Strategic Research Agenda

Input to 9th EU Framework Programme

Status: final for publication

Version: 2.8
Date: 23.03.2018

TABLE OF CONTENTS

This new ERTRAC SRA was developed under the supervision of the ERTRAC Executive Group:

Chairman:
Stephan Neugebauer, Director Global Research Cooperation, BMW Group

Operational Vice-Chairman:
Jean-Luc di Paola-Galloni, Corporate Vice-President for Sustainability and External Affairs, Valeo Group

Vice-Chairman for research providers: Neville Jackson, Chief Technology & Innovation Officer, Ricardo

Vice-Chairman for academia:
Prof. Zissis Samaras, Director LAT, Lab of Applied Thermodynamics, Dept. of Mechanical Engineering, Aristotle University, Thessaloniki

Vice-Chairman for local authorities: Rafael Cuesta, Head of Innovation, Transport for Greater Manchester

Vice-Chairman for EU Member States, representing automotive research: Andreas Dorda, Deputy Head of Unit Mobility and Transport Technologies, Ministry for Transport, Innovation and Technology, Austria

Vice-Chairman for EU Member States, representing road infrastructures:
Jan Juslen, Director Information Management, Finnish Transport Agency (FTA)

Secretary General:
Josef Affenzeller, Director Research Coordination, AVL

More info about ERTRAC on www.ertrac.org

Contact person: Xavier Aertsens, Director, ERTRAC Office, info@ertrac.org

INTRODUCTION

The Strategic Research Agenda (SRA) is the key document of ERTRAC to prepare the next European Research Framework Programme. The last version was published in 2010 in preparation of the Horizon 2020 Programme. This new version is meant to support the development of the 9th EU Framework Programme (FP9): therefore, it provides Innovation challenges and Research and Development topics for the timeframe 2020-2030.

The document is structured in six chapters based on the new Vision of ERTRAC, which provides long-term objectives for the improvement of road transport by 2050. **This approach is a way to anchor the research work into the societal needs.** Compared to the previous version, this new SRA has the ambition to look more at the benefits of innovations for the end users. **ERTRAC also wants to stress the importance of Mobility and especially Road Transport for the society and the economy**. Therefore, the potential impacts of the research topics are always mentioned.

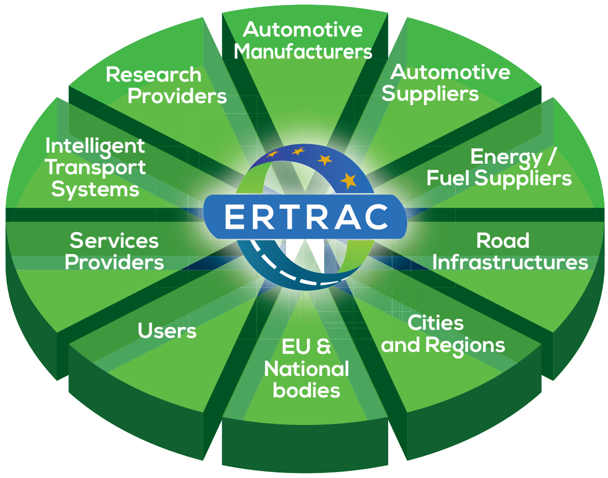
Thus, in preparation of FP9, ERTRAC highlights the important opportunities going with the upcoming innovations in road transport: major transformations are ahead of the European mobility system, with alternative energies, electrification, automation, digitalisation, and the sharing economy. **Europe must act together in order to exploit the potential of these innovations:** to develop Europe-wide solutions, get technology leadership, and keep research excellence, production and jobs in the European Union.

One important remark is that all these research efforts must be done in the short and medium-term timeframe in order to obtain market introduction from 2030 onwards, and become mass market afterwards, progressively towards 2050. **So, there is a direct link between the research work to be done during the 9th EU Framework Programme and the achievement of the transport objectives of the ERTRAC Vision for 2050.**

ERTRAC also calls for a well-balanced funding programme addressing the different levels of research and development activities: from fundamental and long-term research to applied research and up to support for deployment. Supporting implementation of innovative products and services will have a key role for topics like electrification and automation, where user involvement and testing in real conditions are critical aspects. **European pre-competitive collaborative research has a very high added-value because it brings together the many private and public stakeholders who are involved in transport:** working together, developing partnerships, and implementing cross-sectoral collaboration are important assets to speed-up the innovation process in Europe.

Reminder on the author:

ERTRAC is the European Technology Platform gathering all the actors of Road Transport Research. Its uniqueness lies in its public-private multi-stakeholders nature: involving industry, academia and research providers together with public authorities from the national and local levels. ERTRAC works in close cooperation with the European associations that represent the different components of road transport, and has also developed collaboration with other European Technology Platforms. And the work of ERTRAC is of course also organised alongside the needs and recommendations from the European Commission services.



The research topics proposed in this document have been prepared by experts from the ERTRAC members gathered within the six ERTRAC Working Groups:

- **Urban Mobility**, led by: Karen Vancluysen, Polis / Andres Monzon, Transyt, UPM.
- **Energy & Environment**, led by: Heather Hamje, CONCAWE / André Jarasse, Renault.
- **Long Distance Freight Transport**, led by: Bernard Jacob, IFSTTAR / Isabelle Schnell, Volvo Group.
- **Connectivity and Automated Driving**, led by: Mats Rosenquist, Volvo Group / Armin Graeter, BMW / Eckard Steiger, Bosch / Manfred Harrer, ASFINAG.
- **Road Transport Safety & Security**, led by: Peter Urban, IKA, RWTH / Maurizio Miglietta, FCA CRF.
- **Global Competitiveness**, led by: David Storer, FCA CRF / Thilo Bein, Fraunhofer LBF.

1. ENSURE MOBILITY IN URBAN AREAS

VISION 2050: "People and goods can reach their destinations in cities in a way that is healthy, safe, affordable, reliable and comfortable"

- **Walking, cycling, collective and shared mobility services** forming the backbone of the urban mobility transport, complemented by private vehicles.
- **Mobility is higher but fluent**, inclusive and sustainable.
- **Encouraging sustainable and healthy mobility behaviour** thanks to informed choices.
- **Mobility on demand** including Carsharing and Ridesharing.
- **Improved utilisation of shared vehicles and new technologies** have released former parking areas and other infrastructures for new use.
- **Intelligent and dynamic access regulation.**
- **Smart, automated and dynamic parking management** and allocation integrated with smart charging.
- **Pro-active traffic and incidents management.**
- **Emission free** in urban areas.
- **Smart city** logistics, building a link with passenger transport and long distance freight transport.

RESEARCH TOPICS 2020-2030:

Understanding the changes in cities: interactions between land use, transport, technologies and users

- How do land use measures affect urban mobility patterns?
- How can user acceptance/uptake/adoption be optimized, especially to achieve sustainability goals?
- What is the potential of ITS, big data and the Internet of Things to replace certain infrastructure developments?
- How to deal with different roll-out rates across and within cities and deal with different legacies?

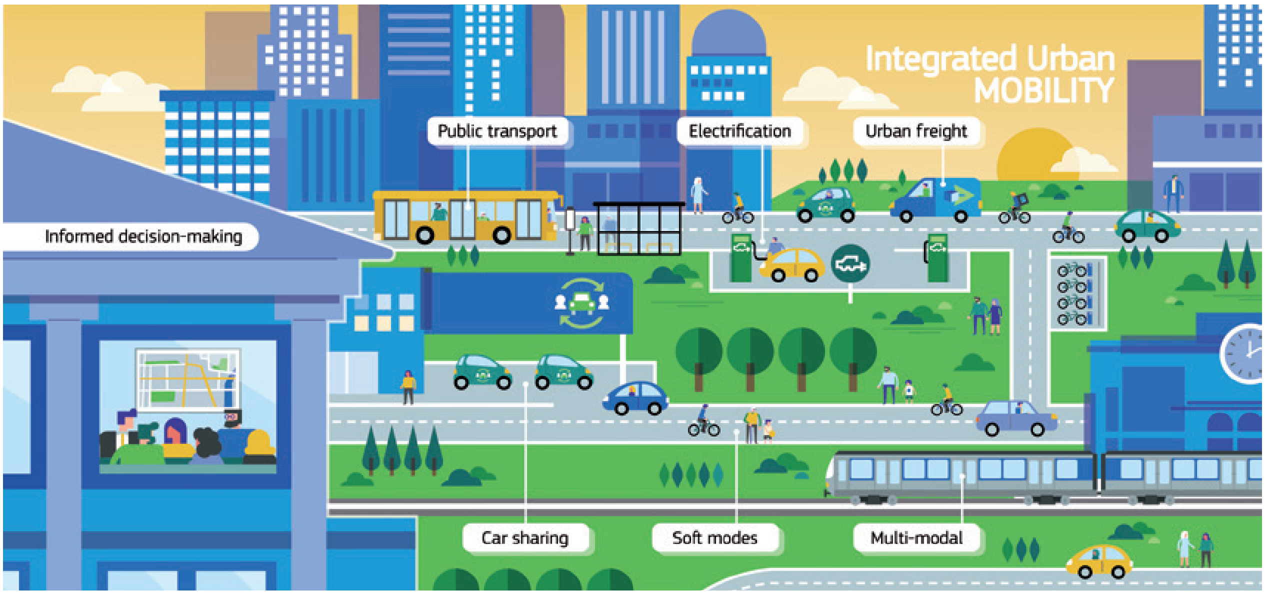
Impact: improved quality of urban space for livable cities; city readiness for disruptive and innovative mobility services; increased economic efficiency - more accessible and inclusive urban areas; better mobility between urban areas and their hinterland; reduced uncertainty for policy makers & investors; reduced rebound effects thanks to better assessment tools.

Simulation, planning tools and assessment methods to support evidence-based decision-making

- Quantify impacts of innovative solutions and mobility services on decarbonisation, air quality and noise, on congestion, modal shift, etc. Define and develop indicators, criteria for assessment and benchmarking.
- Data collection and data sharing across different public and private stakeholders and both for freight and passenger mobility without curbing cybersecurity nor privacy issues, and considering which data actually needs to be shared (may require standardization).

Impact:

- Reduce risks and adverse effects of implementing new infrastructures, solutions, services.
- Support the creation of viable business and procurement models as well as enabling regulatory frameworks.
- Integrate new mobility services in an optimal way so that they generate the envisaged positive result through evidence-based decision making and improved insights into actual impact of new mobility services and policies, including shared solutions, MaaS, automated transport, public transport, etc.



Tools and roll-out of integrated pro-active demand-responsive road transport network management

- Effective coordination and integration of different transport actors, networks and modes, adopting a user and citizen-centric approach to urban mobility and logistics.
- Policy-responsive and dynamic network management tools, supported by digitalisation.

Impact: more inclusive, comfortable, accessible, personalised and flexible infrastructures and multi-modal services, including information, integrated service provision, interchanges, ticketing, and parking; enhanced accessibility of low-density and low-demand areas; optimised use of network capacity and increased cost-efficiency; released space thanks to optimised use of available infrastructure.

Interchange infrastructures and services for smart and seamless intermodality

Planning approaches and business models for smart hubs enabling seamless multimodality and the urban transport energy shift, designed with regard to legacy systems.
Impact: seamless and integrated use of different transport modes; self-explanatory, intuitive, efficient and safe interchanges, inclusive for all users; modal shift to mobility services enhanced by interchange; flexible and upgradeable interchanges easily integrating innovative technologies; sustainable and long-lasting business models for interchanges, vehicles & fleet sharing and pooling, users accepting and using the transport systems thanks to their high reliability and the user's perception of being in control of his trip.

New sustainable and smart ways of delivering goods to make better use of urban space

Curb adverse impacts of increased freight and waste transport as a result of a growing urban population, increasing population density, and new buying patterns (e.g. e-commerce): transport demand, shipment size, consolidation and vehicle movements.
Impact: New sustainable and smart ways of transporting goods to make better use of urban space and minimise congestion, including new delivery patterns such as 3D printing, pods, autonomous, grouped and customised deliveries, drones, etc. Develop related impact assessment tools.

Requirements and concepts for new vehicles for urban use

Next generation of vehicles (all sizes from bicycles to buses) designed specifically and optimized for urban operation: range, platoon capable, fully connected, smart HMI, based on configurable modular architectures, and fully inclusive towards specific user demands (commuters, children, elderly, people with reduced mobility). "City-shaped" vehicles aligning the vehicle configuration to cities demands and fulfilling citizens expectations: enjoyable, smart, green, safe, comfortable, user centric.
Impact: new uses of vehicles matching citizens and cities needs in-real-time, hence improving city dynamics.

2. ENVIRONMENTAL SUSTAINABILITY: ENERGY AND RESOURCE EFFICIENCY, DECARBONISATION AND AIR QUALITY

VISION 2050: "CO_2-neutral road transport with minimal environmental impact including circular economy for vehicles and infrastructure"

- **100% renewable energy** for transport (electricity, alternative fuels).
- **Emissions free** urban areas.
- **Negligible or near zero emission** in rural areas.
- **Energy efficient road vehicles** in real world conditions.
- **Gapless energy supply** – charging infrastructure and alternative fuels everywhere needed.
- **Circular economy** for vehicles and infrastructure.
- **Affordable and energy efficient vehicle production** and maintenance.

RESEARCH TOPICS 2020-2030:

Renewable, low carbon advanced fuels: low cost sustainable production, storage and distribution

A key ingredient to future decarbonisation of the transport system will be the availability of low carbon advanced fuels and blending components, both liquid and gaseous e.g. those produced from biomass, synthetic fuels using green electricity. Their production may potentially remove existing CO_2 from the environment, may occur exterior to the vehicle or on board e.g. reformers, on-board CCS, and they may be used for chemical storage of electrical energy. Higher quality fuels may also have the advantage of providing improved vehicle efficiency and reduced emissions through better combustion. R&D challenges will include more energy and CO_2 efficient ways of production of traditional and new fuels. Novel ways of storing and distributing these fuels may be desirable and the infrastructure to allow them to be freely available where needed whilst minimizing further emissions.
Impact: Near zero CO_2 WTW, allows availability of low carbon energy for sectors whether suitable for electrification or not.

Highly efficient, fully electric battery powertrains and vehicles - long range electric passenger cars

In order to meet personal mobility needs for longer journeys as well as reduced greenhouse gas emissions, it will be necessary to develop electric vehicles with longer ranges as well as connected and automated vehicles to take advantage of efficiency gains obtained from these modes of driving. R&D needs include energy efficiency gains by light weight construction in combination with active safety systems. Optimizing energy needs of the car, and design efficient solutions for auxiliaries to improve the range of the vehicle will be important. Research should also improve efficiency of electric motor and power electronics such as new semi-conductors. Research into tire and brake materials could contribute to reduce residual particulate emissions.
Impact: Increased uptake of BEV in order to contribute to climate change mitigation.

Highly efficient, fully electrified bus system (urban, suburban and inter-urban)

Shared and public transportation will play an important part in decarbonisation of transportation and will include a fully electrified urban bus fleet transferring to electrified rural buses and integrated with other “last mile” solutions. R&D challenges include: Improved energy efficiency of propulsion and auxiliary systems, interfaces for conductive and inductive fast charging; and Integration with other collective and individual transport modes and with urban logistics and utility services.
Impact: Increase in numbers of BEV in order to contribute to climate change mitigation, air quality, noise, energy efficiency improvement.

Highly efficient electrified long distance trucks and coaches (…and roads)

Heavy-duty commercial vehicles driven long distances are a specific challenge for electrification, where reliance only on battery is not a solution in the short-term due to weight, payload and mileage. Hybrid powertrains and architectures must be developed, and solutions relying on integration with the road infrastructure have to be assessed. Energy efficiency of electric batteries for trucks and coaches will be important including on-route charging in combination with efficient operation, improved energy recovery and logistics for longer range trucks and coaches. Research in zero emission energy conversion system such as fuel cells. Scenarios, costs/benefits and energy well-to-wheel assessments. Interface between long distance and urban transport.
Impact: TTW CO_2 reduction per vehicle in the order of 12% under rural driving conditions compared to 2015 baseline, improved air quality, less congestion. WTW impact should also be considered.

Highly efficient, (plug-in) hybrid powertrains and vehicles for passenger cars and delivery vans

Future passenger car and delivery van hybrid powertrains are likely to combine electric propulsion systems, thermal engines and a tailored transmission & drivelines. Particular effort is required to develop new dedicated hybrid powertrains with the best combination of advanced ICE, electric propulsion and transmission technologies to give the best product attributes including energy efficiency and cost. Research needs include defining and development of disruptive powertrain architectures (combustion modes, heat recovery, hybrid transmission…) for extremely high real world energy efficiency and compatible with very low pollutant emissions. Integrated or modular novel architectures are needed to give affordable solutions to the above challenges. Advanced powertrain energy management will take advantage of V2X connectivity to the environment (infrastructure and other vehicles).
Impact: TTW CO_2 reduction per vehicle in the order of 15% under rural driving conditions compared to 2015 baseline.

Disruptive ultra-low emissions concepts for near zero emissions

The objective of this topic is to realize affordable hybrid powertrains contributing to near zero emissions for passenger cars and delivery vans. The pure electric mode will be appropriate for the zero emission areas. For inter-urban journey where the thermal engine will be used in addition to electric motor, research is needed to define and develop new combustion modes and after-treatment for powertrains that generate ultra-low emissions of all kinds under all conditions without fuel economy penalty and define advanced system management that is connected to the environment. Packaging and cost approaches to increase compactness and affordability. Recycling and end of life strategies to minimize life cycle impact.
Impact: Air quality and noise improvement particularly in urban and suburban areas but also in rural areas.

Highly efficient ultra-low emission ICE and other powertrains for long-distances

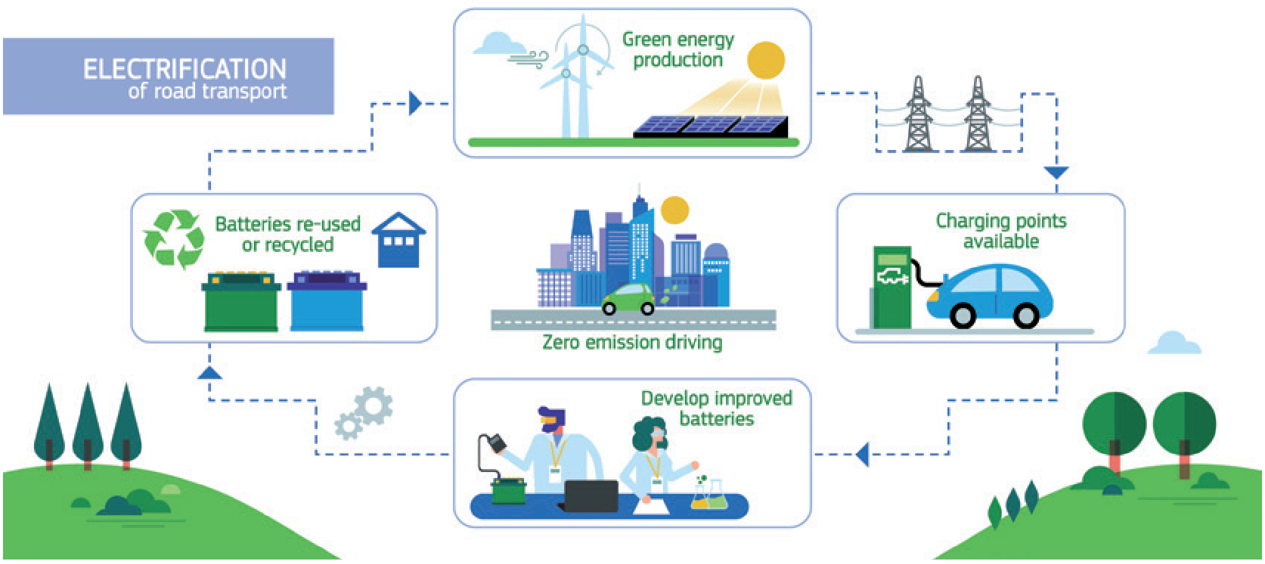
In the future new advanced fuels, with very low / near zero WTW CO_2 emissions, should be available whose use may (i.e. ICE) or may not involve combustion (e.g. fuel cells). Advanced powertrains designed to use these fuels for long distances will be optimized and will most probably be different from current, in order to take full advantage of the new fuel properties. Otherwise, the benefit linked to these new fuels will only be partial. This will also apply to their after-treatment systems. Research needs will include the powertrain control management system which will be crucial, flexibility to handle different fuels, be optimized for these fuels and may include fuel quality sensing capability. Connectivity to the environment will also be desirable. Reduction of catalyst materials will be needed to preserve resources and durability and reliability of engines or energy conversion systems.
Impact: Near zero CO_2 WTW.

New battery and convenient charging opportunities for different use cases: urban charging, high power charging, power transfer technologies

In order to challenge pure ICE vehicles without compromising performance, PHEV and BEV will need long range battery and fast-charging ability. Compact, light and affordable batteries with better tolerance to extreme temperatures will be needed for attractive and energy-efficient cars. Defining chemistry and developing solutions aimed at performance beyond current Li-ion capabilities will be a challenge. Energy efficient batteries and their production considering preservation of available resources are also areas for improvement.
In parallel to battery improvement, the infrastructure evolution needs easily deployable, cost effective and interoperable charging stations as well as ultra high speed charging stations.
Impact: Increased uptake of PHEV and BEV in order to contribute to climate change mitigation, air quality improvement, sustainability/ preservation of critical materials.

Second life / recycling and recuperation of materials including energy balance

EV batteries need to be produced sustainably and have potential for use in stationary units (home and buildings, charging stations, power plant peak support) after use in vehicles. At the end of life, EV batteries need to be dismantled and have high potential for reuse of materials. The value brought by second life, recycling and recuperation is significant for vehicle total cost of ownership (TCO) standpoint. Challenges include research into sustainable production, development of cost-effective processes to produce energy supply units based on reused automotive batteries including standards and advanced cost and energy efficient processes to extract rare materials for reuse (alumunium, copper, nickel, cobalt..). Advanced processes to treat non-recyclable components also need to be developed.
Impact: Lifecycle CO_2 reduction and preservation of natural resources used in the production of the batteries, ensuring residual value of EVs.



3. ENSURE AN EFFICIENT AND RESILIENT ROAD TRANSPORT SYSTEM

VISION: "Infrastructure and traffic management provide high efficiency road network services at competitive cost with minimized congestion, regardless of actual conditions and disturbances"

- Trans - European mobility control **supports pro-active, user-centric and integrated, door-to-door mobility** of people and goods.
- **Adaptive and flexible traffic and transport management systems** across all transport modes.
- Performance based standards determine access of freight vehicles to the road network.
- **Physical and digital infrastructure services** across Europe are **appropriately equipped** for automated vehicles, linking to international standards.
- Infrastructure services across Europe are on "**pay as you use**" basis.
- Construction and maintenance practices are automated, leading to **high cost-efficiency and minimal works related safety risks and congestion**.

RESEARCH TOPICS 2020-2030:

Topics below are limited to Long Distance Freight Transport.

Note about infrastructure research: infrastructure aspects can be found within the different chapters of this SRA, as ERTRAC follows a system approach. For research activities dedicated to infrastructures, ERTRAC acknowledges the work of other organisations such as FEHRL, ECTP and CEDR.

For research dedicated to logistics, ERTRAC acknowledges the work of the platform ALICE.

Pushing boundaries for higher vehicle capacity and efficiency with enhanced compliance

Facilitate vehicle efficiency, innovation and a better compliance with the weights and dimensions regulation; improve the efficiency of the freight transport system:
- High capacity vehicles (HCT): assessment of impacts (infrastructure, safety, modal shift) and benefits (efficiency, emission, labor cost, congestion).
- Preparing for European Performance Based vehicle Standardization (PBS).
- Automated compliance checks; direct enforcement by Weight in Motion (WIM); self control.
- Smart Infrastructure Access Programme (SIAP-vehicle) and monitoring; cross border issues.

Impact: the right vehicles on the right road at the right time; improve asset management, keep fluent optimized traffic and reduce cost (incl. cross-border).

Adaptation of road infrastructure for future vehicles and operations

- Design and equipment of charging and fueling infrastructure for the next generation of vehicles.
- Road infrastructure monitoring, diagnosis and maintenance, incl. vehicle on-board monitoring.
- Smart adaptive operation of vehicles for preventing road lifetime.
- Smart Infrastructure Access Programme (SIAP-infra), parking lots design and management.

Impact: reduced infrastructure cost, extended lifetime, harmonized European networks.

Evolution of logistics hubs, parking lots and networks for future freight operations

- Adapt logistic centers and logistics chains to the future operation modes.
- Cross-modal/co-modal infrastructure for an integrated self-organized and automated logistics.
- Design and equipment of logistic centers and facilities for the next generation of vehicles.
- Smart and automated connected space management (e.g. parking lots, terminal and storage areas).

Impact: optimal use of each mode, harmonized European networks.

4. CONNECTIVITY AND AUTOMATION – AN ENABLER FOR IMPROVED MOBILITY

VISION: "Digitalisation enables people to get the best service at highest level of comfort and safety"

- **Fully multimodal mobility** offerings including trip planning, pricing and payment.
- **Connectivity everywhere** and at any time with stable connection and data rates.
- **Communication between vehicles and infrastructure** to optimize traffic flow, traffic management and safety.
- **Mobility as a service** regardless of ownership.
- **Predicted demand from individual behaviours**, enabling appropriate modal capacity and demand management.
- **Digital technology** for vehicle access regulation, fee payments and prioritisation.
- **Data privacy and international standards** for data exchange and connectivity.
- **Highly automated vehicles** for the inclusion of vulnerable users and people with reduced mobility (PRM).
- Accidents and delays are extremely rare and delays automatically resolved.
- **Harmonized legal frameworks** for automated vehicles.

RESEARCH TOPICS 2020-2030:

Deployment of automated passenger vehicles in mixed traffic for improved safety and efficient road transport

Ensuring and supporting deployment of CAD vehicles addressing society demands and reducing barriers for European harmonization. CAD demands the transport system in general and the automotive sector and road operators in particular speeding up the technology shift from mechanic to software and data defined functionality. This shift requires enhancement of the methods, tools and processes for developing CAD products and services in an ever increasingly distributed and complex development environment. This will also require new competences and development partners. Large scale EU projects of highly automated vehicles (L3-L4) and respective digital infrastructure will be particularly valuable to support a harmonized European deployment:

- in the short-term, pilots from Horizon 2020 should be followed by further level 3 Field Operational Tests including impacts on users, traffic and society.
- in the medium-term, a level 4 deployment research programme should address different uses cases, including complex traffic environments, shared up-to-date digital maps and automated system resiliency.
- in the long-term, assess how integration of connectivity and cooperative systems can support high levels of vehicle automation and automated traffic management.

Impact: Harmonized progressive deployment of connected and automated vehicles for Europe.

Deployment of automated heavy commercial vehicles in mixed traffic for improved safety and efficient road transport

To implement the new automation technologies to improve efficiency and sustainability of freight and heavy commercial vehicles:

- In the short-term, implementation of truck platooning at short distances (»5 m or 0.3 s) and management of “platoons on the fly”.
- In the medium-term, automated truck driving (up to level 4) and multi-brand truck platooning on open road.
- In the long-term, transport automation (level 5): loading, handling, self-maneuvering (in confined areas first, and later on open roads).
- Human factors and driver acceptance (job change).
- Challenges of road network topology (exits, bridges, tunnels, etc.), traffic and environmental situations (congestions, heavy traffic, snow, etc.) and automated system resiliency.
- V2I and I2V communication for safety, security, access regulation, pricing and payment, optimal routing (including IT-infrastructure).

Impact: Improved freight mobility, safer and efficient vehicles, global multi-criteria optimization taking the all supply chain.

Fully automated vehicles for urban use

Development and demonstration of concepts for fully automated un-manned vehicles for specific applications for enhanced mobility of people and goods like robotaxis, bus-trains, innovative freight logistics, hub-to-hub automation, automated modal interchange mobility hubs.
Assess potential impacts on public transport and integration with shared mobility.
Development of innovative mobility services in urban areas demonstrating efficient and resilient road transport systems and environmental urban sustainability (energy efficiency, CO_2 neutrality, noise pollution and air quality).
Study potential use cases in different urban types and traffic structures, including inter-urban and rural.
Impact: Enhanced mobility of people and goods, improving transport efficiency, maximizing the use of road infrastructure in time and space.

Societal benefits and user acceptance

Increasing user awareness, acceptance and trust for CAD will be required through building understanding of user behaviour to enhance vehicle-human system interaction reducing complexity and building trust. Ensure proper user information and assess future skills for users and professionals.
Demonstrate user value, enhancing convenience, comfort, performance, traffic efficiency and safety. Study cost vs user benefits.
Societal benefits e.g. inclusiveness, age group differentiation, diversity and ethics.
Ensuring society acceptance and trust is of key importance to capture the full potential of CAD investments. Including role of local authorities.
Impact: User and society desire for CAD.

Fleet and traffic management of highly and fully automated vehicles under mixed traffic conditions

Operation of mobility services for both people and goods require safe and efficient fleet and traffic management of automated vehicles. Study role and responsibility of road authorities, traffic managers and private fleet operators. Support user acceptance and informed choices.
New models and methods to simulate future scenarios of automated road transport, considering the challenges of mixed traffic, especially in the transition period.
Managing fleets of thousands or even more vehicles at the same time is a challenge requiring novel computational and AI solutions, and addition to needs to develop the physical and especially digital infrastructure to cope with the real-time management of massive fleets.
Transport system level efficiency also likely requires fleet management for fully automated vehicles, although here fleet management is becoming integrated with traffic management.
Impact: Reliable transport systems and mobility for people and goods with at least similar efficiency as with human-operated vehicles and also in the cases of incident-, event- and weather-oriented disruptions and under mixed traffic conditions.

Ensuring Safe, Secure and Resilient CAD

To ensure functional safety requirements/safety cases and cyber-security requirements, CAD-vehicles and the digital infrastructure need to be resilient for both technical faults and external threats such as cyber-attacks, especially data security within the complete system (vehicle, communication, cloud).
Deal with increased system complexity and ensure higher levels of safety thanks to CAD. A specific safety issue is task sharing between automated and human controlled operations.
Develop a European approach and harmonized methodology for verification and validation, up to the high levels of automation, including remote update.
Impact: Safe, secure and resilient CAD is a pre-requisite for deployment of CAD on European roads.

Policies and regulation support

Ensure that research on development and testing (including virtual methods) is linked to future regulations, in order to speed up activities required for CAD policy and regulation.
Support EU harmonization for vehicle certification and safety regulation, road infrastructure requirements and classification as well as national harmonization of traffic rules.
Governance and ethics of data management.
Impact: To enable quick introduction of CAD products and services on European roads and avoid delays compared to competing regions.

Connectivity and Automation technologies for vehicles and infrastructure: sensors, software, systems-of-systems, high performance computing and Artificial Intelligence

In the short-term, master complexity and cost built upon modularity, scalability, standardization and maintenance. Convergence of systems. Provide robust, complementary and highly reliable sensor systems (e.g. solid state laser scanner) and vehicle location technologies.
In the medium-term, get ready high computation, networked, on-board artificial intelligence and machine learning systems. Integrate software defined intelligent systems in modular scalable architectures seamlessly in vehicle, infrastructure, traffic management and back-office systems.
In the long-term, new physics for sensors and perception analyses, as well as new concepts of Artificial Intelligence based on neuronal computers. And human-machine cooperation strategies.
Impact: Promote European technology leadership by cooperation of all involved stakeholders.

New services for people and goods enabled by Connectivity and Automation

Development of innovative, reliable, fair and ubiquitous mobility and transport services for the private user and the logistics operator, based on global standards and systems. New models for sharing of transport assets. Mixing passenger and goods transport services. Role of road operators and public transport. Building new and enhancing existent businesses, partner and competence centers for connected and automated mobility services.
- Develop scenarios for public and commercial services customized to the end user.
- Data ownership, handling, sharing for connected and automated mobility services: role of public and private actors.
- Open data and data privacy and security: legal and anticipated governance issues.
- Decisions tools, algorithms and transparency.

Impact: Improve transport system utilization and mobility efficiency, preventing incidents, mitigating congestion and improving mobility quality such as predictability and transport mode selection.

5. PROVIDE PERFECT PROTECTION: SAFETY AND SECURITY

VISION: “Safe and secure at any time”

- **Nearly zero accidents and injuries** due to safety functions and automated driving functions in fully connected vehicles, road users and infrastructure.
- **Optimised and intuitive Human-Machine Interface** (HMI) following the idea of cognitive safety.
- **Safe and well maintained physical & digital infrastructure.**
- **Dedicated traffic spaces** for different road users where sensible.
- **Improved levels of in- and post-crash safety** in the remaining collisions.
- **Secured privacy.**
- **Safety and security features** impossible to attack and misuse.
- **Continuous maintenance of software and system updates** constantly improving their performance.
- **Systematic verification & validation** of cyber physical systems.
- **Resilience**: highly automated management systems to minimise the impact of incidents and accelerate recovery.

RESEARCH TOPICS 2020-2030:

Understanding and predictive assessment of safety risks and system effectiveness

Improved road safety and shorter development cycles make limitations of traditional road safety analysis methods apparent. At the same time, the residual problem of accidents which still occur, even with new technology being implemented, needs to be better understood. With growing computer power, safety assessment methods should be extended to the transport system level, to future scenarios and to self-learning systems. Such assessment of both technical system performance and socio-economic benefits requires appropriate simulation environments and realistic models of all elements of the transport system (incl. human behaviour and traffic flow). It also calls for current data from naturalistic driving studies and accident analyses as input for realistic modeling. For self-learning systems, methods need to be developed to define when systems are sufficiently trained and how to deal with the inherent dynamics in their properties.

Impact:

- Enabling anticipating transport governance, well-founded prioritisation of road safety measures and efficient (public) investments.
- Supporting the development of rating schemes and/or regulation for safe automated driving.

Smooth interaction between all road users, their vehicles and infrastructure in a safe systems approach

Safe inclusion of new means of transport into the traffic system

Interaction between automated vehicles and between automated and non-automated road users will have to follow new principles without compromising safety. In particular, automated driving functions, road infrastructure and traffic management systems have to be designed, so that they can dynamically adapt to the behaviour of other road users. This should be based on a comprehensive analysis of how the road transport system will change with increased automation and how this will affect scenarios related to safety. Solutions need to be developed to avoid undesired interaction between future road users, considering safety and acceptance criteria. The idea of providing a minimum level of automation also to active modes should be considered in this context as well as the concept of permitting automated driving in a flexible way in the spatial and temporal dimensions. Another specific issue is the management of safe interfaces between road traffic and vertically taking off and landing vehicles.

Impact:

- Facilitating the acceptance of automation and leveraging its potential in increasing road safety.
- Making use of the third dimension of road infrastructure without compromising safety.

Safe interaction of users with vehicles and infrastructure in the digital traffic system

Human is becoming part of large, connected socio-technical systems. In case of the road transport system, the interaction with the system is highly safety-relevant. Therefore, road users (incl. drivers, riders and pedestrians) as part of the digital traffic system should always be aware what actions, if any, are expected from them, which means that human-technology interfaces have to become highly intuitive and adaptive to user needs. This will also require new unobtrusive methods of monitoring user behaviour, wellbeing, states of distraction and fatigue as well as vital functions and of responding to them. At the same time, potential changes in actual and required driver skills with higher levels of automation should be analysed. For driverless vehicles, the need for an acceptable code of behaviour and for corresponding rules should be analysed from a road safety perspective. Situations are also conceivable for such vehicles in which disobeying a traffic rule might actually serve the paramount objective of human life and wellbeing, e.g. in case of medical emergency. The implications should be analysed in detail.

Impact:

- Avoidance of crashes resulting from sub-optimal system adaptation to user needs/characteristics.
- Making optimum use of road automation in terms of road safety.

In-crash and post-crash safety in future scenarios of road transport

Non-fatal injuries have not been following the same positive trend as road fatalities for many years. Moreover, existing safety systems do not offer the same level of protection to all users, yet. For all road users, new ways are needed to better understand and reduce non-fatal accidents, in particular those implying long-term injuries. Virtual human body models are valuable tools in this context, which need improved biofidelity and new biomechanically based injury criteria. Moreover, they must be adapted to evaluate personal protection devices and forgiving road infrastructure for vulnerable road users. Light, but affordable and crashworthy vehicle body structures are another important research area in this context.

With regard to fully automated vehicles, appropriate crash safety systems are needed to allow their occupants to obtain new seating positions or even remain unbelted and move around freely in vehicles perceived as alternatives to conventional means of public transport.

New and improved care and rescue measures should also be a topic of future research to further minimise the long-term effects of road crashes.

Impact: Reduced human suffering and burden for the health care system, while making best possible use of the potential safety benefits of road automation.

Radical improvement of road safety outside Europe and OECD countries

Many low- and middle-income countries are not following the fast technological development in Europe and other OECD countries, in particular with regard to road automation. However, when the technology will arrive, there will be the crucial need to understand what this will mean for the transport system in these countries, especially for road safety. The development of specific infrastructure will be one of the biggest issues in this context, while some countries might even be able to skip a step and develop infrastructures ready for automation right from the start. Moreover, the transferability of European solutions in traffic system management should be investigated. As vulnerable and non-automated road users will continue to play an important role in non-OECD countries, this issue also deserves special attention in the safe design of their future transport systems.

Impact: Increased road safety in low- and middle-income countries, where 90% of fatal road crashes occur (with the highest rate in Africa).

6. EUROPE AS WORLD LEADER IN INNOVATION, PRODUCTION AND SERVICES

VISION 2050: Europe as world leader in innovation, production and services ON:

- **Excellence** in education, research, and training.
- Europe is the **first choice for entrepreneurs, world-leading experts and highly skilled workers** (Attract and retain the necessary research workforce).
- **Cross-sectoral collaboration** is fully established.
- **Energy efficient and sustainable production** in Europe.
- European network for **costumer oriented services.**
- **Methods and processes** to accelerate the innovation process.
- **Develop the new skills and competences needed for the future.**

RESEARCH TOPICS 2020-2030:

Improved vehicle efficiency through optimized design and weight reduction consistent with the Circular Economy

- Develop and deploy advanced and smart lightweight materials and concepts which are economically-viable for automotive applications, e.g. composites with tailored strength properties and ceramics for high-temperature applications, bio-based materials and smart materials with added functionalities such as sensorisation;
- Develop and apply multi-material approaches that allow cost-effective material separation, recycling and recovery, taking into account environmental impact through Life Cycle Assessment.

Impact: Enhanced vehicle performance while increasing production flexibility and reducing cost; Improved vehicle efficiency through weight reduction; Introduction of less wasteful and more cost-effective management of End-of-Life; Phasing-out of materials which are non-recyclable or difficult-to-recycle; Deployment of innovative recovery options, shifting from traditional recycling to re-manufacturing; Reduced dependency on resources only available outside Europe.

Development of advanced digital tools exploiting the 'digital-twin' concept with high-performance computing to enable rapid optimization and customization of next generation vehicles

- Develop advanced methodologies for improved design capabilities via numerical simulation, virtual and physical testing and validation for the design of different vehicle types including purpose-fit and customized vehicles;
- Enable improved performance by design (including optimized energy efficiency, low environmental impact, crashworthiness, structural integrity, reliability and long service life);
- Provide new design capabilities reflecting specific requirements of automated and connected vehicles including mechatronic systems.

Impact: Rapidly re-configurable manufacturing operations for new customized products; Conversion of extensive product and customer usage data into knowledge, enabling auto-optimization of product design and manufacturing by exploiting the 'digital-twin' concept with developments in parallel computing, machine-learning and artificial intelligence; Reduced time-to-market (from initial concept to first production units) and costs, ensuring the affordability of next generation vehicles; Prototype-free design of vehicles with increased opportunities to certify and homologate via simulation and modelling.

Eco-design approaches integrating virtual product development and validation with flexible manufacturing

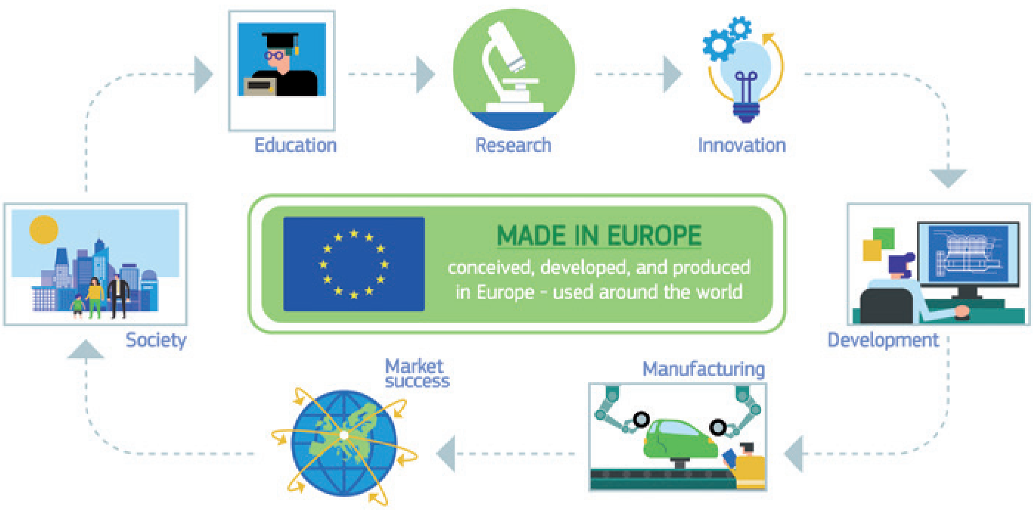
- Develop and apply methods for eco-design, integrating product design and manufacturing including optimal use of recycled materials consistent with the Circular Economy from the earliest stages of vehicle development;
- Develop and apply concepts and methods enabling cost-efficient flexible manufacturing of vehicles as cyber-physical systems.

Impact: Reduced environmental impact significantly via greater efficiency in the primary production and supply chain operations, and through highly energy-efficient vehicles becoming increasingly affordable; Optimised design and production processes through digitalisation, enabling modular vehicle architectures and facilitating the rapid and secure exchange of data between integrators and Tier-1 suppliers to eliminate inefficiencies; Improved integration of SMEs into the product development process through opening and widening the supply chain.

New opportunities to foster research and innovation in the automotive sector through improved University-RTO-Industry cooperation including Education & Training

- Better exploit the potential for improved competitiveness in Europe through enhanced collaboration between Industry and academic centers-of-excellence thanks to the widespread application of proven cooperation schemes and by promoting new education curricula and training courses which better meet the future demands of Industry and Society.

Impact: Future competitiveness of Europe by accelerating the innovation process; Availability of required human resources within Europe with the growth in employment opportunities, particularly for highly-skilled specialists.



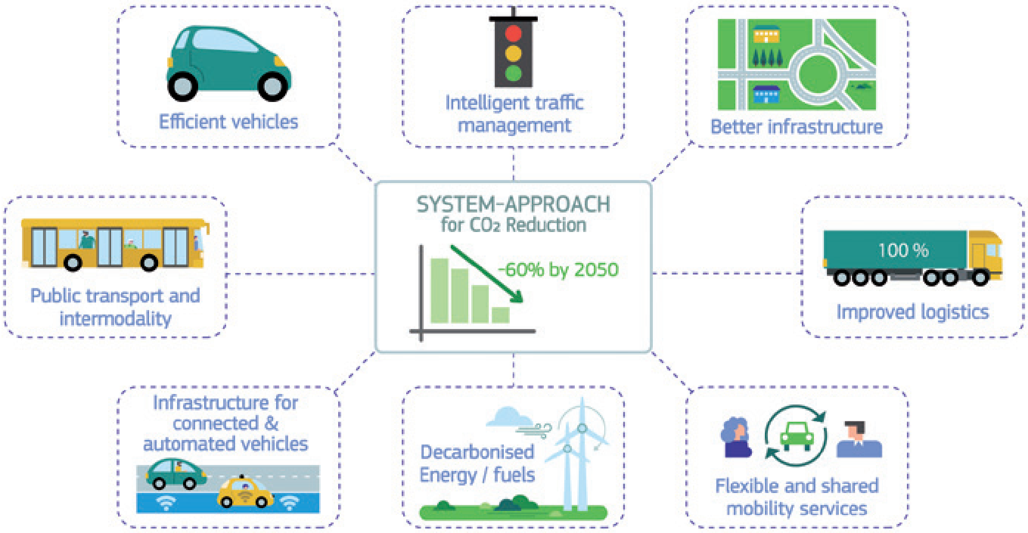
International and cross-sectorial cooperation

- Identify the areas and opportunities across all domains of relevance which would benefit in terms of economies of scale, standardization, etc. from cooperation across different sectors and on an international level.

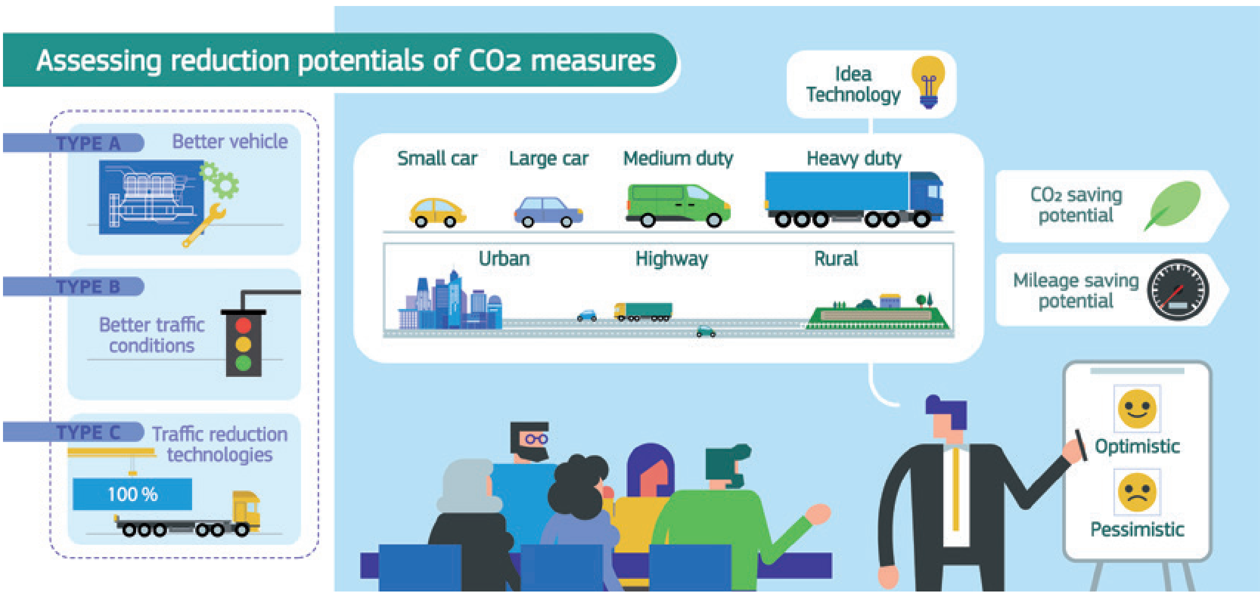
Impact: Guaranteed future competitiveness of Europe achieved through a better understanding of competing markets and regions, and by identifying the opportunities for cooperation and standardization. Accelerated innovation processes in Europe achieved by fostering better cooperation across sectors, utilizing synergies and wider transfer of knowledge, and by exploiting the potential economies of scale.

TOWARDS DECARBONISATION: CO_2 EVALUATION

Decarbonisation is one of the main challenges for road transport. The objective, based on the EU Transport White Paper, is: by 2050, the overall CO_2 (tank-to-wheel, TTW) emissions should be reduced by more than 60%, based on 1990 emissions. But within a context of significantly increasing transport needs and road traffic. Therefore, this ambitious target can only be reached by using all reduction opportunities in the transport system: more efficient vehicles, better traffic conditions and technologies to reduce traffic.

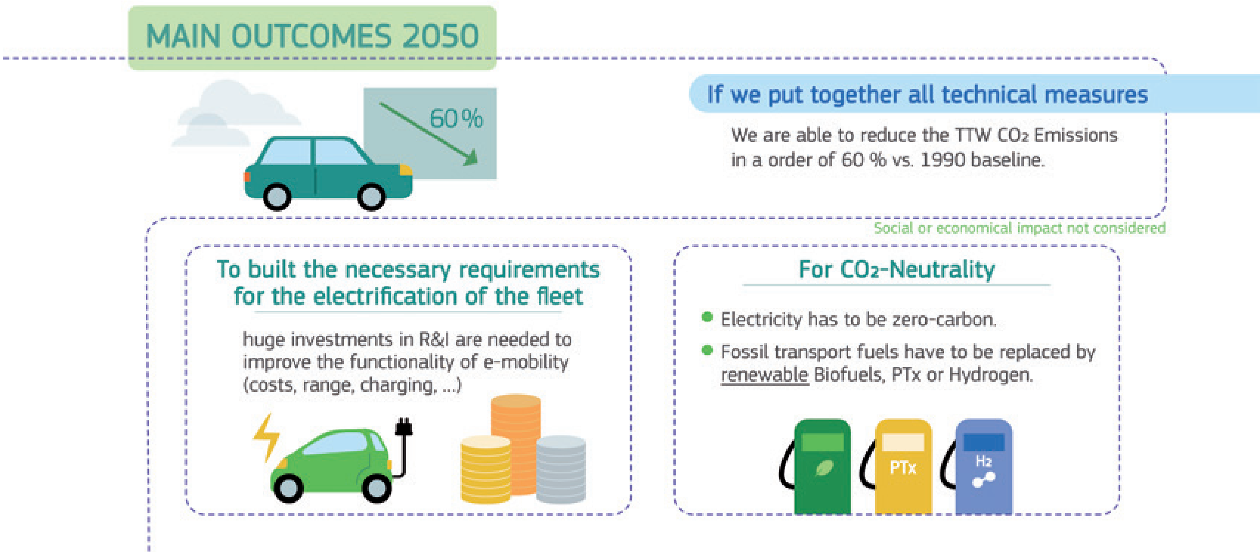


In its CO_2 study, ERTRAC collected all technologies that could be relevant by 2050 and did an experts assessment of the CO_2 saving potentials (TTW), for the different types of vehicles in different use-cases (urban, rural and highway). Note: the study focused only on CO_2 emission reduction and the social and economic effects were not addressed. Using the expert assessment, which includes a range with pessimistic and optimistic values, and applying several scenarios for the market deployment of the different vehicles powertrain technologies, the EU Joint Research Centre JRC made calculations of the CO_2 effect on the overall European fleet under real world driving conditions (TTW).



The database of the CO_2 measures and the calculation results are available in the study, published at the TRA 2018 Conference. All scenarios show clearly that electrification is the main leverage to reduce CO_2 (TTW), and only the fleet mix scenarios with high level of electrified vehicles show a chance to reach the policy objective. This means that an ambition innovation program is needed to support electromobility to improve from today technological level into a stage where all the customer needs are met e.g. range, charging, costs.

Another important message from the study is that even within the highly electrified scenarios, there will still be a significant need for chemical energy carriers, especially for long distance trips and heavy duty transport. Because the usage of these vehicles require much more energy than electric vehicles in urban use, even in highly electrified scenarios we will still face that around 50% of the overall energy need from road transport rely on chemical energy carriers.



Therefore, Europe needs to strengthen its activities in producing renewable energies: not only electricity but also renewable fuels like synthetic fuels, sustainable biofuels or hydrogen. Knowing that the production of renewable fuels in the quantities required will be challenging, considering also the needs from other transport modes and sectors, a further improvement of the combustion engines and of the road traffic conditions are key issues to be addressed by the European Research and Innovation policy.

www.ertrac.org

ERTRAC
66 Avenue de Cortenbergh
1000 Brussels – Belgium
info@ertrac.org
+32 (0)2 736 1221