



EUROPEAN
ROAD
TRANSPORT
RESEARCH
ADVISORY
COUNCIL

European Roadmap

Sustainable Freight System for Europe

Green, Safe and Efficient Corridors

Version May 26, 2011

ERTRAC Working Group on Long Distance Freight Transport

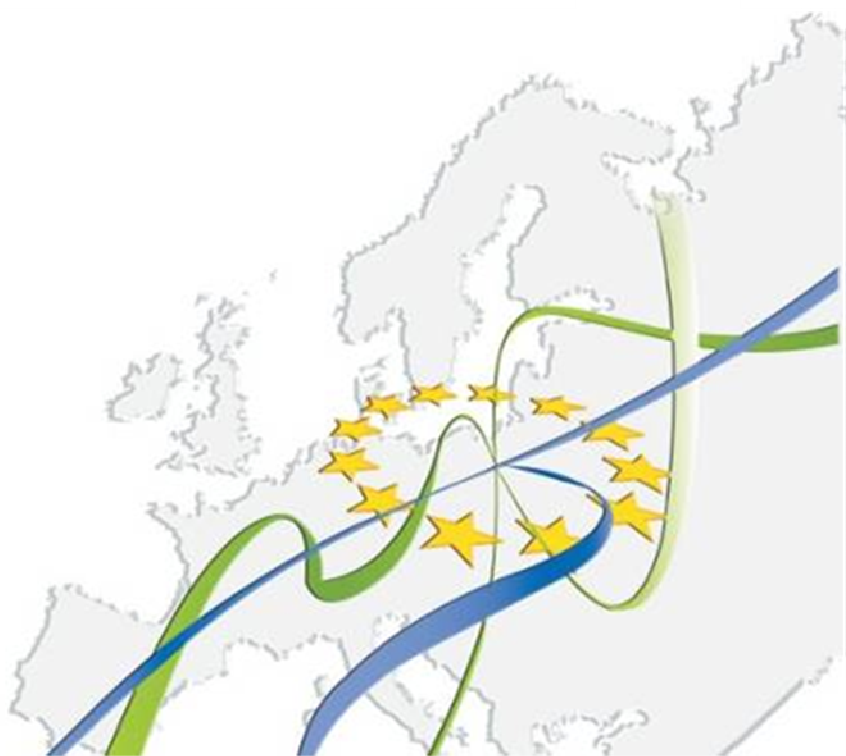


Table of Contents:

1. Introduction
2. General Expectations and Approaches for Road Freight Transport Improvement
3. Challenges and Prospects for green, safe and efficient corridors
 - 3.1 Vehicle Technologies
 - 3.2 Driver Environment
 - 3.3 Logistics and Intermodality
 - 3.4 Infrastructure
 - 3.5 ICT in corridors
4. Milestones
5. Roadmaps

1. Introduction

The transport industry at large is responsible for generating 7% of European GDP and 5% of employment. In an increasingly global market place, the wider economic development and competitiveness of Europe also depends on an effective and efficient transport and logistics system. The mobility of people and the flow of goods to, from and within Europe must be cost effective, safe and environmentally sustainable.

Despite efforts to decouple growth in freight transport from growth in GDP during the last decade, demand for freight transport has increased annually on average by 2.7% whereas GDP increased with 2.5%. This should be compared with passenger transport that grew at a pace of 1.7% during the same period (ibid). The European transport sector is not yet on a sustainable path in several aspects. Transportation is responsible for most of the increase in oil consumption during the last three decades, a trend that is expected to increase. In the EU transport is responsible for the emission of 23.8% of green house gases and 27.9% of CO₂. The sector is 97% dependent on fossil fuels so the environmental concerns are well aligned with efforts to improve energy security and globally the transport sector is responsible for more than 50% of all liquid fuel consumption. Hence, the entire transport sector, and particularly road freight transport, has been identified as a main policy area

where further environmental and overall efficiency improvements are critical for a sustainable future in Europe.

To ensure sustainability and global acceptance in the future, the transport system requires the development of systems that reduce the dependence on oil and minimise the emission of greenhouse gases. The transport system would benefit from a substantial restructuring and reorganization. Transport emanates from the needs of private citizens, business and public organisations to get goods and people moved from one geographic location to another. To accomplish that, a number of modes with their individual infrastructures and traffic operations are available. For each mode there are different types of sub-mode with separate and common infrastructures and traffic operations. Between and within the modes there are hubs making it possible to consolidate and change mode for the transport “packages”. Furthermore, transport and traffic “packages”, carriers, vehicles, drivers, flows, infrastructures, etc are connected to a varying degree through wireless communication infrastructures. The transport operations are planned and managed with different cycle times from hours to months. The effectiveness of the transport system as a whole is gradually increasing but there is an untapped potential for further improvement, particularly in relation to its sustainability, safety, and reliability. Achieving these objectives will need new business concepts and new technologies as well as pan-European standards and regulations developed in collaboration between the public and private sectors.

One example of a new business concept, also identified in the ERTRAC Scenario document, is the ‘green corridor’ concept which could be introduced and used for highly-populated multimodal corridors in Europe by 2030 (see figure 1). This roadmap document is primarily intended to show the likely path to develop and implementing such transport corridor concepts and developing measures to improve the safe and clean usage of transport infrastructure. It will give a consistent overview including benefits and challenges:

- Interfaces and interoperability between different transport modes
- Logistics design; Goods flow optimization
- Interface and interoperability with local/urban network.
- Vehicle concepts
- Intelligent corridor access requirements
- Corridor specific services
- Infrastructural support measures

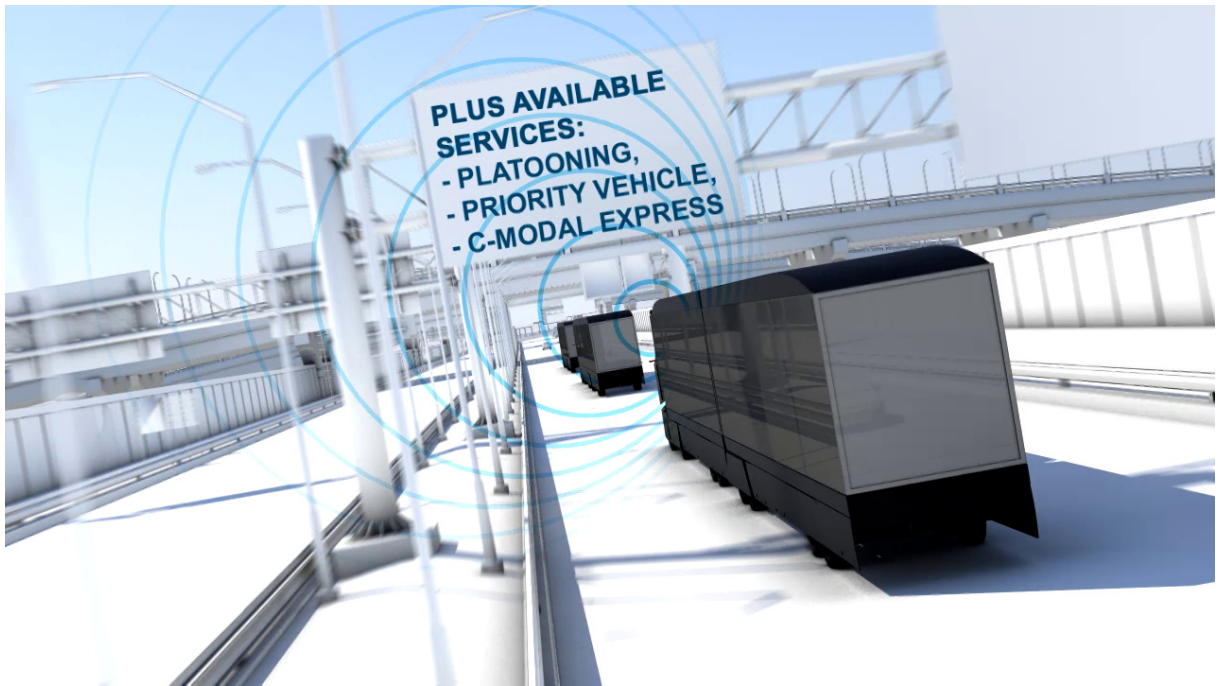


Figure 1 Possible services available in a future transport corridor.

This road map does not cover safety aspects. We refer to and adopt the ERTRAC road map “Safe Road Transport”.

This road map addresses the interface and connection with between urban and long distance transport. It is therefore coordinated with the ERTRAC road map “Towards an integrated urban mobility system”.

2. General Expectations and Approaches for green, safe and efficient corridors

Capacity limitations mean that all transport modes will need to work in seamless coordination in order to increase the level of efficiency. ERTRAC has recently issued scenarios and objectives for road based transport proposing that, with the combined commitment and assumption of responsibility by all stakeholders concerned, transport should become 50% more efficient by 2030 compared with today. This target is translated into three main areas and a number of indicators with corresponding guiding objectives, as shown in figure 2 below.

By 2030 Road Transport is 50% more efficient than Today		
	Indicator	Guiding objective for 2030
Decarbonisation	Energy Efficiency: Urban Passenger	+80%
	Energy Efficiency: Long Distance Freight	+40%
	Share of Renewables	Biofuels: 25% Electricity: 5%
Reliability	Reliability of transport times	+50%
	Urban Accessibility	Preserve Improve where possible
Safety	Accidents with fatalities and severe injuries	-60%
	Cargo Lost to Theft and Damage	-70%

Table 1. Clear guiding objectives for Decarbonisation, Reliability and Safety in Road Transport.
The mission of '50% more efficient Road Transport' is articulated in leading indicators on Decarbonisation (3), Reliability (2) and Safety (2). Each indicator is furnished by a guiding objective for 2030 either indicating the improvement versus a 2010 baseline, indicated with '+' or '-' sign or an absolute level as is the case with 'Share of Renewables'.

Figure 2. Summary of Guiding objectives of ERTRAC's "A Strategic Research Agenda aiming at a '50% more efficient Road Transport System by 2030". (ERTRAC, 2010)

A number of important research, innovation and policy challenges, that will contribute towards these targets and gain from a pan-European approach, have been identified.

This roadmap contributes to the following objectives set by the ERTRAC SRA:

1. The societal target for Long distance freight transport efficiency, as indicated by (volume and/or) weight of freight transported per kWh is an increase of 40 % by 2030 compared to 2010. By increasing the amount of sustainable energy sources CO₂ emissions can be decreased even further, sometimes demanding new carriers and converters.

2. The emissions of air pollutants and noise will be in compliance with existing policies
3. The societal need for Reliability of transport schedules, as measured by average time loss, (scheduled time vs. real travel time). The target is to increase the reliability by 50 % by 2030 compared with today, 2010.

Today many bottlenecks in the road, rail, sea, and air transportation “infrastructure” exist where it is not possible to create new links. The concept of green corridors is intended to help solve this problem by, for example, increased utilization of the available capacity through different means requiring a systems approach involving vehicle, trailer and load carrier manufacturers, infrastructures, logistics operators, etc. Furthermore significant improvements within the transport corridors are expected in the area of safety, reducing accidents and fatalities.

Another resource that should be made more effective is the concept of novel and highly advanced co- and intra-modal hubs to enhance further optimisation of the available modal mix. By co-utilisation between different freight forwarders and by speeding up transfer times, land resources can be freed. In both cases vehicles, load carriers and the equipment for transferring loads must be optimised to work in these new physical environments.

In general, consolidating loads on full vehicles enables the highest level of transport effectiveness and the fewest number of freight movements, thus minimising the contribution of freight transport to congestion. However, many companies aim to minimize the amount of stock they hold in storage, which means that frequent, flexible, and rapid deliveries are required. This can sometimes make it difficult to consolidate freight in large vehicles. This situation can be improved significantly by implementing intelligent logistics solutions including the optimisation of e-freight initiatives and the concept of bundling freight flows controlled by goods operators, which necessitates common platforms for information and business exchange. Research, innovation and policy development are needed to adequately resolve the difficulties that can arise, in addition to focusing attention on business models, service platforms & databases, ICT & protocols, modularised goods carriers & vehicles, etc.

Following this approach has important implications for both vehicle and infrastructure. While respecting the limitations on vehicle size imposed by the road infrastructure, it should be possible to tailor vehicles and load carriers for a better match with the goods transport assignment. Correspondingly focused research is required on the layout and design of vehicles which are optimised for a more specific mission profile and better overall efficiency. In the longer term it should be possible to convert large trucks into smaller vehicles, and vice versa.

The current interest regarding electricity as the energy carrier especially for cars operating in urban areas will be explored also with respect to commercial vehicles. Electrification will open up for a transfer to sustainable energy sources such as wind, hydro, solar and biomass and improved supply security. Key is solving the current limitations in energy storage capacity and energy transfer speed which will require considerable investments in the whole energy supply infrastructure. It is important to emphasize, however, that CO₂ neutral liquid fuels and combustion engines are the basic energy conversion concept for the foreseeable future.

3. Challenges and Prospects for green, safe and efficient corridors

In the 2006 mid-term review of the White Paper 2001 of the European Commission, goods transport (tonne kms) in Europe is projected to increase by 50% between 2000 and 2020. The TERM report (EEA, 2010) suggests that road transport accounts for about 75% of goods transport on land today, and continues to develop rapidly, not least because of its transport and quality characteristics. Regardless of the future scenarios chosen to meet this challenge it is evident that goods transport on European roads will have to absorb the lion's share of the increasing transport demand, as indicated in Figure 3.

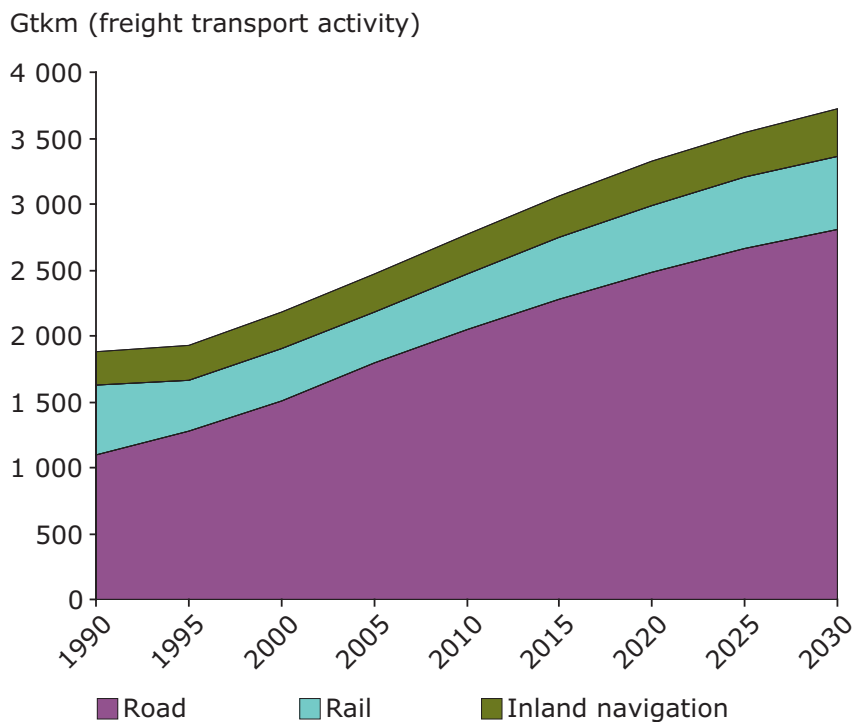


Figure 3. Freight demand projection for the EU 25. Source: The TERM report (EEA, 2009)

Road transport will remain the most important mode. Modal shift from road to rail, short sea shipping and inland waterways are of course put forward as more efficient alternatives to road freight but the potential is intensely debated. What is clear is that these other modes represent only a relatively small proportion of total freight so to produce energy efficiency improvements comparable to the potential of those within the road freight transport system would require very large growth in modal share. A variety of factors such as the infrastructure capacity and quality, investment, competitiveness and the balance between passenger and freight traffic will affect the ability of alternative modes to grow. A study in the UK (McKinnon & Piecyk, 2010) based on a Delphi survey of 100 logistics specialists has suggested that mode shift could potentially decrease roads share of the freight market by 14% (from 64% of tonne-kms to 50%) by 2050. Studies in Sweden have indicated the potential to move freight from road to rail and sea is around 10% (SIKA, 2008). While

these changes are significant and important, the forecast growth in freight transport demand suggests that, Europe will probably still be heavily reliant on long distance trucks to maintain a competitive transport system.

A key factor for the transport sector is its adaptability to dynamic changes in the transport patterns. Complexity and flexibility of logistics will need to increase considerably because of the emergence of new trading partners, increasing integration of the order and production process with transport and delivery, and changing transport corridors, e.g. road and rail transport between Asia and Europe.

One major challenge in road transport is congestion. One measure intended to help meet this challenge is, for example, the concept of green corridors which could, in principle, be applied in both inter-urban and urban environments. This concept will give a strong incentive to the development of more effective vehicles, standardised load carriers and supporting ITS/ICT systems.

The potential for increasing the efficiency and safety of transport corridors is structured into five main areas in which timely R&D, demonstrations, production, market introduction and regulatory framework development are illustrated in a roadmap format.

3.1 Vehicle Technology

It is considered vital for the road transport sector to develop new smart concepts such as modular load-carriers and innovative complete vehicle solutions (including the trailer) contributing to adaptable, tailored, efficient and seamless transport.

Overall transport efficiency will also benefit from optimising the aerodynamic design, reducing rolling resistance and internal friction, and introducing lighter truck and trailer concepts and efficiently designed and controlled auxiliaries.

To increase the efficiency of the vehicles operating within the corridors, then it will be important to consider, for example, optimised vehicle specifications that better tailor truck and trailer components, weight and length of vehicle combinations, increased level of modularity and innovation in the trailer market (e.g. the uptake of light weight high volume low bed trailers) and also more efficient operation of the truck by the driver.

3.1.1 Vehicle technically specified for running in corridors

For efficient transport operation within Green Corridors the vehicle parameters need to be optimized. The vehicle should be adapted to its operation and to the freight it is carrying.

3.1.2 Vehicle dimensions for optimized load capacity within corridors

As freight transport operators are likely to require even more flexibility in the future, accessibility to a set of tailored vehicles or to vehicles able to adapt to different operations is crucial. Today, single vehicles are often used for many different tasks, often inefficiently. Trucks built to carry 40 tonnes will often only carry 20 tonnes because they are carrying low density goods and are full on volume not mass. In these cases a large quantity of “dead” weight is transported, therefore the vehicle load carrying ability would need to be “upsized” to the absolutely maximum volume but “downsized” both from a structural mass and powertrain point of view. Research as well as internationally agreed

and harmonized standards are needed to determine present load factors/fill rates, to make data collection cost efficient and unambiguous and to agree on realistic targets.

An optimized match of vehicles to the tasks will contribute to improving the efficiency of transport. For the operator to be able to adapt to changing operational conditions it is important to look at aspects such as access to the vehicle that best matches the needs and/or vehicle adaptation strategies to freight/cargo composition (weight, volume, shape, sensibility etc) and to its operational environment in the corridor.

An increased level of modularisation of load carriers (e.g. pallets, ISO containers etc) is crucial for freight inter-modality and efficiency. The experiences from the aviation industry handling ULD's should be taken into consideration. Common standards need to be agreed and implemented for the design, dimensions of freight modules (load carriers) in order to optimize the intermodal vehicle. Automated operation and coupling/decoupling of the freight modules as well as built in intelligence e.g. cargo on board monitoring, tracking and distribution are interesting areas for research. Inter-modal shipping involves the movement of freight by multiple modes, preferably in a single freight module (container). The freight modules have to be flexible enough to fit all modes and handling, loading and unloading needs to be efficient and flexible. In other words; a level of increased operational flexibility is needed to be able to implement an efficient inter-modal transport system.

The use of (internationally agreed) modular concepts for pallets, swap-bodies, containers, etc will result in increased efficiency of transport in general and road transport in particular. Standardised load modules give high flexibility and an opportunity to standardize vehicles which are adaptable to different situations, and to use optimised combinations.

The use of modular concepts throughout Europe could have a positive effect on transport efficiency and on the environment, and could also support intermodality. Initiatives to agree on standards and facilitate the implementation of modular concepts in which industry, authorities and policy-makers collaborate are vital. In order to support the setting of this regulatory framework, extensive impact assessments will have to be performed, taking into consideration the whole transportation system, and analyzing the impacts on the environment, on safety, and on mobility aspects (e.g. congestion, user's acceptance, etc.).

According to McKinnon & Piecyk (2010), we can expect several developments over the next forty years promoting consolidation of freight loads into larger and heavier consignments to make better use of the vehicle capacity.

To meet these expectations vehicle design needs to be optimized. Research areas important are:

- mapping and predicting the quantities of different types of load that are carried by trucks on the road
- impact and consequences of road vehicle mass and dimensions on transport efficiency
- modal split
- infrastructure capacity
- strategies to optimize pay load
- chassis control (braking, handling, traction)
- modular vehicle architecture

Other areas important to look into are:

- automatic load factor and weight control
- modularity for load units
- modularity for loading

The weight and length of the vehicles needs to be optimized and flexible as well as technically adapted to performance based standards within the corridor.

3.1.3 Vehicles and infrastructure matching each others

The concept of intelligent vehicles and transport services needs to be supported by matching intelligence in the road infrastructure. Increasingly the level of road based automation will be able to support freight transport through cooperative systems. Whereas to a large extent such systems serve all road users, on selected corridors the systems are expanded or adapted serve efficiency in freight transport. These corridors need to be selected and roll-out strategies should take in consideration that a full scale deployment of the green corridors concept involves many border crossing and will involve cooperation and collaboration of a multitude of road authorities.

3.2 Driver environment

3.2.1 Driving efficiency

The behaviour of the driver has a substantial effect on the vehicle fuel consumption, and thereby its emissions. By combining cooperative systems using vehicle-infrastructure communication, there are potential fuel savings and reliability improvements to be made.

Drivers' driving behaviour is a key-issue for eco-driving/fuel efficient driving. Today, eco-driving can result in 10-12% fuel savings with the use of Driver Coaching Systems (DCS). DCS are technologies that help drivers and fleet managers to improve fuel efficiency. The DCS on market today are based on technologies that record information generated by the vehicles and display information directly to the driver to encourage better driving and/or deliver post-trip reports to drivers and fleet managers.

As described in the "Safe Road Transport" roadmap, DCS are also strongly applicable in the road safety domain and, in the near future, fuel-efficiency- and safety-related DC will merge into common applications. The key challenge for future development of driver coaching concerns the implementation and deployment strategies where a critical issue will be effective incentive schemes to motivate long-term behavioural change. For commercial fleets, it may be foreseen that driver coaching will to an increasing degree form part of general safety/efficiency management strategies, and be combined with other measures, such as driver education and training. Technologically, driver coaching system will merge with other driver support systems including cooperative system technologies. For private driving, new business models for DC will emerge involving incentives, possibly linked to tax reduction and dynamic pricing (e.g. pay-as-you-drive). Finally, as driving becomes increasingly automated, future DCS may focus more on strategic aspects of driving performance (rather than vehicle control).

Related, important, research areas are:

- advanced HMI supporting the driver
- HMI-based information on cargo
- smart loading based on intelligent goods
- automated customs processes
- automated handling of cargo

3.2.2 Drivers safety and comfort

In the corridor it is important to secure a high level of security and efficiency services for the driver, vehicle, and cargo supporting reliability of transport times. Important research areas are:

- safe and secure bookable parking spaces
- smart driver cabin
- driver villages offering high level of services for the driver and his/her vehicle
- driver monitoring system
- driver villages connecting all transport modes
- cargo and driver security systems
- augmented vision. The driver operates in an increasingly complex setting that challenges the human capabilities. Augmented vision can help the truck driver in enhancing the key features in the traffic situation. This will provide good support to the driver, in particular when driving in the night or under extreme conditions that impair a clear view on the traffic situation (rain, snow, fog).

3.3 Logistics and intermodality

The Green Corridor concept has strong links with the business sector, in particular with logistics services. They are driven by an optimised use of all transport modes and network planning based on existing and forecast traffic flows.

3.3.1 Corridors logistic performance

The provision and generation of information from transport activities that can be used to better plan and coordinate other transport activities requires substantial new solutions in information management, data processing, real time planning, data capture technology, and monitoring and evaluation, both by business and by public authorities. More effective provision of information will not only, for instance, match loads to capacity more efficiently, but information availability will also enable government agencies (customs, police, ...) to improve their performance in supervising business activities, increase their hit-rates, and remove administrative bottlenecks.

Another important development is to standardise the measurement frameworks on transport performance, environmental footprint and negative transport effects, and, more importantly, develop ways to feed these measurement frameworks with actual, real time data feeds obtained from ongoing transport and logistics operations. The facilities used to support Green Corridors can be made increasingly complex (e.g. enhanced ITS support) once the logistical and market conditions are

identified, under which these corridors can operate in a sustainable way. Understanding this part of the performance of Green Corridors is an essential objective of the private and public business case.

Important research areas are:

- overall performance requirements
- vision on the dimensions and capabilities of Green Hubs and Corridors
- logistic and sustainability key performance indicators
- identification of Green Corridors and Hubs based on sound logistics concepts
- logistics footprint and energy consumption measurement and reduction, quick-wins
- seamless Integration of corridors and hubs into networks
- connection between long distance and urban freight transport

3.3.2 Co-modality and intermodal seamless interoperability

An important development is a regulatory framework in which partners in the supply chain are allowed to exchange and share information between and amongst existing shared information or supply chain management networks, without facing immediate claims of violating anti-trust regulation, or other impediments.

An important challenge is to identify and select candidates for the “green” hubs and corridors and to integrate them into a European network of green corridors. A first step is to develop an intermodal corridor pilot. To succeed a common framework of national initiatives with similar standards is needed.

Other areas of importance are:

- real time optimization of co-modal routes (traffic information, cargo monitoring)
- efficient (cost, energy, footprint) transshipment between modes, quick-wins
- interoperability between modes & networks increasing intermodal capability and energy efficiency
- extended intermodality and network integration

3.3.3 Logistics and supply chain business models

Collaborative planning can allow for a reduction of empty running and improve load capacity utilization on all modes of transport. Therefore, the development of green corridors should also involve the evolution and assessment of new business models based on collaborative arrangements across partners in supply chains and due to the experimentation of innovative approaches in the regulatory framework of transport.

Areas to look into:

- logistic companies prepared for green corridors business models
- business models for logistic collaboration including information sharing
- load factor improvement
- benefits of off-peak and night time driving
- performance based organizations operating in the supply chain

- real time optimization models to select mode and plan loads
- green logistics business models integrating energy consumption and footprint in decision making
- business plans supporting convergence of technologies and regulations
- performance based services

3.3.4 Intelligent logistics system, optimising e-freight

Existing infrastructure and vehicles can be used more efficiently by developing sophisticated logistic chains and networks, which use advanced information and communication technologies. This management requires data that needs to be generated to a much larger extent than is currently the case. Efficient supply chain management or intelligent logistic systems therefore have a twofold bonus: security and carbon footprint reduction.

Integrating e-freight initiatives at the European level are required to reap the full benefits and achieve real progress on the targets specified above. This requires not only a push on IT investments and choices for the right architectures, standards and approaches, but also the explicit recognition of the similarities and differences in the governance and government supervision of logistics activities across Europe.

The creation of improved supply chain operations will have great repercussions for the demand for service quality and volume of transport systems. With the advent of RFID and similar identification technology in the supply chain the development of Intelligent Cargo systems at the European level is within reach. In addition, possibilities for horizontal collaboration between shippers and increasing responsiveness needs will drive shippers increasingly to develop hybrid distribution channels. A major advantage of these channels is that they allow further bundling of freight between firms. However, this efficiency gain will only materialize if shipper and carrier information systems are sufficiently interconnected and interoperable. This extends the e-freight roadmap towards synchronization between transportation, inventory and production schedules between firms.

Areas for research are:

- implementation of current ITS and e-freight solutions targeting interoperability & intermodality through corridor based multimodal transport management systems
- internet based common management platform
- e-freight pilots
- synchromodality: ITS solutions for the integration of transport and supply chains including electronic booking, dynamic mode allocation and capacity management.
- Information community development and system adoption (logistics operators and service providers)
- cargo units interacting with the system and self optimizing
- enhanced security of goods. Reduction of stolen and damaged goods
- paper less and electronic flow of information
- full internet e-freight transport

3.4 Infrastructure

The Infrastructure component of the Green Corridor concept involves all aspects of road operations involved with green, safe and efficient freight transport. The enabling research and innovation includes the materials, components and physical integration to the road structures as well as the operational strategies for traffic and maintenance management and, on the highest system level, the policy and governance principles that set service levels to the road user (e.g. asset management and liveability issues).

To enable the green, safe and efficient corridors, the supporting road network needs to be highly adaptable, automated and climate resilient in order to accommodate for changing demands and conditions, to enhance the implementation of ITS and intelligent road operations, and to ensure adequate service levels under extreme weather conditions. As the latter research and innovation challenge is covered in a separate roadmap, this green corridors roadmap will focus on the research and innovation that enhance the adaptability and automation of road operations.

The enabling research and innovation solutions need to be proven in the practice of road operations. Moreover, as the green corridors concept is highly integrated and complex the RAMS (Reliability, Availability, Maintainability and Safety) of the solutions need to be proven in practice through full-scale systems field operational tests i.e. on full-scale corridors, and by established RAMS analysis.

Finally, it should be noted that many of the technical solutions already exist and are proven on a 'single technology' level, in specific situations and context. This is the case for the basic materials and components as well as for many ITS solutions. The challenge for the next 15 years will be the testing of the existing solutions in other contexts and situations in the short term (by 2015), followed by proving the integration of the tested solutions in larger scale systems such as city rings on the medium term (by 2020) and ultimately the full-scale corridors (by 2025) (see illustration in figure 4).

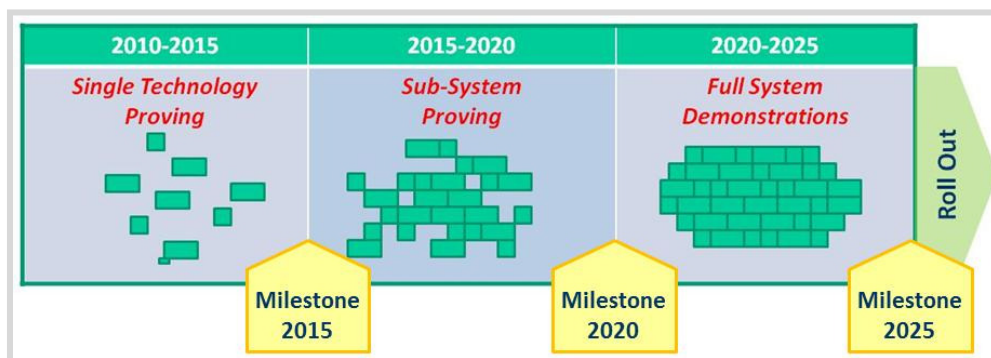


Figure 4. Corridor implementation roll out.

3.4.1 User friendly Design & Construction

For the road user/truck driver the traffic situation becomes more complex. Conditions become more critical to error or failure. Therefore research is needed into improving user friendliness of the road infrastructure to better fit the requirements, expectations and behaviour of the user.

Here the research and innovation topics are concerned with self-explaining and forgiving design of road structures and management systems as well as to provide secure and highly furnished service stations ('driver villages') at well located spots in the network. Self-explaining and forgiving design will improve the ease of instantaneous appreciation of the driver, and the tolerance for erroneous behaviour. Measures involve better lay-out of the road plan, signage and information systems as well as innovative applications of the vehicle-infrastructure communications ranging from basic driver support to augmented vision. The focus is on improving safety hot-spots and other complex, highly integrated locations on the road network.

The service stations should be integrated with the corridor over the entire stretch as to allow ITS facilities such as advanced booking of parking lots in compliance with driving time regulations.

3.4.2 Durable and integrated Pavements, Bridges, Tunnels & Structures

The durability of the road structures (pavements, bridges, tunnels) should be designed to service high volumes of freight traffic. Freight traffic imposes a heavy burden on the road structures and without the proper innovations in durability of the materials and components this will lead to increasing levels of maintenance interventions (e.g. resurfacing), reducing the network availability. Therefore, research and innovation should aim at better technical and functional durability of the surface components in road structures (e.g. long lasting overlays, expansion joints), including self-healing properties. Particular focus is on improving the life span of the pavement surfaces on bridges and the expansion joints. Climate change will also place a heavy burden on the highway, including extremes of heat, precipitation and associated impacts on the sub-soil. Whilst, research topics are covered in a separate roadmap, the research requirements should not be considered in isolation.

3.4.3 Advanced Utility, Sensory and Communication Systems

Advanced road based utility, sensory and communication systems are indispensable for the desired high service levels on the green freight corridors. Such road based systems serve three distinct objectives:

- Automation of the road availability and maintenance e.g. to safe guard against strongly non-linear road surface deterioration phenomena under the intensive freight transport loads
- Enhancing full grade ITS in road transport, integrating the user, vehicle, service provider and operator. For full co-modality this should be connected to the traffic control of the other modes
- Enhancing the penetration of new propulsion concepts in the road transport system, including the supporting alternative energy and fuel supply system

3.4.4 Intelligent Traffic Management strategies

One objective of intelligent infra management is to optimise the utilisation of the available road network within the service levels set by policy and governing principles (reliability, availability, maintainability, safety). Although on a transport system level, this is set in the context of co-modality, here the focus is on road operations. Another important area would be an operation and traffic control-management by e.g. ITS and that provides all actors within the freight transport with a variety of advanced options for efficient and flexible seamless freight shipments.

The user, i.e. the driver and the vehicle, will be supported through these cooperative systems (milestone 2020), as such systems already are under tests, in view of automated driving on the longer term.

The infra management systems are robust in the sense that they allow for maintenance interventions, incidents and disasters as well as for extreme weather conditions. The latter will be addressed in a separate road map. From the viewpoint of European corridor management, the solutions ultimately will allow for high degrees of trans-national remote operation of the road network.

The systems should support advanced information, operation and management concepts to support the user on the road, requiring high levels of accuracy, dependability and operation in real time. Research should also target dynamic real time lane management concepts with the focus of on-line servicing freight transport on the best available infrastructure in a manner that is compatible with the other road users (passenger transport). On specific sections of the corridor, this would include the creation of dedicated lanes for freight transport through targeted reconstruction projects. As an alternative, dedicated lanes for LGV and passenger traffic can be considered, freeing up available capacity for HGV.

Finally the relations between advanced concepts for demand management such as dynamic pricing on the one hand, and capacity allocation measures such as dynamic slot management on the other, need to be better understood. The opportunities for improved asset management and specifically PPS in infrastructure development should be looked into as they can accelerate the implementation of infrastructure needed for Green Corridors.

3.4.5 Freight Corridor Governance

The green freight corridors will be key assets to Europe. Their management must be fitted with an adequate toolbox of data, models & methods to allow adequate risk based evaluations and decisions on the desired performance/service levels by the different road administrations involved in the selected pilot corridors. Governance decisions and the resulting service level agreements should be developed across connected service areas and supported by common toolbox for operational network management and asset management. This tool box can only succeed when based on a harmonized set of compatible data, models and methods. The challenge is to agree on the common architecture and parameters, and to harmonize the different national and regional datasets that concern the pilot corridors. The result will be a Road Asset Observatory/Building Information Model (BIM) in which the pilot corridors are represented in terms of the constituting objects that are described by consistent parameters and relations to the other objects in the corridor.

Furthermore the research and innovation should produce reliable forecasting methods for the highly non-linear phenomena in road operations (e.g. degeneration of pavements, dynamic traffic processes). This would in turn improve (risk-driven) decision supporting models.



Figure 5. Possible design of a sustainable corridor

3.5 ICT in corridors

ICT is one of the key enablers for creating a safe, sustainable and efficient transport system. To create economical sustainable solutions some of the main challenges for ICT is interoperability and harmonisation as well as roll out of those systems compared to the stand alone solutions.

Stakeholders are basically divided into vehicle, driver, logistics/ co-modality and infrastructure. ICT solutions are a transversal input, affecting these areas. The research and innovation activities in all areas should start with collating existing ITS solutions to assess the needs for further research and requirements for integration of individual technologies in to sub-systems and full-scale systems.

3.5.1 Communication infrastructure (X2X)

Areas of importance:

- Interoperable, harmonized V2V, V2I communication creating awareness about vehicle surrounding enabling e.g. traffic safety, automation and eco-mobility services
- Adoption of EU-wide regulations for management of data exchange and storage.
- Increased position, integrity and authentication (GNSS) solutions
- Open Service Platforms for robust, secure, safe and efficient service management
- Connectivity, vehicles "fully connected" with other vehicles, infrastructure, road operator and their logistic provider
- Demonstration and deployment projects in selected corridors

3.5.2 Sustainable transportation (X2X)

Areas of importance:

- Accurate Real-Time traffic data: Creating accessible, harmonised, accurate in real-time traffic data for all users enabling e.g. optimisation of real-time route planning and control and efficient travel time estimation

- Solutions to detect and communicate incidents and accidents
- Sustainable Traffic management solutions
- Harmonized Access Control solutions to prevent access to corridor for non-compliant vehicles
- Demonstration and deployment projects in selected corridors
- Methods and services for transport utilization optimization
- Solutions enabling pay for performance and polluter pays services

3.5.3 Automated driving (X2X)

Areas of importance:

- ICT for speed and distance control (V2V)
- Europe wide standardisation regarding vehicles dimensions, communication systems for automated driving
- Interaction vehicle + infrastructure towards automated driving
- ICT considering infrastructure limitations for automated driving such as bridges (weight limits), tunnels
- Demonstration projects in selected corridors
- Automated driving demonstrations in all existing corridors. By 2030 automated driving "business as usual" in all corridors
- Review and harmonisation of policies and regulations
- Sustainable business models and methods for platooning

4. Milestones

- Milestone 1: Supportive corridor, 2015
- Milestone 2: Interactive corridor, 2020
- Milestone 3: Mass market corridor, 2025

	Milestone 1: 2015 Market 2018-2020	Milestone 2: 2020 Market 2023-2025	Milestone 3: 2025 Market 2028-2030
Corridor concept	Supportive corridor	Interactive corridor	Mass market corridor
Main elements	Some selected corridors with dedicated lane and dynamic lane management	Selected international cross border corridors Interactive corridors (v2v and v2i)	Automated driving Extended intermodality Seamless integration

	<p>National initiatives with similar standards, open for further standardisation</p> <p>International Cross border initiatives</p> <p>(Additional value as testbeds)</p> <p>One road corridor intermodal with one rail corridor</p> <p>Harmonised enabling legislation in place</p> <p>Vehicles dedicated for corridors</p> <p>Flexible fuel platform support</p> <p>Safe and secure bookable parking spaces</p> <p>Interoperability management platform (future internet PPP)</p> <p>Implemented (already known and available) ITS+logistics solutions, some targeting interoperability & intermodality</p> <p>Proposed business models for logistic collaboration</p>	<p>communication)</p> <p>User oriented Multimodal traffic and travel information services</p> <p>Common road operation and management systems and processes (remote operation, Incident and Calamities Management)</p> <p>Performance (standard) based services</p> <p>Technological initiatives on standardised electrified infrastructure concepts validated (i.e. proof of concept but not extensive rollout)</p> <p>Vehicles optimised for corridors and its operation incl. hybrid and electric vehicles</p> <p>Extended modularity for vehicles and cargo units</p> <p>Implementation of 'intelligent cargo units' – enhanced</p>	<p>of urban mobility and long distance transport</p> <p>Adaptive vehicles incl. aerodynamics</p> <p>Driver villages connecting all modes</p> <p>Full E-freight within the corridors</p> <p>Alternative energy & fuel recharging fully supported along the pilot corridors, some level of standardised electrification</p> <p>Automated Asset Condition Monitoring and forecasting along the pilot corridors</p> <p>Integration of Alternative Energy sources and utility functions I</p> <p>Implemented business models for logistic solutions targeting e.g. cost and load factor efficiency</p> <p>Cooperative systems along pilot corridors</p>
--	---	---	--

	<p>solutions for e.g. load factor improvement E-freight pilot</p> <p>Reliable Infrastructure with maintenance and management regimes</p> <p>Monitoring and enforcement of efficient driving, vehicle weight and dimension</p>	<p>security in terms of no stolen goods, no damage</p> <p>Implemented business models for logistics: Collaboration info sharing</p> <p>Cooperative systems: Automated monitoring and operation enabled; Decentralized, local traffic management tested; Regulatory framework adapted.</p> <p>Interaction vehicle + infrastructure towards automated driving</p> <p>Driver villages offering high level of services for the driver and his/her vehicle</p>	
--	---	---	--

	Milestone 1: 2015	Milestone 2: 2020	Milestone 3: 2025
	Supportive corridor	Interactive corridor	Mass market corridor
Vehicle Technology			
Vehicle technically specified for running in corridors	Optimized vehicle parameters for efficient transport operation within transport corridors	<p>Vehicles fully adapted to its operation and freight</p> <p>Modularity Intermodal efficiency</p>	Optimized vehicles dedicated and tailored to its operation

Vehicle dimensions for optimized load capacity within corridors	<p>Vehicle optimized length, weights and design for corridors</p> <p>Weight & dimensions</p> <p>Truck technically adapted to performance based standards within the corridor</p>	<p>Vehicle optimized for all corridors</p> <p>Improved aerodynamics for complete vehicle (incl. trailer)</p> <p>Load factor and weight control</p> <p>Modularity for load units and vehicles</p> <p>Modularity for loading</p> <p>Flexible weight and dimensions, optimized for performance based standards</p>	<p>Efficient transformable vehicle for all corridors</p> <p>Adaptable exterior vehicle geometry</p> <p>Automatic load factor and weight control</p> <p>Optimized and flexible weight & dimensions, for performance based standards</p>
Vehicles and infrastructure matching each other	<p>Vehicle technologies and road infrastructure are supporting each other in the corridor</p> <p>Rollout strategies for selected regional corridors</p>	<p>Rollout strategies for border crossing corridors</p>	<p>Rollout strategies for all corridors</p>
Driver Environment			
Driving efficiency	<p>Advanced HMI supporting the driver: e.g. smart route planning, coaching for efficient driving, information on the corridor and intelligent</p>	<p>Intelligent goods: HMI between driver cabin and cargo (paperless and electronic flow of information, see also Logistics)</p>	<p>Translational freight transport: automated customs processes (no stop at borders)</p> <p>Automated driving</p> <p>Automated handling</p>

	communication with back office and customer	Smart loading of cargo (reducing time to load and unload by 50%)	of cargo at driver villages and hubs
Driver safety and comfort	Safe and secure bookable parking spaces Smart driver cabin: Multi-use driver cabin	Driver villages offering high level of services for the driver and his/her vehicle (e.g. maintenance and repair) Driver monitoring systems	Driver villages connecting all modes: seamless flow of goods Cargo and driver security systems: reducing incidents by 90%
Logistics and Intermodality			
Corridors logistics performance	Developing a vision on the dimensions capabilities of Hubs and corridors Define corridors logistics key performance indicators Identification of Corridors and Hubs Reduction of logistics footprint.	Integration of Hubs and Corridors.	Seamless integration of urban mobility and long distance transport
Co-modality and intermodal seamless interoperability.	Pilot one road corridor intermodal with one rail corridor National initiatives with similar standards, common	Optimize transshipment between modes Optimized interoperability between modes,	Extended intermodality and network Integration

	<p>framework open for further standardisation</p> <p>Harmonised enabling legislation in place to reach physical interoperability</p>	<p>networks and opportunities</p>	
Logistics and Supply Chain Business Models	<p>Logistic companies prepared for green corridors business models</p> <p>Proposed business models for logistic collaboration solutions for e.g. load factor improvement</p>	<p>Business models for green hubs and corridors</p> <p>Performance (standard) based services</p> <p>Implemented business models for logistics, collaboration and info sharing</p>	<p>Extended logistics collaborative business models for logistic solutions targeting e.g. cost and load factor efficiency</p>
Intelligent logistics Systems, optimising e-freight	<p>Implemented (already known and available) ITS and e-freight solutions some targeting interoperability & intermodality</p> <p>Interoperability management platform (future internet PPP)</p> <p>E-freight pilots</p> <p>Information community development (logistics operators and service providers) for</p>	<p>Implementation of 'intelligent cargo units' capable to interact with the systems and self-optimize</p> <p>Enhanced security in terms of no stolen goods, no damage</p> <p>Paperless and electronic flow of information.</p>	<p>Full internet E-freight within the corridors</p> <p>Paper free transport</p> <p>Large demonstration projects</p>

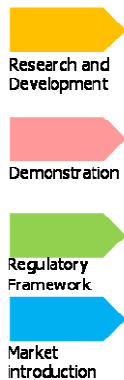
	<p>information system adoption.</p> <p>New legal and regulatory framework for e-freight implementations</p>		
Infrastructure			
Corridor scope	<p>Pilot Corridors Agreed & Assessed</p> <p>Stakeholders engaged & corresponding Programmes Aligned</p>	<p>Impacts Assessed Ex-Ante</p> <p>Common Regulatory Framework agreed</p>	<p>Impacts Assessed Ex-Post</p> <p>European Roll-Out Plans Agreed</p>
User friendly Design & Construction	<p>First demonstrations of 'advanced driver villages' concept (bookable parking spaces, full information services)</p> <p>Self-explaining and forgiving design demonstrated in safety hotspots</p>	<p>Roll-out strategy for Advanced driver villages agreed</p>	<p>Roll-out strategy for self-explaining and forgiving design agreed</p>
Durable and integrated Pavements, Bridges, Tunnels & Structures	<p>Self-Repairing Abilities</p> <p>50 % improvement of current lifespan (asphalt overlays)</p>	<p>100% improvement of current lifespan (asphalt overlays)</p>	<p>Self-Repairing Abilities standard in asphalt overlays</p> <p>Non-bituminous, durable overlays</p>
Advanced Utility, Sensory and Communication Systems	<p>Vehicle Recharging Systems demonstrated in several service locations along the</p>	<p>Roll-out strategy for vehicle recharging systems agreed</p> <p>Automated Asset Condition Monitoring</p>	<p>Alternative energy & fuel recharging fully supported along the pilot corridors</p> <p>Automated Asset</p>

	<p>pilot corridors</p> <p>In-Built & Wireless Sensors demonstrated</p> <p>Open Standard Interfaces agreed</p>	<p>and forecasting</p> <p>Roll-out strategy for sensory systems agreed</p>	<p>Condition Monitoring and forecasting along the pilot corridors</p> <p>Integration of Alternative Energy sources and utility functions</p>
Intelligent Traffic Management Systems	<p>Cooperative systems locally enabled.</p> <p>Impact assessment and cost/benefit finished; Business models available; Deployment plans with other cooperative stakeholders coordinated</p> <p>Dynamic traffic management enabled</p>	<p>Cooperative systems: Automated monitoring and operation enabled; Decentralized, local traffic management tested; Regulatory framework adapted.</p> <p>User oriented Multimodal traffic and travel information services demonstrated on national sections</p> <p>Common Remote Operation along corridor</p> <p>Common Incident and Calamities Management Systems and Processes</p>	<p>Cooperative systems along pilot corridors.</p> <p>Automated Roads demonstrated locally (e.g. platooning, intersection control). Liability issues settled.</p> <p>User oriented Multimodal traffic and travel information services demonstrated along pilot corridors</p>
Freight corridor governance	<p>Asset Management toolbox demonstrated on national network (SLA, Road Network planning & Asset Observatory)</p>	<p>Asset Management (Multi-Modal SLA; national/regional sections, Risk/Performance Management)</p> <p>Common Cost-Benefit Evaluation/LCC</p>	<p>Asset Management (Fully optimised for pilot corridors on basis of a common set of performance indicators, Road Asset Observatory/ BIM, Reliable Operations</p>

		calculation tools operational on pilot corridors	Forecasting) Common dynamic traffic forecasting models operational on pilot corridors Common advanced risk driven decision support models operational on pilot corridors
ICT			
Communication infrastructure (X2X)	Adoption of EU-wide regulations for management of data exchange and storage Increased position, integrity and authentication (GNSS) solutions Open Service Platforms for robust, secure, safe and efficient service management	Interactive transport within corridors (V2V and V2I communication) for high energy efficiency Construction of safe, secure, robust and efficient X2X infrastructure in any location of the network	Vehicles "fully connected" with other vehicles, infrastructure, road operator and their logistic provider
Sustainable Transportation	Optimisation of real- time route planning and control ICT solutions integrating all transport modes	V2I and V2V avoiding bottlenecks in a corridor Solutions to prevent access to corridors for non-compliant vehicles Vehicle status monitoring.	Methods and services for transport utilization optimization Deployed harmonized pay for performance and polluter pays services

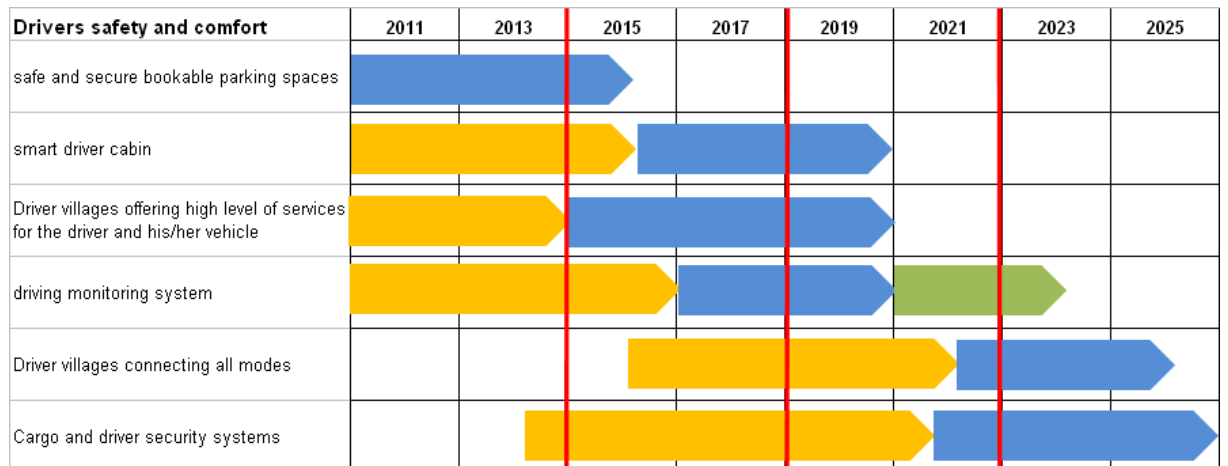
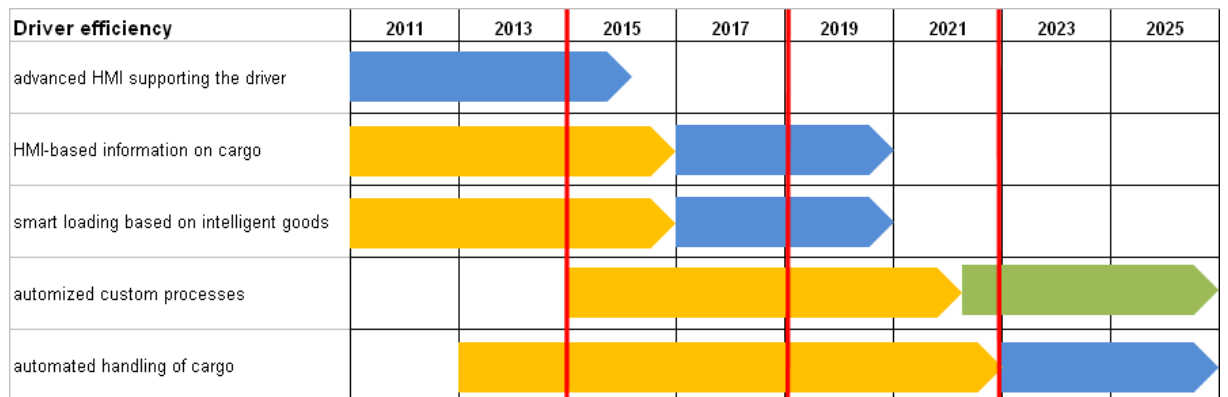
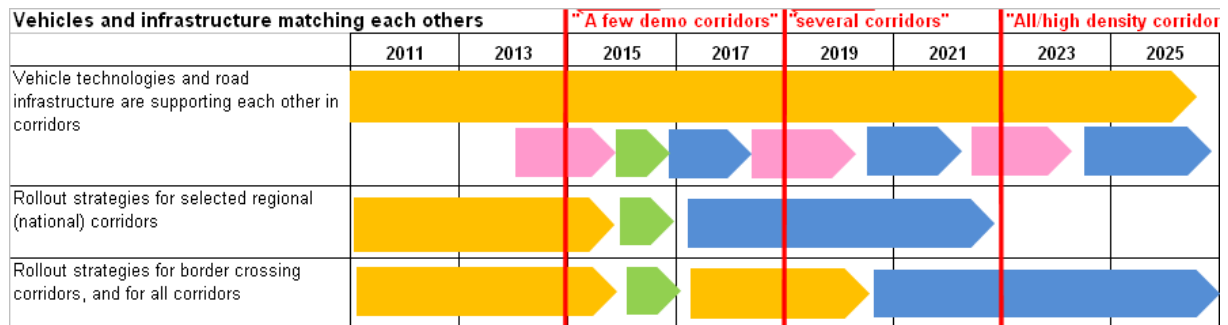
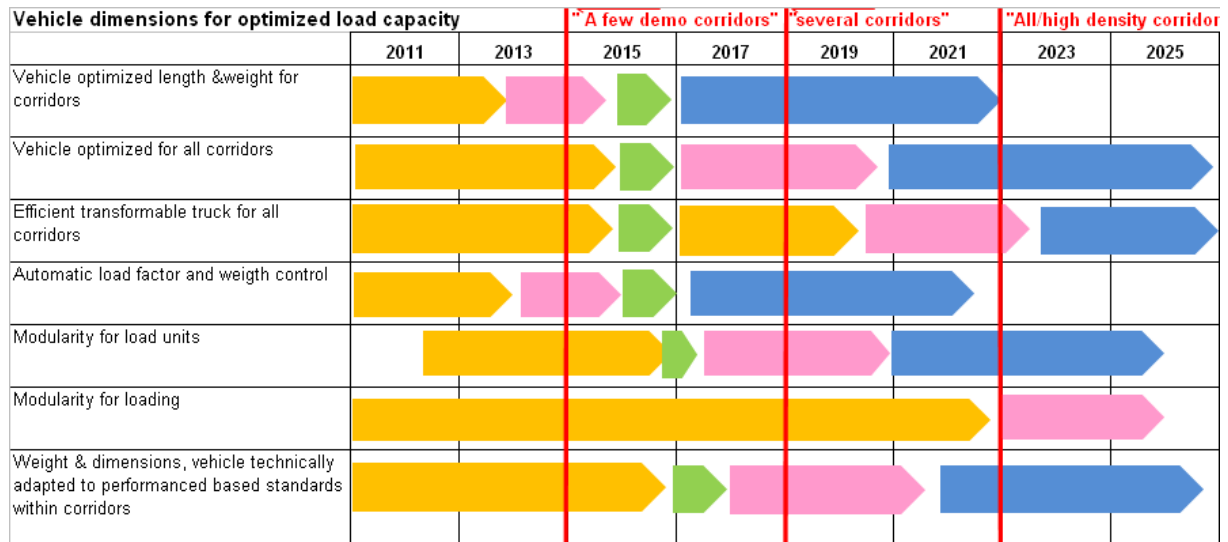
Automated driving (X2X)	ICT for speed and distance control (V2V) Europe wide standardisation regarding vehicles dimensions, communication systems for automated driving	Interaction of vehicle and infrastructure towards automated driving. ICT considering infrastructure limitations for automated driving such as bridges (weight limits), tunnels Demonstration projects in selected corridors	Automated driving demonstrations in all existing corridors. By 2030 automated driving "business as usual" in all corridors.
-------------------------	--	---	--

5. Roadmaps

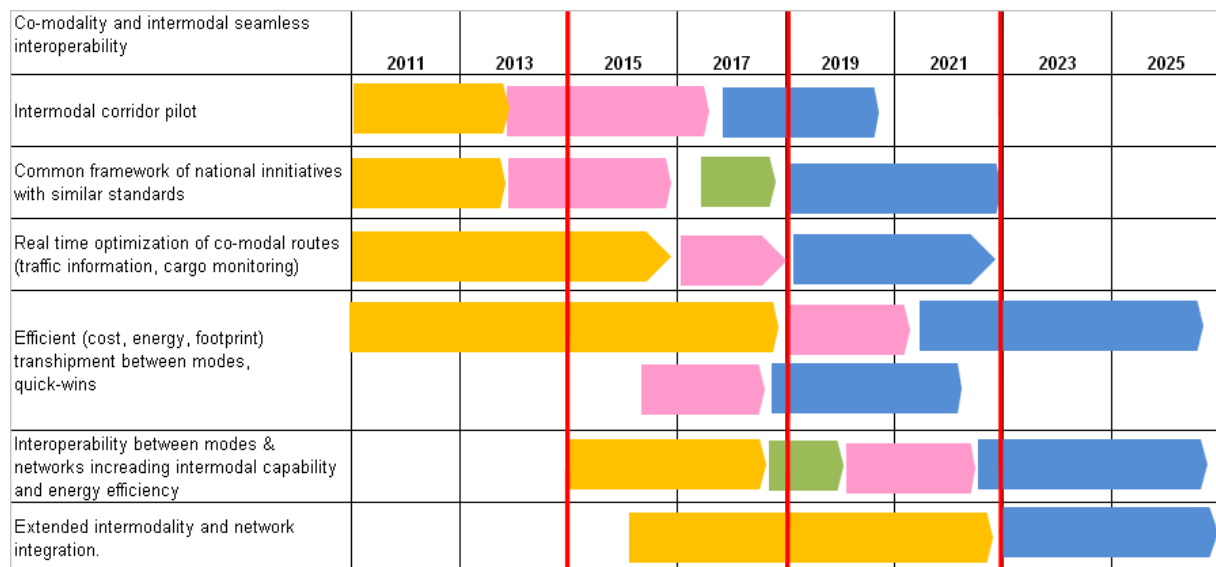
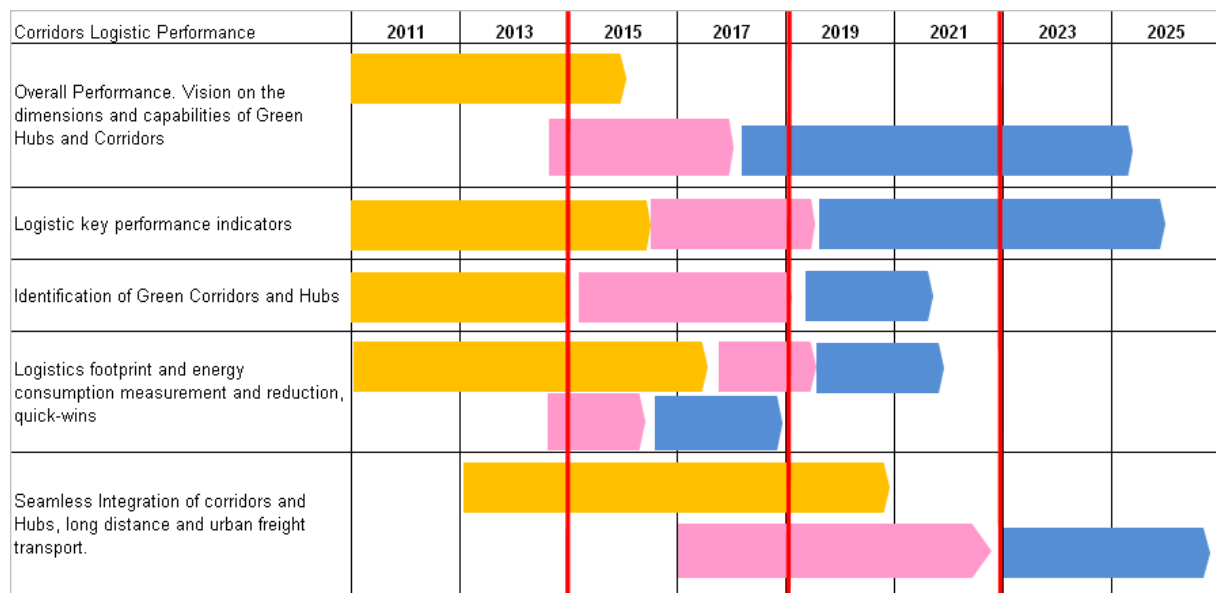


Vehicle technically specified for running in corridors	2011	2013	2015	2017	2019	2021	2023	2025
Optimized vehicle parameters for efficient transport operation within Green Corridors								
Vehicles fully adapted to its operation and freight								
Optimized vehicles dedicated and tailored to its operation								
Vehicle modularity								

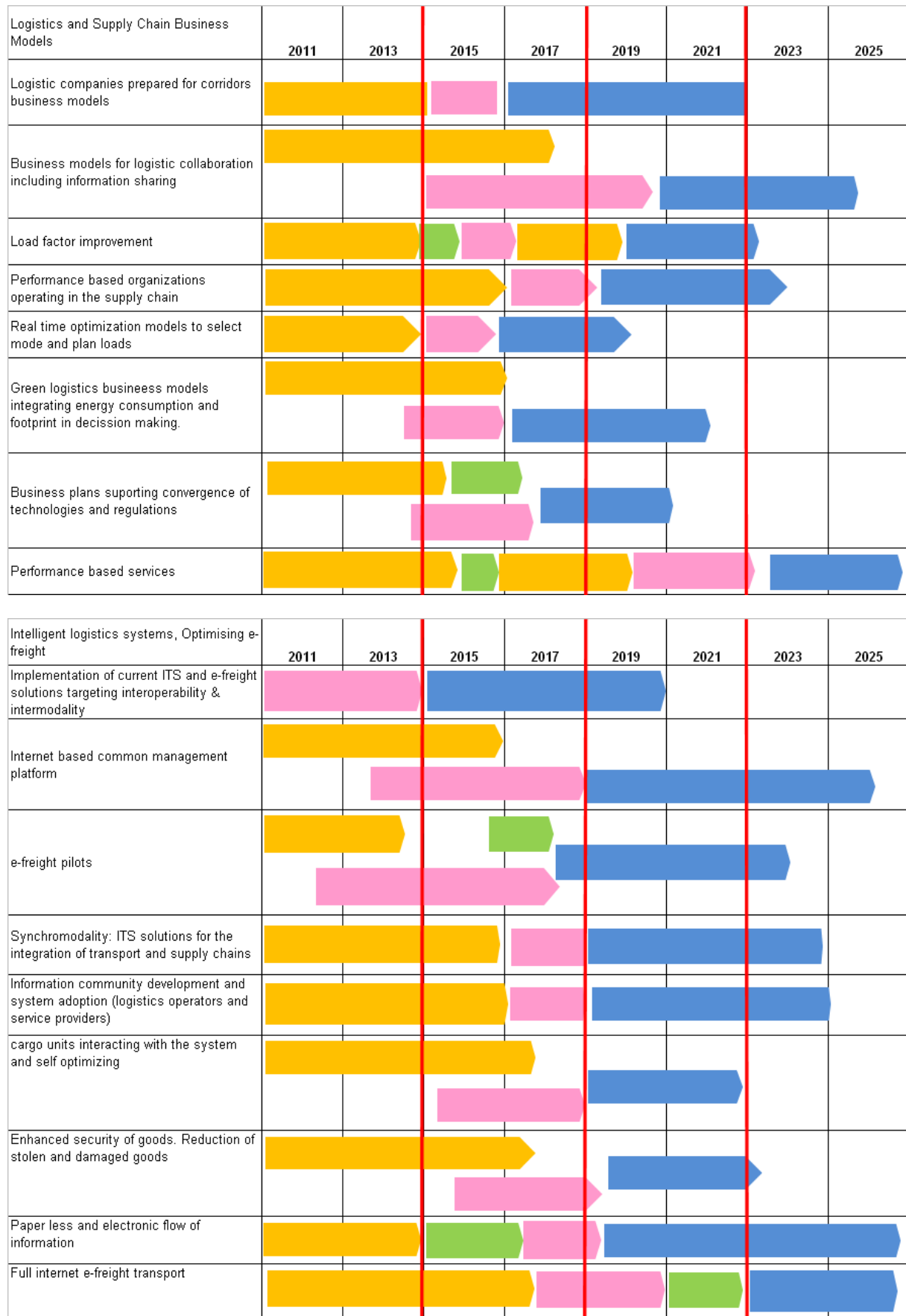
ERTRAC Research and Innovation Roadmaps



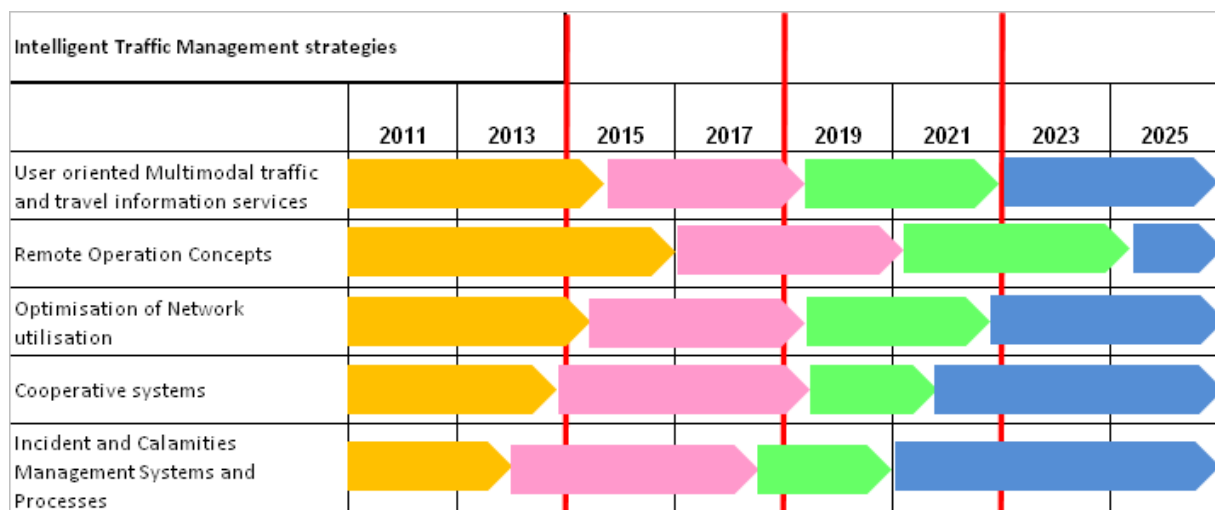
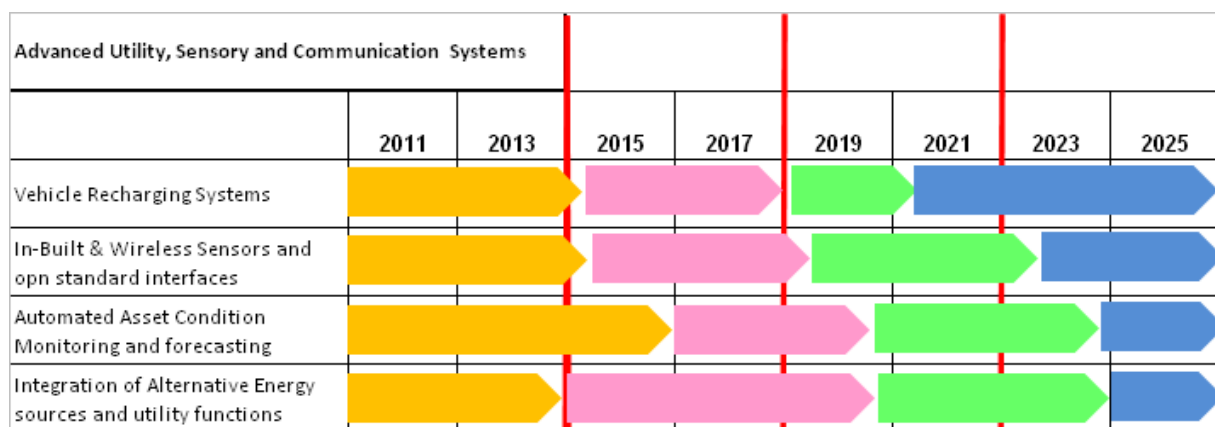
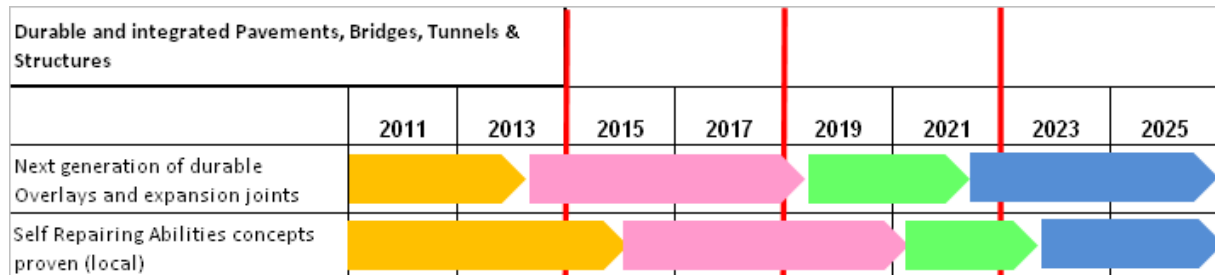
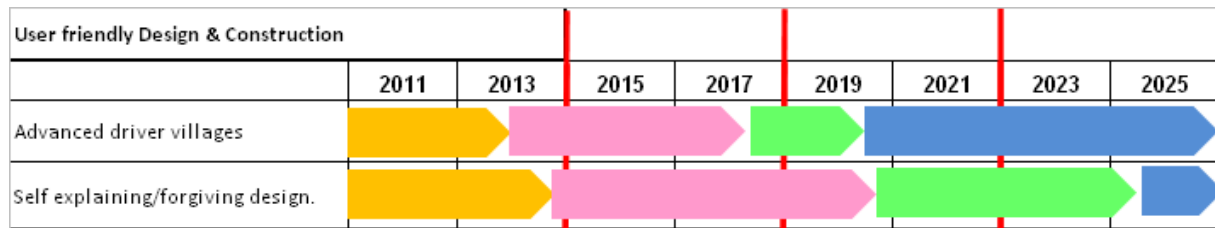
ERTRAC Research and Innovation Roadmaps



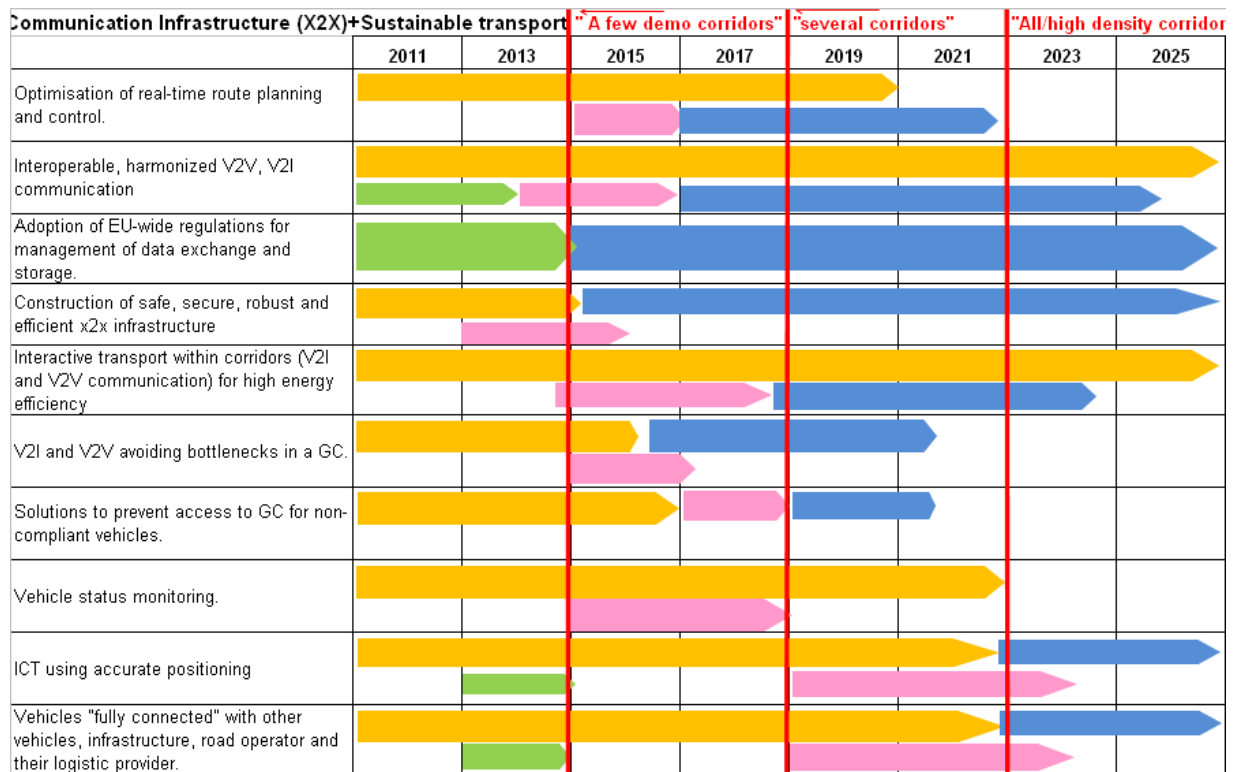
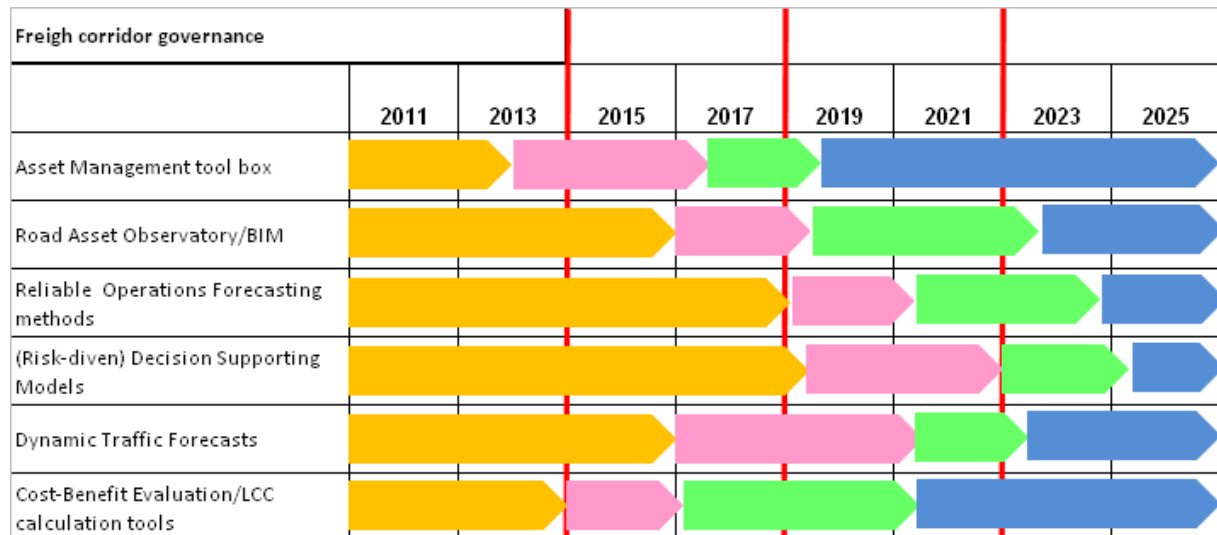
ERTRAC Research and Innovation Roadmaps



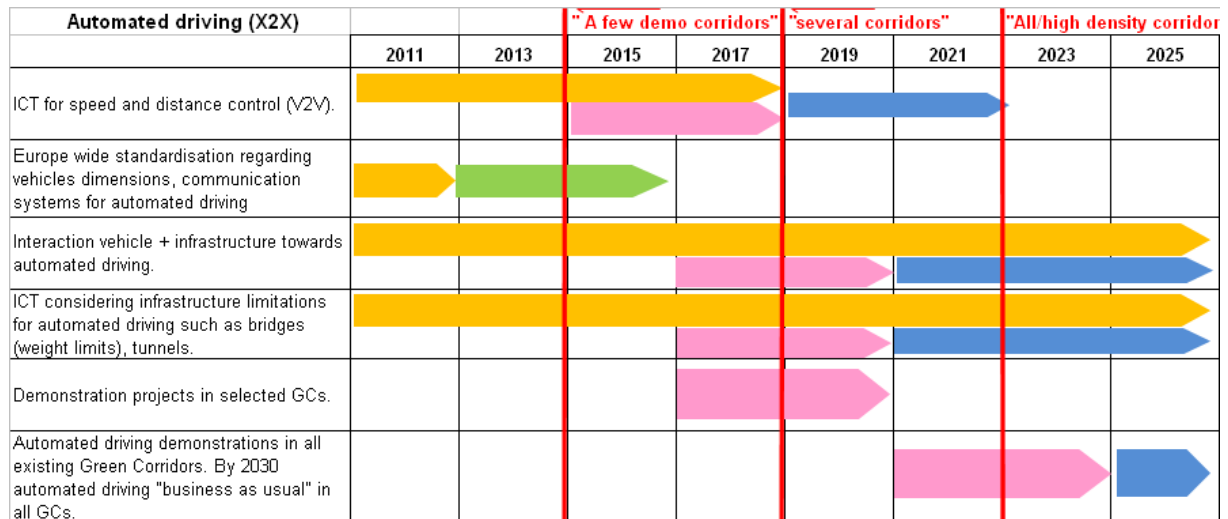
ERTRAC Research and Innovation Roadmaps



ERTRAC Research and Innovation Roadmaps



ERTRAC Research and Innovation Roadmaps



References

Members of the working group:

Contributing members		
FEHRL / TRL	Knight	Iain*
EUCAR / Volvo	Niklasson	Helene*
EUCAR / SCANIA	Johnson	Anders
MS Netherlands/ DAF	Martens	Jack
AVL	Holleis	Alexander
MS / Sweden	Berndtsson	Anders
EARPA / Fraunhofer	Bein	Thilo
ERRAC	Olsson	Bo
EARPA / TNO	Tavasszy	Lori
MS / Spain / Logistop	Liesa	Fernando
IRU	Billiet	Marc
FEHRL	Smit	Ruud
Consulted members		
ERTICO	Jeftic	Zeljko

FEHRL / IFSTTAR	Jacob	Bernard
EIRAC / DHL	Sonnabend	Peter
Academia / University College Dublin (UCD)	O'Brien	Eugene
CLEPA / Bosch	Hernier	Markus
EARPA / Ricardo	Jackson	Neville
MS / Greece	Patsiavos	George
EARPA / Southampton University	Cherret	Tom
NCP UK	Funnell	Cliff
EUCAR	Godwin	Simon
EC members		
	Gouvras	Stefano
	Hoefs	Wolfgang
	Basso	Paolo

* coordinator for this roadmap

Additional persons consulted:

- David Rylander, Volvo Technology Corporation
- Bjarne Schmidt, Danish Road Authorities
- Johann Litzka, University Vienna (ISTU)
- Gary Bridgeman, IRU
- Martin Lamb, TRA
- John Berry, European Commission

European projects of reference:

- EGCI-Capire
- Freight Vision
- CVIS

Reference documents:

eia (2010), U.S Energy Information Administration, International Energy Outlook (2010), Transportation Sector Energy Consumption,
<http://www.eia.doe.gov/oiaf/ieo/transportation.html>

COM(2011) 144, White Paper 2011 'Roadmap to a Single Transport Area - Towards a competitive and resource efficient transport system'

EGCI (2010). *Long Distance Trucks*, EGCI Road map v5-11-2010. <http://www.green-cars-initiative.eu/public/documents>

EGCI (2010). *Electrification of Road Transports*, EGCI Road map v2.0 November 2010. <http://www.green-cars-initiative.eu/public/documents>

EGCI (2010). *Logistics and Co-Modality*, EGCI Road map v November 2010. <http://www.green-cars-initiative.eu/public/documents>

ERTRAC (2010). *A Strategic Research Agenda aiming at a '50% more efficient Road Transport System by 2030*. www.ertrac.org

McKinnon & Piecyk (2010). *Logistics 2050 – Moving Freight by Road in a Very Low Carbon World*.

SIKA, 2008:10, *Potential för överflyttning av person- och godstransporter mellan trafikslag*, http://www.sika-institute.se/Templates/FileInfo.aspx?filepath=/Doclib/2008/Rapport/sr_2008_10_lowres.pdf

COM(2009) (279) European Commission communication on "A sustainable future for transport"