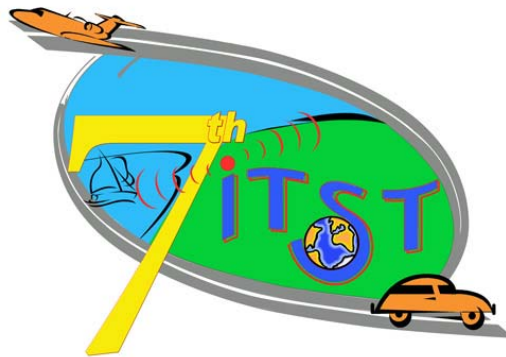


Impact of Galileo on the road sector

Towards guaranteed integrity

Pierre -Yves Gilliéron

Geodetic Eng. Lab.
EPFL - Lausanne



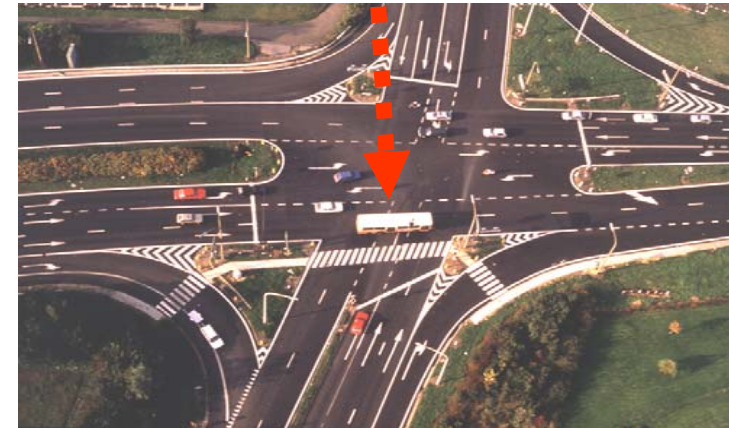
Sophia Antipolis

06 – 08 June

07

Content

- Context
- ITS Services
- Classification of ITS services
- Performance of positioning in ITS services
- Types of positioning systems
- Services and Certification
- Conclusion
- Summary



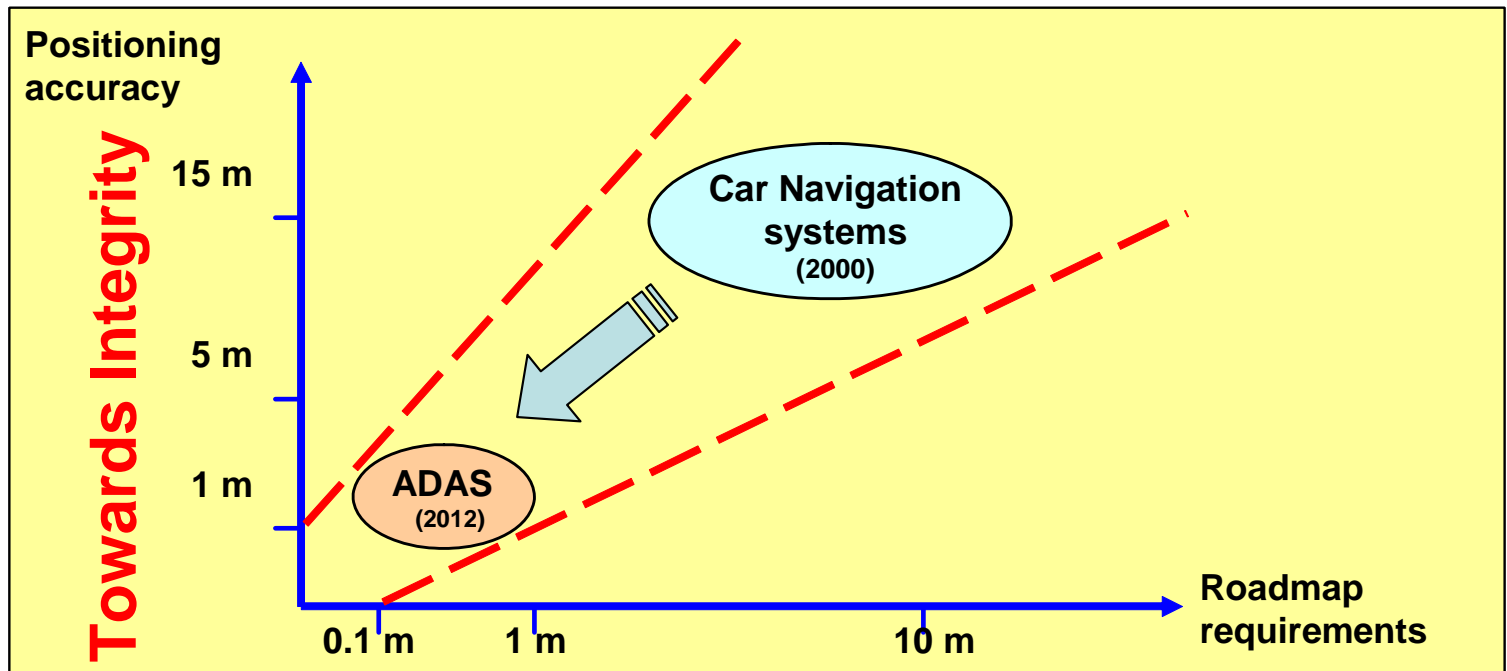
Context

- **Road Safety and ITS applications**
 - European transport policy
 - Reduction of road fatalities by 2010
 - Improvement of road infrastructure, safer cars
- **Initiatives**
 - Include new developments of the information society technologies (IST) > **TELECOM**
 - Interaction between the driver, the vehicle and the road environment > **NAVIGATION, Galileo**
 - Development of advanced road databases

➔ **Development of Intelligent Integrated Transport Safety Systems**

Context

- Deployment of transport safety system
 - Evolution of GNSS and digital map databases
 - Development of ITS and Advanced Driver Assistance Systems (ADAS)



Towards Certification

Context

- **New driver assistance system-ADAS**
 - BMW Group is developing a dynamic road prediction system (DPP) for safe overtaking
 - The ADAS is combining digital map data, GPS position and velocity and acceleration from the car's system
 - This ADAS enhance safety and support drivers actively without interfering
 - **DPP is based on available GPS and common map databases designed for ADAS**

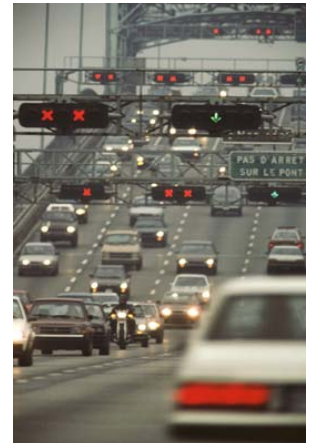
ITS Services

- **ISO 14813-1: Intelligent transport systems (ITS)** – Reference model architecture for the ITS sector – Part 1: **ITS service domains**, service groups and services
- **Main ITS service domains**
 - Traveller information
 - Traffic management and operations
 - Driver assistance and vehicle control
 - Freight transport
 - Public transport
 - Emergency
 - Transport-related electronic payment
 - Road transport-related personal safety
 - ...

ITS Services

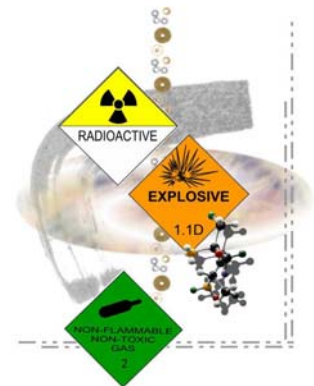
Role of the positioning in the main ITS services

- Traveller information
 - Pre-trip information
 - On-trip driver information
 - Route guidance and navigation
- Traffic management
 - Transportation planning support
 - Policing/enforcing traffic regulation



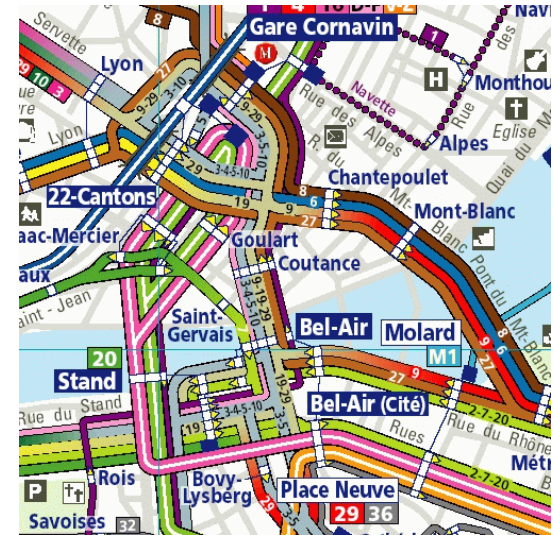
ITS Services

- Driver assistance and vehicle control
 - Vision enhancement
 - Automated vehicle operation
 - Collision avoidance
 - Safety readiness
- Freight and fleet management
 - Commercial fleet management
 - Management of dangerous goods



ITS Services

- Public transport
 - Public transport management
 - Shared transport management
- Emergency
 - Emergency notification and personal security
 - Emergency vehicle management
- Electronic financial transactions
- Safety



Classification of ITS services

- Positioning plays a key role in several ITS services
 - What is the level of performance required ?
 - What are the main characteristics of the positioning performance ?
- Classification may be based on various criteria
- **Issue**
 - **What is the impact of a misleading information?**
 - **What is the acceptable level of risk ?**
 - **What kind of implications: legal, commercial, liability, Safety of life,... ?**

Classification of ITS services

- Classification proposed within the Giroads (www.intelligentroads.org) project:
 - **Safety-of-life**: all applications considered as safety critical, or having any safety implication
 - **Liability-critical**: all applications presenting any commercial or legal relationship between the provider of service and the final users
 - **Non-safety-of-life**: all applications not presenting any commercial, legal or safety implication

Classification of ITS services

- Examples of applications:
 - **Safety-of-life**: emergency services, ADAS, ...
 - **Liability-critical**: electronic fee collection and road pricing, legal speed enforcement,...
 - **Non-safety-of-life**: navigation and in-car information, fleet management,...

The main differentiator among this classification is the **integrity requirement at the user level**

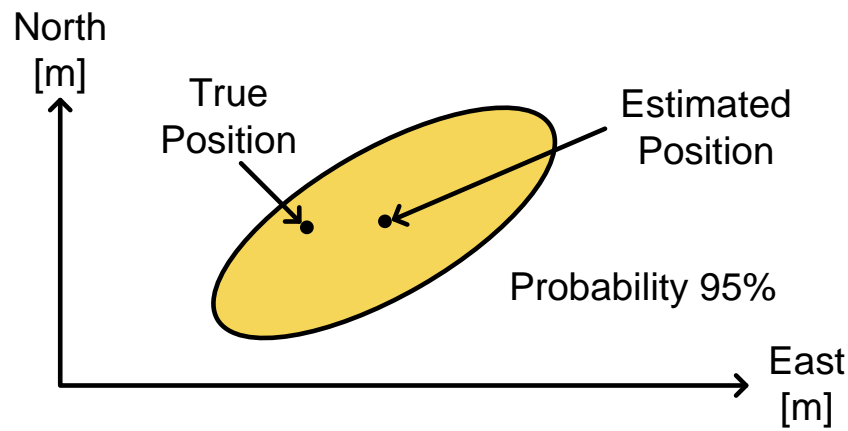
Performance of positioning systems

Main features used for the evaluation of the performance

- **Position accuracy**
 - **Predictable accuracy**: accuracy of a position with respect to the charted position (true)
 - **Relative accuracy**: accuracy of a position relative to another user or to a road feature
- **Coverage**: area (region, cordon, specific point) where the performance of the system is adequate
- **Integrity**: ability of the system to provide timely warnings to the users when the system should not be used
- **Availability**: ability of the system to determine a position with the required accuracy at any time and any location in the coverage area
- **Continuity**: ability of the system to perform its function without interruption during the intended operation
- **Update (Fix) rate** : number of independant position provided by the system during a time interval
- **Time to first fix** :time interval until the system output a position

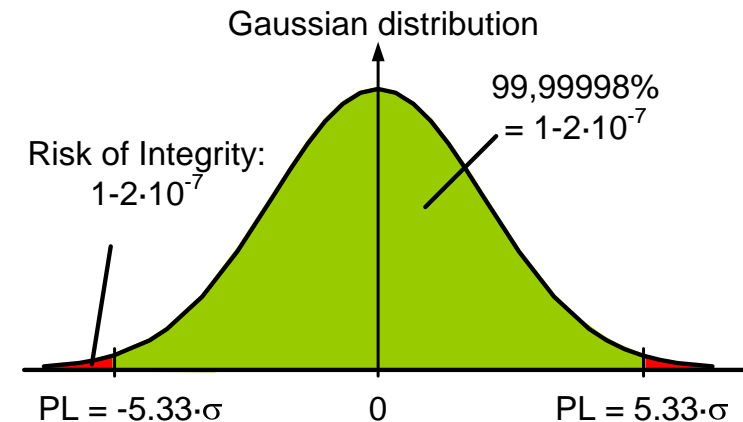
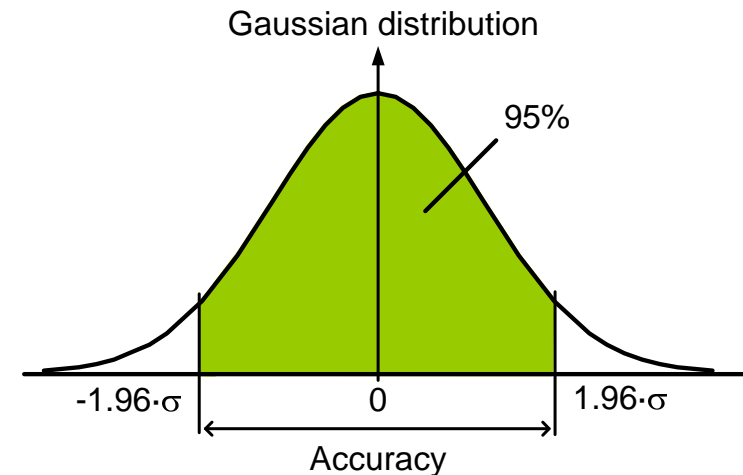
Performance of positioning systems

- Accuracy
 - Horizontal
 - Estimated global position & error (ellipse)
 - Level of probability
 - True position included or not



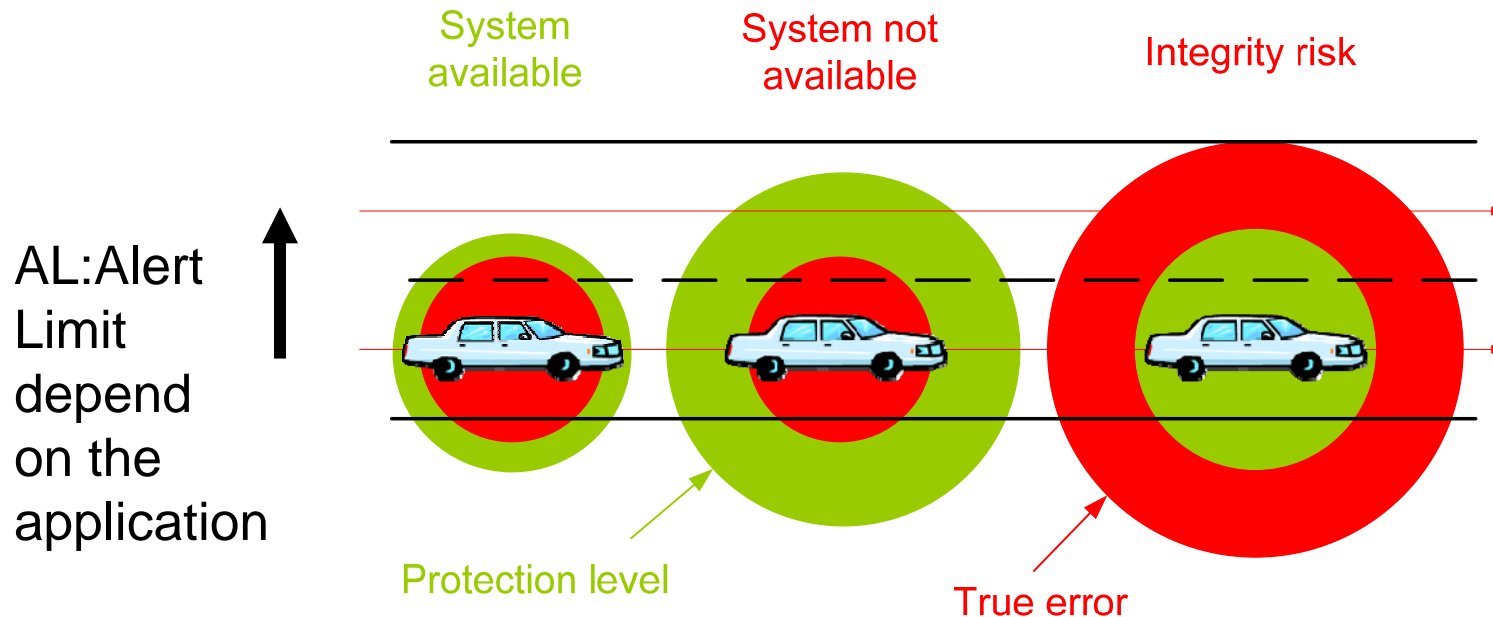
Performance of positioning systems

- Integrity Concept
 - Ability of a system to timely provide valid warnings to the users
- Risk of Integrity
 - Probability of providing a signal that is out of tolerance without warning the user
 - PL : Protection Level
Statistical error bounds



Performance of positioning systems

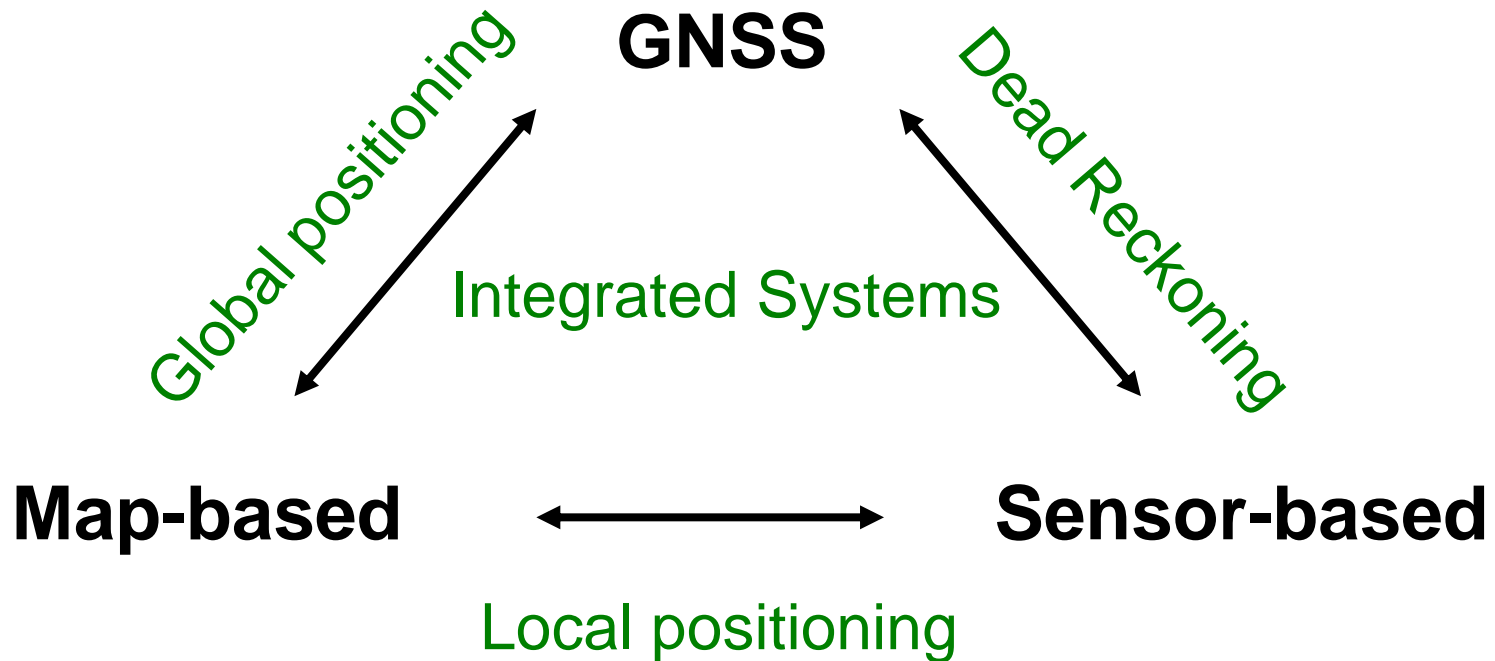
- Available: True error < Protection level < Alert Limit
- Not available: True error < Protection level > Alert Limit
- Integrity Risk: True error > Protection Level



Types of Positioning Systems

- **GNSS-based**: satellite-based positioning, provide a 3D position (lat., long., altitude) in a global reference system (WGS84)
- **Sensor-based**: provide a geometric information (distance, angle) relative to a fix or to specific road features in a local reference system
- **Map-based**: provide positioning relative to a map feature in a mapping reference system

Types of Positioning Systems



- Most of ITS applications are based on global/local positioning and are linked to onboard digital maps

Types of Positioning Systems

- **GNSS/Sensor-based** : enhanced positioning system with better availability and continuity based on an integrated system and a dead reckoning (DR) method
- **GNSS/Sensor & Map-based** : integrated positioning systems requiring map information
(don't run without map information)

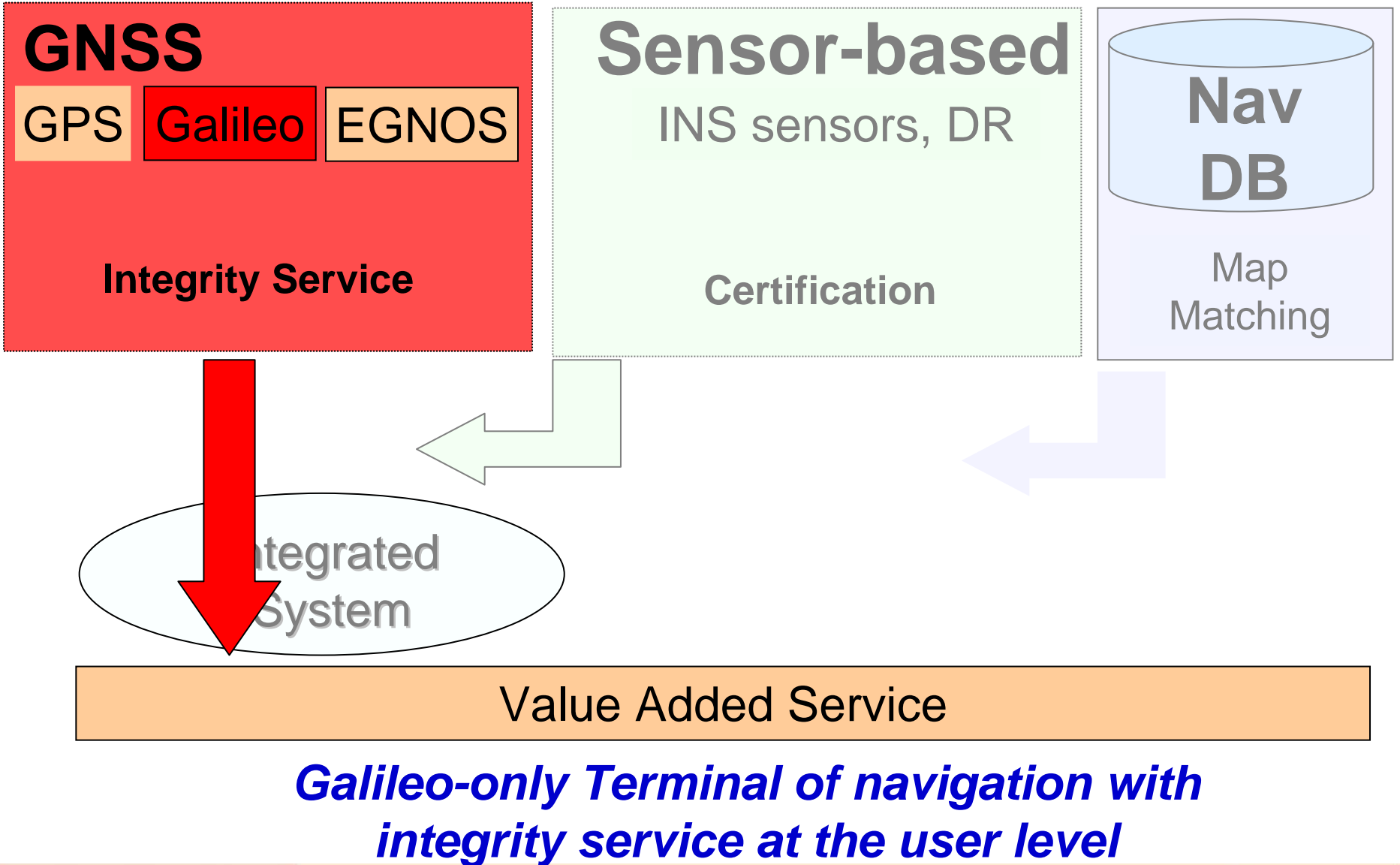
ITS applications require to combine all types of positioning concepts

Services and Certification

- **GNSS/Galileo** : Navigation services
Commercial, Safety of Life
 - Improved accuracy and better availability
 - Integrity of the navigation signal (in space)
 - Certification and service guarantees
 - Provided by the Galileo operator
 - Possibility to implement value-added services
 - Provided by a local operator

Issue

- Appropriate for « open-sky » area (controlled environment)
- What kind of services should be proposed for challenging areas (non-controlled) ?
(Urban canyon, forested & mountainous areas)
 - How to provide guaranteed integrity at the user level ?



ITS Service : Example

- Road charging
 - Use of GNSS: identify whether and when the vehicle is within a specific area
 - When applied to road charging, the provision of guaranteed integrity translates directly into the availability to charge for the service
 - In addition to the GNSS integrity service, robust algorithms have to be implemented at the user level (**value added service**)

Ref: project ADvantis, GMV SA

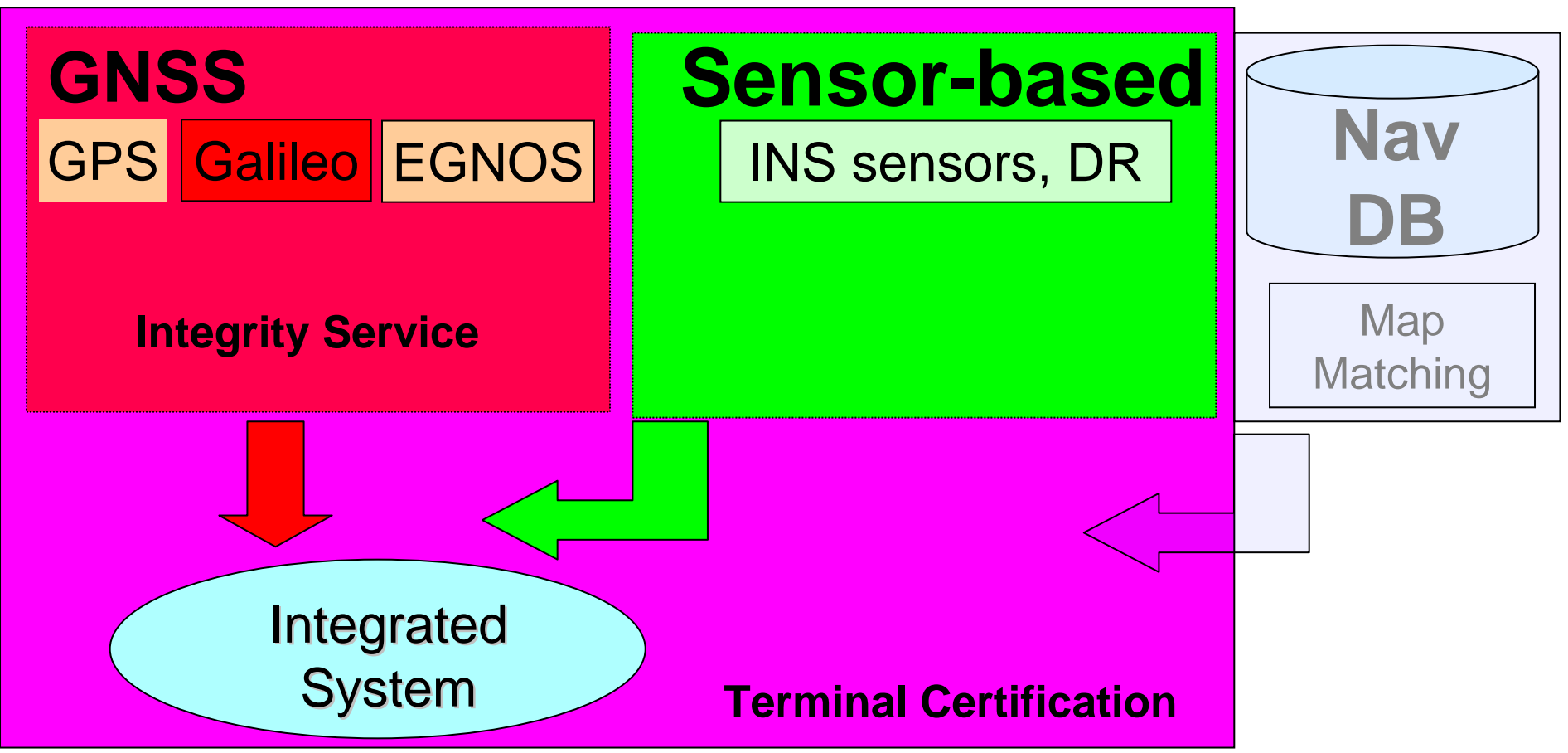
Services and Certification

- **Galileo/Sensor-based** : Terminal of Navigation with integrated services
 - Improved accuracy and **update rate**
 - Better availability and **continuity**
 - Integrity monitoring
 - Combine Galileo services with dynamic sensors information
 - Provide Integrity monitoring at the user level
 - Possibility to implement value-added services
 - Provided by a local operator

Issue

Better performance in uncontrolled environments (urban area, forested & mountainous areas)

Towards terminal certification



Value Added Service

Galileo/Sensor-based Terminal of navigation with integrity service at the user level

Services and Certification

- **Digital Maps (Nav DB)**

- On board digital maps can be seen as a special sensor for road safety system
- Digital maps will provide safety relevant information
- Types of maps: (ref.: Project Maps & ADAS, FP6)
 - Prediction along the road
 - Provision of context information
 - Acting as an intelligent filter
 - Acting as a spatial memory

Issue

To define a standard interface for ADAS and ITS applications

To make safety related data available

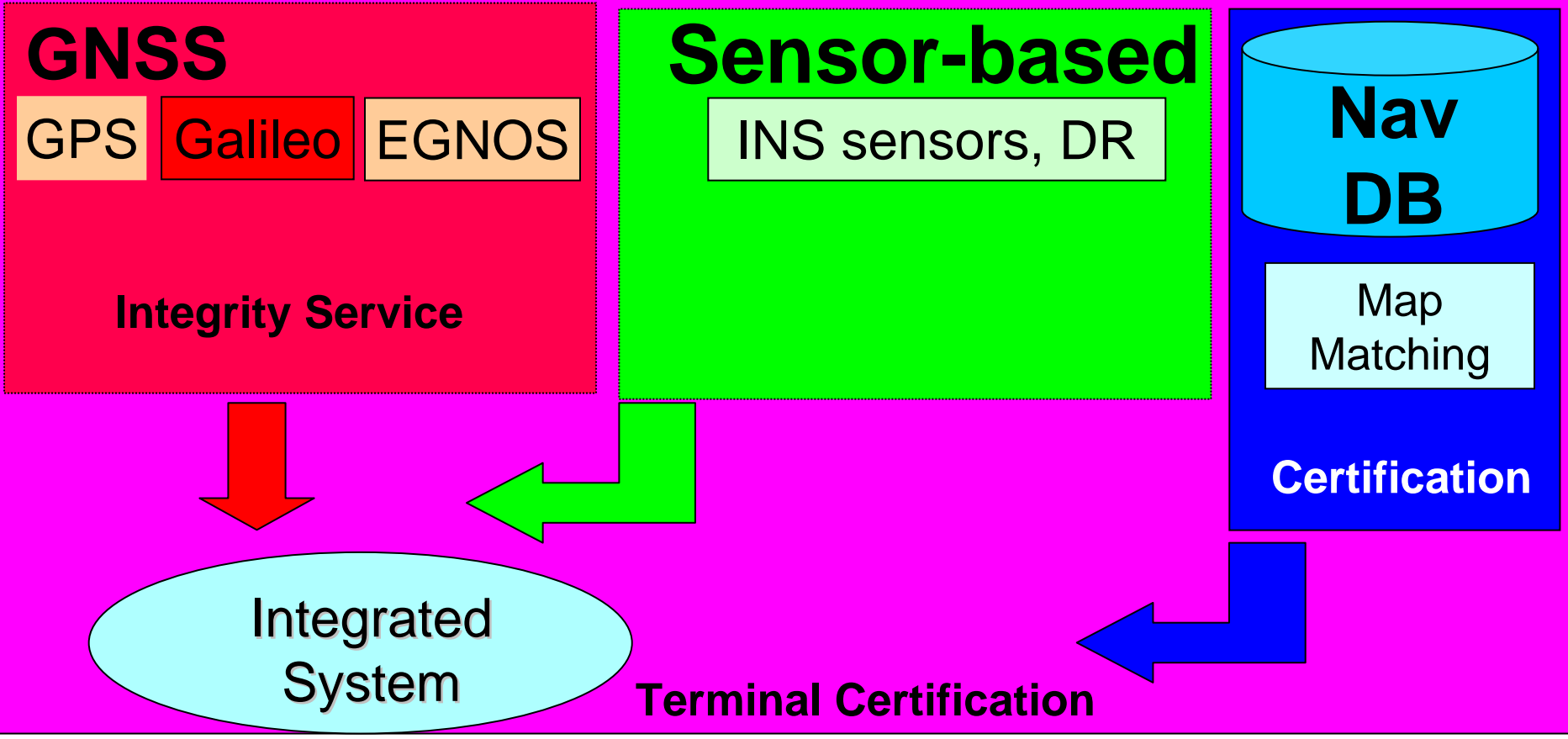
What about the certification of navigation data ?

Services and Certification

- **Galileo/Sensor & Map-based** : Terminal of Navigation with integrated services and link with a map database
 - Improved accuracy and comparison with road features
 - Better availability and continuity
 - Integrity monitoring
 - Combine Galileo services with mapping information (Nav DB)
 - Matching of GNSS information with road features
 - Possibility to implement value-added services
 - Provided by a local operator

Issue

Cooperation of multiple providers (GNSS, maps,...)
How to guarantee a combined service (GNSS/Sensor + Nav DB) ?



Value Added Service

Terminal of navigation with integrity service at the user level

ADAS: Example

Lane departure warning

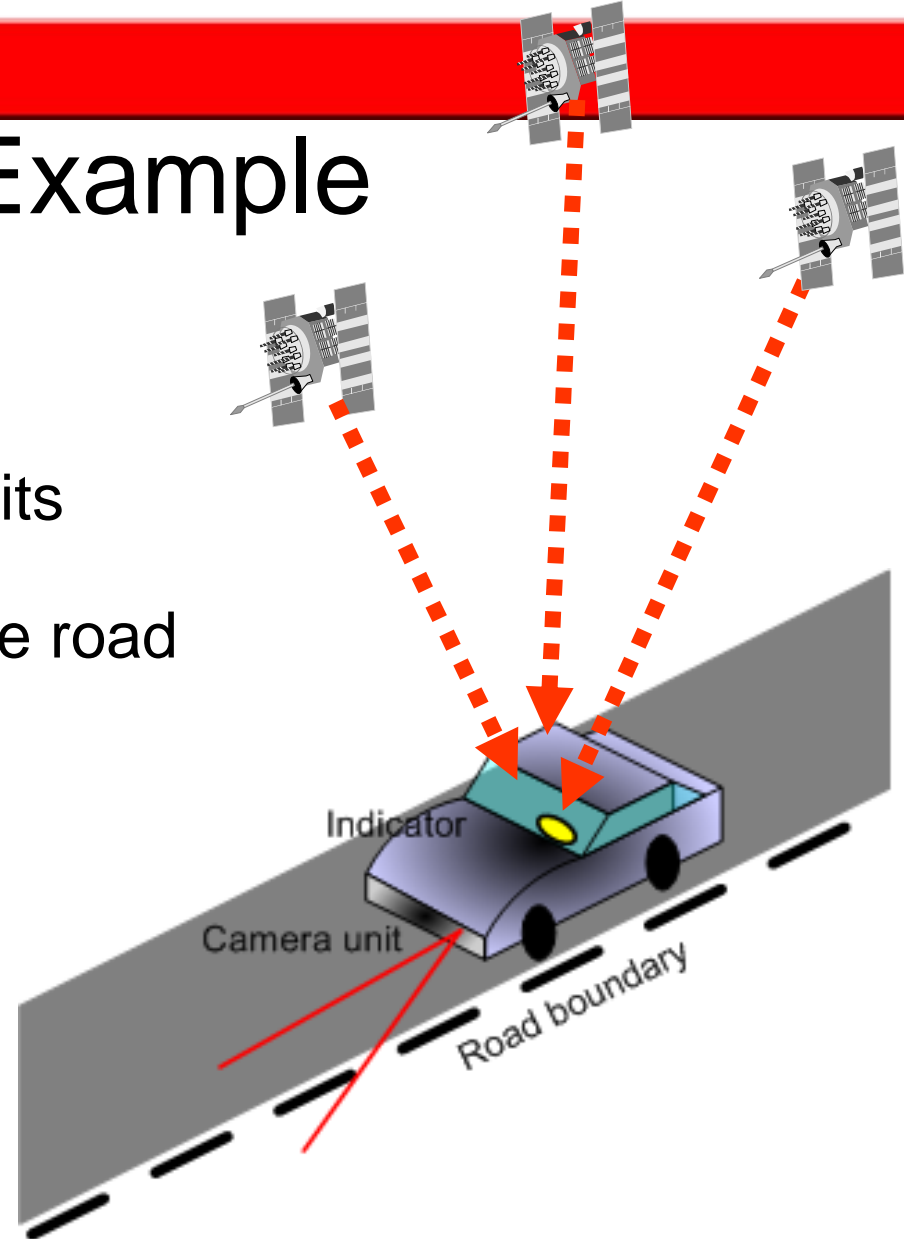
- ADAS: Lateral control
 - Positioning the vehicle on its lane
 - Tracking the marking of the road

Local positioning

- Close range sensors (radar, CCD)
 - Tracking road features
 - High frequency

Global positioning

- GNSS-based positioning
 - Low frequency
 - Combined with road geometry



Conclusions

- **Why Galileo in ITS Services ?**
 - GNSS positioning in a global reference system became necessary in many applications **linked with digital maps**
 - Safety of life and liability-critical applications require a high level guarantee of **integrity at the user level**
 - Galileo will not cover all the links in the integrity chain (from space to the user)
 - **The development of value-added services is absolutely necessary for the implementation of integrity services at the user level**

Summary

- ITS and especially ADAS applications will increase the interaction between **the driver, the vehicle and their environment**
 - This interaction is only possible with high performance navigation systems and high quality digital maps
- The reliability of ITS applications is based on integrated solutions
 - Extended map database with safety relevant information
 - Combined positioning systems : GNSS/Galileo & positioning sensors
- **Integrity play a key role in the implementation of liability-critical and safety of life applications**

Thank you for your attention

Mail: pierre-yves.gillieron@epfl.ch

Web: <http://topo.epfl.ch>