Position Paper on:

Physical and Digital Infrastructure

Summary

Currently there are many open issues related to the deployment, operation and maintenance of the physical and digital infrastructures for connected and automated driving and transport. The roles and responsibilities of the different stakeholders, the likely deployment scenarios and the time plans need to be agreed upon by the stakeholders from both the demand and supply side of the infrastructure. Investments in physical infrastructure are long-term investments, implying to consider also the possible future needs of road users.

The open issues concern, among others, infrastructure maintenance, security, economic feasibility, business models, differences in operating environments ranging from rural roads in remote areas to busy interurban motorways and from residential areas to central business districts, and the specific problems in the transition phase towards full connectivity and automation.

Introduction

In lower vehicle automation levels (SAE 1-3), the vehicles are expected to cope with the existing road infrastructures. The needs to adapt the existing physical infrastructure and to deploy new digital infrastructure for automated driving and transport are likely increasing as the (SAE) road vehicle automation level gets higher, and even SAE L3 functions may already have impacts on efficiency of transport system. As we are moving towards levels 4-5, the adaptation of physical infrastructure and its link with the digital infrastructure is becoming a key issue for the deployment of connected and automated vehicles.

Physical infrastructure, from roads, junctions and bridges to traffic signals and lamp posts, may need to be updated:

- Advanced and affordable transport infrastructure (e.g. reference to the Forever Open Road concept)
- Upgrading and adaptation of processes and requirements for maintenance of the road infrastructure, e.g. repaving, winter maintenance, road marking and traffic sign condition upkeep
- Specific infrastructure (road, street, junction, ramp, bridge, superstructure, pavements) design elements to facilitate safe and efficient automated driving in full deployment as well as in the transitory phase, utilizing the principles of a safe system approach
- Role of the traffic management centres in order to effectively and safely manage traffic and, in case, accidents/incidents by regulating the traffic flow both for conventional and automated vehicles
- Functional road categorisation and the closely connected speed regimes (safe speeds) are still considered as a frame of reference for all aspects of road design.

However, such measures are very expensive. Therefore, research must assess whether they are really needed and evaluate their costs to facilitate road operators' decisions.

The "Digital Road infrastructure" may be defined as "the digital representation of road environment required by Automated Driving Systems, C-ITS and Advanced Road/Traffic Management System". It can be understood as the integration of multiple geo-located information layers containing:

- Static - Basic Map Database (e.g. Digital cartographic data, Topological data, Road Facilities)
- Semi-static - Planned activities and forecast (e.g. traffic regulations, road works, weather forecast)
- Semi-dynamic - Traffic Information (e.g. accidents, congestion, local weather)
- Dynamic - Information through V to X (e.g. surrounding vehicles, pedestrians, timing of traffic signals)
- Dynamic driving recommendations (e.g. lane change, distance gap)

In addition, the infrastructures include those for integrating afore-mentioned elements, i.e. the positioning infrastructures (e.g. satellite positioning, cellular and LAN positioning, roadside landmarks), communication infrastructures, and the

back-office processes (e.g. information management centres, servers and databases, data interchange servers, traffic flow sensors etc.). The connection between the physical highway infrastructure, digital mapping, digital traffic information, and autonomous vehicles including the concept of local dynamic map plays an important role.

Input for research agenda

Research and Innovation and/or large scale FOT to assess especially the physical (road and roadside) infrastructure needs for and consequences of higher level automation. This relates to use and adaptation of existing physical infrastructure (consequences to pavements, bearing capacity, utilisation of hard shoulders, roundabouts, new road monitoring/maintenance tools, allocation of special use lanes, forms of visual guidance, traffic management, connectivity solutions, considering all road user groups, electrification, need of standardized road infrastructures for automated driving) and for building up new physical infrastructure (city planning, road/street planning and design). The transition phase needs to be addressed specifically. The interaction between road infrastructure and connected automated vehicles needs to facilitate functional safety in distributed functions for automated road transport.

With regard to digital and data-oriented infrastructure and especially off-board sensors, in urban environments new infrastructural sensing methods could overcome blind spots in vehicle surround sensing by aggregating data from multiple sources to cope with critical situations. Another approach could be to use large-scale heterogeneous vehicle fleet data for a backend-based collective perception resulting in a near-real-time map. In this case, the needs and the conditions for the use, reuse and sharing of data generated by connected and automated vehicles need to be assessed. To set up a suitable backend solution, integrated, efficient and dependable computing platforms and control strategies are required. Altogether, a scalable consolidation of large amounts of floating car data is needed while data reliability must be assured. New standards for the applied data interfaces are to be established.

Impact

The impacts are not known yet, but knowledge of them is essential for the further development of physical and digital infrastructure. They should be determined via ongoing and planned tests, pilots, Field Operational Tests as well as the first deployments. In order to identify possible impacts horizontal issues regarding privacy, ethics, security, data management, costs, etc., need to be taken into account. The privacy of drivers and users of automated vehicles needs to be maintained under all circumstances – especially the data that is generated by tracking of the vehicles, which is used by the back office systems, other drivers and stakeholders. Security issues are also a concern for the physical infrastructure, and its users.

Cyber-security issues with the digital infrastructure are quite wide-arching from GPS spoofing to take hostile control of the vehicle or its subsystems. Liability issues involves both physical and digital infrastructure. We need to determine at all times who is responsible for the data, and also of the maintenance of the physical and digital infrastructure, among others. Careful preparation of contracts and service level agreements provide at least some solutions to these issues. In addition to that, the assessment of costs will be a key factor to support road operators' decisions will be. Therefore all measurements and activities regarding automated driving should be planned in coordination with the issues of physical and digital infrastructure.