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Smart Transportation Alliance

A STRATEGIC ROAD RESEARCH AGENDA 2015-2025

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1.   Introduction

Roads must adapt their role in the context of a safe, sustainable and integrated transport system, in order to successfully tackle the main challenges faced by this type of transportation infrastructures: more operational efficiency, a better safety performance, enhanced security conditions, reduced traffic congestion, a decrease in pollutant emissions, and in addition a guaranteed long-term financing of their operations and maintenance.

Following a detailed review of existing R&D efforts at the international level and bearing in mind the degree of market uptake of the technological solutions available today, this STA Technical Report maps out a set of **116 R&D priorities** bringing the **Smart Roads** concept[1] to reality.

Each R&D priority is classified into an **innovation topic** (*Smart and Green Road Construction & Operation*; *Road Infrastructure Safety*; *Road Mobility & Modal Integration*), and in addition has been scheduled in a **10-year roadmap** (2015-2025) leading to market deployment.

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[1] The 'Smart Roads' concept has been defined in the STA Discussion Paper 1/2015 and is downloadable from http://www.smart-transportation.org/publications.

2. R&D Priorities for Innovation Topic 1: SMART AND GREEN ROAD CONSTRUCTION AND OPERATION

ENERGY AND SUSTAINABILITY

The 'Highway of the Future' must satisfy high mobility demands, but at the same time they should secure the lowest possible energy consumption and CO2 emissions when it comes to their construction, operation and maintenance. However, today there is no a reliable tool providing sound 'sustainability' data derived from all phases of the road's life-cycle. Such information would be most valuable to designers, road agencies, contractors, operators and users.

- ### Innovation subtopic 1.1 (2015-2018)

  - **ROAD INFRASTRUCTURE LIFE-CYCLE ASSESSMENTS (LCAS). ENERGY CONSUMPTION AND POLLUTANT EMISSIONS**

It is a priority to carry out a rigorous audit of the energy consumption and pollutant emissions associated to the planning, construction and operation of roads. Analytical models and software tools must be coupled with full-scale demonstration programmes that endorse the predicted outcomes. The research priorities identified are:

1. *Comprehensive LCA methodologies and carbon-footprint calculators for the selection of alternatives along road design, construction, operation and maintenance.*
2. *Road energy labelling: identification of energy consumption factors and patterns.*
3. *Vehicle fuel consumption according to pavement typology (and related maintenance).*
4. *Advanced research on tyre-road surface interaction.*
5. *On-site sensors to generate real-time information and identify energy consumption patterns.*
6. *Albedo effect in urban and interurban pavements.*
7. *Calculation of temperature drops in urban environments according to the capacity of pavements to reflect sunlight and reduce building energy consumption.*
8. *CO2 emission sinks in concrete pavements.*

- ### Innovation subtopic 1.2 (2019-2021)

  - **MINIMISATION OF ROAD ENERGY CONSUMPTION**

  - **ADAPTATION OF ROAD INFRASTRUCTURES TO NEW-GENERATION VEHICLES AND TO NON-CONVENTIONAL ENERGY SOURCES**

- **INTEGRATION OF NEW ENERGY SOURCES IN DAY-TO-DAY ROAD OPERATION**

To comply with the energy efficiency objectives set up by international organisations, road infrastructures will have to catch up with the eventual massive deployment of electric, hybrid and hydrogen-powered vehicles. In doing so, roads will reconfigure themselves to host charging points, hydrogen and biogas stations, among others. At the same time, the sector must develop technological solutions and procedures that minimise the energy consumption associated to road construction and operation. The research priorities identified are:

9. *Advanced infrastructures guaranteeing the interurban mobility of new-generation vehicles (electric, hybrid, hydrogen-powered).*
10. *Technologies supporting electricity demand management: charging infrastructure, charging spaces management, payment management, access management, service areas, etc.*
11. *Sustainable procedures and recycling tools to minimise energy consumption during asphalt mixture production.*
12. *Minimisation of energy consumption during road construction and operation.*
13. *Intelligent lighting systems using new technologies (replacement of sodium by LEDs) and switchable luminaires adapting to environmental and traffic conditions.*
14. *Utilisation of renewable energies and optimisation of energy consumption in traffic control systems, road equipment, etc.*

   ○ Innovation subtopic 1.3 (2022-2025)

- **ENERGY GENERATION IN ROAD INFRASTRUCTURES**

- **RECOVERY OF ROAD TRAFFIC ENERGY (ENERGY HARVESTING)**

A better management of energy resources is needed at a global level. In this spirit, it is noted necessary to rethink road design. Road infrastructures should not only provide for the mobility of citizens and businesses, but also become self-efficient and improve their socioeconomic contribution. The research priorities identified are:

15. *Energy harvesting generated from road traffic to supply power to management and traffic control systems.*
16. *Energy harvesting associated with solar and thermal energy.*
17. *In-motion charging of electric vehicles. Charging time reduction.*
18. *New supply networks based on V2G (Vehicle to Grid, bi-directional connection between vehicles and electricity grids).*

ENVIRONMENT

Transportation infrastructures (roads, railways, airport and seaports) have a major impact in land use and the surrounding environmental conditions. Combining today's social demand for better road mobility with a more extensive care for the environment is an essential move, vital to meet a long-term sustainable development.

- ○ Innovation subtopic 1.4 (2015-2018)

    - · WASTE RECYCLING

    - · RE-USE OF MATERIALS

    - · NEW TRENDS IN INFRASTRUCTURE DESIGN

    - · ABSORPTION OF AIR POLLUTANTS

    - · GREEN CORRIDORS

Until quite recently the sector has followed a 'restrictive' approach, focused on assessing the negative impacts of a road to the environment, to then identifying afterwards the corrective measures required. A 'comprehensive' vision is now required, also identifying the economic savings and the potential benefits brought to the environment by road infrastructures. The research priorities identified are:

19. Partial or total re-use of waste generated during road construction and maintenance.
20. Use of industrial waste in road construction.
21. Reduction of waste generation in road construction.

22. *Integral methodologies allowing cost estimation and monitoring of both corrective (minimising negative impacts to the environment) and compensatory (increase of positive impacts) measures.*

23. *Photo-catalytic pavements combating air pollutants (NOx, SOx, particles, etc.).*

24. *Infrastructure design optimizing vehicle-road interaction from an emission perspective.*

25. *Assessment of potential toxicological and eco-toxicological impacts in asphalt concrete laying.*

26. *Dedicated 'green' corridors: integration with other solutions and demonstration tests.*

27. *Innovative low-noise road surfaces. Advanced noise barriers.*

- ○ Innovation subtopic 1.5 (2015-2018)

    · **ECO-LABELLING OF TRANSPORTATION PRODUCTS**

    · **ECO-LABELLING OF TRANSPORTATION INFRASTRUCTURES**

Research efforts in the environmental field must be summarised into easily understandable 'eco-labels' that convey available 'green' alternatives to designers, authorities, operators, contractors and users. This will highly stimulate the use of these alternatives in public procurement. The research priorities identified are:

28. *Eco-labelling of road products (according to the use of recycled/reused products, CO2 emissions during construction, energy consumption, durability and noise generation).*

29. *Eco-labelling of road infrastructures, considering the whole cycle of road construction and maintenance.*

30. *Updated legislation and technical specifications taking eco-labelling into consideration.*

MATERIALS AND CONSTRUCTION TECHNIQUES

The road infrastructure sector has devoted important efforts to improving road construction materials, becoming these long-lasting, climate resilient and more environmentally-aware. Today this drive is matched by a growing user perception of the driving conditions offered by a given road section (e.g. in relation to low-noise pavements, longitudinal evenness and skid resistance coefficients). Moreover, parameters such as the durability and the re-use and recycling of materials are becoming more relevant in an economic context that demands higher efficiency, safety and sustainability.

o Innovation subtopic 1.6 (2019-2021)

· **NEW TECHNOLOGIES FOR SAFETY, EFFICIENT AND SUSTAINABLE MATERIALS AND CONSTRUCTION TECHNIQUES**

It is a priority to promote go-to-the-market solutions: likely to be deployed in the medium-term. Some examples are recycled pavements, the utilisation of construction by-products and other waste materials, low-temperature manufacturing and emission reduction in road construction procedures. Traditional pavement binders (bitumen, bitumen emulsions and concrete) are produced using important quantities of energy and fuel, therefore emitting considerably high amounts of CO_2: innovative binders should be tested to reduce this impact. The research priorities identified are:

31. *New technologies, processes and mixtures for asphalt recycling.* The purpose is to obtain higher (if possible 100%) recycling rates, as well as a lower concentration of new-generation binders in mixtures. An additional target is the reduction of energy consumption and emissions during the hot-mixtures recycling process, the recycling of warm-mix and half-warm mix asphalt mixtures.

32. *Minimisation of energy consumption during asphalt mixture production.*

33. *Life-Cycle Analysis (LCA) and Life-Cycle Cost Assessment (LCCA) of materials and pavements and processes.*

34. *Ecological binders for more sustainable roads.* The main objective is replacing some conventional binders by developing advanced binders that use waste materials with pozzolanic properties.

35. *Re-use of fillers from asphalt plants.*

36. *Innovative alternatives for the utilisation of tyres that are no longer in use.*

37. *Carrying out tests to evaluate the durability of materials according to traffic and other road conditions (e.g. weather.).*

38. *Use of fast-track concrete pavements during pavement rehabilitation.*

39. *Studies to improve PSV (polished-stone value) in aggregates and skid resistance in road surfaces.*

40. *Advanced de-icing agents for winter maintenance.*

o Innovation subtopic 1.7 (2022-2025)

· **MATERIALS AND CONSTRUCTION TECHNIQUES FOR THE SMART ROAD OF THE FUTURE**

Research efforts must bring to reality cutting-edge construction and maintenance solutions that address the safety, efficiency and sustainability challenges faced by road infrastructures nowadays. The research priorities identified are:

41. *Perpetual pavements.*

42. *No-shrinking concretes that allow increasing the distance between joints in mass concrete pavements.*

43. *Broader use of nanotechnologies in road construction materials.*

44. *Construction components (form-works, centrings, modular elements) for on-site pre-manufacturing.* The traditional factory-based pre-manufacturing has today numerous limitations. Pre-manufacturing represents a major step that allows better construction procedures and monitoring. However, further progress is needed for on-site pre-manufacturing techniques, in order to optimize the use and storage of materials in work zones.

45. *Steel oxidation in metal structures.* Although the use of metal structures in bridges and viaducts in road construction has brought many advantages to the sector over the past, maintenance activities must be reinforced to prevent issues derived from wear and corrosion.

46. *Simulation tools for fire tests in road tunnel projects.* For instance, small-scale virtual tests reproducing the main characteristics of a tunnel entail a powerful tool to obtain relevant data for the adequate management of hypothetical fire incidents.

47. *Fire-resistant road surfaces for high-risk areas.* The use of active fire protection systems must be combined with the utilisation of road materials with low smoke and heat emission reactions to fire. In this sense, high-risk areas such as tunnels and underground parking facilities deserve special attention.

48. *Improved fire-resistance performance in noise barriers.* This road equipment is essential to protect users and citizens from nearby fires.

49. *Improved combination of materials in between pavement layers.*

3. R&D Priorities for Innovation Topic 2: ROAD INFRASTRUCTURE SAFETY

Road safety still constitutes a major societal tragedy at the global scale. The need for a sustained effort in training and enforcement programmes, coupled with the phase-in period required by the massive deployment of new car technologies, is benefitting the implementation of solutions acting directly on the road infrastructure, since they derive in immediate social benefits.

o Innovation subtopic 2.1 (2015-2018)

- **TECHNOLOGIES, TOOLS AND METHODOLOGIES SUPPORTING THE IMPLEMENTATION OF SYSTEMATIC ROAD SAFETY IMPACT ASSESSMENTS, AUDITS AND INSPECTIONS AT THE PLANNING, DESIGN, CONSTRUCTION AND OPERATION STAGE**

Some international and national regulations have laid down the guidelines for conducting – through qualified auditors - systematic road safety impact assessments, audits and inspections at the planning, design, construction and operation stage of roads. Being this a main pillar to secure a substantial reduction in road victims and fatalities, the concern towards better road safety conditions must drive the sector's innovation efforts. The research priorities identified are:

50. *Cost-benefit ranking of infrastructure safety measures (investment costs vs. reduction in the number and severity of accidents).*
51. *Automated, non-intrusive and non-destructive road inspection systems.*
52. *Optimization of road maintenance processes by means of using new technologies. More automated road maintenance.*
53. *Road safety solutions for work zones and maintenance activities.*
54. *On-site and self-monitoring systems able to collect and deliver information on road conditions (advanced preventive maintenance, physical perimeter assurance).*
55. *Winter serviceability.*

o Innovation subtopic 2.2 (2015-2018)

- **INNOVATIVE ROAD SAFETY SOLUTIONS**
- **ADVANCED ROAD EQUIPMENT**

Road infrastructure conditions -and its interactions with drivers and vehicles- are a determining factor in at least a third of all road accidents. New technological developments, including high-quality signposting, containment systems, advanced pavements and lighting

devices, must reduce both accident rates and their severity. The research priorities identified are:

56. *Improved installation and better integration of Vehicle Restraint Systems.*
57. *Adaptation of safety barriers to the U.S. and European regulatory frameworks.*
58. *Securing the durability of roughness, texture and skid resistance characteristics in pavements.*
59. *Advanced studies on pavement-tyre interaction.*
60. *Advanced signposting and optimization of road lighting.* In order to inform drivers adequately, road designers and operators have 'flooded' many roads with signs that often are not as effective as they should be, as they do not provide concise information according to the road environment conditions.
61. *Design and deployment of safety measures in road level-crossings.*
62. *Adaptation of road equipment and road design specifically aimed at the requirements of vulnerable users and the elderly, especially in urban areas.*
63. *Advanced labelling of road safety equipment.*
64. *Definition of the optimal geometric conditions for variable-speed and no-speed-limit roads.*

○ Innovation subtopic 2.3 (2019-2021)

· **ACCIDENTOLOGY AND ACCIDENT RECONSTRUCTION**

· **ADVANCED STATISTICAL ANALYSIS**

Scientific and technological activities must address the quantitative and qualitative factors influencing road accidents. It is a priority to correctly understand the representativeness of the different types of accidents in order to define the most effective guidelines and best practices. The research priorities identified are:

65. *Innovative technologies linking road infrastructure safety with human factors.*
66. *Advanced studies on high-risk road environments, namely roadsides and intersections.*
67. *Special statistical analyses to define issue-specific safety measures.* Some examples are cross-town links, urban accidents, vulnerable users, animal run-overs, road sections with a low concentration of accidents, etc.
68. *Collection of safety-related real-time information through on-site sensors embedded in the infrastructure.*
69. *Ex-ante assessment of road safety conditions by means of using simulation tools.*
70. *Definition of 'acceptable risk levels' in roads. Methodologies for the quantitative risk assessment of road safety equipment.*
71. *Safety-related statistical forecasting models.*

4. R&D Priorities for Innovation Topic 2: ROAD MOBILITY AND MODAL INTEGRATION

INTELLIGENT TRANSPORT SYSTEMS

Intelligent Transport Systems (ITS) have revolutionized the way business, public and private mobility is understood. Despite the progress made, further solutions need to be deployed, so ITS systems provide the most effective transportation services to businesses and citizens alike.

- ○ **Innovation subtopic 3.1 (2015-2018)**
  - · **EFFECTIVE IMPLEMENTATION OF INTELLIGENT TRANSPORT SYSTEMS (ITS)**
  - · **ENHANCED SYNERGIES BETWEEEN DATA SUPPLIED BY ITS EQUIPMENT CURRENTLY INSTALLED IN ROAD INFRASTRUCTURES**

Roads being the essential link in the transportation modal chain, it seems a priority to improve the existing ITS products, going beyond the elaboration of simple studies, analysis and strategies. The binomial 'enforcement agents - cameras & radars' needs to be overcome, benefiting from the existing information and data provided by more advanced systems. The ultimate objective here is to obtain more detailed journey times by combining data from a variety of sources (sensors, Bluetooth, license plate recognition, satellite, etc.).

The development of user-oriented, practical and accessible ITS systems will support the deployment of innovative solutions. In addition, more efforts should be allocated to the 'demonstration' and 'exploitation' activities included in international R&D projects. The research priorities identified are:

72. *Mapping of ITS systems installed in road infrastructures.*

73. *Assessment of the effectiveness of ITS systems in service, both from an objective point of view (speed recording, travel times, type of vehicle, etc.) and taking into consideration their influence on user behaviour.*

74. *Improved mobility management through the integration of information from heterogeneous sources, in order to enhance data robustness and the dynamic calculation of service standards.* Nowadays, much of the data obtained from the ITS systems installed (related to infrastructure, traffic and weather conditions) are only used independently. Their usefulness is considerably higher when compared with each other. Based on the available equipment and data, adequate tools must be developed to provide valuable information in a fast, seamless and useful manner. In addition, public road authorities and highway operators must jointly exploit and optimise the ITS data sent to traffic management centres.

75. *Development of a harmonized traffic-data system at the trans-national level.*

o **Innovation subtopic 3.2 (2015-2018)**

· **OPTIMISING THE UTILISATION OF EXISTING ROAD INFRASTRUCTURES**

It is vital to promote a greater optimisation of existing road infrastructure. In the future, the traffic management systems should run tools allowing an efficient and dynamic operation of roads, catering to the specific traffic conditions at a given moment. The research priorities identified are:

76. *Improvement of real-time technologies monitoring road conditions, taking into account flow rates, incidents, adverse weather conditions, real speeds and travel times.*

77. *Advanced sensors and warning systems for the monitoring of mobility and traffic parameters (speed, position, vehicle classifications, accidents, incidents, road conditions, etc.) in primary roads.*

78. *Advanced sensors and warning systems specific for the monitoring of mobility and traffic parameters in secondary roads.*

79. *Road asset management and maintenance tools implemented by using augmented reality in mobile devices.*

80. *Development of algorithms adapted to traffic changes or special situations (traffic congestion, adverse weather conditions, accidents, incidents, etc.).*

81. *Flow control and operation systems (dynamic mobility management through origin-destination matrices, vehicle positioning, demand management, public transportation, etc.).*

82. *Prognosis tools for decision-making.*

○ Innovation subtopic 3.3 (2015-2018)

· **PROVISION OF QUALITY AND REAL-TIME INFORMATION TO USERS ON THE TRAVEL OPTIONS AVAILABLE IN THE ROAD NETWORK, BOTH IN PUBLIC TRANSPORT AND IN OTHER TRANSPORT MODES**

ITS systems must contribute towards developing technologies that facilitate freight and travellers to switch seamlessly between modes and across borders. Furthermore, more efficient coordination will cut transport times and costs. The research priorities identified are:

83. *Improved coordination between transport modes in freight and passenger transport.*
84. *Intermodal cooperative traffic management through ad-hoc information tools based on mobile devices (OBUs, nomadic devices, etc.).*
85. *Management services for shared vehicle mobility (car-sharing, car-pooling).*
86. *Enhanced connectivity between private vehicles and public transport.*
87. *Risk management systems for road networks, defining models for alternative corridors and itineraries. Decision support systems for road operators in emergency and/or evacuation situations.* There is a growing public perception of the disturbances and damages caused to the road network by natural and man-made disasters. Road operators need to develop adequate risk evaluation models able to decrease the degree of vulnerability of a road to natural and man-made disasters as well as intelligent protocols for ameliorating recovery times.

○ Innovation subtopic 3.4 (2019-2021)

· **A MORE SUSTAINABLE AND ENVIRONMENTALLY-FRIENDLY ROAD MOBILITY**

· **DEFINITION OF MOBILITY MODELS ADAPTED TO A NEW GENERATION OF VEHICLES**

Transportation sustainability demands that infrastructure-based ITS systems promote more efficient mobility scenarios that match with a fast-developing car industry. The research priorities identified are:

88. *Mobility management related to pollution levels (CO_2, NOx).*
89. *Mobility models associated to low-emission vehicles (electric, hybrid, hydrogen-powered).*
90. *Traffic management influencing in the vehicle fuel consumption (steady speed, no traffic jams) by using trip-time sectorisation techniques.*
91. *Tools and strategies that encourage a more environmental and ecological driving style.*
92. *Adaptative green corridors for low-emission vehicles (electric, hybrid, hydrogen-powered).*

○ Innovation subtopic 3.5 (2019-2021)

- · **DEVELOPMENT AND DEPLOYMENT OF I2V, V2I, V2V AND I2I COOPERATIVE SYSTEMS IN URBAN AND INTERURBAN AREAS**

Integrating data generated by both vehicles (V) and infrastructure (I) must become a reality in order to provide high-quality road services. These cooperative systems must operate within a common framework and an integral architecture, with a clear definition of roles assigned to both above-mentioned elements. The research priorities identified are:

93. *Advanced cooperative systems to manage accidents/incidents, e-Call, weather conditions tools, minimum headways (distance between vehicles), variable speed limits, search and monitoring of stolen and reported vehicles, monitoring of special vehicles and vulnerable road users, etc.*
94. *Field Operational Tests (FOTs).*
95. *Minimisation of parking search time ('search traffic') via V2I and I2V communications.*
96. *I2V services providing information to users from a cognitive point of view: more efficient hearing and visual channels (research into new Human Machine Interactions, HMI).*
97. *Prioritisation rules for V2V and I2V services.*
98. *New Business models for innovative services based on cooperative systems.*

○ Innovation subtopic 3.6 (2022-2025)

- · **ELECTRONIC ROAD 2.0**
- · **DYNAMIC INFRASTRUCTURE CHARGING SYSTEMS**

ITS systems must pave the way for ground-breaking solutions, such as automated mobility, prediction of driver behaviour, and the dynamic charging of the vehicle by using a reliable and precise positioning system. In the context of the future collaborative *eROAD*, the so-called *Electronic Road 2.0*, users will exchange data and share information that will be useful to a sustainable road operation and maintenance. The research priorities identified are:

99. *Technology requirements for a dynamic pricing system related to the use of infrastructure. Long-term business models and charging frameworks (including prognosis of future technology changes).*
100. *Dynamic charging technologies associated to specifically-designed corridors (e.g. for light vehicles).*
101. *Definition of parameters for the introduction of automated road navigation system.*

102. *Mobility prognosis through on-line simulators in order to optimise travel demand (calculation of trust level routes, pricing tools, etc.).*

103. *Road data connectivity with the 'outside world'.* The Highway of the Future must go beyond V2I and I2V cooperative systems, connecting the infrastructure with the external information networks.

MODAL INTEGRATION

The on-going increase in traffic volumes as a result of economic development is undeniable. It has been largely noted that there is a direct link between a nation's income level and the mobility of its citizens and freight. Roads must satisfy the users' travel demand and adapt to new travel habits. But in doing so, there is a compulsory need to cooperate with the other transportation modes.

   o ## Innovation subtopic 3.7 (2015-2018)

   · **IMPROVED CONNECTIVITY AND SERVICES**

   · **'DEDICATED' CORRIDORS**

Roads being an integral – and inevitable – part in almost any multi-modal transportation 'solution', the research priorities identified are:

104. *Improved efficiency of road networks when connecting to other transport modes and to social infrastructures (hospitals, schools, libraries, etc).*

105. *'Dedicated' corridors reserved to freight transport, light vehicles, cyclists, etc.*

106. *Secure safety issues associated to the use of mega-trucks.*

107. *Utilisation of non-viable conventional railroads by road transport.*

108. *Adaptation of road design to logistic operations.*

   o ## Innovation subtopic 3.8 (2019-2021)

   · **ENHANCED COOPERATION BETWEEN TRANSPORT MODES (CO-MODALITY)**

Improving the coordination between transport modes reduces transport times, cuts costs and improves competitiveness, all three essential factors to achieve a sustainable transportation system. However, the combination of different modes to obtain a sustainable use of resources must be logically grounded and go beyond promoting modal change regardless specific circumstances. The research priorities identified are:

109. *Provision of high-quality, real-time information to users on available travel alternatives using private vehicles and/or public transport.*

110. *Management systems connecting transport modes in multi-modal stations, seaports and airports.* Point-to-point travel can be optimised by i) identifying the most critical changing points and ii) coordinating adequately the timetables offered by each transportation mode.

111. *Standard interfaces to facilitate data exchange between public transport and (passenger & freight) road transport operators.*

112. *Integrated management platform for the transportation of dangerous goods: detection, monitoring, reporting, permits, etc.*

113. *Integrated systems for route-planning and sustainable mobility management in urban environments, based on real-time traffic data, infrastructure sensors and nomadic devices and OBUs in vehicles, taxis and commercial fleets.*

114. *Parking policies promoting co-modality (Park & Ride, deterrent parking, enhanced parking capacities in stations) and optimizing the existing parking capacity (parking sharing).*

- ○ Innovation subtopic 3.9 (2019-2021)
  - · **PAY-PER-USE IN ROAD INFRASTRUCTURES**
  - · **COOPERATIVE TRANSPORT**

In many OCDE countries citizens are used to the regular allocation of public resources to transportation infrastructures. In the light of the existing budgetary constraints, attracting private sector investment is fundamental.

Research efforts must analyse the use of pay-per-use schemes, allowing a direct payment of road operations by users and not by taxpayers. In addition, the technical and economic feasibility of deploying a dynamic charging of road external costs must be further studied. The research priorities identified are:

115. *Comprehensive road charging and pay-per-use systems.* It is essential to define viable, realistic, long-term solutions that meet the existing road travel demand and secure the provision and maintenance of high-quality road infrastructures, while they remain neutral from a taxation perspective.

116. *Private cooperative transport and cooperative navigation.* Cooperative navigation lets users the freedom to choose the origin and destination of their travels, while at the same time does not decide the route or transport mode to be utilised. The optimal route is defined by an intelligent system, by fitting the user's requirements and individual privileges with the traffic conditions.

5. VISUALISING THE STA´S STRATEGIC ROAD RESEARCH AGENDA

INNOVATION TOPICS		
Calendar for market deployment		
2015-2018	**2019-2021**	**2022-2025**
TOPIC 1 – SMART AND GREEN ROAD CONSTRUCTION & OPERATION		
▪ Road infrastructure Life-Cycle Assessments (LCAs) (energy consumption and pollutant emissions) ▪ Waste recycling ▪ Re-use of materials ▪ New trends in infrastructure design ▪ Absorption of air pollutants ▪ Green corridors ▪ Eco-labelling of road products and infrastructures	▪ Minimisation of road energy consumption ▪ Adaptation of road infrastructures to new-generation vehicles and non-conventional energy sources ▪ Integration of new energy sources in the day-to-day operation of roads ▪ New technologies for safety, efficient and sustainable materials and construction techniques	▪ Energy generation in road infrastructures ▪ Recovery of road traffic energy (energy harvesting) ▪ Materials and construction techniques for the smart road of the future
TOPIC 2 - ROAD INFRASTRUCTURE SAFETY		
▪ Technologies, tools and methodologies supporting the implementation of	▪ Accidentology and accident reconstruction	

INNOVATION TOPICS		
Calendar for market deployment		
2015-2018	**2019-2021**	**2022-2025**
systematic road safety impact assessments, audits and inspections ▪ Innovative road safety solutions ▪ Advanced road equipment	▪ Advanced statistical analysis	
TOPIC 3 – ROAD MOBILITY & MODAL INTEGRATION		
▪ Effective implementation of Intelligent Transport Systems (ITS) ▪ Enhanced synergies between data supplied by ITS equipment currently installed ▪ Optimising the utilisation of existing road infrastructures ▪ Provision of quality and real-time information to users on travel options available ▪ Improved connectivity and services ▪ 'Dedicated' corridors	▪ A more sustainable and environmentally-friendly road mobility. ▪ Mobility models adapted to a new generation of vehicles ▪ Development and deployment of I2V, V2I, V2V and I2I cooperative systems in urban and interurban areas ▪ Enhanced cooperation between transport modes (co-modality) ▪ Pay-per-use in road infrastructures ▪ Cooperative transport	▪ Electronic road 2.0 ▪ Dynamic infrastructure charging systems