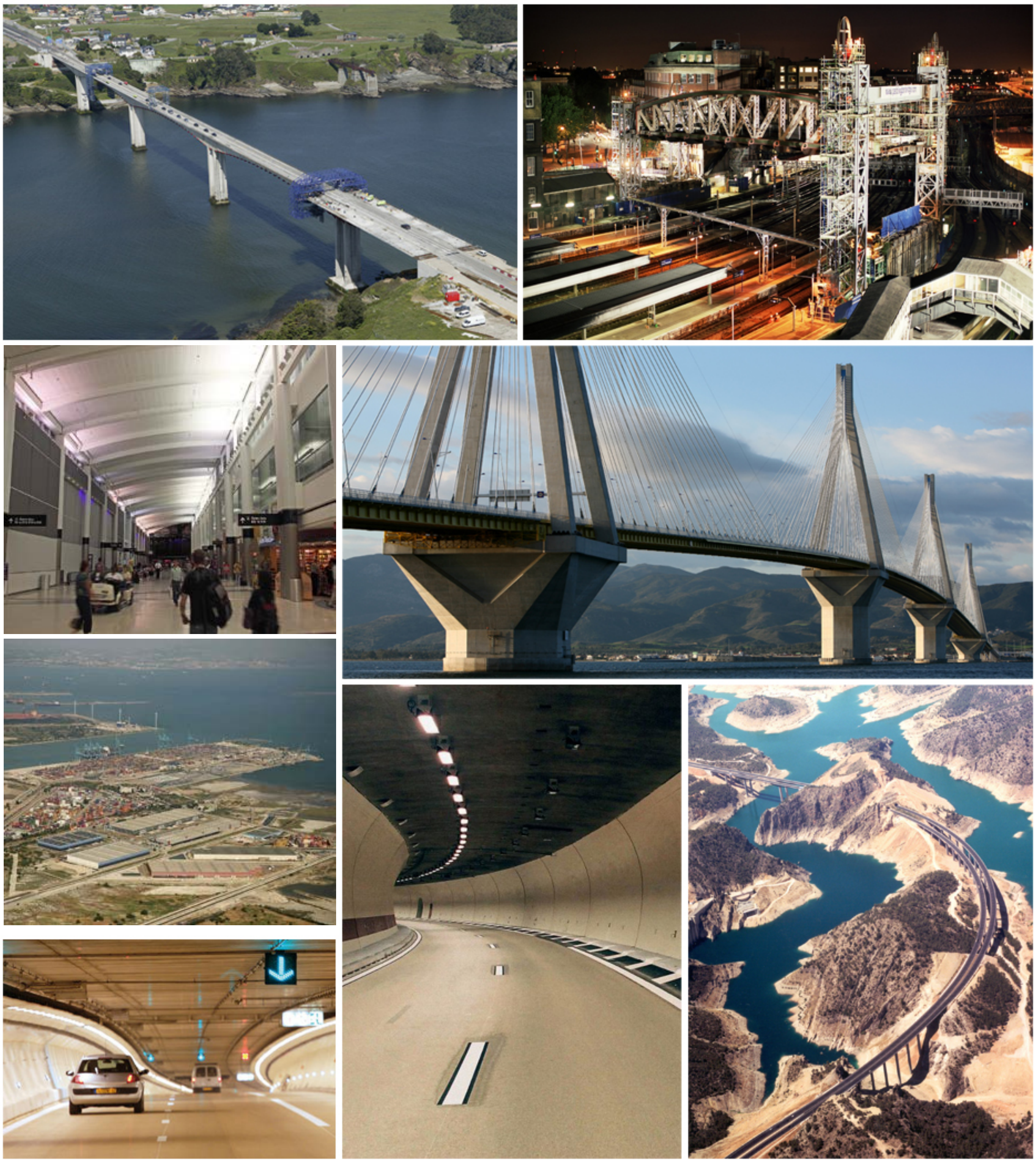
An initiative of the European Construction Technology Platform

ECTP EUROPEAN CONSTRUCTION TECHNOLOGY PLATFORM

Research for Future Infrastructures in Europe reFINE

Building Up Infrastructure Networks of a Sustainable Europe

Strategic Targets and Expected Impacts



From left to right:

Los Santos Bridge. *Paddington Bridge.*

New Orleans Terminal. *Rion Antirion Bridge.*

Marseille Harbour*.Tunnel in A-86.* ***Toulon Tunnel****.*

Viaducts and Tunnels in A-3

Octobre 2012

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Content

Paris’ Pont Royal (France)

1. Foreword

Construction is uniquely placed to power Europe out of recession. All over Europe governments are seeing infrastructure investment as a key component for reinvigorating their ailing economies. Europe's infrastructure deficit is slowing growth, and increased investment will leave a totally beneficial legacy by removing the physical constraints to growth. In parallel, and in times of high unemployment, a new construction job spending €1, costs €0.44 and produces benefits of €4-€5[1]: that will solve unemployment and inject money into our economies. Infrastructure is increasingly an inter-dependent system; transport, energy, water, communications are now totally trans-national, and no respecters of boundaries. Construction is being called upon to deliver and support a modern urban realm that only a systems view can succeed in.

However, without construction innovation and research, the only option is to build infrastructure the 20th century way – high carbon, low innovation and at high cost and this is all very wasteful and inefficient. It is therefore vital that we improve infrastructure delivery for people and freight, and to become globally competitive. Across Europe there is an urgent need to modernise construction delivery, and industry will not do it on its own – the risks, the structure of the industry and the implementation of EU procurement mitigates against innovation.

There are a lot of optimistic initiatives across Europe and elsewhere, whether through Science and Technology Innovation Centres, or University Centres of Excellence, where agendas are being set. Our own European Construction Technology Platform (ECTP) has initiated the Energy Efficient Building (E2B) research agenda. The E2B initiative was supported by Commission funding and could mobilize 150 industry players (a quarter of them being SMEs). The **reFINE** (**re**search for **F**uture **I**nfrastructure **N**etworks in **E**urope) initiative has been established by ECTP to create the new green competitive and inclusive society, bringing together European enterprises active in infrastructure research, construction, maintenance and operation.

This document describes the reFINE context, both in terms of the economic and societal value of transport infrastructure as well as in the European policy context, and introduces the vision and challenges, for future "green, smart, and low-cost" European infrastructure:

- **Green,** to reduce carbon emissions linked to infrastructure by 30% by 2020,
- **Smart,** to improve and increase infrastructure utility (capacity, safety and efficiency) by 30%, and
- **Low Cost,** to increase end value whilst reducing first costs by 30%.

Then it introduces to the various identified RDI (*Research Development and Innovation*) Domains and associated Targets that have been identified to meet the above-mentioned challenges and achieve the reFINE vision, along with potential qualitative or quantitative KPIs (*Key Performance Indicators*). This provides a first assessment of potential impact that has to be generated by the required future R&D in the infrastructure industry.

[1] Construction in the UK Economy - The Benefits of Investment. UKCG – L.E.K., October 2009

2. Context

2.1. The economic and societal value of transport infrastructure

Transport infrastructure provides the arteries for European trade and society[2]. The European transport infrastructure network is commonly regarded as a shared heritage of great economical value, as it enables wealth to be generated and enjoyed across the continent. The magnitude of Europe's transport infrastructure is indeed truly impressive – in terms of:

- Roads: more than 60,000 km of motorways in a total road network of approximately 5 million km in the 27 European Union Member States (EU 27).
- Railways: the total length of railway lines is around 215,000 km, of which 107,400 km are electrified.
- Waterways: 41,000 km of navigable inland waterways.

High Speed 1, formerly CTRL (UK)

Moreover, as exhibited in the document "EU transport in figures" – EC Statistical pocketbook 2011:

- With respect to *Passenger transport*: in 2009, total passenger transport activities in the EU27 by any motorized means of transport are estimated to have amounted to 6 503 billion pkm[3] or on average 13.063 km per person. This figure includes intra-EU air and sea transport but not transport activities between the EU and the rest of the world. Passenger cars accounted for 73.5% of the total, powered two-wheelers for 2.4%,

[2] Horizon 2020 - The Framework Programme for Research and Innovation (2014-2020)

[3] Passenger-kilometre (pkm) is a unit of measure: 1 passenger transported over a distance of 1 kilometre

buses & coaches for 7.8%, railways for 6.2% and tram and metro for 1.4%. Intra-EU air and intra-EU maritime transport contributed 8.0% and 0.6% respectively.

- With respect to *Goods transport*: in 2009, total goods transport activities in the EU27 are estimated to have amounted to 3 632 billion tkm[4]. This figure includes intra-EU air and sea transport but not transport activities between the EU and the rest of the world. Road transport accounted for 46.6 % of this total, rail for 10.0 %, inland waterways for 3.3 % and oil pipelines for 3.3 %. Intra-EU maritime transport was the second most important mode with a share of 36.8 % while intra-EU air transport only accounted for 0.1 % of the total.

It therefore appears obvious that it is vital that Europe continues to have access to an efficient transport infrastructure to ensure solid links between production, distribution and consumption places, with good internal networks at local, regional and national and cross-national (European) levels, or it will lose enterprises and potential investors. People and businesses depend on the availability of transport infrastructure which is a critical asset for the European economy.

2.2. An existing infrastructure to be strengthened and transformed

Europe possesses one of the densest and most developed infrastructure networks in the world, a huge legacy and accumulated investment inherited from its long history. It owns the oldest road networks, the first ever underground railway networks that facilitated its prosperity. Most infrastructure that was constructed in the period 1960-1970 was designed for a working life of 50 years, as shown in Figure 1. Now these infrastructure networks are often strained far beyond their intended capacities in terms of traffic flows and traffic loads. Large sections already require significant refurbishing. Furthermore, climate change may also have altered the climatic conditions considered at the design stage. Consequently, many of the existing infrastructure no longer fulfil the current functional requirements and today’s safety and quality standards and no longer form a resilient foundation for Europe’s economies.

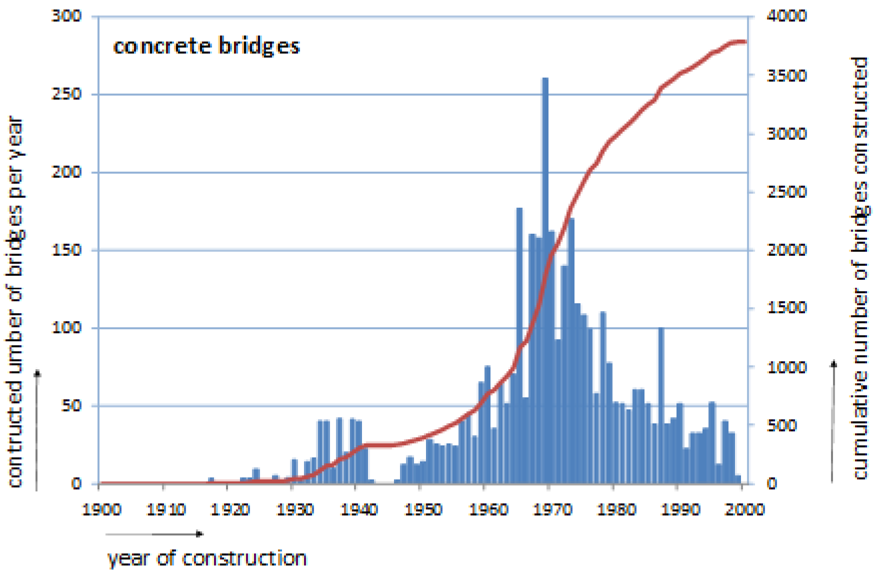

Figure 1: Concrete bridges and their evolution per year[5].

[4] Tonne-kilometre (tkm) represents 1 ton of cargo over a distance of 1 kilometre

[5] J. Gijsbers, G. Dieteren, C. van der Veen; Beoordelingskader bestaande Constructies; Cement 4/2012.

Figure 2 shows the continuous increase of transport infrastructure investments in relation to GDP between 1995 and 2008. The investments for road, rail, inland waterways, sea and air have been included for 20 European countries (Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Liechtenstein, Lithuania, Luxembourg, Norway, Poland, Portugal, Slovakia, Spain, Switzerland and the UK).

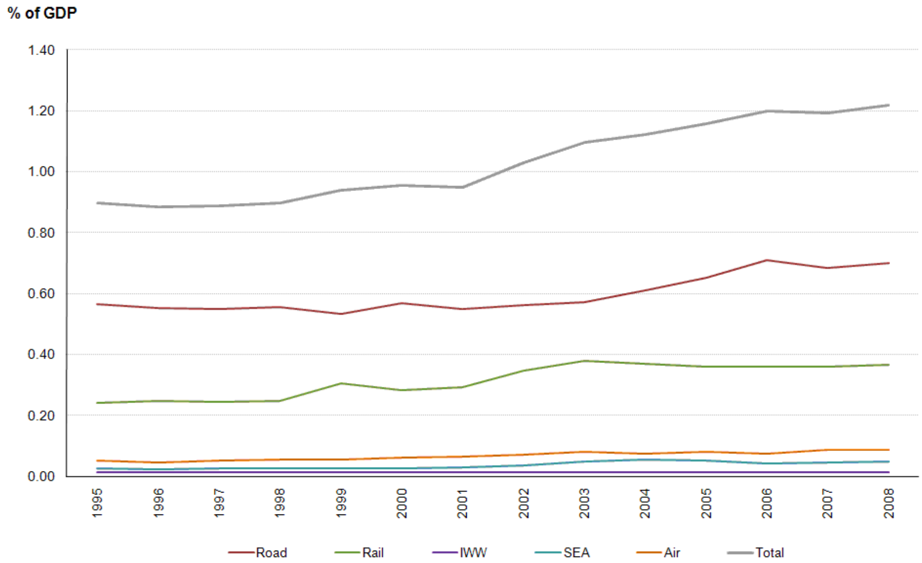

Figure 2: Percentage of GDP used for transport infrastructure (European GDP 2008: 12,500 billion Euros)[6].

With a 50-years design life at an end, we now faced the issue that a large part of the existing infrastructure reaches the end of its lifetime. Is it still safe enough to continue being used? Will it have to be demolished, strengthened and/or put under intensive care? The ensuing reconstruction works will inevitably create an important disturbance to traffic with associated economic consequences. The cost of replacing the existing European infrastructure is astronomical, and massive coordinated investment and funding is necessary.

Pont de la Confédération (Canada)

[6] http://www.eea.europa.eu

2.3. *Challenging societal trends*

The European infrastructure network confronts important economic, societal and environmental trends which are set to play a major role in its future development. Such a network must be a key pillar in future answers towards society's expectations, and indeed must form the strong foundation for the upcoming ***Single European Transport Area*** (SETA) supporting European-scale mobility of people and goods, as promoted by the European Commission (EC) in its White Paper – "*Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*" (COM(2011) 144 final, Brussels, 28.3.2011). Furthermore, it lies within the scope of a single framework for coherent funding through TEN-T, cohesion and structural funds, sustaining the deployment of innovative solutions.

As a support to SETA, reFINE advocates the need for developing ***High-Level Service Infrastructure (HLSI)***, to be considered the core element of a future fully functional and EU-wide multimodal integrated transport by 2030. "HLSI" has the following features:

- providing infrastructure for high quality mobility services for people and goods while using resources more efficiently;
- ensuring overall better service and performance, including multimodal integration and intermodal continuity for the end-user, less congestion, optimised transport time, etc.;
- higher degree of convergence and enforcement of social, health, safety, security and environmental rules for infrastructure, with adequate service standards (including adequate service obligations) at all time;
- interconnected solutions for the next generation of multimodal transport management, including information services and systems for all infrastructure.

HLSI is considered in reFINE as the ultimate answer to the societal challenges:

- **Passengers and goods volume:** The deeper integration of countries and regions into an emerging global system of production and exchange is expected to reshape patterns of long distance transport, trade and supply. **Volumes of passengers and goods will increase**, continuing the trend shown in Figure 3. Freight transport activity is projected to increase by around 80% by 2050 compared to 2005, while passenger traffic should grow by 51%.

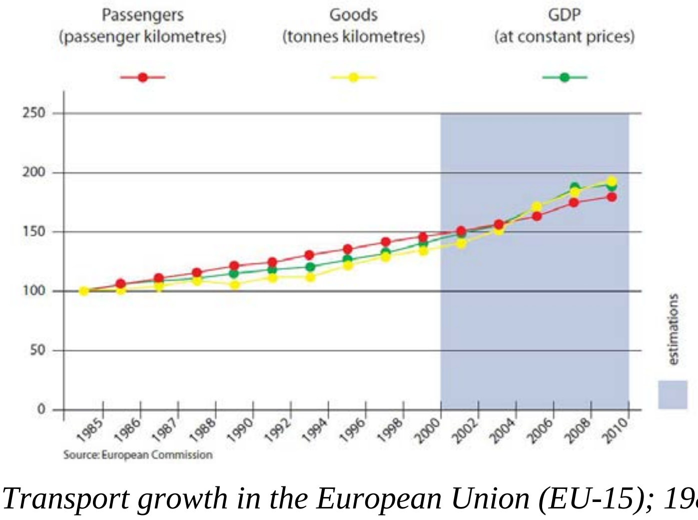

Figure 3: Transport growth in the European Union (EU-15); 1985-2010[8]

[8] FEHRL: Vision Road Transport in Europe 2025

- **Urban population:** By the year 2050, **84% of the world's population will be living in urban and suburban areas**[9] as a consequence of demographic developments and there will be a changing age structure, with an increase in elderly people, as well as migration and demands for increased internal mobility. As recognised in the Green Paper "*Towards a new culture for urban mobility*"[10], **achieving a better and safer mobility** is one of the great challenges and obligations of our society, a necessity for a competitive Europe and for the quality of life of European citizens. The development of efficient urban, suburban and regional transport systems are thus critical elements for a sustainable transport system. The challenge is therefore to increase the attractiveness of integrated public transport systems for existing and new passengers and to achieve more attractive rail-related transport products and services, with a progressive harmonisation across Europe (though the concept of *HLSI* and especially the associated *Urban mobility* as introduced in section 3.1).

  The transport system needs to be modernised, integrated and made interoperable, connecting cities as well as major industrial and commercial centres for commuting and supplying goods. Challenges include integrating modal networks in terminals and platforms, completing the European transport system (TEN-T network), upgrading the existing infrastructure and connecting to non-EU countries for international trade.

  The cost of EU infrastructure development to match the demand for transport has been estimated at over € 1.5 trillion for 2010-2030 (European Transport 2050 White Paper). The completion of the TEN-T network requires about € 550 billion until 2020 out of which some € 215 billion can be referred to the removal of the main bottlenecks. Given the scale of the investment required, it is necessary to strengthen the coordination dimension of network planning and development at European level, in close collaboration with national governments.[11]

- **Transport decarbonisation and greening:** Figure 4 shows the shares of transport modes in GHG (Green House Gas) emissions and substantiates that transport is a major issue as regards decarbonisation.

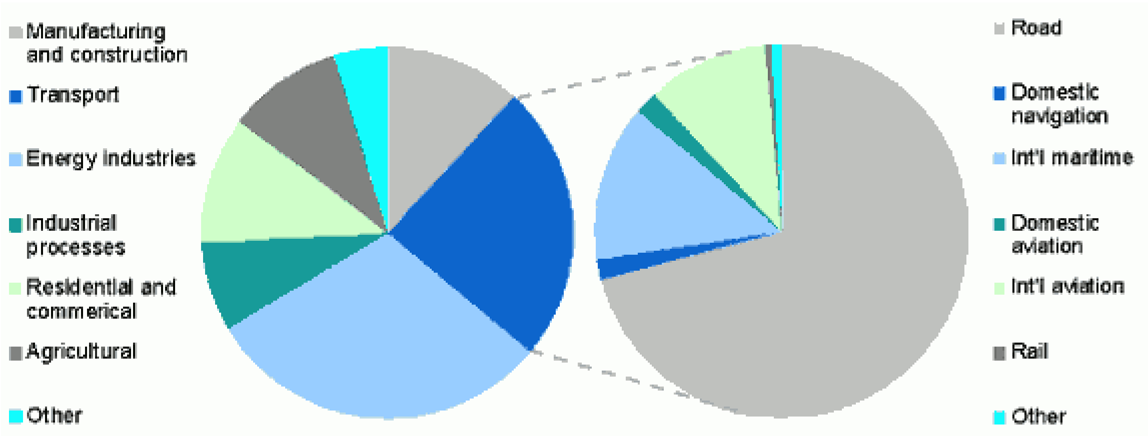

Figure 4: EU27 greenhouse gas emissions by sector and mode of transport, 2007 (Source: Policies - Climate Action - European Commission)[12].

[9] Population Reference Bureau : http://www.prb.org/Educators/TeachersGuides/HumanPopulation/urbanization.aspx
[10] COM(2007) 551 final, GREEN PAPER Towards a new culture for urban mobility
[11] Ref: http://ec.europa.eu/transport/infrastructure/index_en.htm
[12] http://ec.europa.eu/clima/policies/transport

Citizens and public authorities in urban areas are increasingly demanding new modes of transport that are better, faster, safer, cheaper and greener, including - but not only - electrical vehicles. Achieving **transport decarbonisation** is a key challenge. Indeed climate change demands that the transport sector reduces its greenhouse gas emissions (urban transport is responsible of about a quarter of CO_2 emissions[13]). Drastic reduction of noise impact, NOx emissions and particle matters (dust) should also be targeted, particularly in cities. This is necessary in order to maintain a healthy environment as well as sustainable growth in urban areas. The EU policy objectives on transport decarbonisation[14] can be only met with innovative concepts for overcoming the high development and implementation costs of such new modes of transport. Current and future infrastructure will have to be made compatible with **electric mobility**: new types of rolling stock will be required, as well as adapted types of infrastructure requiring both new products and new regulations.

Figure 5 shows the trends in energy sources for road transportation. Future infrastructure will have to adapt to these new energy sources that will transform the transportation activities[15]. For urban transport, a big shift to cleaner cars and **cleaner fuel vehicles** is expected, including 50% shift away from conventionally fuelled cars by 2030, getting them out from cities by 2050. By the horizon 2050 full electric vehicles will represent more than 50% of passenger vehicle sales.

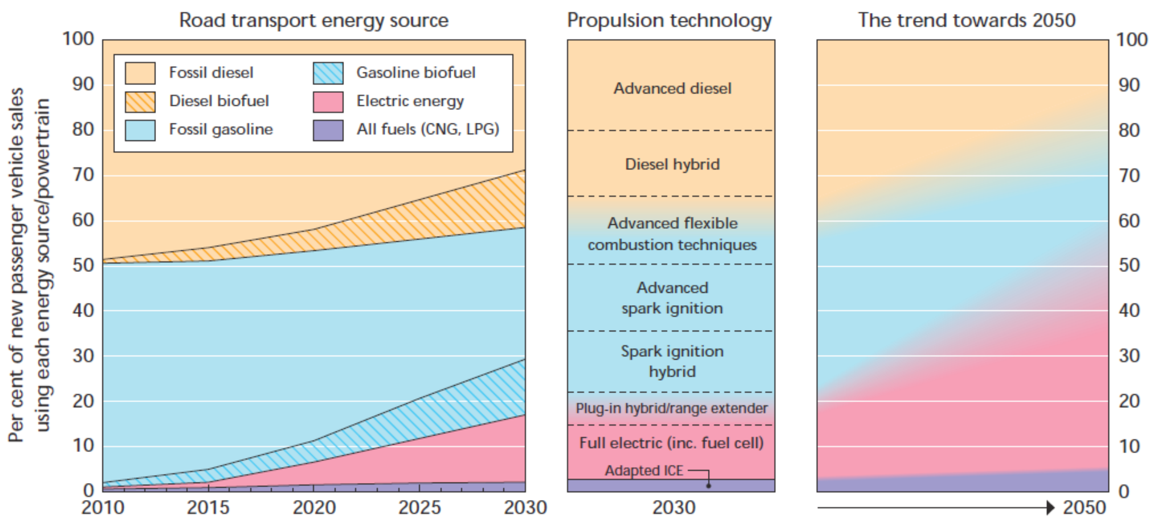

Figure 5: Trends of road transport energy sources
(Source: ERTRAC Research and Innovation Roadmaps).

Moreover a reduction of GHG emissions by the infrastructure construction sector itself (e.g. building roads which lead to less fuel consumption) will contribute as a reduction in GHG emissions by transport sector.

- **Impact of resource efficiency and climate change:** there is currently an obvious trend towards energy and resource efficiency, fighting increasing environmental impact and ecosystem degradation. The issue of climate change also plays a role in the enormous challenges in terms of investments for new infrastructure and upgrading existing infrastructure. Extreme climatic events are occurring ever more frequently,

[13] Transport 2050 IP/11/372
[14] Europe 2020 targets
[15] ERTRAC Research and Innovation Roadmaps

and the transport infrastructure needs to be able to cope with these, to provide a reliable service even under extreme weather conditions. This means that the robustness of the infrastructure network must be improved – by considering since inception and design a multi-risk approach (including in addition to the impact of the physical risks their social and environmental effects) together with a life-cycle impact analysis using the most state-of-the-art concepts and tools (e.g. tools to accurately predict the actual service life of infrastructure). The construction process itself should adopt "low-consuming" concepts and methods, like lean construction, better use of resources including water and so on.

London King's Cross railway station (UK)

2.4. European policies and targets

The European Commission (EC) has recently adopted the strategy "Transport 2050", with accompanying documents:

- The White Paper - Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system[17];
- The EU Strategic Transport Technology Plan[18];
- The TEN-T Guidelines - with a new version updating the 2004 one (under preparation).

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[17] COM(2011) 144 final - WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system

[18] COM(2012) 501 final – Communication from the EC to the Council and the European Parliament – Research and innovation for Europe's future mobility – Developing a European transport-technology strategy

The White Paper describes a comprehensive strategy (Transport 2050) for a competitive transport system that will increase mobility and remove major barriers and bottlenecks in many key areas across the fields of transport infrastructure and investment, innovation and internal market. The objective of the strategy is to dramatically reduce Europe's dependence on imported oil and **cut carbon emissions in transport by 60% by 2050**. This includes the creation of a Single European Transport Area with more competition and a fully integrated transport network that links the different modes and allows for a profound shift in transport patterns for passengers and freight. To this purpose, the roadmap lists 40 initiatives for the next decade.

New transport patterns must emerge, according to which larger volumes of freight and greater numbers of travellers will be carried jointly to their destination by the most efficient (combination of) modes. Freight multimodality has to become economically attractive for shippers. The EU needs specially developed freight corridors optimised in terms of energy use and emissions, minimising environmental impacts, but also attractive for their reliability, limited congestion and low operating and administrative costs. Individual transport is preferably for the final miles of the journey and performed with clean vehicles. Information technology provides for simpler and more reliable transfers. Transport users pay for the full costs of transport in exchange for less congestion, more information, better service and more safety.

Future development must rely on a number of strands:

- ***Improving the energy efficiency performance of vehicles across all modes***[19]. Developing and deploying sustainable fuels and propulsion systems. The EU proposes to halve the use of conventional fuelled cars in urban areas by 2030, and phase them out by 2050. This will lead to the need to adapt infrastructure.
- ***Optimising the performance of multimodal logistic chains, including by making greater use of inherently more resource-efficient modes***, where other technological innovations may be insufficient (e.g. long distance freight). This includes the following targets:
    - 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed.
    - By 2050, a European high-speed rail network should be completed. The objective is to triple by 2030 the length of the existing high-speed rail network and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail.
    - A fully functional and EU-wide multimodal TEN-T ‘core network’ by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services, should be achieved.
    - By 2050, all core network airports should be connected to the rail network, preferably high-speed; similarly all core seaports should be sufficiently connected to the rail freight and, where possible, inland waterway system.

[19] Example: PPP on Green Cars

- ***Using transport and infrastructure more efficiently through use of improved traffic management and information systems*** (e.g. ITS, SESAR, ERTMS, SafeSeaNet, RIS), advanced logistic and market measures such as full development of an integrated European railway market, removal of restrictions on coastal shipping, abolition of barriers to short sea shipping, undistorted pricing, etc.
- ***Moving close to zero fatalities in road transport***. In line with this goal, the EU aims at halving road casualties by 2020. Improved highly efficient management and operation of networks, through the use of the latest technologies, will increase safety and security. Fatalities and severe injuries could decrease by 35%, and cargo lost to theft and damage by 40%. This will help make EU a world leader in safety and security of transport in aviation, rail and maritime.

Elevated tracks in the Chicago Loop (US)

2.5. Prospective scenario if things are not changing

This new strategy described in the EC White Paper imposes significant changes from all stakeholders of the European Transport System. In particular, the construction sector, in charge of procuring the infrastructure networks, is obliged to reconsider the entire construction processes. Holistic design processes such as Integrated Project Delivery and the use of Building Information Modelling (BIM) will drive changes in construction processes towards lean construction and industrialization of the sector. If present trends continue, and if there is no intensification of RDI activities in a near future beyond available technology and tools:

- Requirements for resource efficient and environmentally friendly construction will increase construction and maintenance costs. It will be more and more difficult to maintain the quality of services.
- Traffic jams (congestion) will continue to develop, with associated societal and economical costs.
- Inefficient transport corridors will penalise the efficiency of industrial companies. Deficient and deteriorating infrastructure will cost EU companies billions of Euros in

lost growth potential. Additionally, it will reduce the benefits drawn from investments made on other sections of strategic transportation axes.

- The new transport technologies will fail to develop because of inadequate / insufficient infrastructure needs. It will result in an even more energy-consuming and polluting transportation network.
- Failing infrastructure will not support the new conditions created by climate change. Disruption will become more and more severe and frequent, with ever deepening consequences on quality of life and efficiency of economy.
- The environmental impact of infrastructure during its whole life-cycle will remain high, ranging from energy and raw materials consumption during construction (including upgrade) and maintenance, nuisance (e.g. noise, vibrations, pollution of air and groundwater) and land occupation during service life, to waste generation during maintenance and demolition.
- The vital investments which are needed to upgrade a large majority of all infrastructure that reaches the end of its design life will be hard to bear (the last 10 years already show a clear increase of 35% in investment on transport infrastructure, and this trend will be intensified over the next decades[20]).

Building infrastructure as usual is not an option. Whole sets of new construction concepts, design methods, materials, and components must be developed, tested, implemented to satisfy the new requirements. A huge effort of research and innovation, coordinated at European level, is necessary to create and implement these concepts rapidly at the scale of the European continent, across the frontiers of Member States.

In the Impact Assessment document accompanying the Transport White Paper, a reference scenario is described in case of no policy change. This projection is built on a set of assumptions related to population growth, macroeconomic projections, and developments in oil price and technology improvement. Following this reference scenario, final energy demand by transport is projected to reach 32% of total final energy consumption by 2050, driven mainly by aviation and road freight transport. The EU transport system would remain extremely dependent on the use of fossil fuels. Renewables would gradually increase to 13% of total energy consumption in transport by 2050, however the pace of electrification in the transport sector (electric propulsion) would remain slow. In this scenario, with insufficient incentives to shift away from road transport, road would remain the dominant mode in both freight and passenger transport. Consequently the share of CO_2 emissions from transport would increase from one fourth today, up to almost 50% by 2050. This trend is not compatible with the objective of a low-carbon, competitive economy that would meet the long-term requirements for limiting climate change to 2 °C.

External costs of transport would continue increasing. The increase in traffic would lead to a roughly 20 billion € increase of noise-related external costs by 2050 and external cost of accidents would be about 60 billion € higher. The external cost of accidents in urban areas would increase by some 40%. In particular, congestion would continue to represent a huge burden on the society. Congestion costs are projected to increase by about 50%, to nearly 200 billion € annually.

[20] According to the Accompanying Document to the Transport White Paper, the cost of EU infrastructure that would be required to match the demand for transport is estimated at over € 1.5 trillion for 2010-2030

3. Vision & Challenges

3.1. The Vision: a "green, smart, and low cost" European Infrastructure

Transport infrastructure networks have a very long lifetime, typically 50 to 100 years or more. Decisions made today will have a decisive effect for mobility patterns extending beyond 2050, to the end of the 21st century. The Strategy adopted by the European Commission is built upon a *Single European Transport Area* (SETA) supporting at European scale mobility of people and goods based on integrated & optimised services provided by Global Operators, and supported by *Intelligent Transport Systems* (ITS).

The vision of reFINE, as exhibited in Figure 6, advocates that an essential requirement of ITS is the development of intelligent vehicles envisioned for each transport mode by the 'modal' European Technology Platforms such as ERRAC and ERTRAC. But it necessarily requires the ***High Service Level Infrastructure (HSLI)*** as envisioned by reFINE that is also crucial to form an efficient and sustainable *backbone network* of integrated mobility services provided by the SETA.

In such a landscape, the reFINE initiative has a key role to play, in cooperation with other stakeholders and initiatives, for the realisation of the SETA.

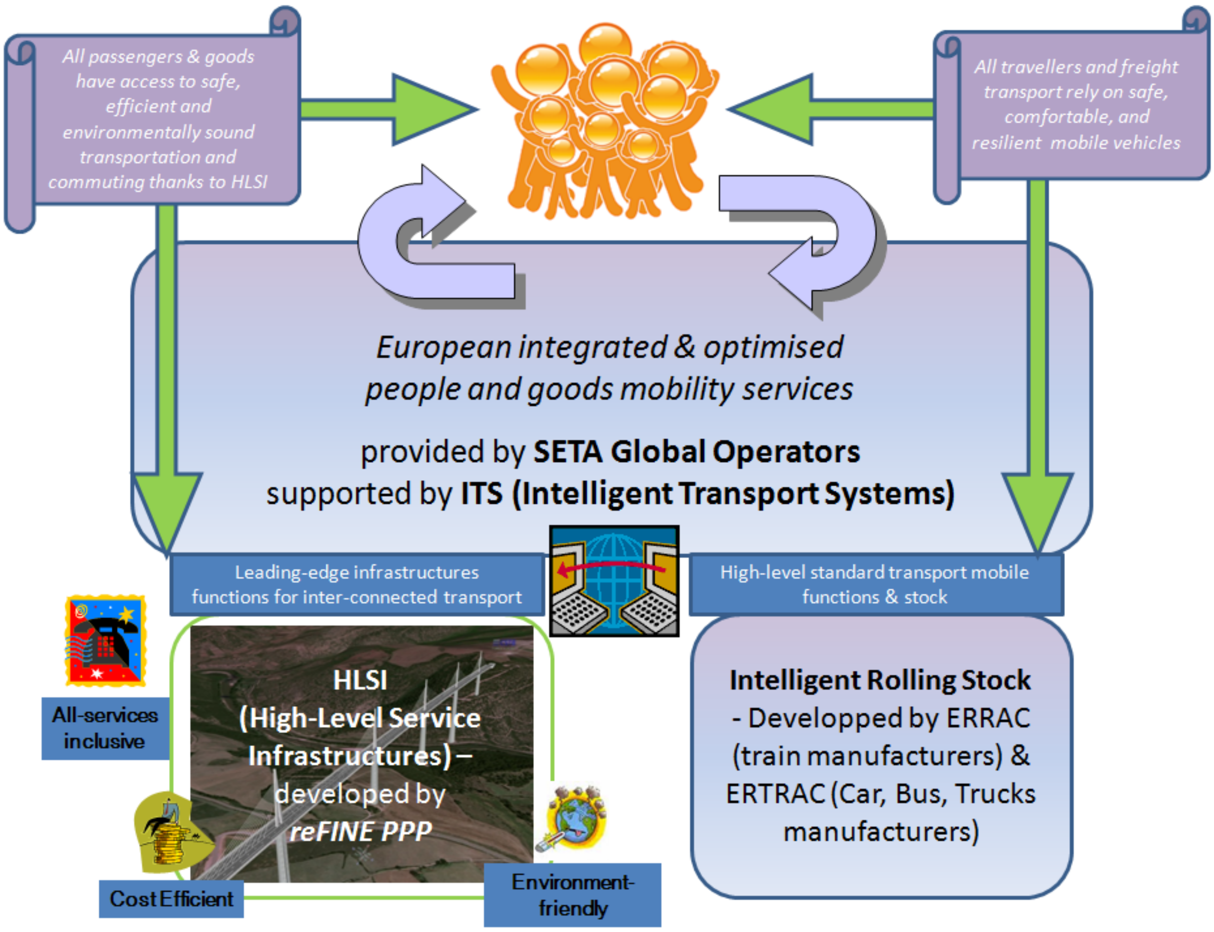


Figure 6: the reFINE vision of the future integrated SETA

The reFINE vision is that, by 2030, a new generation of intermodal networks and infrastructure will ensure smooth and efficient urban and inter-urban mobility. This vision is relying on the previously introduced concept of ***HLSI*** (High-Level Service Infrastructure):

Multimodal Hubs: *Infrastructure networks support the European social and territorial cohesion. Infrastructure networks are integrated, efficient and well connected, thanks to multimodal hubs that constitute essential nodes of the integrated transport systems. They guarantee Europe's integration with the international and intercontinental market, while complying with the principle of sustainable development.*

Examples: Schipol Amsterdam Hub / King's Cross Station Hub / Genoa Hub.

Urban Mobility: *Infrastructure networks support a high quality of life in sustainable European cities by ensuring a continuous and safe circulation of life, water and food and by providing the physical means for mobility to live and work.*

Examples: Grand Paris Express Network / Dublin M50 Motorway / Stuttgart 21.

Long Distance Corridors: *Infrastructure networks support a competitive European economy by providing fast means to develop European trade in a sustainable way between city centres and along major routes connecting Europe with the rest of the world.*

Examples: South Europe Atlantic (SEA) high-speed line / Greek Attiki Odos Motorway / Seine-Nord Europe (SNE) Canal.

Rheola Bridge, Porth (UK)

The three cornerstones of the HLSI are:

Green *infrastructure networks are designed for a* ***minimum environmental impact*** *over their entire life cycle from design and construction stage, to service and final recycling.*

Continuous, efficient and reliable quality of service makes infrastructure a major contributor to reducing energy and materials resources by European economy. The environmental impact of infrastructure during their whole life-cycle are to be dramatically reduced, optimising their energy and raw materials consumption during construction (including upgrade) and maintenance, reducing nuisances and environmental impacts (e.g. noise, vibrations, pollution of air and groundwater, affection to biodiversity…) and land occupation during service life, reducing waste generation during maintenance and demolition, etc.

***Smart** infrastructure networks provide a high quality level, continuous and safe service throughout natural and man-made hazards, and climate change. They support European quality of life in **sustainable cities** by a continuous and safe circulation of people and goods, providing the physical means for mobility to live and work. Quality of services is visible and recognised by all categories of users and by society.*

Existing and new infrastructure must be considered as key components of an inclusive society, in which everyone's life chances are maximized. All people must have access to the services and facilities they need and transport infrastructure is one of them. The needs of specific groups such as disabled people, minority ethnic communities, elderly people, children and young people and faith groups are met. Their voices are considered in the community planning and decision-taking, and they are able to use community resources. Associated challenges are the assurance of the Equality and Diversity, the fostering of the Citizenship Participation and the accessibility and affordability to Services and Infrastructure.

***Low Cost** infrastructure networks are commonly regarded as a shared heritage of great economical value; their maintenance and upgrade costs are optimised and safely managed as a necessity to preserve and increase the quality of life for the future generations of European citizens.*

Important: Low cost does not mean "low quality". It means affordable costs that are socially acceptable, targeting cost-benefit optimisation and coping with contradictory constraints from cost to environmental friendliness (see details below in section 3.3.3).

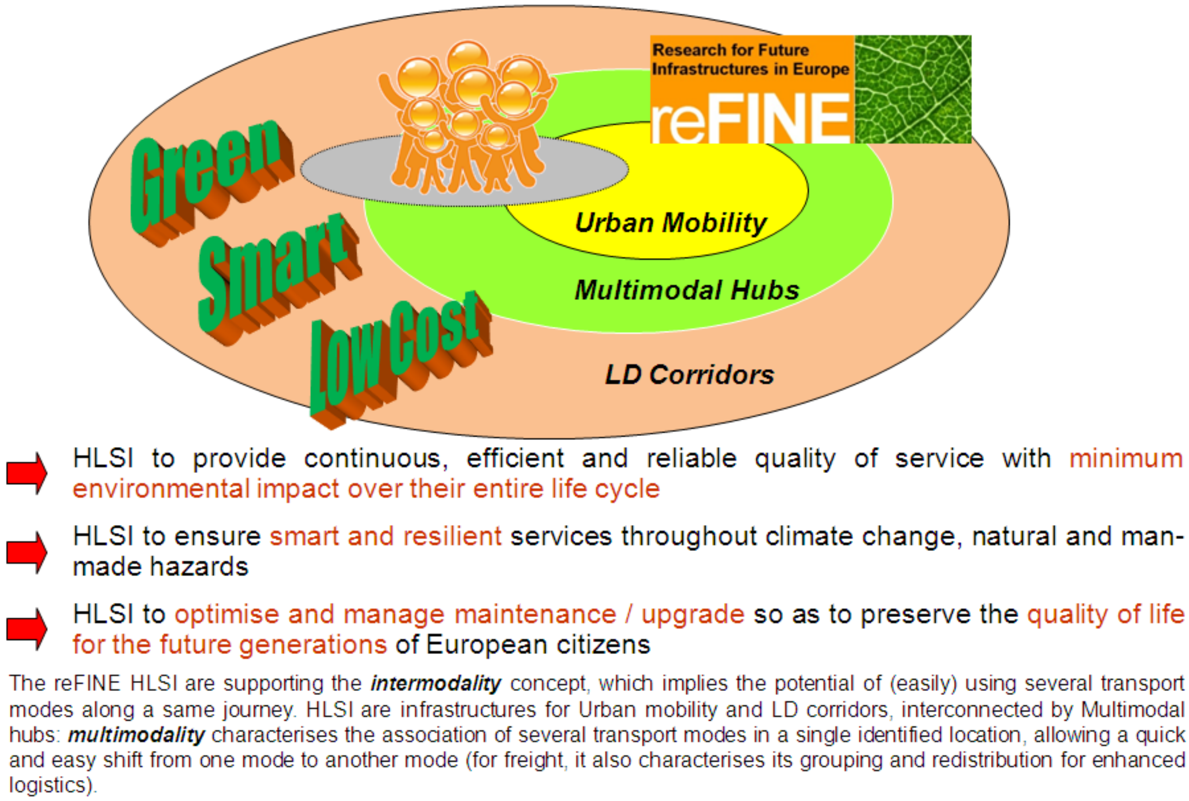


*Figure 7: Re-thinking infrastructure for the future → the **HLSI** concept.*

3.2. The expected impacts

Main expected impact is to achieve by 2030 the following "***3x30***" impact – thanks to appropriate R&D and innovation on infrastructure:

- ➔ ***GREEN:*** **-30%** of CO_2 emissions, mainly thanks to an improved organisation of transport relying on this new generation of intermodal networks and multimodal hubs;
- ➔ ***SMART:*** **+30%** performance in terms of:
  - o Infrastructure capacity regarding people and goods "on the move", thanks to a new generation of "all services inclusive" networks and infrastructure;
  - o Infrastructure safety with respect to reduction of accidents, mainly thanks to an optimisation of use and safety in the various "intelligent" components forming the future networks and infrastructure, and enhanced interactions with intelligent transport systems;
- ➔ ***LOW COST:*** **-30%** of costs in the development of new infrastructure and networks and refurbishment of old ones, as well as in the operating, maintenance and administrative costs of all infrastructure (preventive maintenance becoming the standard): this will also ensure that sustainable infrastructure is provided at socially acceptable cost. Revisiting the construction and procurement processes may also lead to decreased costs.

Oresund Link (Denmark - Sweden)

This expected impact must be considered to extend well beyond 2030. A new generation of infrastructure networks is needed and to be developed to support the future Intelligent Transport Services. It can be developed only by research optimised at European scale, and through the integration of advanced technologies and tools: new materials, nanotechnologies, ICT, new contracting and financial models, Lean Construction, etc. Furthermore, in order to ensure competitiveness, facilitate speedy use of innovation and allow for free movement of innovative products within EU territory, the conditions for placing innovations on the market should become an integral part of research programmes utilising existing and foreseen tools specified in European legislation.

Three fundamental components of this High Service Level Infrastructure can be identified: Multimodal Hubs, Urban Mobility Infrastructure, and Long Distance Corridors. Within each component, new process solutions orientated towards performance and optimised services are expected, as shown in Figure 8.

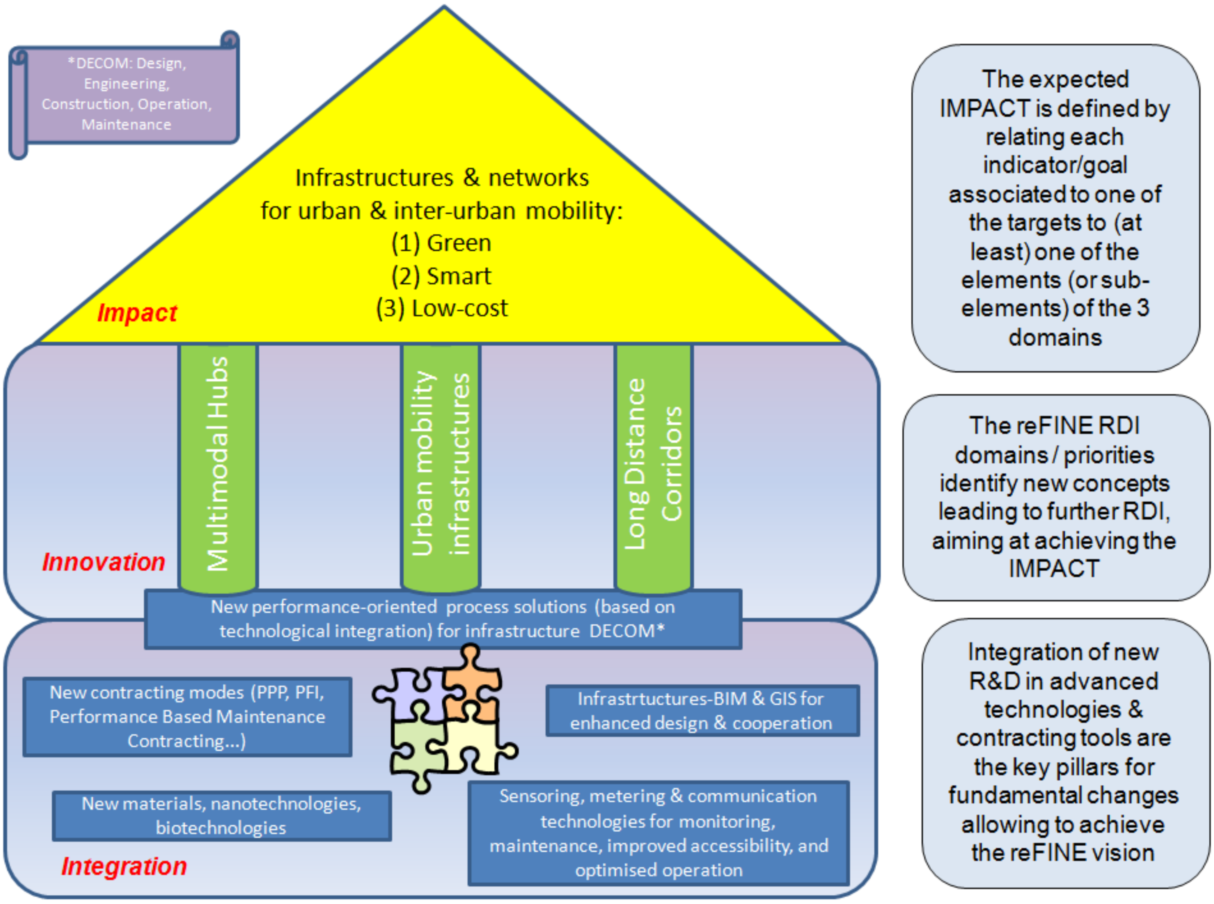


Figure 8: Approach towards impact achievement

3.3. The reFINE Challenges

As above-mentioned, key challenges have to be faced by the infrastructure networks to reach the vision and impact. Efficiently meeting these challenges through strategic RDI priorities will contribute to achieve the expected impact.

3.3.1. GREEN: Environmentally friendly infrastructure

As a consequence of their huge size and very long lifetime, the environmental impact of Infrastructure Networks is enormous. It develops in all stages of infrastructure lifetime (including construction[21], service life, maintenance, upgrade and demolition), and occurs at many different levels. It ranges from energy and raw materials consumption during construction (including upgrade) and maintenance, nuisances (e.g. noise, vibrations, pollution of air and groundwater, congestions, degradation of biodiversity, etc.) and land occupation during service life, to waste generation during construction, maintenance and demolition. The challenges are to reduce the environmental impact of Infrastructure Networks, to reduce their consumption of land and natural resources, to reduce their consumption of energy.

- Reduction of environmental impact

The first need is to develop and implement a Life Cycle Assessment (LCA) approach by using the most state-of-the-art concepts and tools (e.g. tools to accurately predict the actual service life of infrastructure). Moreover more specific technology solutions are needed to decrease negative environmental impact, such as noise, vibration, air and (ground)water pollution, Green House Gases (GHG) emissions, induced by infrastructure planning, design, construction operation and maintenance.

- Resource-efficient infrastructure

Infrastructure can significantly contribute to reduce the exhaustion of our natural resources.

Existing Infrastructure Networks must be completed and upgraded, to ensure adequate transport capacity. It is necessary to minimise the amount of natural resources (construction materials, water) involved in this process as well as associated waste. This requires developing best practice, waste management policies and using more of alternative, locally available, natural materials.

Furthermore, natural land is a vital resource that must be protected. Infrastructure Networks should develop without increasing the occupied land; open land should be protected, natural ecosystem conserved and infrastructure’s impact on soil and (ground) water systems should be reduced.

Considering the need for recycling and even upcycling construction and demolition wastes, innovative systems for environmentally friendly processes for demolishing and sorting of wastes have to be developed, as well as cradle-to-cradle systems.

- Energy-efficient infrastructure

The transport sector is the fastest growing consumer of energy and producer of greenhouse gases in the European Union. The construction, operation and maintenance of transport infrastructure are themselves high energy consuming.

Improving the sustainability and energy efficiency of the transport sector, from the infrastructure point of view, requires reducing the energy consumption of transport infrastructure along their whole lifecycle, a gradual shift to clean energy sources, a technological progress to get more rapid growth in the use of energy from renewable sources in the future, but also a drastic adaptation to break the transport system’s dependence on oil and support a much larger use of non fossil energies in transport means, without sacrificing its efficiency and compromising mobility.

[21] Contributions of construction related phases may appear relatively low compared to impact of traffic itself, but the sheer size of the networks still make this contribution a major component of the environmental footprint of EU economy.

3.3.2. SMART: Inclusive services at all times

Undisrupted service offered by trans-European infrastructure networks is vital for Europe's ability to compete in the world, for economic growth, job creation and for peoples' everyday quality of life. Delayed action and timid introduction of new technologies can condemn the EU infrastructure sector to irreversible decline. Various impacts are expected.

- Economical impact

Limited disruptions of the network, avoiding bottlenecks in key freight corridors and especially in cross border sections, are vital to improve the efficiency of the transportation system of goods and passengers. An efficient transportation network, with an increased level of service and operation and an improved integration of long distance transport with the urban and peri-urban context will increase competitiveness toward non-EU countries. This efficient transportation network demands a commitment to system preservation to maintain our existing roads, bridges, and transit systems in good repair.

- Social impact

An inclusive society is a society in which people's life chances are maximized. This means that every people have access to the services and facilities they need. The needs of specific groups such as disabled people, minority ethnic communities, elderly people, children and young people and faith groups are met. Some of the challenges in relation to the promotion of an inclusive society are the assurance of the Equality and Diversity, the fostering of the Citizenship Participation and the accessibility and affordability to Services and Infrastructure.

Transport infrastructure and related services should adapt to be accessible and usable to all kinds of citizens, including impaired people. Infrastructure networks should also develop by avoiding the creation of urban ghettos (urban areas with difficult accessibility from other urban areas because of a physical divide).

- Access to fast and reliable transport

Reliability and predictability of mobility of goods and passengers within Europe will improve within the EU. Less degree of congestion will be achieved, as well as a significant decrease in failure frequency and duration. Time lost to maintenance, repair, reconstruction, and incidents is expected to decrease by 50%. Additionally, guaranteeing undisrupted mobility contributes towards greater European integration.

Indeed, the quality, accessibility and reliability of transport services will gain increasing importance in the coming years, inter alia due to the ageing of the population and the need to promote public transport. Attractive frequencies, comfort, easy access, reliability of services, and intermodal integration are the main characteristics of service quality. The availability of information over travelling time and routing alternatives is equally relevant to ensure seamless door-to-door mobility, both for passengers and for freight.

- Job creation

Maintenance, repair and reconstruction works to guarantee service at all times will generate employment for construction workers and will demand construction materials, as well as the development of quite a bunch of new technological components and services.

Besides, as freight transport and competitiveness of EU companies will increase the same will happen with the number of employees needed by these companies. This is a side effect of good infrastructure networks.

- Safety

EU Commission White Paper on Transport 2050 aims at moving close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020.

An improved, highly efficient management and operation of networks will increase safety and security. Combined to security improvements in transport modes, accidents with fatalities and severe injuries will decrease by 60% by 2030[22]. Besides, cargo lost to theft and damage will be reduced by 70%. This will help make EU a world leader in safety and security of transport in aviation, rail and maritime.

- Environmental impact, energy and resource efficiency, ecosystem protection

A reduction of congestions and travel times will result in a reduction of negative impact on the citizenship quality of live (air quality, noise, public space occupation…) and the environment (key natural assets like water, land and ecosystems).

Service at all times will involve constant control of the infrastructure and networked systems, which will result in more sustainable infrastructure, with well-balanced impacts (embodied energy, emissions footprint, maximised reuse of existing structures, use of natural non/renewable etc).

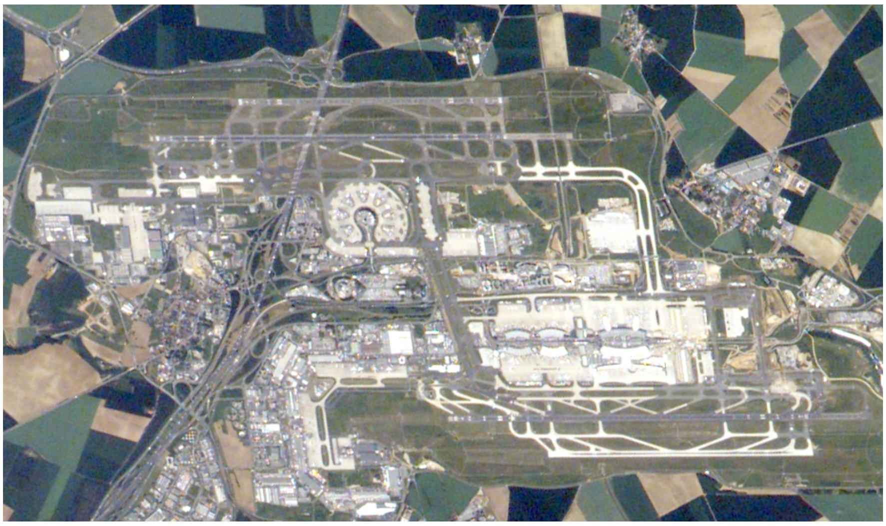
A net balance of approximately zero will be achieved for the energy consumed by road operations. Energy-efficiency of passenger and freight transport will increase by 10-20%, and the energy enclosed in materials will decrease by 25%.

Eventually, decreasing levels of fuel consumption due to the reduction of congestions will improve the air quality, decrease noise, and contribute to the protection of natural habitats.

Maintenance will have to shift from a traditional "palliative" maintenance to a "preventive" maintenance which will realize a real breakthrough in minimizing associated social, environmental and financial impacts.

Reducing construction time, and associated negative impacts, will be also facilitated by increased prefabrication.

This last section also strongly relates to the GREEN characteristic of future HLSI, and is more detailed in the next section.



Paris - Charles de Gaulle Airport (France)

[22] ERTRAC Strategic Research Agenda

3.3.3. LOW COST: Infrastructure at acceptable social cost

According to the Transport 2050 White Paper, the cost of EU infrastructure development needed to match the demand for transport has been estimated at over € 1.5 trillion for the period 2010-2030. This concerns not only the construction of new infrastructure, with higher level of requirements (new uses, better quality, high serviceability, better sustainability), and their interconnection with the existing network, but also the maintenance, upgrading, and adaptation to new needs, of existing ones.

The challenge is to keep this huge cost socially acceptable, and maintain funding at adequate level.

Technical and organisational innovations have to be adopted to reduce construction and maintenance costs, and extend lifetime of existing infrastructure (materials saving, optimized & integrated and smart design (BIM for infrastructures), simulation & nD models, decrease of operational costs, etc.). Moreover, indirect costs like economic losses due to nuisance from construction, maintenance and retrofitting, or the ones due to traffic congestion or disruption caused by maintenance and retrofitting, should be reduced as well thanks to new design, construction and maintenance methods.

Regarding existing infrastructure and their required evolution, a **cost-benefit optimisation** is needed to decide between several options: upgrading the old infrastructure to a new status, demolishing the old one and building a new one, or combining the old infrastructure with a new one.

In terms of financing, considering the huge amounts brought into play, the associated risks, and the required quality commitment, appropriate contracting forms and financing schemes, like PPPs, BOTs, etc., should be further developed and improved, to attract better classes of finance, with a focus on the conditions for an efficient implementation and use by public administration With these new schemes, construction companies would evolve from a traditional role of infrastructure providers, to a new role of infrastructure operators or concessionaires.

Amsterdam's Nesciobrug (The Netherlands)

4. Strategic RDI Domains and targets

This section introduces to a synthesis of the RDI Domains and associated Targets (details are provided in the Annex) that have been identified to meet the above-mentioned challenges and achieve the reFINE vision, respectively to the 3 identified pillars, as shown in Figure 9.

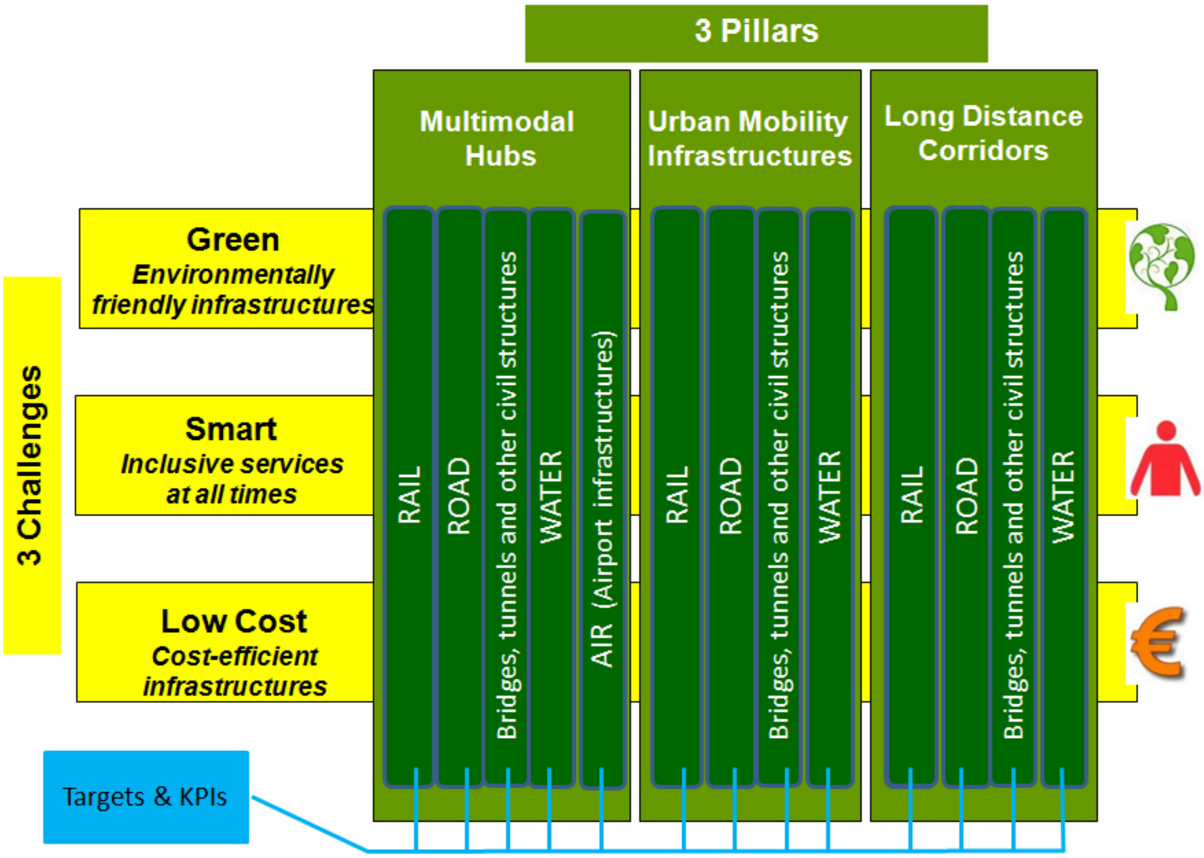


Figure 9: From challenges to Targets and KPIs (Key Performance Indicators)

The table below provides with a synthesis of the main RDI **Targets** for the reFINE initiative, for each or the 3 identified pillars (Multimodal hubs, Urban mobility infrastructure, Long distance corridors), and according to the 3 main challenges (Green, Smart, Low Cost).

Pillars	*Targets*
Multimodal Hubs	
General	Multimodal Hubs contribute to a low-carbon Integrated Transport Systems by optimising the use of energy by the various concerned transport modes. By 2050, their Life-Cycle environmental impact is assessed and optimised in a multi-criteria approach including use of natural resources (land, water, energy, construction materials). Multimodal Hubs are accessible for *all* commuters (incl. impaired / disabled), and provide seamless door-to-door multimodal mobility, with integrated transport and logistics (typically, urban logistic platforms for

	serving the cities, allowing to mutualise the means for the last mile), and with no bottlenecks and congestions. They are safe for all people, and resilient to climate changes. Construction and managements costs of Multimodal Hubs are optimised. By 2050, construction, upgrade and maintenance works are easy to plan and to optimise, because they are industrialised, highly automated and furtive (with no impact on operations).
RAIL	By 2050, all multimodal hubs accommodate fast connection to commuting trains and high-speed trains, by providing all interfaces needed for rapid passenger transit between rail station and other public transport networks, integrating interoperable electronic Passenger information systems and appropriate interfaces & communication protocols (including NFC) in the hubs, and efficiently managing sea-rail and road-rail freight transport modes.
ROAD	High-level service connections between road infrastructure network for short to medium distances (below 300 km), and other relevant modal networks.
BRIDGES, TUNNELS, CIVIL STRUCTURES	New technologies to enable safe, quick and very deep underground works that are affordable and sustainable. A suite of interoperable new calculation tools for interaction of the dynamic loads on structures caused by airplanes, trains and cars enabling multi-layered structures. Real-time systems for monitoring underground works conditions.
WATER	Full integration of waterborne infrastructure and traffic management systems with the other modes of transport is achieved. New harbour infrastructure (e.g. longer and deeper quays, new quay walls) allow accommodating longer vessels. Harbour platforms are reinforced to face climate changes and extra solicitations. Holistic marine monitoring allows optimised operations. A comprehensive ICT framework is deployed for the optimisation of logistics chains, the process optimisation and chain integration in the industrial sector, and the realisation of appropriate infrastructure components (e.g. fast container cranes) to increasing the sustainability of transport modes.
AIR	Full integration of air transport infrastructure and traffic management systems with the other modes of transport (most notably rail, sea carriers and local and regional transport) is achieved. Integration of renewable energy production and utilization in airports infrastructure is generalized. Airport operations are resilient against weather and other disruptions. New products and services allow holistic air and railway operations monitoring. The Single European Sky is fully implemented and the successor programmes of SESAR and similar interoperable programmes globally have ensured that capacity meets expanding demand in the air and at airports.

	A comprehensive ICT framework is deployed for the optimization of logistics chains, the process optimization, and the realization of appropriate infrastructure components.
Urban Mobility Infrastructure	
General	By 2030, Urban Mobility Networks contribute to a low-carbon Integrated Transport Systems by supporting new low-carbon vehicles and transport modes. Urban Mobility Networks are efficient and accessible for all users, and provide seamless door-to-door multimodal mobility through integrated logistics and supply chains. Construction and managements costs of Urban Mobility Networks are optimised. Associated risks are controlled.
RAIL	By 2050, holistic approach and global solutions (new design and simulation solutions, tailor-made full electrification for mass transit, automation, serviceability) are provided so that railways are designed and renovated in such a way that city barriers (barriers that block connexions among different city sub-areas and suburbs) are deleted. Specific infrastructure is developed to support tramway/light rail systems, both for passenger and good transportation.
ROAD	A multifunctional and user-friendly urban road infrastructure network that enables low environmental impact (re)construction and maintenance, and supports sustainable energy sources vehicles. European cross-sectoral and cross-disciplinary standards for workflow organization, procurement and data integration to support advanced transport information systems.
BRIDGES, TUNNELS, CIVIL STRUCTURES	Developed design and construction techniques are compatible with existing structures for adaptation to electrified transport. New technologies and processes are developed to reduce land take and nuisance for people living in densely built areas. New techniques are developed that lead to a high level industrialization of production, processes and worksites for a significant increase in construction speed, workers safety and security.
WATER	Accessibility and connection with other modes of transport, including the integration of River Information services (RIS) with the information systems of the other urban transport modes. Quicker freight and people transport, based in particular on river monitoring solutions. Integration of the river corridors in urban landscape and cultural heritage.
Long Distance (LD) Corridors	
General	Long Distance Corridors contribute to a low-carbon Integrated Transport Systems by accommodating new low-carbon transport vehicles and/or innovative transport modes, thanks to new materials and components forming the LD Corridor infrastructure that reduce the consumption of energy by vehicles. By 2050, their Life-Cycle environmental impact is assessed and optimised in terms of use of natural resources (land, water,

	energy, and construction materials) as well as reduction of carbon emissions and noise impact. Intelligent infrastructure of Long Distance Corridors provides efficient means to manage and optimise the traffic. Accidents and emergency situations are mitigated efficiently, with minimum impact on traffic. Smart and advanced monitoring solutions are integrated to optimise LD Corridors life time and maintenance works. Construction, operation and managements costs are optimised. By 2050 construction, upgrade and maintenance works are easy to plan and to optimise, because they are industrialised, highly automated and furtive.
RAIL	A European cross-disciplinary framework is developed for the fast development and deployment of high-speed lines (HSL), with ballast-less tracks, adapted catenaries, switches and crossings, and enlarged tunnel sections of classic lines to allow electrification and transport of trucks by train. A European structured supply-chain is put in place for the fast production, integration, management and refurbishment of the HSL.
ROAD	New resilient road construction concepts. Operations that involve private land occupation, pollution and soil loss, are strictly controlled and integrated with land use planning. Smart infrastructure networks that allow a closer interaction between the infrastructure and the vehicle (information, safety and security, energy transferring…). Improved, highly industrialized and ICT supported road construction and maintenance strategies, leading to a safer road infrastructure network with an improved capacity and availability.
BRIDGES, TUNNELS, CIVIL STRUCTURES	A complete suite of advanced calculation and simulation methods and tools, as well as adequate monitoring methods, to estimate the remaining service life of existing structures in order to plan and adapt the actual repair strategies, including solutions to give second life to existing structures. Reliable traffic load measurement methods and systems to avoid overdesign of structures. New advanced techniques to determine and upgrade tunnel safety. Development of high quality prefabricated bridge (elements) leading to low cost, quick and easy to build bridges.
WATER	By 2050, a European framework of infrastructure is deployed to support inland trans-European water-based transport system, with intermodal connections in the ports and the hinterland connections to allow for a smoother transport chain. Design and assessment tools are fully suited to a risk-based approach to flood risk management of dikes and other water works. A holistic approach and set of Waterways Information Services (WIS), supported by IT systems, is available for traffic monitoring and optimisation.

5. Conclusion

This document introduces to a synthesis of the vision and targeted challenges for future European transport infrastructure. It identifies research development and innovation domains, and associated targets, to meet these challenges and achieve the reFINE vision. The main expected impact is to achieve by 2030 the *"3x30"* impact:

- ➔ ***GREEN:*** **-30%** of CO_2 emissions;
- ➔ ***SMART:*** **+30%** performance in terms of infrastructure capacity regarding people and goods "on the move", and infrastructure safety with respect to reduction of accidents;
- ➔ ***LOW COST:*** **-30%** of costs in the development of new infrastructure and networks and refurbishment of old ones, as well as in the operating and administrative costs of all infrastructure (new and renovated).

This expected impact must be considered to extend well beyond 2030. A new generation of infrastructure networks is needed and to be developed to support the future Intelligent Transport Services. It can be developed only by research optimised at European scale, and through the integration of advanced technologies and tools: new materials, nanotechnologies, ICT, new contracting and financial models, etc. Furthermore, in order to ensure competitiveness, facilitate speedy use of innovation and allow for free movement of innovative products within EU territory, the preparations for placing innovations on the market should become an integral part of research programmes utilising existing and foreseen tools specified in European legislation.

Three fundamental components of this High Service Level Infrastructure can be identified: Multimodal Hubs, Urban Mobility Infrastructure, and Long Distance Corridors. Within each component, new process solutions orientated towards performance and optimised services are expected.

Construction is uniquely placed to power Europe out of recession but uniquely, it needs help. Focussing on infrastructure and networks, all over Europe Governments are seeing infrastructure investment as a key component for reinvigorating its ailing economies. Europe infrastructure deficit is slowing growth, and increased investment will leave a totally beneficial legacy by removing the physical constraints to growth. In times of high unemployment a new construction job spending €1, costs €0.44 and produces benefits of €4-€5. That will reduce unemployment and inject money into Europe economies.

Infrastructure is increasingly an inter-dependent challenge: transport, energy, water, communications are now totally trans-national, and no respecters of boundaries. Construction is being called upon to deliver and support a modern urban realm that only a systems view can succeed in. Rising sea levels, safe and speedy transport, energy demands using renewable means that our living systems have to be intelligent and responsive to both demand and supply, and resilient and future proofed. At the same time, the time is now to build or renew infrastructure, with the benefits accruing for hundreds of years. Research and innovation is needed urgently to enable this vision of smart, green and low cost infrastructure.

Without innovation and research in Construction, the only option is to build infrastructure the 20^{th} century way – high carbon, low innovation and at high cost – all very wasteful and inefficient. But construction is notoriously difficult to bring the benefits of innovation to. In other sectors, innovation mostly occurs in young, small, entrepreneurial companies. Big construction is risky, and innovation in construction is constrained by the risk aversion of funders that want tried and tested techniques using established technology. The barriers to technology adoption in construction are training (it has always been done this way), standards (too prescriptive and not outcome-based), over-regulation, blunt financial instruments, and low risk appetite.

It is vital that we improve infrastructure delivery for our people, and to become globally competitive. Across Europe we are seeing the influx of US investment and technology professional services companies crowding out European players, and this in turn causes Europe to loose out in global markets. Chinese companies are advancing first at lower cost and increasingly and impressively in innovative delivery efficiency.

Across Europe there is an urgent need to modernise construction delivery, but industry will not do it on its own only – the risks, the structure of the industry and the implementation of EU procurement mitigate against innovation. Unlike other industries (e.g. automotive, aerospace, pharmaceuticals), the delivery of long distance highways, high speed rail, city metros, and transport hubs, are characterised by high cost one-off solutions delivered by a supply chain comprising relatively small and medium enterprises (e.g. in *UK: 300,000 companies, average size: 7 employees)*. The asymmetry of risk is not conducive to long term private sector research and innovation investment.

Current public procurement processes can limit research agendas and inhibit innovation. They foster conservatism in the hope of avoiding legal challenge, and safe if uninspiring solutions. This must change – procurement must open up to innovation, alternative solution bids and lateral thinking. So it is not just money that will solve this failure of markets not delivering the right research and innovation – the single market across Europe needs unlocking; academic institutions, public procurement, EU programmes all need transparent porosity to bring innovation by removing boundaries – nothing short of open-source knowledge transfer to broker new low carbon, efficient infrastructure for successful economic growth strategies. Infrastructure and investment in the built environment are the best way of securing a sustainable path out of recession and pan-European solutions are vital to delivering this. This needs substantial research investment – the long term nature of Construction's investment risk/reward asymmetry is the cause of a market failure. But this in turn places the European Commission (EC) and the EU's Parliament in a uniquely rewarding position to back the Construction research agenda.

This identified joint task of reFINE and the EC is challenging because as we become more informed about the tasks, they become ever more vital – the infrastructure imperative is with us now. Coordination and directive investment is needed to avoid overlap, conflicts and wasteful effort. The challenge is far too important for that. This is not self-starting and the scale is too daunting for single companies, let alone Small and Medium Enterprises (SMEs). The force of the markets alone will not do this – the risks and the scale daunt the private sector, and are beyond what single nations can optimally achieve. reFINE brings together European enterprises active in infrastructure research, construction, maintenance and operation, that are likely to support the EC in taking on the drive and obligation to leverage step change advances in construction research, in energy efficient built environment, in intelligent infrastructure retrofit upgrades and in city renewal for the 21st century.

<u>ANNEX</u>: Detailed Strategic RDI Domains and Targets

The table below provides with the detail of the main RDI **Targets** for the reFINE initiative. It provides with definitions of the targets along with some typical examples of infrastructure in Europe. It also provides with **KPI** – ***Key Performance Indicators***, which may be quantitative (i.e. with explicit figures) or qualitative.

<u>Symbols for challenges</u>

Environmentally friendly infrastructure (GREEN)

Inclusive services at all times (SMART)

Cost-efficiency (LOW COST)

<u>Content</u>

A.1 MULTIMODAL HUBS

MULTIMODAL HUBS - GENERAL

DESCRIPTION	***EXAMPLES***	***TARGETS***
New transport patterns are required to accommodate and exchange larger volumes of freight and greater numbers of travellers efficiently through a combination of modes and exchange terminals and hubs. They have to accommodate better modal choices too, as a result from greater integration of the modal networks. A systemic approach towards "global management" organization for multimodal hubs needs to further streamline the commuting of travellers and the dispatching of goods (transported by different inland and water transport systems). This requires the technical and functional integration of several modal networks: airports, ports, railways, metro and bus stations, achieved in particular through multimodal connection platforms (hubs) for passengers and freight. Ultimately, the ambition is to realize a comprehensive European network of multimodal hubs - the set of hubs	1. Ports of Bari and Brindisi (route of Corridor 8) Specific targets: • Integrate the Balkan countries in the EU • Increase exchanges/trade with Turkey and western Asia 2. Genoa hub (Corridor A – ERTMS; Corridor 5) Specific targets: • Eliminate "bottlenecks" to make use of existing capacity • Improve railway safety • Increase both freight and passengers by 30% 3. "Grandi Stazioni" project (Italy): integration of railways stations with metro lines 4. CDG airport (current & future), Schiphol airport, Heathrow airport	By 2050, all transport hubs are Multimodal Hubs, as vital nodes of High Level Service Infrastructure, of which the design and operation will accommodate any type of transport systems and the new transport patterns. Those nodes are characterised by the following green, smart and low-cost features: ***GREEN***: Multimodal Hubs contribute to a low-carbon Integrated Transport Systems by optimising the use of energy by the various concerned transport modes. By 2050, their Life Cycle environmental impact is assessed and optimised in a multi-criteria approach including use of natural resources (land, water, energy, construction materials). All Multimodal Hubs have a LCA-based green building certification. ***SMART***: Multimodal Hubs are vibrant and attractive nodes of the Integrated Transport System: they are accessible for *all* commuters (incl. impaired / disabled), and provide seamless door-to-door multimodal mobility, with integrated transport and logistics, and with no bottlenecks and congestions – ensuring a fast and easy interoperability among different transportation modes for every people (especially sensitive or vulnerable groups) avoiding all type of barriers (architectonical, language, digital divide…). Transport users have access to various adapted interfaces linking different transport modes available (in the cities) in a seamless and convenient way. Eventually, by 2050, all Multimodal Hubs (new & existing) have been made intrinsically safe for all people (with near-0 accidents & mitigation of security threats) and resilient to climate changes. ***LOW COST***: Multimodal Hubs are nodes at the heart of regional economic activities. Construction and managements costs of these large and complex structures are optimised; associated risks are controlled, and management of those hubs is done in a sustainable way (energy efficient construction, resources saving…). Construction of large underground facilities is as safe and economical than surface facilities. By 2050 construction, upgrade and maintenance works are easy to plan and to optimise, because they are industrialised, highly automated and furtive (with no impact on operations).

forming in turn a hub network interconnecting all Europe’s industrial and logistic areas, and all large urban areas, thanks to LD Corridors	5. Rotterdam port 6. Valencia port (Spain)	***KPIs for Environmentally friendly infrastructure*** *Environmental impact* • Reduction of carbon emissions - by 30% by 2030 • Generalisation of multi-approach for LCA *Energy-efficiency* • Reduction of energy consumption in multimodal hubs management and operation by 30% by 2030 • Increase of renewable energies use by 30% by 2030 • Energy related to fossil fuels sources will reduce in 30% by 2030 in Multimodal Hubs uses *Resilience to climate change* • No services disruption - Services offered by multimodal hubs do not stop during episodes related to climate change impacts (floods, sea level rising, extreme events…)	***KPI for All-inclusive services*** *Mobility* • Multimodal hubs are 100% usable for *autonomous and disabled* people by 2030 • Real-time multimodal information: 30% of hubs equipped by 2030 • Full real-time public information about traffic conditions of all connected transport modes (using monitoring of freight and passengers), - with real-time proposal of alternative transport routes: 30% of hubs equipped by 2030 • Intermodal ticketing: 30% of cities equipped by 2030 – System fully developed w.r.t. highway fares and interconnected networks operated by different operators: one ticket at the entry point, payment at the exit only, not when changing network operator • Fully optimised interface between long-distance and last-mile baggage and freight transport. *Safety* • Reduction of accidents (near-0 accidents by 2050) • Increased security	***KPIs for Cost-efficiency*** • Cost reduction (maintenance & new infrastructure) – with unobtrusive construction works and maintenance (hub maintenance and retrofit while operating the hub). • Full interoperability of technical systems, connections, transport operations and modes

<table>
<tr><th colspan="2">MULTIMODAL HUBS - RAIL</th><th></th><th></th><th></th></tr>
<tr>
<td rowspan="2">DESCRIPTION

According to the EC Document “Transport 2050”, Rail is to largely contribute to the transformation in Europe’s current transport system. The requested shift from road to rail needs adequate multimodal hubs. Rail doesn’t allow door to door journeys. A combination of public transport modes has to be used, going from buses, metro, tramway, commuting trains up to high speed trains. The efficiency of the whole journey is highly depending on the easiness to move from one mode to the other one, taking into account the mode availability, the time tables, the disruptions, the luggage follow-up, the constraints of disabled people... For rail in particular, the multimodal hub is the key component of the whole transport infrastructure needed for the journey.</td>
<td rowspan="2">EXAMPLES

1. London King’s Cross Station and Eurostar Terminal (UK)
2. Paris Gare Saint Lazare (FR)
3. Connection of NS metro line at Amsterdam Central Station (NL)
4. L9 metro in airport station of Barcelona (ES)
5. La Sagrada Station (ES)</td>
<td colspan="3">TARGETS

By 2050, all multimodal hubs accommodate fast connection to commuting trains and high-speed trains:
• Providing all interfaces for rapid passenger transit between rail station and other public transport services (bus and taxi stops, tram and metro stop, as well as airports and seaports), and with transportation networks (roads, footpaths, cycle routes) for private transportation (automobile and electric cars, walking, bicycle);
• Integrating interoperable electronic Passenger information systems and appropriate interfaces & communication protocols (including NFC) in the hubs:
• With respect to freight, hubs manage sea-rail and road-rail freight transport modes, with modern warehouse and logistical facilities adapted to the growth and generalisation of containerization – including loading and unloading of all types of units from rail to other transport modes.</td>
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<tr>
<td>KPIs for Environmentally friendly infrastructure

Environmental impact
• 50% reduction in construction, demolition and excavation waste to landfill compared to 2008 by 2013

Energy-efficiency
• Locomotive fuel savings as a result of reduced delays
• Improved efficiency by real time location info (reduced consumption)</td>
<td>KPI for All-inclusive services

Mobility
• Intermodal baggage and container handling from door-to-door

Inclusive society
• Access to impaired people: step-free access from interchange platforms to transport vehicles, in 30% of stations by 2030

Quality of life
• No driving through residential and commercial areas: improvement of quality of life, reduction of noise and traffic, and increasing of safety</td>
<td>KPIs for Cost-efficiency

• Life time extension
• Intermodal containers moved by train
• Heavy shipments removed from roads: reduction of highway maintenance costs
• Reduction of collisions</td>
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<table>
<tr><th colspan="2">MULTIMODAL HUBS - ROAD</th><th></th><th></th><th></th></tr>
<tr><td rowspan="2">DESCRIPTION

Multimodal hubs assure a fast and easy interoperability among transportation modes for freight and people (especially sensitive or vulnerable groups), avoiding all types of barriers (architectonical, language, digital divide…).

From a road infrastructure point of view, and in line with the Transport White Paper, multimodal hubs facilitate a High Level Service exchange of freight and passengers (to be) transported over short to medium distances (< 300 km): i.e. quick, low costs, resource efficient (energy, materials, water…), low environmental impact (CO2 emissions, noise, visual impact…).

Their functioning relies on intelligent management as well as ICT and Intelligent Transport System (ITS) in order to handle, in real time, in a safe and sustainable manner, the flows of passengers, vehicles and freight and their reciprocal interaction and dialogue with the infrastructure.</td>
<td rowspan="2">EXAMPLES

1. Schiphol Amsterdam Almere project
2. Eduardo Dato Parking (Madrid, Spain)
3. Parking Liverpool SF (Mexico)</td>
<td colspan="3">TARGETS

High Level Service connections between road infrastructure network for short to medium distances (below 300 km) and other relevant modal networks, meaning:
• Enhanced resource efficiency and low environmental impact during construction and management operations (GREEN);
• ICT and ITS integrated, enabling optimized hub management for a smooth (i.e. available, reliable, safe and accessible for all) road-hub connection without congestions (SMART);
• Enhanced cost efficiency through fast hub construction and maintenance under operation with impact on demand (LOW COST).</td></tr>
<tr><td>KPIs for Environmentally friendly infrastructure

Environmental impact
• 20% less noise and 50% less local air pollution by 2050.
• Less CO_2 emissions due to the increased transport flux (reduction of congestion, improved interconnection). thanks to multimodality.
• Reduction of at least 60% of GHG emissions by 2050 (with respect to 1990).

Energy-efficiency
• 100% of multimodal Hubs will support EVs by 2050 (Use of electric, hydrogen and hybrid technologies).</td>
<td>KPI for All-inclusive services

Mobility
• Less congestion, bottlenecks and travel time for all (incl. impaired) thanks to improved multimodality and real-time, interactive road infrastructure management support (through ITS) by 2030.
• Full interoperability of different transport modes management systems

Safety
• Close to zero fatalities</td>
<td>KPIs for Cost-efficiency

• Cost savings generated by an increase in capacity of the road-hub connection through ITS road infrastructure support (i.e. reduction of congestion and bottlenecks, improved efficiency in combining transport modes supported by ITS).
• Reduction of 30% overall costs and optimisation of resources for maintenance and construction activities</td></tr>
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<table>
<tr><th colspan="2">MULTIMODAL HUBS - STRUCTURES</th><th></th><th></th><th></th></tr>
<tr><td rowspan="2">DESCRIPTION
Structures attached to multimodal hubs have two main functions: provide the appropriate interfaces between the hubs and the (LD) corridors and the urban mobility, and at the same time providing easy commuting and passenger/goods intermodality.</td><td rowspan="2">EXAMPLES
2nd North West Tunnel connection to Rotterdam</td><td colspan="3">TARGETS
• A validated European cross-disciplinary framework with new techniques to enable safe, quick and very deep underground works that are affordable and sustainable.
• A suite of interoperable new calculation tools for interaction of the dynamic loads on structures caused by airplanes, trains and cars enabling multi-layered structures.</td></tr>
<tr><td>KPIs for Environmentally friendly infrastructure
• 25% decrease of CO_2 emissions by better access to different transport modes</td><td>KPI for All-inclusive services
• 30% increase in passengers travelling through hubs.</td><td>KPIs for Cost-efficiency
• 20% reduction of building materials
• 15% reduction of building time</td></tr>
<tr><th colspan="2">MULTIMODAL HUBS - WATER</th><th></th><th></th><th></th></tr>
<tr><td>DESCRIPTION
Innovation in infrastructure for water transport in Europe must accommodate the ambition of a pan-European network of multimodal inland shipping hubs, while ensuring the delivery of extensive, integrated, efficient and sustainable waterborne transport systems, with cargo that can</td><td>EXAMPLES
Rotterdam Harbour area
Railway access to Valencia port
Sevilla sluice
Road access to Exterior port in Ferrol</td><td colspan="3">TARGETS
• By 2050, solutions are generalised in terms of integrated management of the water systems – considering that besides improving utilisation of infrastructure, up to 2030, more cargo needs to be transported by rail and inland shipping rather than by truck (corresponding to a modal shift). Full integration of waterborne infrastructure and traffic management systems with the other modes of transport is achieved. Integration of renewable energy production and utilization in waterborne infrastructure is generalised and modal optimization of the infrastructure upgrades environmental effects.
• New harbour infrastructure (e.g. longer and deeper quays, new quay walls) allow</td></tr>
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<td rowspan="2">be transported to its destination fast and efficiently. The inland hubs need to develop into gateways for the port and Customs should be able to already check the cargo at these locations, and with appropriate connecting links in the regional and national infrastructure.

Waterborne infrastructure transformation must be realized within environmental thresholds – including measures that reduce noise and air pollution, reduce impact on the environment in particular on rivers, seas and oceans contributing to the environmental enhance of water bodies.</td>
<td></td>
<td colspan="3">accommodating longer vessels. Existing facilities are adapted (platform reinforcement, adaptation to deeper water, prevention of scour in front of quay walls) for an extended life.

• Harbour platforms are reinforced to face climate changes and extra solicitations (e.g. more severe storms).

• New products and services allow holistic marine monitoring, with e.g. sailing times that can be synchronized to the occupancy of berths, the streamlining of the dispatch of containers transported by barges to the port (inland shipping)

• A comprehensive framework (methods and tools, including the use of IT systems for the required exchange of information and coordination) is deployed for the optimisation of logistics chains, the process optimisation and chain integration in the industrial sector, and the realisation of appropriate infrastructure components (e.g. fast container cranes) to increasing the sustainability of modes of transport – with such a framework adopted on a large European scale. New waterborne infrastructure typologies within lower costs and higher performance standards are set and generalised.</td>
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<td></td>
<td>KPIs for Environmentally friendly infrastructure

• By 2030, full integration of LCA (Life-Cycle Analysis) in waterborne infrastructure is achieved.</td>
<td>KPI for All-inclusive services

• By 2050, all inland shipping hubs as well as large port are interconnected with roads and rails.
• 20% by 2030 (and 50% by 2050) of road transport is shifted to waterborne transport systems thanks to new or renovated water infrastructure.</td>
<td>KPIs for Cost-efficiency

• Generalisation of waterways, waterborne infrastructure cargo handling and passenger boarding systems, in order to provide safe, reliable, fast and cost efficient port operations.
• Full integration of waterborne with railway and road transport networks in order to minimize costs.</td>
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MULTIMODAL HUBS - AIR		
DESCRIPTION	***EXAMPLES***	***TARGETS***
Innovation in infrastructure for air transport in Europe must accommodate the ambition of a pan-European network of intermodal airports hubs, while ensuring the delivery of extensive, integrated, efficient and sustainable air transport systems, primary for passengers, but also for airfreight that can be transported to its destination very fast and efficiently. The inland hubs need to develop new installations to ensure an easier and fast connection with the regional, national and also international railway infrastructure. Airport hubs infrastructure must be improved within environmental – including measures that reduce noise and air pollution, reduce impact on the environment in particular on noise for close resident areas.	Schiphol airport in Amsterdam with international railway lines access. Dusseldorf Airport and its access to the ICE high speed train. Frankfurt Airport hub (Fraport), connecting air to road and train (regional and long-distance) transport. Charles de Gaulle Airport in Paris and its direct access to the high speed train international corridors.	• By 2050, solutions are improved in terms of integrated management of the passengers transport systems at world level. Airports became the access doors connecting continents and this necessary optimizes the utilization of infrastructure. Up to 2030, more airfreight cargo needs to be transported inter continents and that means the need to ensure news solutions for fast transfers to the railway and road (truck) inland networks. Full integration of air transport infrastructure and traffic management systems with the other modes of transport (most notably rail, sea carriers and local and regional transport) is achieved. Seamless door-to-door travel of passengers and freight is the norm. • Integration of renewable energy production and utilization in airports infrastructure is generalized, and modal optimization of the infrastructure implies good environmental effects. Airport operations are resilient against weather and other disruptions. Environmental impacts are reduced in particular on quiet urban areas. • New products and services allow holistic air and railway operations monitoring, e.g. for passengers landing and take-off times that can be synchronized to the high speed trains arrivals and departures. For cargo the streamlining of the dispatch of goods transported by cargo aircrafts to the distribution transport networks is optimized. Delays are mitigated by highly efficient operations and through night operations enabled by ultra-quiet aircrafts. Congested airports are no longer a bottleneck due to action taken by the Single European Sky, SESAR, successor programmes, connections to other ATM systems worldwide and new aircraft concepts. • The Single European Sky is fully implemented and the successor programmes of SESAR and similar interoperable programmes globally have ensured that capacity meets expanding demand in the air and at airports. These developments have optimised the access and trajectories of air vehicles, ensured equity of access and safe and efficient vehicle operations with the most efficient possible fuel consumption and emissions at the lowest possible cost. • A comprehensive framework (methods and tools, including the use of ICT systems for the required exchange of information and coordination) is deployed for the optimization of logistics chains, the process optimization, and the realization of appropriate infrastructure components (e.g. fast handling systems). It also supports optimised and interconnected services by providing real-time information to professionals and travelling public for enhancing system resilience in the event of disruption and crisis.

		KPIs for Environmentally friendly infrastructure • By 2030, full integration of LCA (Life-Cycle Analysis) in air transport infrastructure is achieved.	***KPI for All-inclusive services*** • By 2050, all inland airports hubs are interconnected with roads and rails. The intercontinental traffic ensures its fast and inclusive connection to its final destination in all Europe areas.	***KPIs for Cost-efficiency*** • Generalization of hubs airports infrastructure cargo handling and passenger boarding systems, in order to provide safe, reliable, fast and cost efficient airport operations. • Full integration of air transport with railway and road transport networks in order to minimize costs.

A.2 URBAN MOBILITY

URBAN MOBILITY - GENERAL

DESCRIPTION	***EXAMPLES***	***TARGETS***
Low-density suburbs developed throughout Europe in the 20th century as a result of economic growth and lack of concern for urban development strategies, are now seen as main drivers of loss of biodiversity. Moreover they cannot be efficiently irrigated by public transport systems and they are now considered as a major source of traffic congestion and CO2 emissions. Therefore, a critical challenge of sustainable European cities is to control urban sprawl by stricter regulation on land use, by developing denser cities, well irrigated by efficient networks of public transport, denser in urban centres, and spreading all over vast urbanised territories.		By 2050, High Level Service Infrastructure of Urban Mobility Networks, as a vital component of sustainable European cities, are removing congestion, facilitating a massive mobility shift from private to public transportation – especially relying on upgrade of ICT networks for traffic management and information. They are characterised by : ***GREEN***: By 2030, Urban Mobility Networks contribute to a low-carbon Integrated Transport Systems by supporting new low-carbons vehicles and transport modes. Their CO2 emissions are assessed and controlled. By 2050, their Life Cycle environmental impact is assessed and optimised in terms of use of natural resources (land, water, energy, materials); the construction processes are made fully compatible with the urban environment (no damages to existing built environment, no noise, no dust, no vibrations, no congestion of traffic). ***SMART***: Urban Mobility Networks are efficient and accessible for all users, and provide seamless door-to-door multimodal mobility. Cultural Heritage structures are preserved and maintained in operation. By 2050, new and existing Urban Mobility Networks have been made intrinsically safe for all and resilient to climate changes. ***LOW COST***: Construction and managements costs of Urban Mobility Networks are optimised; associated risks are controlled. New technologies allow extending their life time without compromise on safety and load capacity. Construction of deep underground networks is as safe and economical than surface facilities. By 2050 construction, upgrade and maintenance works are easy to plan and to optimise, because they are industrialised, highly automated and furtive (with no impact on operations).

KPIs for Environmentally friendly infrastructure	***KPI for All-inclusive services***	***KPIs for Cost-efficiency***
Environmental impacts • Increase of cities air quality (reduction of atmospheric emissions) • Reduction of noise	*Transport capacity* • 50% more passengers by 2030 *Mobility shift* • Shift from private to public	• Life time extension (by 50%) • Cost reduction (by 30%): o Materials saving o Optimized design &

		complains *Resilience to climate change* • Connections offered by urban infrastructure do not break during episodes related to climate change impacts (floods, sea level rising, extreme events…)	transportation • 40% of urban space change their use from transportation to citizenship services (leisure for instance) *Inclusive society* • Make urban mobility accessible for “all” travellers *Safety* • Reduction of accidents and fatalities	simulation o Decrease of operational costs, including reduced maintenance costs • The time for developing or upgrading infrastructure to meet new demands is reduced by 50%.
URBAN MOBILITY - RAIL				
DESCRIPTION	***EXAMPLES***	***TARGETS***		
Rail systems look as the most sustainable transport mode in urban areas. Nevertheless to be able to compete with the freedom image attached to the road transport, rail systems has to solve endless problems: capacity, disruptions, delays, security, maintenance and costs.	1. London CrossRail 2. Grand Paris Express Network 3. Stuttgart 21 4. Many other subway projects in Hong-Kong, Singapore, Australia, India... 5. Lines 1 and 2, Malaga underground (Spain) 6. Line 5, Bucharest underground (Romania)	By 2050, holistic approach and global solutions are provided so that Railways are designed and renovated in such a way that city barriers (barriers that block connexions among different city sub-areas and suburbs) are deleted. These approach and solutions will offer: • New design and simulations solutions, e.g. to free space and reduce congestions at ground level, with the solution of going underground, assuming that construction and maintenance works will not create more congestions; • Tailor-made full electrification for mass transit, based on efficient and reliable traction power supply and contact line systems that accommodate with local electricity production and distribution; • Automation, dealing with any kind of rail vehicle (trams, light trains, metros, etc.), passenger capacity (according to variable commuting in urban areas), and ensuring reliable and convenient commuting operation by optimum line usage controlled by automated systems; • Serviceability, with extensive range of services including flexible solutions for professional maintenance, spare parts supply, modernization and accident repairs, as well as for easing testing and validating new rail systems – including maintenance services that ensure larger time for operation and less time for maintenance, Railway operators will be provided with complete urban railway system packages with diverse interests: on-schedule completion, reliable operation, low-emission technology, low life-cycle costs, passenger safety, and adaptability to the city’s dynamic growth - none of these features being provided at the expense of another.		

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<td>KPIs for Environmentally friendly infrastructure
Environmental impacts
• Enable underground operations with zero impact on existing surrounding urban areas by 2050
Resources efficiency
• Minimise non renewable resources ballast consumption</td>
<td>KPI for All-inclusive services
Transport efficiency
• Development of underground transportation
• Monitoring of tracks and ballasts for infrastructure assessment
Inclusive society
• City railways are adapted to all people (including disabled)
• Absence of cities “ghettos” by 2030 (ghetto: urban area with difficult accessibility from other urban areas because of a physical divide: railways, highways, etc.
Liveability
• Reduction of noise and vibrations</td>
<td>KPIs for Cost-efficiency
• Minimise maintenance costs
• 20% increase of the productivity of underground construction activities by 2050</td>
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<tr>
<td colspan="2">URBAN MOBILITY - ROAD</td>
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<td>DESCRIPTION
The main focus of ROAD in Urban Mobility is the development and upgrading of high service level urban road infrastructure in terms of mobility, travel time and energy consumption, comfort and safety.
This includes improved</td>
<td>EXAMPLES
1. Underground parking lots in Paris (France)
2. M-50 in Dublin (Ireland)</td>
<td colspan="3">TARGETS
Multifunctional urban road infrastructure networks that offer high level service for all residents and under all circumstances, meaning:
• A multifunctional and user-friendly urban road infrastructure network that enables low environmental impact (re)construction and maintenance, which supports sustainable energy sources vehicles (EVs for instance) – with no more conventionally-fuelled cars in cities (GREEN).
• European cross-sectoral and cross-disciplinary standards for workflow organization, procurement and data integration to support advanced transport information systems through ICT and ITS and PMV (SMART).</td>
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</table>

integration of and interaction with other (subterranean) functions - e.g. supply infrastructure networks such as gas, water, electricity – and facilitating improved compatibility with vehicles using sustainable energy resources (e.g. EVs) and public transportation. Most importantly, this is achieved within the existing infrastructure boundaries and without disrupting other urban functions.		***KPIs for Environmentally friendly infrastructure*** *Environmental impacts* • Support of electric vehicles - Increasing of 60% in the use of EVs (or similar) in cities by 2030 • Reduction of carbon emissions *Resilience to climate change* • The urban infrastructure is 100% reliable during extreme events caused by climate change	***KPI for All-inclusive services*** *Transport capacity & mobility* • The increase of required urban space for road infrastructure development and upgrade is restricted (e.g. increase in use of subsoil). • The capacity of the urban infrastructure is increased by 30% (e.g. through enhanced interoperability of different transport modes, facilitated by ITS applications). • Reduction of traffic disruption due to maintenance • Adapted infrastructure for Freight management in cities • The time for developing or upgrading infrastructure to meet new demands is reduced by 50%. *Health & Safety* • Reduction of accidents by 30% • Reduction of casualties by 40% by 2030 • 30% less people suffer from noise, pollution and vibrations	***KPIs for Cost-efficiency*** • Economic losses due to nuisance from construction, maintenance and retrofitting are reduced by 50% • By 2050, 50% upgrading and operation of urban road infrastructure.

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<tr><th colspan="2">URBAN MOBILITY - STRUCTURES</th><th></th><th></th><th></th></tr>
<tr><td rowspan="2">DESCRIPTION

New and renovated structures for urban mobility in cities and urban areas have to accommodate a great and long-lasting tendency towards transport relying on electrification and renewable (electric cars, trams, etc.) and potential strong evolution regarding cycling and walking. This especially leads to considering deep transformation (construction works) in cities in the future, that must be done in a seamless way (“furtive” works) and in all cases treat all cultural (inherited) buildings and structures with respect.</td><td rowspan="2">EXAMPLES

Millennium Bridge, London</td><td colspan="3">TARGETS

• Developed design and construction techniques are compatible with existing structures for adaptation to electrified transport – including e.g. upgrade of electric networks to meet green vehicles needs (link with ERTRAC).
• Measures and regulations are developed to keep in service the cultural heritage of structures.
• New technologies and processes are developed to reduce during the building service lifetime land take and nuisance for people living in densely built areas.
• New techniques are developed that lead to a high level industrialization of production, processes and worksites for a significant increase in construction speed – along with management of interferences with utilities and existing networks (gas, water, etc.), improved localisation, works coordination, etc.</td></tr>
<tr><td>KPIs for Environmentally friendly infrastructure

• 30% reduction in CO_2 emissions of construction materials production by 2030
• 30% reduction in land take and nuisance of civil structures</td><td>KPI for All-inclusive services

• 50% more passengers by 2030
• 20% less disruption – thanks to increasing robustness of inner-city structures.</td><td>KPIs for Cost-efficiency

• 30% cost reduction through efficient new structures and through a second life for existing structures</td></tr>
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<tr><th colspan="2">URBAN MOBILITY - WATER</th><th></th><th></th><th></th></tr>
<tr><td>DESCRIPTION

The urban mobility based on waterways is to rely on two key pillars: the adaptation of current urban waterways and inner-city ports, and the integration of river and port information services in</td><td>EXAMPLES

River-bus network along the Seine river (Voguéo project) – 3 lines connected to metro, bus, tramways and regional express network (RER).</td><td colspan="3">TARGETS

• Integrate use of inland waterways for transport with other uses (water quality).
• Accessibility and connection with other modes of transport, including the integration of River Information services (RIS) with the information systems of the other urban transport modes.
• Quicker freight and people transport, based in particular on river monitoring solutions.
• Integration of the river corridors in urban landscape and cultural heritage.
• Develop the necessary infrastructure for maintenance and services for the urban transport vessel.</td></tr>
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the global city information service. Adaptation is about associated works for new quaywalls, but also for life extension of existing facilities, e.g. platforms reinforcement (for larger/bigger loads), accommodating existing quays for a deeper water, and prevention of scour in front of quay walls. Improvement of connection modes has to rely on the integration of river Information Services with information systems of other city transport modes.		***KPIs for Environmentally friendly infrastructure*** *Resilience to climate change* • Reduced effects of climate change on water infrastructure *Environmental impacts* • Reduction of noise and air pollution from the urban traffic • Minimized effects of transportation on water quality	***KPI for All-inclusive services*** • Generalisation of inland waterways infrastructure cargo handling and passenger boarding systems, in order to provide safe, reliable, fast and cost efficient urban transport	***KPIs for Cost-efficiency*** • Integration of waterways with other transport modes in order to minimize costs and obtain resilient and accessible urban transport networks

A.3 LD (Long Distance) CORRIDORS

LD CORRIDORS - GENERAL

DESCRIPTION

Long Distance Corridors form the backbone of the European multi-modal transport network. They transform an existing fragmented system of European roads, railways, airports and canals into a unified transport network, ensuring the free-flow of goods and people, and leveraging growth, jobs and EU competitiveness. They ensure a full coverage of the EU and accessibility to all regions with the same high quality of service.

LD Corridors heavily rely on many Civil Engineering structures playing a key role in terms of crossing large rivers, straits, mountains: for instance bridges, tunnels, embankments, locks, etc.

EXAMPLES

1. A core transport network (by 2030)
2. A comprehensive network of routes, feeding into the core network at regional and national level (by 2050)

Both layers include all transport modes: road, rail, air, inland waterways and maritime transport, as well as intermodal platforms

TARGETS

By 2050, Europe is easily and quickly accessible in all regions thanks to a systematic and well organised web of HLSI Long Distance Corridors, linking together the Multimodal Nodes and Urban Mobility Networks in a efficient way, characterised by :

GREEN: Long Distance Corridors contribute to a low-carbon Integrated Transport Systems by accommodating new low-carbon transport vehicles and/or innovative transport modes, thanks to new materials and components forming the LD Corridor infrastructure that reduce the consumption of energy by vehicles. They are well integrated in the landscape, with minimal land use, and preserve biodiversity. By 2050, their Life Cycle environmental impact is assessed and optimised in terms of use of natural resources (land, water, energy, construction materials) as well as reduction of carbon emissions and noise impact, with Eco-labelling schemes in infrastructure construction and maintenance to become usual from 2030 onward.

SMART: Intelligent infrastructure of Long Distance Corridors provide efficient means to manage and optimise the traffic (based on smart and advanced monitoring solutions), with increased capacity to accommodate freight transport and passenger transport while at the same time reducing congestion, and optimising the safety of the users. By 2030, accidents and emergency situations are mitigated efficiently, with minimum impact on traffic. Smart and advanced monitoring solutions are integrated to optimise LD Corridors life time and maintenance works. Specific solutions are developed for the most significant Civil Engineering structures such as bridges, tunnels, embankments, etc. By 2050, a full European Network of Long Distance Corridors has been made intrinsically safe for all and resilient to climate changes.

LOW COST: Long Distance Corridors are to form an essential pillar of European economy. Construction, operation and managements costs are optimised; associated risks are controlled. New concepts and components are available to extend the capacity and life time of infrastructure, including the pieces of Civil Engineering. By 2050 construction, upgrade and maintenance works are easy to plan and to optimise, because they are industrialised, highly automated and furtive (with no impact on operations). LD Corridors rely on optimised logistics chains, with deep use of IT systems of vital importance for the required exchange of information & coordination.

		KPIs for Environmentally friendly infrastructure *Environmental impacts* • Visual impact related to infrastructure reduced by 30% by 2030 • Biodiversity impacts (habitat fragmentation, animals mortalities…) reduced by 40% by 2020 • Noise impacts reduced by 20% by 2030 • Atmospheric emissions reduced by 30% by 2030 *Resilience to climate change* • Connections offered by LD Corridors do not break during episodes related to climate change impacts (floods, sea level rising, extreme events…)	***KPI for All-inclusive services*** *Transport capacity* • Freight: +80% capacity by 2050 • Passengers: +50% capacity by 2050 • Modal shift of freight transport from trucks to rail and inland shipping *Safety* • Monitoring of hazardous goods transport	***KPIs for Cost-efficiency*** • 30% cost reduction (maintenance & new infrastructure), with special attention to long-life pavements and perpetual pavements • Life extension of the aged infrastructure by appropriate maintenance and management
LD CORRIDORS - RAIL				
DESCRIPTION The main focus of RAIL on LD Corridors is considered in the development and future generalisation of high-speed train networks for passengers and freight	***EXAMPLES*** 1. SEA: South Europe Atlantic high-speed line 2. Mediterranean Corridor (in TEN-T) 3. Betuwe Route (NL) 4. AVE (high-speed line) Girona (Spain)	***TARGETS*** According to the EC "Transport 2050" white paper (IP/11/372), the transformation in Europe's current transport system requires a 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport. This requirement will be addressed on one hand by the development and maintenance of a European high speed line network for passengers and freight, and on the other hand by the refurbishment of the existing classic network interconnected with the HSL network. Main identified targets are: • A European cross-disciplinary framework is developed for the fast development and deployment of high-speed lines (HSL), with: o Very high speed tracks – including ballast-less tracks (due to scarcity of ballast quarries);		

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<td rowspan="2"></td>
<td rowspan="2">5. AVE Alhama-Totana (Spain)</td>
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Adapted catenaries;
Adapted switches and crossings;
And with enlarged tunnel section of classic lines to allow electrification and transport of trucks by train (the so-called “rolling motorway system”), as well as the interconnection of classical railway lines with HSL.

A European structured supply-chain is put in place for the fast production, integration, management and refurbishment of the HSL – including the furtive maintenance of HSL under operation.

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<td>KPIs for Environmentally friendly infrastructure
Resources efficiency
30% reduction of the natural raw materials need of construction materials production</td>
<td>KPI for All-inclusive services
Transport capacity
The overall number of transported passengers is increased by 30% by 2030
The freight transport is increased by 30% by 2030
Liveability
Noise generated by hi-speed lines is decreased by 20% by 2030</td>
<td>KPIs for Cost-efficiency
Furtive maintenance works are generalised by 2030
The new supply chain allows for an overall +50% life time extension, thanks to appropriate maintenance and management
30% reduction of lifecycle costs by 2030</td>
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<td colspan="2">LD CORRIDORS - ROAD</td>
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<td>DESCRIPTION</td>
<td>EXAMPLES</td>
<td colspan="3">TARGETS</td>
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<td>In line with the Transport White Paper, the European road infrastructure network should accommodate freight and passenger transport over short to medium distances (below 300 km). For longer distances, other modes of transportation of freight and people (rail and waterborne) are encouraged.</td>
<td>1. Attiki Odos (EL)
2. FEHRL Forever Open Road initiative:
the Automated Road
the Adaptable Road
the Resilient Road
3. Arad-Timisoara Motorway (Romania)</td>
<td colspan="3">Available and safe long distance road infrastructure networks offer high level service over short to medium distances for all users and under all circumstances, meaning:
New resilient road construction concepts (including fully integrated information systems for users vehicles, operations and infrastructure management) that can gradually be implemented and adapted to changes in the road users’ demands, societal constraints and impacts of extreme weather conditions (GREEN)
Operations that involve private land occupation, pollution and soil loss, are strictly controlled and integrated with land use planning (GREEN)
Smart infrastructure networks that allow a closer interaction between the infrastructure and the vehicle (information, safety and security, energy transferring…) (SMART)</td>
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<td rowspan="2">Therefore, the main focus of ROAD in LD Corridors is development of a high level service core road network – most importantly in terms of availability and safety, with the use of advanced ITS and ICT – superimposed on the existing but upgraded basic layer.</td>
<td rowspan="2">4. Transmontana Motorway (Portugal)</td>
<td colspan="3">• Improved, highly industrialized (thus fast and without impact on demand) and ICT supported road construction and maintenance strategies, which lead to a safe road infrastructure network with an improved capacity and availability (LOW COST)</td>
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<td>KPIs for Environmentally friendly infrastructure

Environmental impacts
• New infrastructure has a positive impact on ecosystem services and bio-diversity
• Generalised use of sustainable materials to control water and noise pollution

Resources efficiency
• Increased use of more durable materials (e.g. for pavement) with higher performances and less nuisance
• 20% less traffic disruption due to maintenance by 2030
• In 2030, 70% of materials used in road infrastructure construction, upgrade and maintenance consists of recycled, renewable and local materials.
• 100% re-utilization of demolition waste by 2030

Energy efficiency
• Energy used for infra-structure construction and operation is reduced by 50%</td>
<td>KPI for All-inclusive services

Transport capacity & mobility
• The network capacity is increased by 30% within the existing space
• Implementation of efficient infrastructure (for intelligent transport systems) and traffic management
• 30% reduction of traffic congestions by 2030
• The time for developing or upgrading infrastructure to meet new demands is reduced by 50%
• Lower disruption of traffic due to roads maintenance and upgrading: 30% less traffic disruption by 2030.
• 30% reduction of overall travel time.

Safety
• Reduction of road fatalities - 40% reduction of casualties by 2030
• Improved accidents and emergencies management
• Monitoring of hazardous goods transport</td>
<td>KPIs for Cost-efficiency

• Cost reduction (maintenance & new infrastructure) - Less maintenance intervals: 50% cost saving
• Life extension of the aged infrastructure by appropriate maintenance and management - The life time of critical parts of the infrastructure is extended by 50%
• Reduced time loss due to traffic congestions
• More efficient management of works and worksites under operation
• Onsite construction under traffic, with low impact on circulation
• 30% reduction of energy intensity (energy/€) and/or GHG emission intensity (emission/€) related to interurban transport
• Economic losses due to congestion caused by maintenance and retrofitting are reduced by 50%</td>
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- “optimised” vehicle-road grip, road design and alignment and use of ITS lead to 40% reduction of energy consumption by vehicles by 2030
- 30% increase of the use of alternative fuels, <u>in particular electrical power</u>, reducing the use of fossil fuels by 2013 (thanks to appropriate *refuelling infrastructure such as continuous electrical cables enabling inductive electrical fuelling*)
- 30% reduction of energy consumption for transport by optimised use of pavement materials by 2030

Resilience to climate change

- The network is 100% reliable during extreme events caused by climate change

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<td colspan="2">LD CORRIDORS - STRUCTURES</td>
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<td>DESCRIPTION

Structures for LD Corridors are robust enough to manage high-speed transport systems while at the same integrating the required technologies to mitigate impact of climate conditions and environmental hazards (e.g. fires,</td>
<td>EXAMPLES

1. Turin – Lyon tunnel
   Specific targets:
   - Freight speed: 120km/h
   - Passenger speed : 220 km/h
   - Passenger service between Milan and

</td>
<td colspan="3">TARGETS

- A comprehensive set of safety philosophy and guidelines for existing structures enabling a safe use of existing structures.
- A complete suite of advanced calculation and simulation methods and tools, as well as adequate monitoring and new repair methods to give second life to existing structures.
- A complete suite of advanced calculation and simulation methods that make possible to design robust structures under accidental actions.

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<td rowspan="2">earthquakes of small/medium intensity, etc.). Permanent continuity of service is ensured too, thanks to easy maintenance techniques and furtive construction and renovation works.</td>
<td rowspan="2">Paris to fall from six hours and 35 minutes to three hours and 40 minutes
• Reduction of high road traffic densities and serious pollution in Alpine valleys
2. Rion-Antirion Bridge (EL)
3. Viaduc de Millau (FR)</td>
<td colspan="3">• Reliable traffic load measurement methods and systems to avoid overdesign of structures.
• New advanced techniques to determine and upgrade tunnel safety, leading to a pan-European traffic network.
• Development of high quality prefabricated bridge (elements) leading to low cost, quick and easy to build bridges for a wide application, and development of techniques that allow adaptation of civil structures to function properly under extreme weather conditions.</td>
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<td>KPIs for Environmentally friendly infrastructure
Resources efficiency
• 30% reduction in use in building materials – also thanks to more durable materials & use of recycled materials
• 100% re-utilization of demolition waste by 2030
Environmental impact
• Reduction of noise by 50%
• Reduction of CO2 emissions during concrete production by 50%</td>
<td>KPI for All-inclusive services
Traffic
• 30% increase in transported people and goods
• 30% less traffic disruption
• New quick refurbishment, using prefab and new materials: 40% less traffic disruption
• Increasing robustness of infrastructure: failure of one component does not lead to failure of complete system: 30% less traffic disruption
Safety
• Safety increase of European network, modelling and design for incidental actions (explosion, impact, fire, earthquake,): 20% less traffic disruption</td>
<td>KPIs for Cost-efficiency
• Realisation of 40% cost saving
• Life extension of existing infrastructure by 50%
• Traffic load monitoring to take measures in time, and to avoid using conservative construction standards at design stage: 20% cost saving
• High industrialization – Quick building, use of prefabrication</td>
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<tr><th colspan="2">LD CORRIDORS - WATER</th><th></th><th></th><th></th></tr>
<tr><td rowspan="2">DESCRIPTION

After road, maritime freight transport recorded the strongest growth of all modes during the last decade. Intra-EU shipping increased by more than 20% between 1998 and 2008.

The future LD Corridors are to accommodate the fact that maritime transport flows between large trading or passengers areas are to increase in close correlation with the rate of growth of the world economy and global trade. LD Corridors are to be the answer to the different degrees of fragmentation of inland waterways along national borders, and to the rebalancing of the modal distribution of transport, away from congested roads and airports towards less congested and more environmentally friendly (inland) sustainable waterways mode.</td><td rowspan="2">EXAMPLES

1. Seine-Nord Europe (SNE) Canal
2. Hydra Ring project (NL)</td><td colspan="3">TARGETS

• By 2050, a European framework of infrastructure is deployed to support inland trans-European water-based transport system, with intermodal connections in the ports and the hinterland connections to allow for a smoother transport chain. This also includes integrated transport management services (e.g. multi-modal journey planner), as well as better interconnections (supported by appropriate infrastructure) with cities surrounding sea ports and inland water hubs.
• By 2030, design and assessment tools are fully suited to a risk-based approach to flood risk management of dikes and other water works, enabling decision making for cost effective measures for new and existing water defence systems.
• A holistic approach and set of Waterways Information Services (WIS), supported by IT systems, is available for traffic monitoring and optimisation. Customer oriented waterway management strategies, as well as improved logistics through real-time information systems, are developed. Information[23] management and exchange (through WIS) should make it possible to locate at source and communicate to any authority accurate and up-to-date information on ships in European waters, their movements and their dangerous or polluting cargoes, as well as marine incidents – so as to improve safety and efficiency of transport by inland waterways.</td></tr>
<tr><td>KPIs for Environmentally friendly infrastructure

Resilience to climate change
• Reduced risks due to climate change thanks to innovative solutions for infrastructure upgrading and adaptation (e.g. flexible river engineering elements)</td><td>KPI for All-inclusive services

Traffic
• Increased traffic capacity (objective: +50% by 2030).
• Reduced time of operations in docks (objective: -20% by 2030).</td><td>KPIs for Cost-efficiency

• New high-end calculation methods for failure risk of dikes to quantify conservatisms in design: 20% cost saving</td></tr>
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[23] Information is to be related to e.g. short-sea shipping information, fairway information, traffic information, transport management, statistics and customs services as well as waterway charges and port dues.