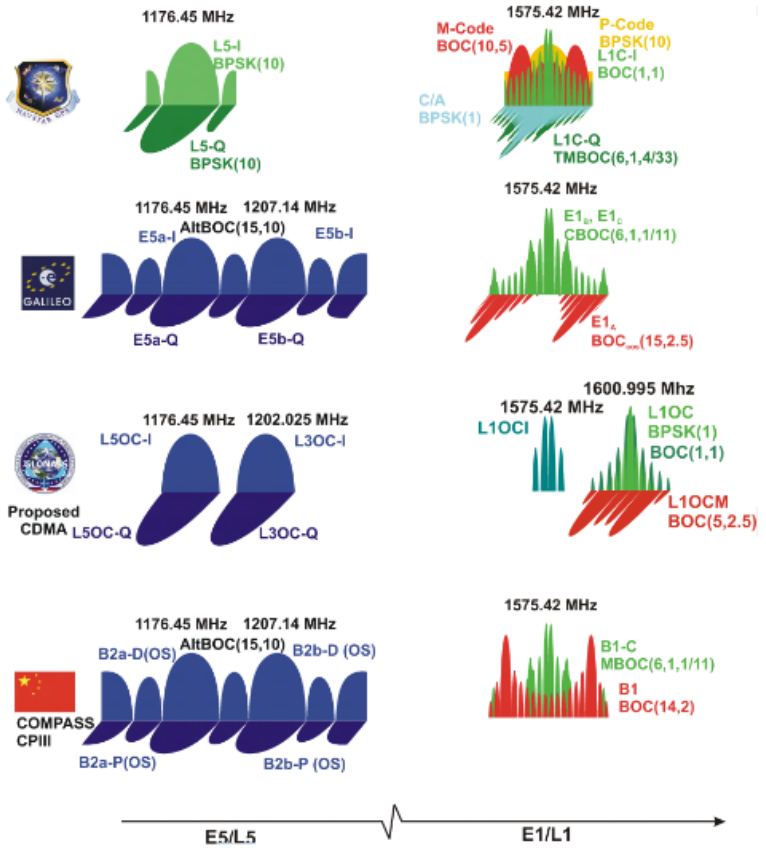
- Minimum Functionality
- Minimum Performance

GNSS User Performance

- Timing RAIM (T-RAIM) introduced in 1995 by Motorola paper "PREDICTION OF THE TIME ACCURACY AND INTEGRITY OF GPS TIMING"
  - Effective against 2004 event: "Field Experience and Assessment of GPS Signal Receiving and Distribution System for Synchronizing Power System Protection, Control and Monitoring"

- Dual-frequency, multi-constellation GNSS enables new integrity frameworks, known as Advanced RAIM (A-RAIM)
  - GPS-Galileo Working Group C ARAIM Technical Subgroup Milestone 3 Report

- Multi-constellation RAIM can detect certain spoofing attacks, e.g. spoofing of single constellation



Source: www.navipedia.net/index.php/GNSS_signal

GNSS User Performance

Many RAIM algorithms follow these steps:

- Preliminary step: Compute the navigation solution,
- Step 1: Fault detection Mechanism,
- Step 2: Isolation of “faulty” satellites,
- **Step 3: Protection levels computation *(optional)***
  - Requires error models/assumptions
  - Need for standardization

- System Available for operation if Protection Level < Alert Limit
- Integrity Failure: Hazardously misleading information (HMI)

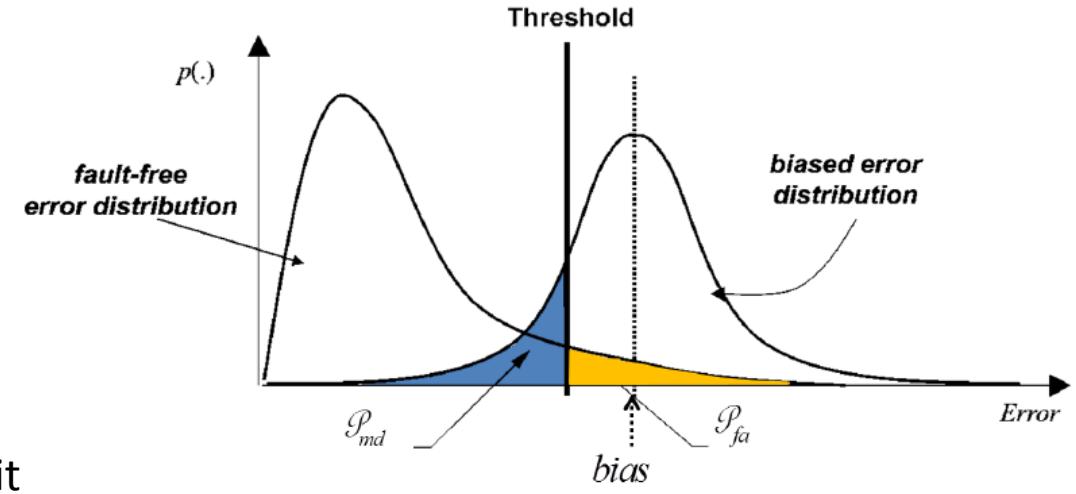


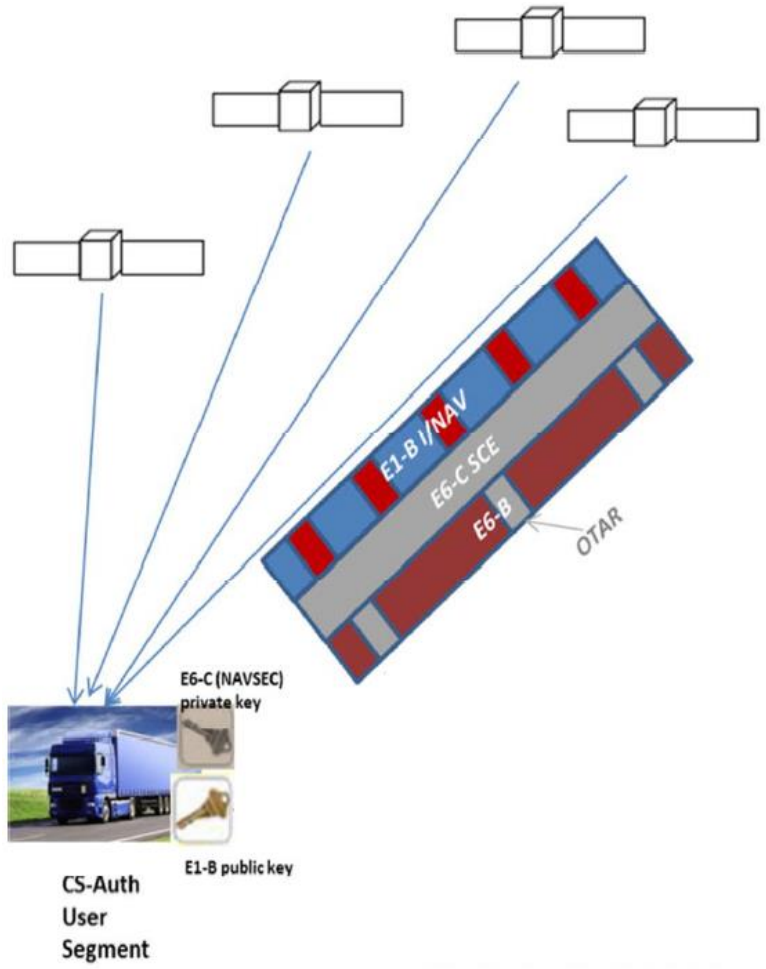
Figure: Nominal and non-nominal error density functions and associated miss-detection (in blue) and false alarm (in orange) probabilities.

Source: GSA, „REPORT ON THE PERFORMANCE AND LEVEL OF INTEGRITY FOR SAFETY AND LIABILITY CRITICAL MULTI-APPLICATIONS “, May 2015

Trusted Time Application

- **Time Protection Levels** in combination **with Authenticated GNSS Time Solution** provides trusted time solution

- EC implementing decision (EU) 2017/224 on Galileo authentication:
  - Galileo OS Navigation Message Authentication (NMA), Initial commercial operating phase between 2018 and 2020
    - **Authentication data** provided by the system
  - Commercial Service – Authentication (CS-Auth), Testing and validation phase to be concluded in 2020 at the latest
    - **Encrypted signals** supplied by the system operating manager
  - *Commercial Service – High Accuracy (CS-HA), Initial commercial operating phase between 2018 and 2020*
    - *High precision data provided by one or more service providers*

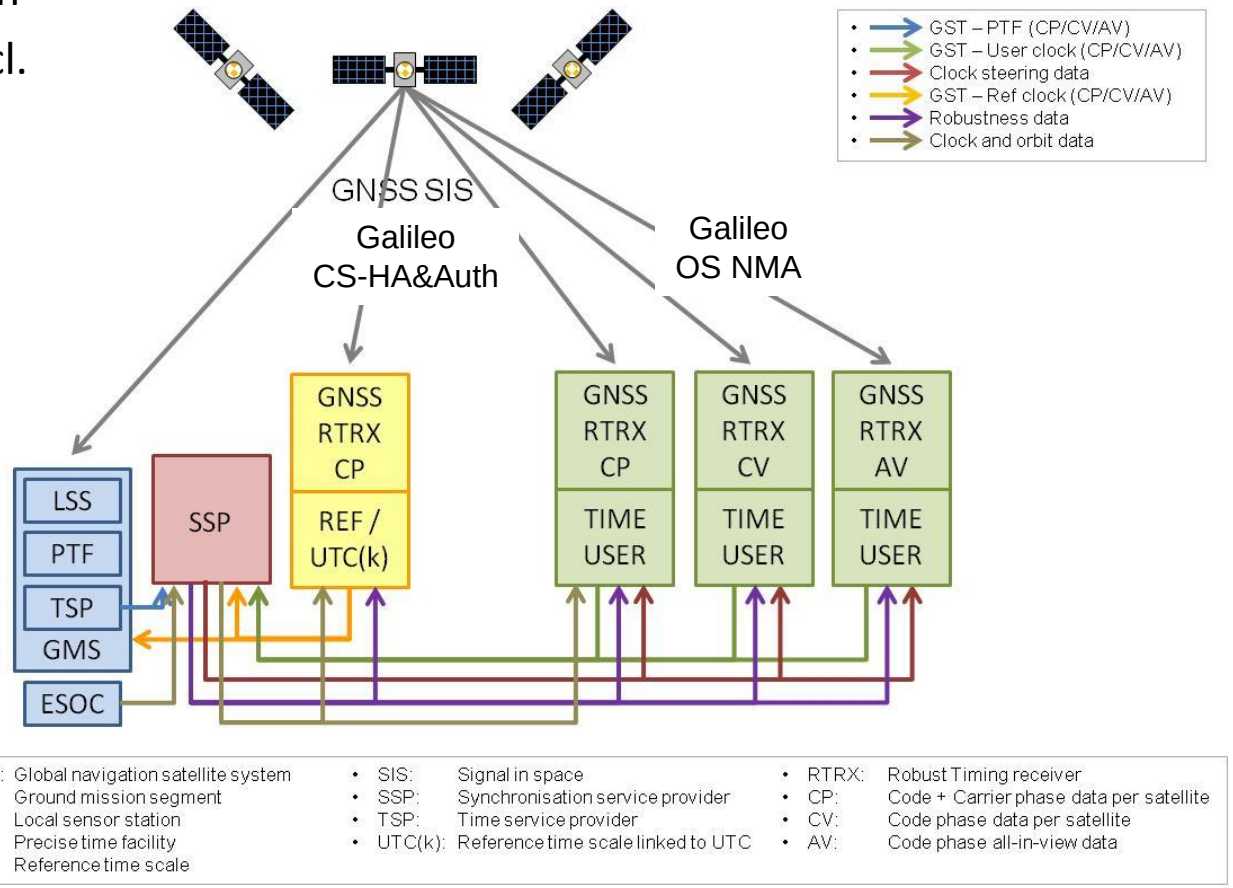


Trusted Time Application

- Synchronization Service
  - Offset GST – Ref-clock based on Galileo CS-HA&Auth
  - Offset GST – Ref-clock based on Galileo OS NMA incl. Time Protection Level
  - Clock steering data from Synchronization Service Provider (SSP)

➢ Authenticated Traceable Time Solution

- Added value for proof of compliance with MiFID II
- Question: Authenticated Galileo Time Solution with Time Protection Level as Trusted time source for Time Stamp Authority (update Recommendation ITU-R TF.1876)



Standardization

Examples of Development and Implementation Guides and Standards:

- EGNOS and RAIM
  - EC User Guide for EGNOS Application Developers
  - RTCA document DO-229D, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment
    - Appendix J describes required methods of calculating SBAS-based **protection levels**, based upon the data in the SBAS message
  - ICG Working Group C - ARAIM Technical Subgroup Milestone 3 Report
    - Annex A.III ARAIM USER ALGORITHMS
- Timing Receiver
  - BIPM guidelines for GNSS calibration
- Critical Infrastructure
  - US DHS Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure

Standardization

- Examples of GNSS Test Standards:
  - CWA 16874 Verification of performance levels of EGNOS Enabled mass-market receivers
  - ETSI TS 103 246: GNSS based location systems;
    Part 3: Performance requirements, Part 5: Performance Test Specification
  - EN 16803-3: Assessment field tests for security performances of GNSS-based positioning terminal, in development
  - Maritime navigation and Radiocommunication equipment and systems – Global navigation satellite systems (GNSS) – Part 1: Global positioning system (GPS) – Receiver equipment – Performance standards, methods of testing and required test results

➢ Development of specifications and standards for
  - Reference Architecture
    - Focus on Integrity – Time Protection Levels
  - Test specifications (minimum performance)
    - Focus on Fault Detection and Interference Awareness

Standardisation

- **Receiver architecture** against which the system (Galileo/EGNOS) can **ensure the specified performance**

- Timing related Specifications/Standards by organizations
  - GNSS Time Transfer (e.g. CGGTTS-Version 2E)
  - Time-stamping services (e.g. ISO/IEC 18014)
  - Clock Characteristics (e.g. ITU-T G.8272)
  - Precise Time Protocol Profiles (e.g. IEEE C37.238)
  - Performance Standards (e.g. ETSI TS 103 246)

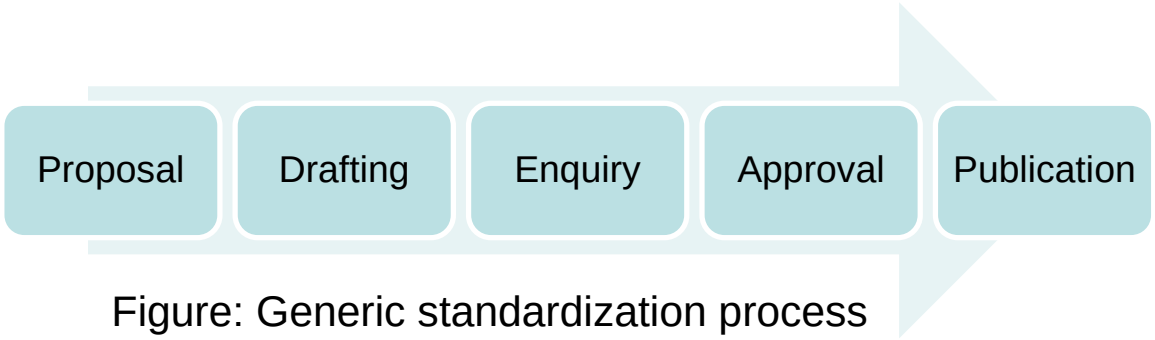


Figure: Generic standardization process

Organisation	Normative Deliverable
ITU	Recommendation
ISO/IEC	International Standard
	Technical Specification
	Publicly Available Specification
IEEE-SA	IEEE Standard
ETSI	European Standard
	ETSI Standard
	Technical Specification
CEN-CENELEC	European Standard
	Technical Specification
	Workshop Agreement
BIPM	Recommendation
OIML	Recommendation

Certification

- ISO/IEC 17000 suite is the basis for the development of certification processes and documentation of competence
  - ISO/IEC 17067 describes the fundamentals of product certification and provides guidelines for understanding, developing, operating or maintaining certification schemes for products, processes and services

	Test Laboratory	Certification Body
Public Accepted Organisation	Defined by association of companies or market dominating company	
Accredited Organisation	ISO/IEC 17025 accredited	ISO/IEC 17065 accredited
Notified Body	Notified by the Member State to the Commission	
Designated Body	Designated by approval authority of a Member State	

Roadmap

Potential Approach with focus on European Organizations:

- CEN Technical Specification
  - Time Protection Level Computation
  - Performance features and metrics of GNSS timing receivers
  - Test procedures for evaluation of GNSS timing receiver performances

- Conformity Assessment Scheme based on accredited authorities
  - At European level: European co-operation for accreditation (EA)
  - Document EA-1/22A “EA Procedure and Criteria for the Evaluation of Conformity Assessment Schemes by EA”

Conclusions

- Definition of Galileo Timing Service and EGNOS Timing Service to reflect the needs for timing users and the performance and limitations of the systems
- Standardization of reference receiver processing for the assurance of specified service performance
- Certification to provide trust

➢ stakeholder's opinions, pros and cons, on possible certification of timing service, timing receiver or timing applications is very welcome

NavCert GmbH
Tal 26
80331 München

roland.bauernfeind@navcert.de
www.navcert.com

NavCert