Challenges and Methods for Integrity Assurance in Future GNSS

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Advanced User Positioning, Navigation and Timing (PNT)

User requirements:

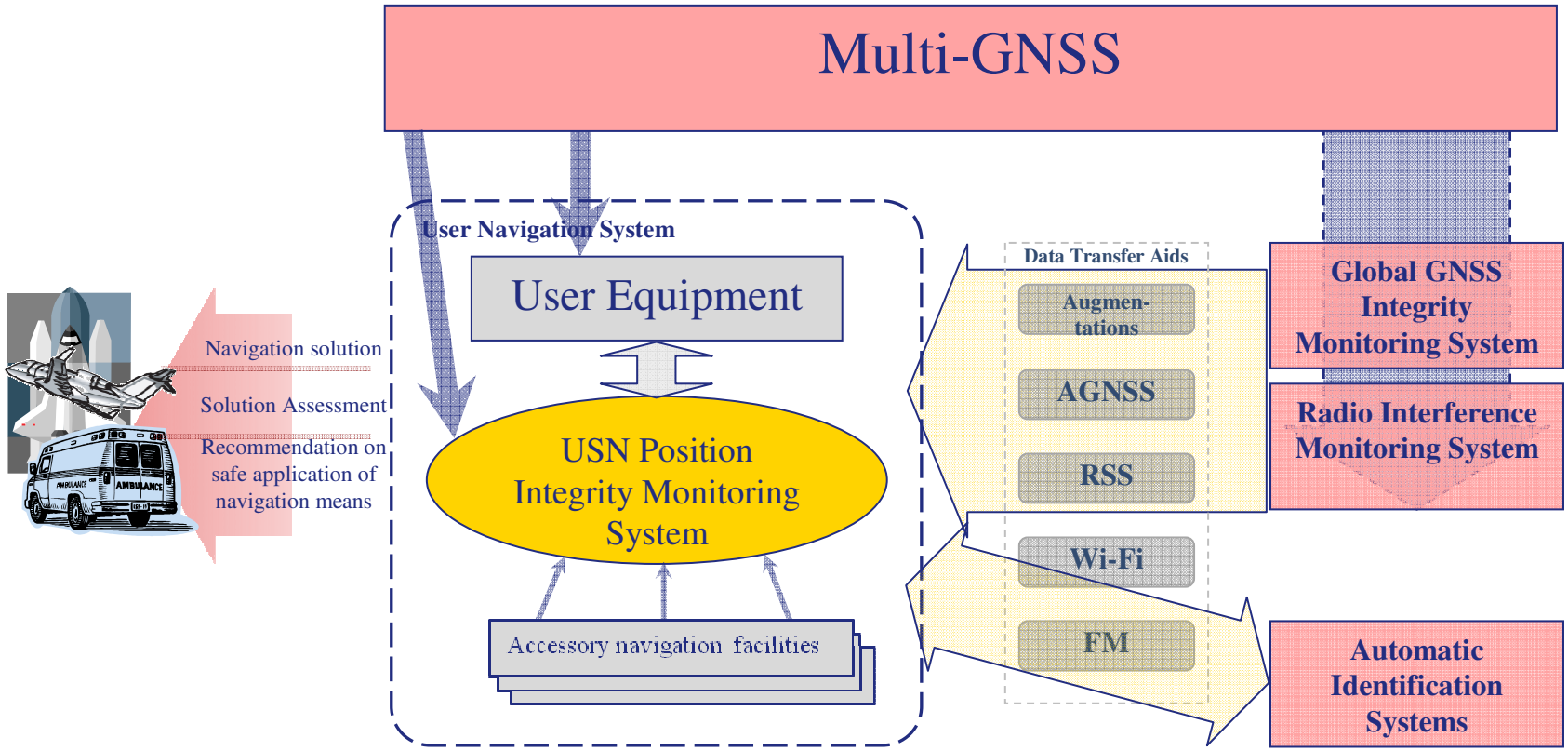
- Sub-meter accuracy in absolute mode;
- Enhanced navigation field availability and continuity;
- 10^{-7} and better integrity ;

Means of PNT :

- GNSS (GLONASS, GPS, Galileo, Compass and others);
- Augmentation Systems (SDCM, WAAS, EGNOS, MSAS and others).

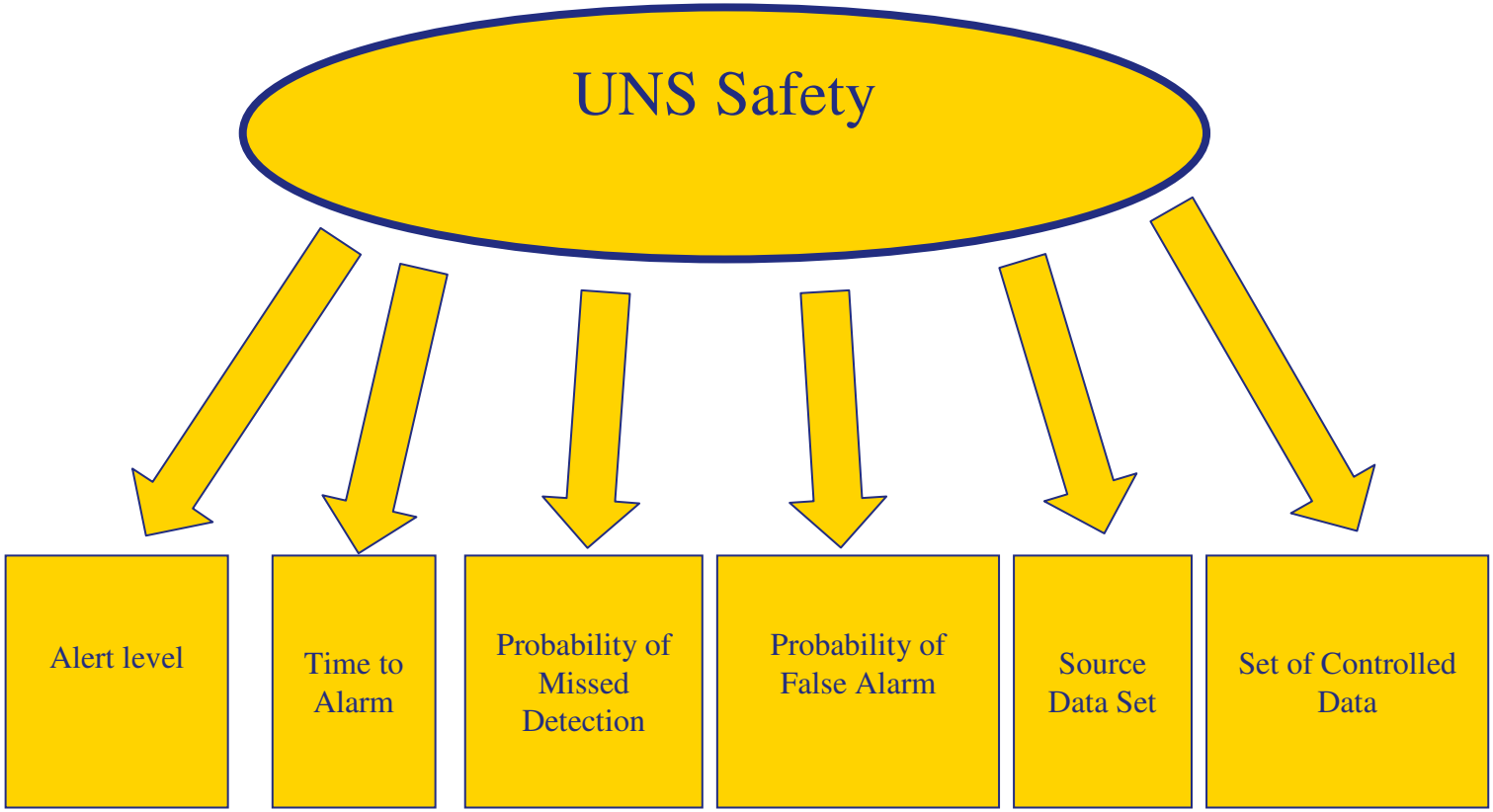
User Navigation System (UNS)

- GNSS Integrity is one of the main source data used to monitor the safety of UNS applications;
- Safety monitoring system is the crucial element of UNS.



- Future user should have an algorithm for assessment of integrity solution based on the whole set of augmented information.

Safety of UNS (User Navigation System) Operation (1)



- Alert level is a variable value (it can be changed by an operator or automatically);
- Composition of UNS Safety Monitoring System source and controlled parameters vary to suit specific user group .

Safety of UNS Operation (2)

Safety of UNS Operation is the ability to detect outages, failures, malfunction of USN external sources of navigation information

Crucial factors for UNS safety:

- Relevancy of architecture of the navigation system in use (User equipment type, GNSS, integration with augmented navigation systems);
- Adequacy of the used movement models;
- Disturbing measurement factors:
  - Space segment error;
  - User equipment entailed errors;
  - Signal propagation errors (ionosphere, troposphere);
  - Relief features in an area of user equipment operation;
  - Natural/man-made interference (intentional or unintentional);
  - Selective availability.

Multi-GNSS Integrity Monitoring

GNSS Integrity is assumed to be the system's ability to form timely alert that the system should not be used for navigation purposes

GNSS Integrity Monitoring is the basis for UNS safety monitoring which should be carried out in combination with monitoring of other factors

Existing Approaches to User Integrity Assurance

Error / Method	Space segment error	Signal propagation error	User equipment error	Radio interference
SBAS Integrity	✓			
GBAS Integrity	✓			
Galileo Integrity	✓			
Space Vehicle Autonomous Integrity Monitoring (SAIM)	✓			
Receiver Autonomous Integrity Monitoring (RAIM)	✓	✓	✓ *	✓*

* perspective

Requirements to Future User Positioning Integrity Assurance Techniques

- Global Integrity Assurance;
- Minimum TTA;
- Higher Reliability;
- Versatility.

Existing Approaches to User Integrity Assurance

Requirement	Development of Integrity Data Transfer Techniques through GNSS Satellite Signal	Development of Global Network of GNSS Monitoring Stations	Development of Integrity Computation Techniques	Development of Autonomous Integrity Monitoring Techniques
Global Service	✓			✓
Shorter TTA	✓			✓
High Service Reliability and Availability	✓	✓	✓	✓
Versatility			✓	✓

General Challenges of UNS Safety Monitoring System

- **Dissemination of integrity information on commercial or open basis;**
- **Creation and advancing techniques and algorithms for UNS safety monitoring, including:**
  - **Approaching time scales mismatch in multi-GNSS environment;**
    - Receiver algorithms;
    - Using one system as a standard;
- **Expanding the range of integrity data transfer means;**
- **Establishing international mechanism for coordination and supervising UNS safety monitoring development**
  - **Options:**
    - Establishing national UNS safety monitoring services;
    - Establishing international coordination council, whose tasks include:
      - **Coordination of integrity data transfer techniques and formats;**
      - **Providing information exchange between national monitoring services;**
      - **Establishing regulation mechanisms.**

Summary

- Integrity assurance is one of key trends of future multi-system GNSS development;
- GNSS integrity assurance system is the base to ensure safety of user;
- The main system developers and users have to participate in development of both current and advanced integrity assurance techniques;
- Future GNSS integrity assurance techniques should be based on advanced technologies including a global service, time to alarm (TTA) minimization, high reliability and service versatility;
- The following tasks should be solved within the framework of advanced user position integrity monitoring system development:
  - creation of reliable algorithms and techniques to ensure integrity of user navigation system assurance;
  - development of time scale mismatch (discrepancy) techniques;
  - development of alternative ways to transmit integrity data (Internet, telecommunication networks);
  - Development of national GNSS integrity monitoring services;
- Establishment of International Coordination Council on GNSS User Position Integrity Monitoring.