Intelligent Transport Systems: a Tool or a Toy ?

GNSS positioning challenges for Autonomous Driving

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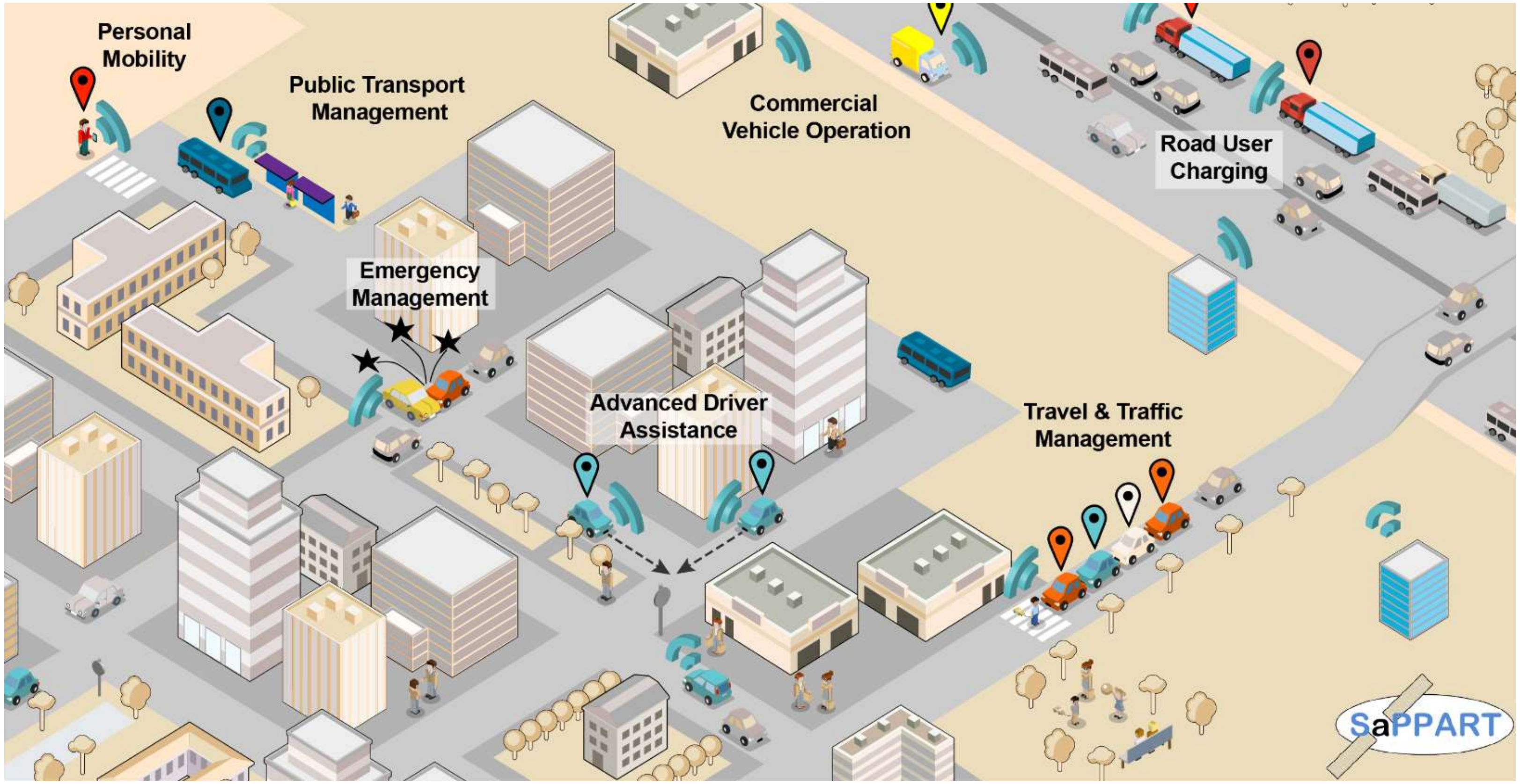
GNSS have a bright future in ITS…



- Increasing capacity, improving safety and reducing congestion
- ITS represent 50% of the GNSS market

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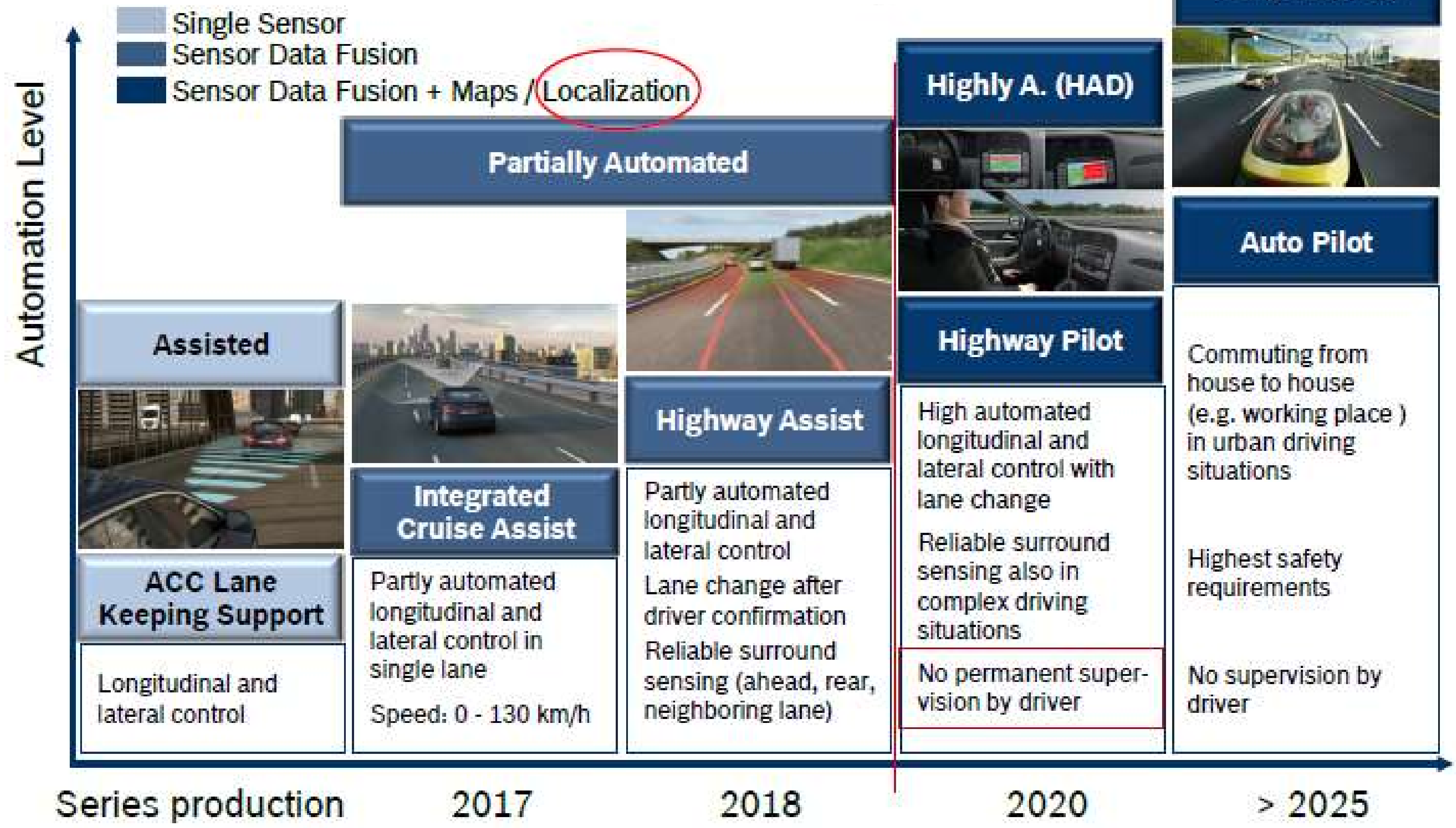
Evolution in Automated Driving



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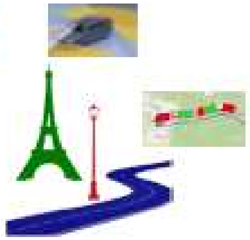
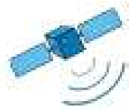
Sensor Concepts for Localization for HAD / FAD

- **Surround sensors** like Radar, Camera or Lidar provide good relative position, but depend on proper road markings, landmarks & online map matching and can be disturbed by external factors (rain, blending effects,...).



- **GNSS** (**G**lobal **N**avigation **S**atellite **S**ystem*) provide absolute position and are highly long term stable, but availability is not sufficient for HAD.



- **Inertial sensors** are very short term stable and can hardly be disturbed from the outside, but drift over time.

→ Highly accurate position estimate can be provided through combination of landmark and map-based localization, GNSS and inertial sensor data.

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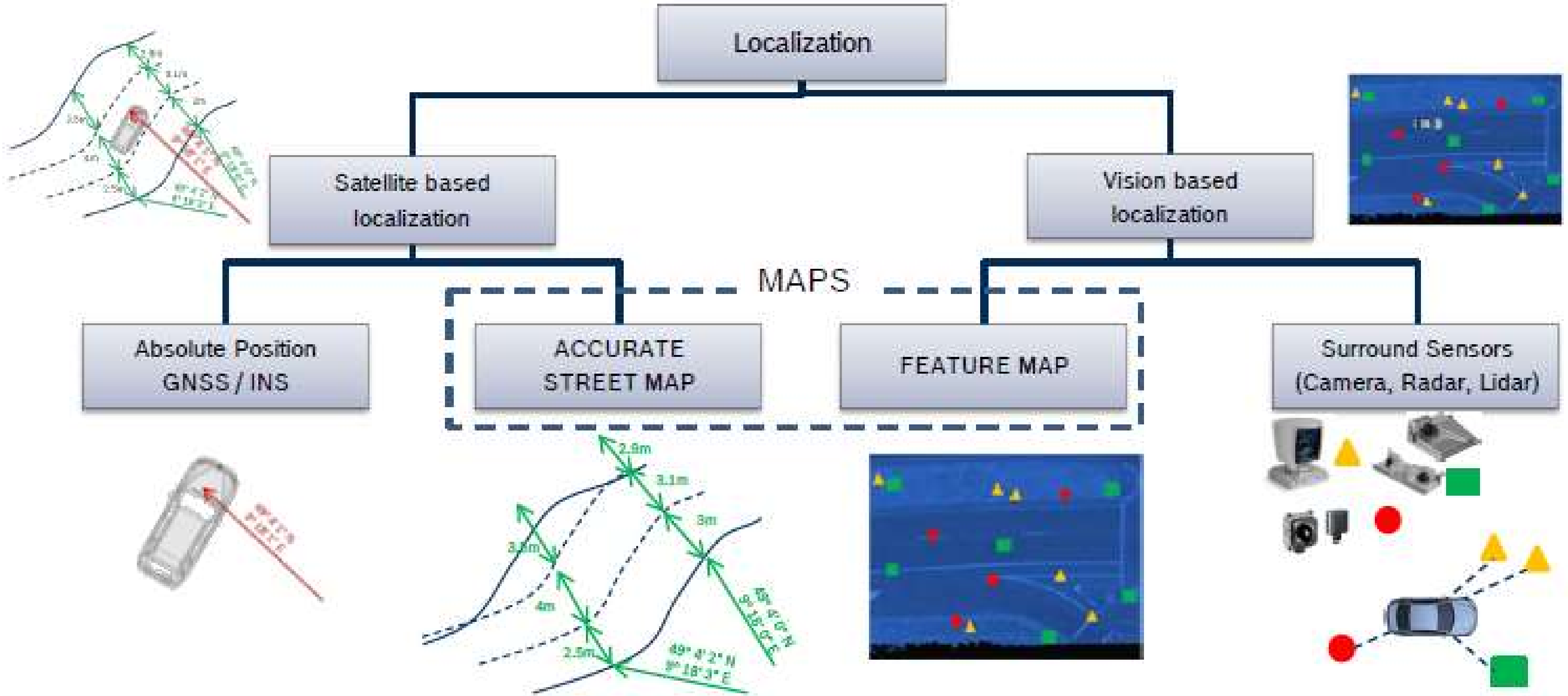
Options for Absolute Localization



→ **Localization can be done with MAPS, surround sensors and GNSS systems. Benefits and drawbacks on all sides.**

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GNSS Challenges

Parameter	GNSS Market	Challenges
absolute position accuracy	~2 m (no correction) ~ 20 cm (PPP*) < 10 cm (RTK**)	Availability at blockage, worldwide correction service availability
velocity accuracy	> 0,1 m/s	
time to first fix (full accuracy)	> 20 min (PPP**) > 30 s (RTK**)	Fast availability for automotive applications crucial
Life time, temperature, durability	Several applications driven from short lifetime with non safety of life functionality	Approved lifetime, durability and temperature ranges for automotive safety applications
functional safety,	no Application of ISO26262 Integrity concepts for Airplanes	Fulfilling automotive standards and high integrity important
Guarantee of service…		… for automotive lifetime w/o hardware / (software) changes (up to 30yrs***) not yet clarified

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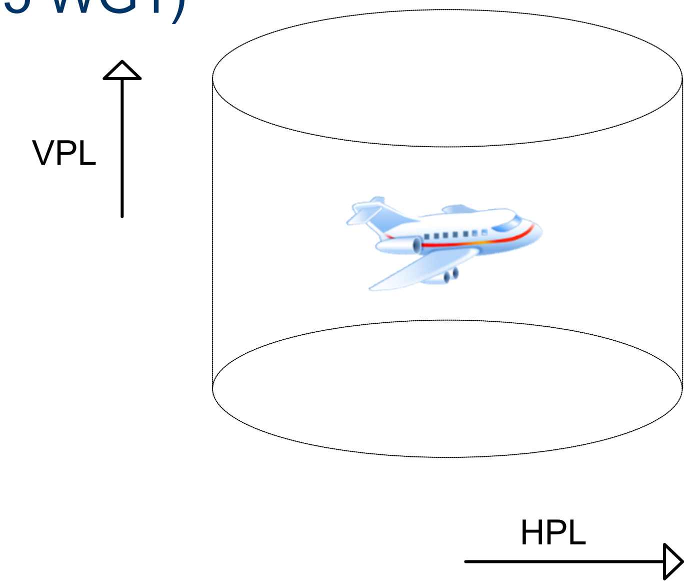
How to address the GNSS challenges ?

- **AVAILABILITY**
  - Through sensor fusion
  - Best candidates:
    - CAN bus sensors: odometers, gyroscopes…
    - Smart cameras (outputs soon available on the CAN bus), but need of **accurate maps**…
    - Should be low-cost (strong trend)
- **ACCURACY (lane-level positioning is required)**
  - GNSS improvements:
    - Multi-constellation (GNSS, GLONASS, Galileo…)
    - Multi-frequency
    - Phase processing (PPP = Precise Point Positioning)
  - Through sensor fusion also, the same ones as for Availability

Integrity of positioning: a new concept in the transport domain…

Integrity: "*General performance feature referring to the level of trust a user can have in the value of a given position or velocity component as provided by a positioning system*" (CEN TC5 WG1)



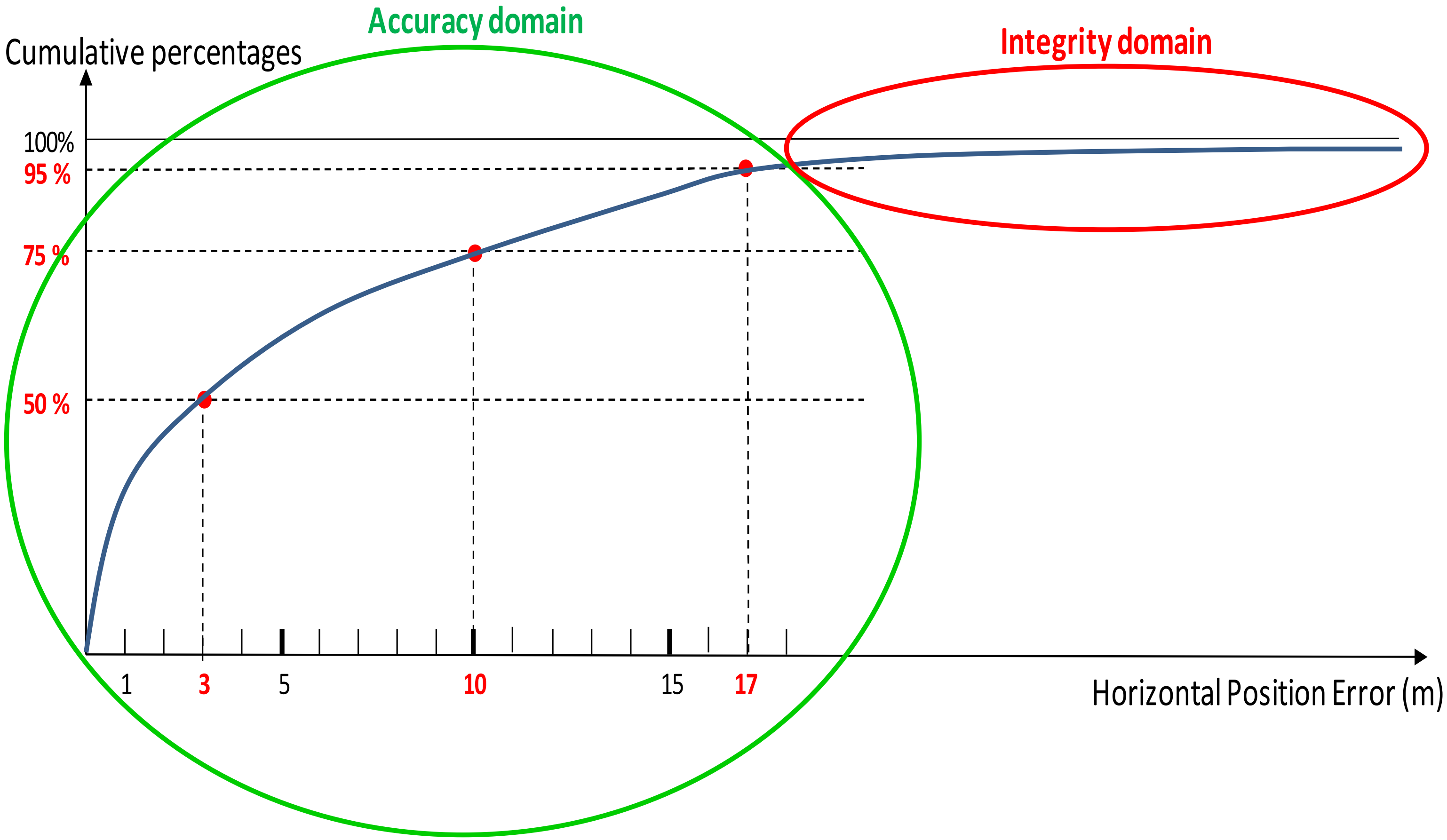
Concept developed by the civil aviation for bounding the errors:

- HPL = Horizontal Position Level
- VPL = Vertical Position Level

Expressed by 2 associated quantities:

- The **Protection Level** (PL)
- The **Integrity Risk** (IR) defining the probability that the actual error exceeds the PL (very low probability, e.g. 10^{-5}…)

Accuracy and integrity are 2 different ways of looking at the error Cumulative Distribution Function (CDF)



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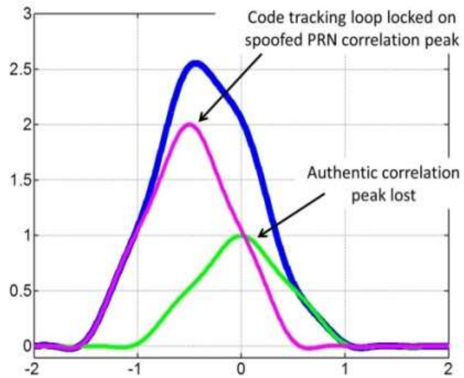
How to address the GNSS challenges ?

- **INTEGRITY**
  - Can be obtained only by combining the best of the present science and technology:
    - Sensor fusion (once again…)
    - Satellite Based Augmentation Systems (EGNOS)
    - Smart on-board SW processing the raw measurements with respect to the environment
  - A continuous and high Integrity could be irrealistic in constrained areas (deep urban) ➔ the AD system will have to take it into account and degraded modes should be available

Other GNSS challenges

- **SECURITY**
  - GNSS are sensitive to radio perturbations, unintentional (interferences) or intentional (jamming or spoofing)
  - Taxonomy of the security attacks is complex and rapidly evolving
  - Several tracks are investigated:
    - Pure signal processing techniques
    - Signal authentication (Galileo)
    - Consistency with other sensors information



Other GNSS challenges

- **STANDARDIZATION AND CERTIFICATION**
  - The emergence of critical applications (such as AD) requires a substantial change to develop systems **according to the actual customer needs**
  - In order for these changes to be implemented properly, **standardization** and **certification** are required
  - The work should focus on:
    - Establishment of a common language for performance measurements (**metrics**)
    - Definition of **performance at application level**
    - Definition of **performance at positioning level**
    - Engineering **procedure to link the two above**
    - Establishment of **procedures for testing** (measurement of performance metrics)

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Conclusions (1)

- **Where do we need more research ?**
  - Clearly on **Integrity**
    - Smart hybridization techniques
    - Smart FDE algorithms (improved RAIM techniques, etc.)
  - Improvements in Integrity will also improve Accuracy and Availability
  - On **robustness to security attacks** also
  - On **standardization** and **certification**, the efforts should be re-inforced to accelerate the process
    - Technology-independant performance standards
    - Classes of performances
    - Certification framework is urgently needed

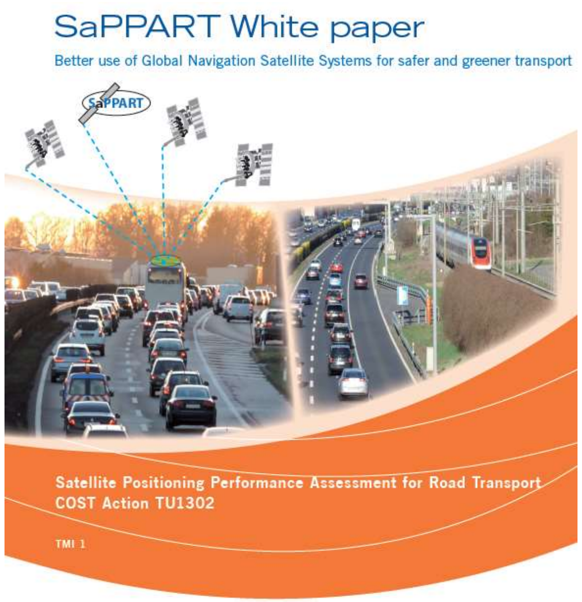
Conclusions (2)

- **Changes in the industry landscape**
  - The arrival of the big Internet players (from the Silicon Valley)
  - The reaction of the automotive industry
  - The digital revolution affecting in depth the mobility practices
  - The explosion of the geolocalized applications and services

- **How to create innovation dynamics ?**
  - To find the good balance between the liberal bottom-up approach (start-ups…) and the European/national programs, too often poorly efficient due to the administrative complexity of the European administration

Conclusions (3)

- **Main contributions of the TU1302 SaPPART COST Action**
  - Raise of awareness on GNSS technology and the issues related to its use in ITS
  - Establishment of a general framework for the assessment of GNSS performance for ITS applications
  - Active support to European groups working on performance standardization (CEN, ETSI, ISO)



THANK YOU FOR YOUR ATTENTION !

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