Impact of Galileo on the road sector
Towards guaranteed integrity

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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)
Context

• New driver assistance system-ADAS
  – BMW Group is developing a dynamic road prediction system (DPP) for safe overtaking
  – The ADAS is combing 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 independent 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

\[ PL = -5.33 \cdot \sigma \]

\[ 0 \]

\[ PL = 5.33 \cdot \sigma \]

\[ 99,99998\% = 1 - 2 \cdot 10^{-7} \]

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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

AL: Alert Limit depend on the application
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.

- GNSS
  - Global positioning
  - Dead Reckoning
  - Integrated Systems

- Map-based
  - Sensor-based
  - Local positioning
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 ?
Galileo-only Terminal of navigation with integrity service 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
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)?
Terminal of navigation with integrity service at the user level
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

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