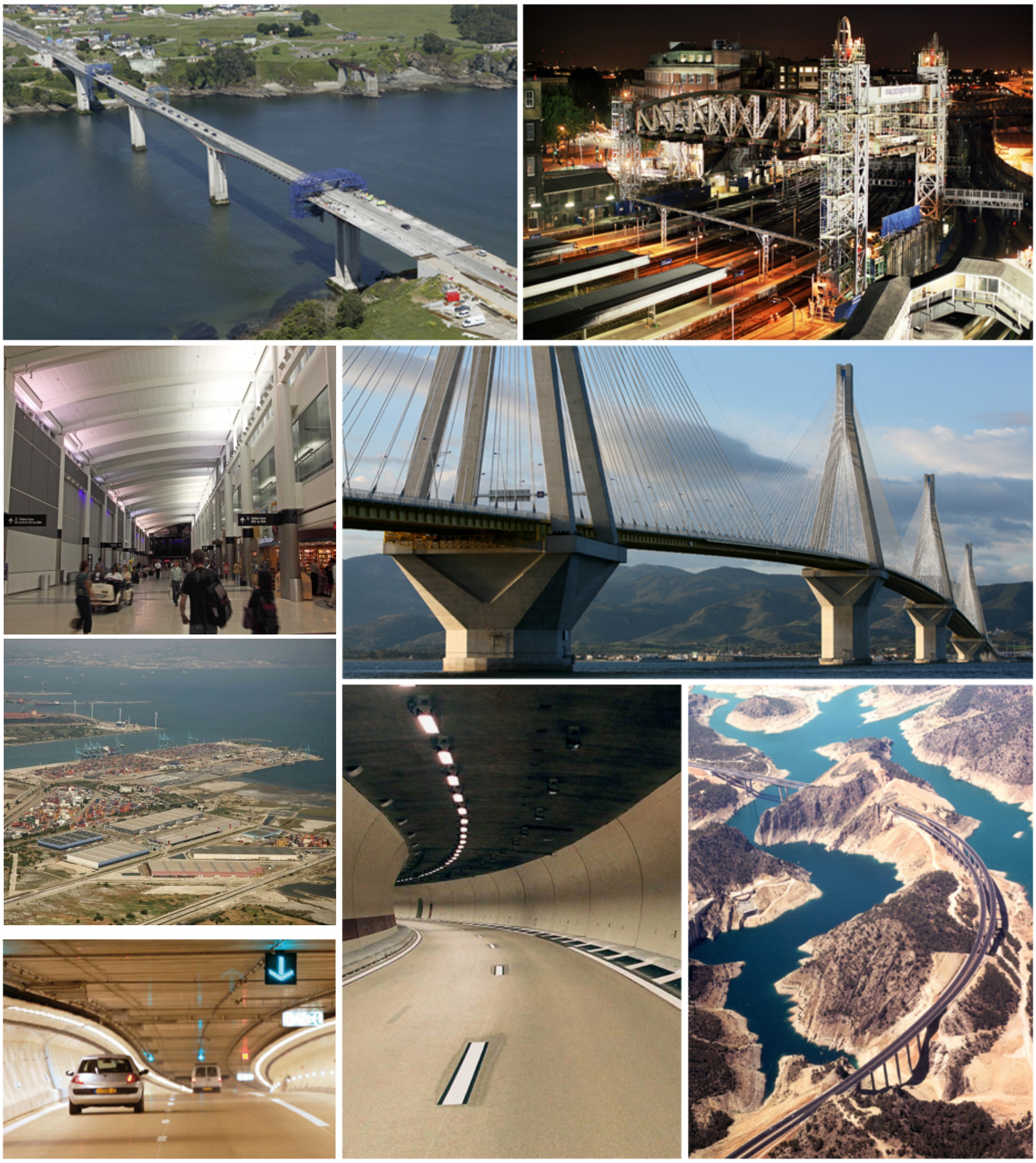
An initiative of the
European Construction
Technology Platform

Research for Future Infrastructures in Europe

reFINE

Building Up Infrastructure Networks of a Sustainable Europe

The reFINE Roadmap



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

V2, May 2013

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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.

Following the reFINE "Strategic Targets and Expected Impacts" document (Public draft – August 2012), this document, after a short reminder of the reFINE vision, introduces to the different Research areas and topics that have been identified so far to hit the expected impacts, presented under a summarized form. This document builds on the afore mentioned documents by suggesting RTD priorities at various time spans – aligning those priorities against the three identified pillars of the reFINE ***HLSI*** (High-Level Service Infrastructure) concept: Multimodal Hubs, Urban Mobility, and Long Distance Corridors.

This document introduces to the second reFINE roadmap version, which integrates the priority topics identified for the first 2014-2015 years of the Horizon 2002 period.

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

Reminder of the reFINE vision

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 ***High Service Level Infrastructures (HSLI)*** envisioned by reFINE as crucial to form an efficient and sustainable *backbone network* of integrated mobility services provided by the future Single European Transport Area (SETA). The HLSI concept presents itself the range of:

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.*

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.*

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.*

The elements presented in the next chapters dedicated to the reFINE roadmap are introducing preliminary finding in terms of key ***Reseach Areas*** and corresponding research items for the 3 pillars introduced above, as well as for Transversal Reseach Areas, based on a large set of inputs.

MULTIMODAL HUBS	**URBAN MOBILITY**	**LD CORRIDORS**
RESEARCH AREA 1: **CONCEPTS** for a NEW GENERATION of HLSI MULTIMODAL HUBS	RESEARCH AREA 1: INFRASTRUCTURE FOR ACCOMODATING **NEW LOW-CARBON VEHICLES**	RESEARCH AREA 1: HOLISTIC DESIGN TO IMPROVE **ENVIRONMENTAL INTEGRATION**
RESEARCH AREA 2: **ENERGY** OPTIMIZATION	RESEARCH AREA 2: **MINIMIZING NUISANCES** OF URBAN NETWORKS	RESEARCH AREA 2: **INCREASING THE CAPACITY** of EXISTING INFRASTRUCTURE
RESEARCH AREA 3: REDUCTION OF LC **ENVIRONMENTAL IMPACTS**	RESEARCH AREA 3: HLSI SERVICING **CITY DEVELOPMENT**	RESEARCH AREA 3: **EXTENDING THE LIFE TIME** of EXISTING INFRASTRUCTURE
RESEARCH AREA 4: INCREASING **ACCESSIBILITY**	RESEARCH AREA 4: INCREASING **RESILIENCE** OF URBAN NETWORKS	RESEARCH AREA 4: INNOVATIVE INFRASTRUCTURE for **INNOVATIVE TRANSPORT MEANS**
RESEARCH AREA 5: **RISK MANAGEMENT** and INTERMODAL INFORMATION SYSTEMS	RESEARCH AREA 5: **OPTIMISATION of COST**	RESEARCH AREA 5: **REDUCING COSTS** and **DISRUPTION**
RESEARCH AREA 6: **OPTIMISATION of COST** of OWNERSHIP (Maintenance)	RESEARCH AREA 6: **INCLUSIVENESS** & **SAFETY**	RESEARCH AREA 6: **RESILIENT, SAFE and SECURE** CORRIDORS
	RESEARCH AREA 7: **INFORMATION** & **COMMUNICATION NETWORKS** INFRASTRUCTURE	RESEARCH AREA 7: **REDUCING ENERGY USED DURING OPERATION**

TRANSVERSAL AREAS	RESEARCH AREA 1: **FORESIGHT** & **ROADMAP**	RESEARCH AREA 2: **MATERIALS** & ASSOCIATED CONSTRUCTION **PROCESSES**	RESEARCH AREA 3: **INFORMATION SYSTEMS** & **ICT**

MULTIMODAL HUBS

KEY RESEARCH AREAS	Importance (High, Medium or Low)	Topics	Timing (ST, MT or LT)
RESEARCH AREA 1: **CONCEPTS** for a NEW GENERATION of HLSI MULTIMODAL HUBS	Medium	• Identification and development of new **concepts and innovative scenarios** for green, smart and low-cost multimodal hubs (mega-structures). Consider architecture, passenger and freight flow, construction methods etc.	MT
		• Development of **guidelines** for the design of new / upgraded multimodal hubs – including consideration for prefabricated modular construction and disassembling (considering need for MH evolution according to future needs); include a standardised BIM code.	MT
		• Upgrading existing infrastructure networks: o design of new **furtive/low-intrusive construction methods** to be used during MH in service conditions (for acceptable interruption of traffic and acceptable impact on user mobility in MH); o New methods to **extend service life**, increase the service load (e.g. passengers per hour through put), in view of functional upgrade.	ST MT
		• **Back analysis of newly constructed MH** to allow optimisation of construction techniques to be used as the stating place for future construction works.	MT
RESEARCH AREA 2: **ENERGY** OPTIMIZATION	Medium	• Development of new **concepts to turn multimodal hubs into energy exchange nodes**, improving the energy efficiency of the whole transport chain – and considering integration of MH into city districts heating and energy networks	LT
		• **Integration in MH of energy efficient components**, construction products, including use of renewable energy sources (RES); including geothermal energy. Investigate how such measured can impact on Capex and Opex.	LT
		• Development of processes for **near-zero, zero and energy-positive multimodal hub** operation in MH.	LT

RESEARCH AREA 3: REDUCTION OF LC **ENVIRONMENTAL IMPACTS**	**Medium**	• **Life Cycle (LC) assessment tools** for environmental effects (CO_2 emissions, noise and pollution, biodiversity, soil and water system, etc.) of MH in operation to be used at the design stage – and with Integration of monitoring data into LC assessment during the at operational stage;	**MT**
		• **Optimizing occupied space and multifunctional use of space**; both in terms of minimising land occupancy and optimising space occupancy by users (with a capacity to adapt their functions to users' needs);	**LT**
		• Integration of **new materials**, and development of integration of **recycled materials** – with consideration for low maintenance, high and predictable durability, long-term sustainability and low lifecycle environmental impact (e.g. green concrete, light-weight-aggregates, etc.);	**MT**
		• **Methodologies and evaluation tools for measurement and assessment of GHG emissions** related to MH construction, operation and repair - and mitigation practices including demolition, disposal and reuse/recyclability of materials;	**MT**
		• **Reduction of (grey) energy required for the construction / maintenance process** – thanks to methodologies for better assessment of MH energy performance and improved interactions of various EE products and components (RES, low energy lighting systems, efficient ventilation systems for tunnels, energy management systems)	**MT**
RESEARCH AREA 4: INCREASING **ACCESSIBILITY**	**Low**	• **Design for all of MH** – including the development of a holistic understanding of needs (especially with respect to mobility and safety) of sensitive and vulnerable groups and ageing population relative to access and move in MH;	**MT**
		• Identification of new strategies for addressing **"Design and Build" approach for MH taking into account the needs of all users**, with a particular focus on accessibility issues. Develop innovative concepts for construction or use of safe infrastructures for sensitive or vulnerable groups;	**MT**
		• Develop a better understanding of the **impact of infrastructures on health, comfort and perception of safety** of all users – along with harmonized assessment methods for the interaction between human and infrastructure from the human point of view (holistic approach), including objective and subjective relations between stimulus and perceptual behaviour. Identify harmonized performance indicators for evaluating the perception of health, comfort and safety;	**LT**

		• Develop enriched **information-based interfaces integrated to MH** (visual info, acoustic info, language, colour codes, etc.) and improvement of the accessibility to this information to facilitate mobility of all users. Development of sensors, actuators and systems that anticipate human perception in relation to the human-MH interaction (allowing the development of user-MH interactions patterns).	**LT**
RESEARCH AREA 5: **RISK MANAGEMENT** and INTERMODAL INFORMATION SYSTEMS (FLUX of PEOPLE)	**Medium**	• New processes and project management improvements in order to **facilitate social acceptance of construction works in crowded MH** – and more globally to ensure risk identification, management strategy, and mitigation in governance of MH;	**LT**
		• Development of **accurate information systems** (integrated with predictive urban and LD traffic models) **for decision making in MH traffic inter-connection**; link to real-time information and mobility services, e.g. in relation to network maintenance operations, to inform end-users on traffic conditions, and suggest alternatives adapted to the mobility demands, based on co-modality principles (variable signalling panels, innovative communication methods etc.).	**LT**
		• Development of multi-disciplinary approach (methods and tools – relying on use of information systems and ICTs, architectural design, etc.) for **anticipation of emergencies, disruption, congestion, and mobility-connectivity re-planning** in MH;	**LT**
		• Compatibility of **standards at interfaces.**	**LT**
RESEARCH AREA 6: **OPTIMISATION of COST** of OWNERSHIP (Maintenance)	**High**	• Develop innovative **methods to minimise construction costs**, number and duration of interventions, ensuring safety conditions and no interruption of service (including through industrialisation of upgrade and maintenance works, high automation furtive/low-intrusive maintenance works);	**MT**
		• New techniques for **maintenance and upgrading which assure safety conditions and no/minimal interruption of service**, e.g. trenchless technology or in-situ soil improvement – including furtive techniques for repair, maintenance, replacement and upgrading of MH;	**ST**
		• New (non-destructive) **testing methods** (radar, ultrasound, optical fibre, wireless smart sensors, robotic techniques for inspection...) **for diagnostic, early damage detection and maintenance** of the infrastructures;	**ST**
		• **Robotic techniques for the assessment / automatic evaluation of hazards and uncertainties on MH** in operation, and during the maintenance process. Automation/robotic	**MT**

		assistance for hazardous occupations;	
		• Integration of terrestrial and satellite systems for the **structural health monitoring** of MH located in a natural risk (earthquakes, landslides, floods) prone area;	**MT**
		• Development of **standards and best practices**. Dissemination of **quality training** for maintenance operators and workers. Establish European information network of databases for maintenance / costs of MH (taking into account occupational safety and health).	**MT**

URBAN MOBILITY

KEY RESEARCH AREAS	Importance (High, Medium or Low)	Topics	Timing (ST, MT or LT)
RESEARCH AREA 1: INFRASTRUCTURE FOR ACCOMODATING **NEW LOW-CARBON VEHICLES**	**Medium**	• Development of solutions to make urban road infrastructures able to **support operation of new sustainable energy sources vehicles** (EVs for instance): o In particular, needed infrastructures for the deployment of electric public urban transport systems; o Facilitate dedicated road capacity for fully electric transport modes.	**MT** **MT** **LT**
RESEARCH AREA 2: **MINIMIZING NUISANCES** OF URBAN NETWORKS	**High**	• Development of solutions to **reduce impacts and nuisances related to urban infrastructure operation**, like vibrations, noise, etc., for people living in densely built areas;	**MT**
		• Development of solutions (e.g. new construction methods) to **reduce impacts and nuisances related to urban infrastructure construction, upgrade and/or maintenance**, like noise, pollution (dust), traffic disruption, etc., in densely built areas. In particular: o Development of new "discreet" methods to build new infrastructure with no interruption of traffic, o Development of new "discreet" methods to maintain or upgrade existing infrastructure network under service conditions (no interruption of traffic), o Development of "green" construction methods and materials reducing transport of materials (lean design, in-situ recycling etc.), o New or improved technologies and processes to increase productivity and reduce the environmental impact of tunnelling (underground construction) in urban areas; o Development of efficient and "discreet" techniques for construction, repair, maintenance, replacement, reinforcement and relocation of utilities networks in view of transport infrastructure construction / maintenance works. In particular,	**MT**

		robotic techniques for inspection and repair, accurate methods for locating existing utilities; new techniques to minimize the size and costs of excavations and backfilling - small-dimensioned trenching with new, mechanized laying techniques; new concepts for integration of utility networks (gas, water, sewer, electricity...) in a single built infrastructure or duct;	
		• New technology, process and project management improvements in order to **facilitate social acceptance of construction works** in crowded and congested urban areas.	**MT**
RESEARCH AREA 3: HLSI SERVICING **CITY DEVELOPMENT**	**Medium**	• Development of **innovative concepts of urban infrastructure to support city development** strategies and optimise usage of urban space: example by improving urban mobility, by avoiding city barriers, by connecting city sub-areas.	**LT**
RESEARCH AREA 4: INCREASING **RESILIENCE** OF URBAN NETWORKS	**Medium**	• Development of solutions to **preserve the functional use of urban networks in emergency episodes** caused to transport infrastructure by natural and man-made hazards and climate change impacts. • Development of concepts and tools to **adapt urban networks to climate change impacts**.	**MT** **LT**
RESEARCH AREA 5: **OPTIMISATION of COST**	**High**	• Development of innovative solutions (techniques, processes) based on **industrialisation, automation and / or robotics** for the optimisation of costs of works related to construction, renovation and maintenance of urban infrastructure. • Development of new methods to **extend life span** and develop service capacity of existing infrastructure networks; • New construction processes to **minimise 'by design' all maintenance costs**: number and duration of interventions; interventions without interruption of service while ensuring safety conditions.	**MT** **ST** **MT**
RESEARCH AREA 6: **INCLUSIVENESS & SAFETY**	**Medium**	• Development of solutions to ensure **free and secure access and usage of urban networks**, as well as seamless door-to-door mobility, to all urban citizens, including disabled and impaired people. In particular: o Development of efficient and user-friendly information systems addressing mobility needs of sensitive or vulnerable groups; o Enrichment of the information on the infrastructure itself (visual info, acoustic info, language, colour codes, etc.) and improvement of the accessibility to this information to facilitate mobility;	**MT** **LT** **MT**

		• New technology & process improvements in order to create inherently **safe underground working and operating environments** (e.g. automation/robotic assistance).	**LT**
RESEARCH AREA 7: **INFORMATION & COMMUNICATION NETWORKS INFRASTRUCTURE**	**Medium**	• Development of required c**ommunication infrastructure for real-time information and mobility services**, e.g. in relation to network maintenance operations, to inform end-users on traffic conditions, and suggest alternatives adapted to the mobility demands, based on co-modality principles. This can make use of information signs like variable message signs (matrix signs) to manage traffic flow (journey time, route opening) or inform on transportation means, innovative communication methods like internet 2.0, mobile phones and social media so as to broaden and facilitate to mobile users the access to transport and traffic conditions and status information, available parking places, etc. This can be based, in particular, on: o Predictive urban traffic models for decision making in traffic regulation, and for providing accurate information and recommendations to users; o Advanced management systems at control centres integrating operational functions regarding predictive, preventive / corrective maintenance of urban transport systems; o Automatic incident detection systems with capacity to provide early warnings to the traffic control system.	**MT** **MT** **LT** **MT**

LD CORRIDORS

KEY RESEARCH AREAS	Importance (High, Medium or Low)	Topics	Timing (ST, MT or LT)
RESEARCH AREA 1: HOLISTIC DESIGN TO IMPROVE **ENVIRONMENTAL INTEGRATION**	Medium	• New **concept, products, technologies, and tools to improve environmental integration** by reducing the visual, noise, atmospheric and biodiversity impacts due to road and rail infrastructure. Examples are: low noise pavements, new technologies for rail-wheel interaction and noise reduction; self-cleaning infrastructures that capture pollutants, ecological engineering, etc.	MT
RESEARCH AREA 2: **INCREASING THE CAPACITY** of EXISTING INFRASTRUCTURE	Medium	• New **solutions to increase freight and passenger transport** by using existing infrastructure more intelligently	MT
		• Advanced ICT and ITS systems to **optimize traffic, serviceability, and security of networks**, integrating traffic and transport monitoring and management. o In particular, development of GNNS solutions for real time traffic tracking, reporting and planning to avoid congestion	MT
		• Advanced systems and tools for **network-wide management and daily operations**	MT
		• New concept, products, technologies, and tools that allow for an **increased transport by inland shipping** and reducing the time of operations in sluices and other water hubs	LT
RESEARCH AREA 3: **EXTENDING THE LIFE TIME** of EXISTING INFRASTRUCTURE	High	• New methods and tools for **monitoring and assessing (the status of) existing structures**, e.g. relatively to structural loading and deterioration potential. This includes: o Better understanding of damage and deterioration mechanisms and their effects on asset performance and residual life o New (non-destructive) testing methods (radar, ultrasound, optical fibre, wireless smart sensors...) for diagnostic, early damage detection and maintenance of the infrastructures o Integration of terrestrial and satellite systems for the structural health monitoring of key infrastructures located in a natural risk (earthquakes, landslides, floods)	ST ST ST MT

		prone area	
		• Development of new advanced **methods for characterization and assessment of the safety of existing structures**, also taking into account economic considerations and limits for human safety: o Development of performance indicators and performance based design closely connected to probabilistic modelling and prediction	**MT**
		• **Innovative non-intrusive solutions to extend the life time of components**, e.g.: o new reinforcing techniques, composite materials (for instance Carbon Fibre Reinforcing Polymer) for strengthening and reinforcing existing transport infrastructures (bridges, viaducts, tunnels …) and adapt them to evolving transport means (e.g. larger and heavier freight trucks), new or non-conventional multifunctional materials, traditional materials with enhanced performances, etc.	**MT**
		• New methods and tools for **reducing maintenance duration (leading to cost saving), and time loss due to traffic congestions** by appropriate maintenance and asset management tools	**MT**
RESEARCH AREA 4: INNOVATIVE INFRASTRUCTURE for **INNOVATIVE TRANSPORT MEANS**	**Low**	• **Adaptation of existing and new infrastructure to new transport means** (e.g. based on advanced technologies like magnetic levitation trains, automatic driving)	**LT**
		• Development of innovative means for **adaptation of existing and new infrastructure to transport modes using new energy sources**	**LT**
RESEARCH AREA 5: **REDUCING COSTS** and **DISRUPTION**	**High**	• Development of **monitoring systems for measuring loads and structural response** that allow for taking measures in time avoiding conservative (and costly) design.	**ST**
		• **Advanced systems for survey, inspection and testing of infrastructure**, like Structural Health Monitoring (SHM) of bridges.	**ST**
		• Development of new **methods and techniques to reduce costs, construction time, and impact on circulation**. In particular: o Development of highly industrialised construction with the objective to minimise life cycle costs o New methods for on-site construction with prefabricated components o New solutions (e.g. based on larger use of prefabricated materials) that allow for	**MT** **MT** **MT**

		a significant lower disruption of traffic due to roads maintenance and upgrading o Methods and tools for an optimal management of asset maintenance, repair and upgrading, and eventually replacement, with low impact on service and environment. o New concept, products, technologies, and tools that contribute to a safer construction, reducing the number of casualties among personnel and users of the transport infrastructure (e.g. smart construction methods) o Development of Re-construction systems with low impact on demand and environment	**MT** **MT** **MT** **LT**
		• Develop **methods and tools for planning and optimization of construction processes related to asset maintenance, repair and upgrading, and eventually replacement**, taking into account construction time and logistics as well as short and long-term impact on the network, future maintenance issues, and last but not least, environmental aspects such as emissions of greenhouse gases from temporary transport services: o New concept, products, technologies, and tools that allow for a significantly lower disruption of traffic due to roads maintenance and upgrading; o Methods and tools for an optimal management of asset maintenance, repair and upgrading, and eventually replacement, with low impact on service and environment.	**MT**
RESEARCH AREA 6: **RESILIENT, SAFE and SECURE** CORRIDORS	**High**	• Develop **models, methods and tools for assessing and reducing impact of seismic events** and improved assessment and protection: o Experimental and theoretical studies (design procedures and improvement techniques) on the seismic response of structures o Setting up of models and criteria to define optimal strategies for the reduction of the global seismic risk	**MT** **MT** **LT**
		• New **methods, techniques and tools to guarantee the continuity of services** in LD corridors in case of unexpected events like accidents and risks. For instance: o Tools to enhance the controls, localization and safety of goods and passengers (e.g. GNSS-based tools) o Tools for providing efficient and fast appropriate measures in case of accidents and reducing their impact (esp. when hazardous freight is involved). GNSS-based solutions integrated in GIS networks for assisting first responders and infrastructure managers in case of natural or man-made disasters. Tools for crisis	**MT**

		management and contingency planning.	
		• **Mitigating risks linked to climate change**. In particular (environmental risks): o Risk management tools and decision-support systems for assessing flood risks and the safety of hydraulic structures o Innovative solutions and techniques reducing climate change related risks, allowing for flexible measures related to river engineering and heavy rainfall o New technologies for optimizing earth structures, like new retaining systems to build steep slopes with environmental benefit / Mitigation of unstable slopes in existing and new infrastructures, minimizing slide hazards by identification, prevention, corrective measures, monitoring and emergency response systems o Impact and adaptation of infrastructures to sea level rise (e.g. roads as flood defences).	**MT**
RESEARCH AREA 7: **REDUCING ENERGY USED DURING OPERATION**	**Low**	• **New road structures** with low rolling resistance in order to **reduce energy losses** without compromise on user's safety	**LT**
		• New **concepts for capturing energy from infrastructure operation** (e.g. electro-kinetic road ramps)	**LT**
		• **Low energy lighting systems, efficient ventilation systems for tunnels**	**MT**

TRANSVERSAL RESEARCH AREAS

KEY RESEARCH AREAS	Importance (High, Medium or Low)	Topics	Timing (ST, MT or LT)
RESEARCH AREA 1: **FORESIGHT & ROADMAP**	High	In order to **define an pan-European futuristic vision towards "HLSI 2040",** there is a need to: • Bring together all relevant stakeholders including buildings and infrastructure sector companies, process engineering specialists, equipment providers, RES providers and energy companies, ICT software companies, as well as local and regional authorities, to develop the notion of HLSI and the transition from current infrastructures to these drastically innovative concepts of HLSI in a holistic dimension; • promote, through community building activities, a better understanding, a closer dialogue and a more active cooperation between researchers, end-users/practitioners, facilities owners, infrastructures builders as well as operators, technology-suppliers, software developers, etc., thus establishing multi-disciplinary and complementary communities for the evolution of the infrastructures domain towards a new generation of HLSI to be intensively deployed by 2040. The <u>*FORESIGHT* activity</u> in reFINE indeed plans to rely on a critical thinking and shared formal approach so as to **shape the future of infrastructures and networks**, aiming at visionary scenarios including prospective evolution and profound transformations of infrastructures, based on large-scale changes induced by society and sustainability, and influencing on the long term public policy and strategic management and business in companies. *Whilst the FORESIGHT activity is relying on prediction and forecasting of futuristic needs and breakthrough innovation, there is a need to update views on closer (short-term and medium-term) activities in terms of applied RDI, based on the current state-of-the-art: this is the objective of the reFINE Roadmap to be updated on a regular basis.* This is why besides devising this reFINE futuristic vision, it is also essential to continuously work out a permanent community building and comprehensive operating method that will allow these communities to act as *breeding and nurturing grounds for innovation* in bringing together	**ST** (roadmap) **LT** (foresight)

		the relevant organisations and stakeholders for the purpose of **starting up “innovation cycles in HLSI development and management**” **-** implying the completion of the following main activities: • Build a ***strategic alliance at a European level*** (with potential of world-wide extension) to create all the required conditions for dialog and consultation between all actors, and to generate a common vision as regards needs for collaborative R&D covering products, systems & services for HLSI development, operation & management. • Put in place mechanisms to achieve relays in each country through ***national strategic alliances***; • Develop a shared ***vision***, and elaborate the ***Strategic Research Agenda*** (SRA) and detailed ***Implementation Activity Plan*** for future R&D and innovation; • Achieve and realise a detailed plan for **coordination of information exchange and dissemination** between all energy-related ICT projects, initiatives and stakeholders. The strategic alliances (both at European and national levels) will act as “breeding grounds” for innovation and collaboration so as to achieve, *among others*: • Investigation of overall transportation system weaknesses and strengths to accommodate the predicted changes in travel requirements for passengers and freight including consideration of: o Use of natural resources and legislative requirement to reduce CO2 – and how can infrastructure contribute to this; o Predicted change in passenger and freight quantities and routes; o Predicted long-term performance of existing infrastructure facilities; o Climate change impacts; • Development, experimentation and assessment of cost effective and highly performing technologies and systems leading to smart, green and cost-efficient HLSI; • New schemes for HLSI deployment & operation – including provision for exploitation of new business models and new market opportunities; • Continuous improvements in standards & potential regulations ; • Full dissemination of the know-how and technologies; • Facilitation of project generation – thanks to awareness raising of all different kinds of actors, networking coordination, and greater access for industry and research organisations to funding and partnership.	

RESEARCH AREA 2: **MATERIALS & ASSOCIATED CONSTRUCTION PROCESSES**	**High**	• **New materials, and new construction methods and techniques using materials, that lead to lower costs** (for construction / operation / maintenance / upgrade), **longer product lifetime, higher performance** (including increased comfort for end-users and citizens), and **lower life-cycle environmental impact**. This includes: o new, more durable and sustainable materials, with low maintenance, high and predictable durability and low lifecycle environmental impact (e.g. new road pavement, green concrete) o composite materials (for instance Carbon Fibre Reinforcing Polymer) for strengthening and reinforcing existing transport infrastructures (bridges, viaducts, tunnels …) o new or non-conventional multifunctional materials, traditional materials with enhanced performances o self-healing materials and conservation techniques (e.g. based on natural processes in the subsurface) o saving of materials (as natural resources) in construction processes o recycling of materials, advanced techniques for materials optimization and reuse, new demolition techniques that allow recycling and reuse of materials (considering internal re-use or towards other applications) o life-extension of materials and components (with improved properties) o reduction of CO_2 emissions in the production of materials o reduction of natural raw material included in infrastructure components o use of materials from renewable resources (e.g. wood, bioplastics, biobinders) o easy to use and install materials and components for friendly and safe construction o use of local materials, e.g. geotextiles, for the production of new types of concrete, light-weight-aggregates, etc.	**MT**
RESEARCH AREA 3: **INFORMATION SYSTEMS and ICT** *The overall aim of this*	**Medium**	• Development of **PLM (Product Life-cycle Management) concepts, methods and tools for managing HLSI product information** from conception to service. In particular, information models and tools for sustainability and LCA (Life-Cycle assessment), including environmental impact, and resilience to changes. Definition of common performance indicators.	**MT**

research area is to develop/adapt ICT models, methods, infrastructures and tools to enable or support HLSI design, construction, operation, maintenance and upgrade.		• **Development of technical data sharing and archiving standards** (e.g. CityGML, IFC, and extensions) **for virtual prototyping of infrastructures**. These standards shall be accompanied by tools (SDK, reference viewers…), validation and certification procedures for the best quality implementations by the software editors of the domain (CAD, analysis…);	**MT**
		• **Integration of information systems between transport modes,** and development/adoption of harmonized cross-national communication standards, to allow seamless communication and systems interoperability, supporting trans-European and multi-modal mobility;	**LT**
		• **ICT-based information systems** (using e.g. widespread real-time monitoring) to inform users on traffic conditions, incidents, traffic disruption, etc., including the suggestion of best travel routes, to optimize traffic and serviceability;	**MT**
		• **HLSI for new mobility patterns** (focusing on e.g. safety improvement and user comfort) supported by improved ICT-based interaction between vehicles and infrastructure;	**LT**
		• Development of **e-training methods and tools for construction workers**. In particular, development of smart and modular e-learning systems, adaptive (to the user) and evolutionary (in time), to improve prevention of occupational hazards as well as training of users in hazardous situations, possibly based on enhanced or virtual reality;	**MT**
		• Smart **integration of new (high performance) technologies & devices** (e.g. intelligent LED solutions, or nanomaterials);	**MT**

PRIORITY TOPICS 2014-2015

This section presents the result of a process carried out to identify the strategic priorities for the first years 2014-2015 of the Horizon 2020 period.

It was mainly elaborated from the level of importance of the expected impacts and the urgency of the topics, as presented in the previous sections, but was also based on further pondering made on the absolute results of the prioritization process to gain from identified synergies and avoid overlaps between topics.

Each of the priority research topics is described through a title, its scope and focus, related scientific and technological objectives/outcomes and expected impacts. Links to the reFINE Roadmap (Pilar and Key Research Area), the Cross-Modal Transport Infrastructure Roadmap (v. 29 March 2013) and the EC Working Document accompanying the Communication on “Research and Innovation for Europe’s Future Mobility” (COM(2012) 501 final) are also referred.

A summary of these priority research topics is presented on the next page

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Research Topic Title	Reference to reFINE Roadmap	Reference to Cross-Modal Roadmap	Reference to EC Working Doc^{t} accompanying COM(2012) 501
Improvement and Deployment of a Life Cycle Assessment (LCA) Approach for Multimodal Hubs	Multimodal Hubs • Reduction of Life Cycle Environmental Impacts	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Construction Concepts and Processes Towards Zero Carbon Footprint • Low Carbon Construction	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Set up multimodal centres throughout the European transport network and deploy eco-innovations in existing terminals, e.g. new terminal design concepts in ports to facilitate interaction between modes
Optimising Costs of Infrastructure Networks by Extending their Service Life	Urban Mobility • Optimisation of Costs	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Maintenance and Rehabilitation	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Carry out R&D to extend the life-span of existing infrastructures, to achieve a better understanding of degradation and ageing processes and to reduce disruption caused by network congestion
New solutions to reduce impacts and nuisances related to urban infrastructure construction, upgrade and/or maintenance	Urban Mobility • Minimizing Nuisances of Urban Networks	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Maintenance and Rehabilitation	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries
Solutions to preserve the functional use of urban networks in emergency episodes related to natural and man-made hazards and climate change impacts.	Urban Mobility • Increasing Resilience of Urban Networks	Resilient Transport infrastructure Operations across Europe • Climate Resilient infrastructure Network	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries

Extending the Life Time of Existing Infrastructure	Long Distance Corridors • Extending the Life Time of Existing Infrastructure • Increasing the Capacity of Existing Infrastructure	Safe and Secure Transport Infrastructures and Operations • Advanced Safety Technology • Advanced Safety Management Systems	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Carry out R&D to extend the life-span of existing infrastructures, to achieve a better understanding of degradation and ageing processes and to reduce disruption caused by network congestion
Assessing Risks Associated to Long Distance Corridor Structures	Long Distance Corridors • Resilient, Safe and Secure Corridors	Resilient Transport Infrastructure Operations across Europe • Climate Resilient Infrastructure Networks	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries • Develop coordination mechanisms and structures that would allow operators to provide seamless services with a minimum number of interruptions. The structures and mechanisms must be sufficiently resilient to handle the impact of these services, using integrated information and communication systems • Find innovative ways to improve safety, such as technologies and infrastructures for informing drivers about road hazards, and road infrastructure that is ‘self-explanatory’ and ‘forgiving’
Reducing Costs and Disruption of Long Distance Corridors	Long Distance Corridors • Reducing Costs and Disruption	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Construction Concepts and Processes • Advanced Maintenance and Rehabilitation	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries

Foresighting and roadmapping activities for the generation of the HLSI of the future - *Coordination & Support Action*	Transversal Areas • Foresight and Roadmap	All items	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • All items
Information Data Management for Infrastructure	Transversal Areas • Information Systems and ICT	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Construction Concepts and Processes Decision Making in European transport Infrastructure Investment • Advanced Asset Management Systems Supporting Systems and Services • Integrated Transport Infrastructure Data / Information Systems	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries

Research Topic Title	**Improvement and Deployment of a Life Cycle Assessment (LCA) Approach for Multimodal Hubs**
Reference to reFINE Roadmap	Multimodal Hubs • Reduction of Life Cycle Environmental Impacts
Reference to Cross-Modal Roadmap	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Construction Concepts and Processes Towards Zero Carbon Footprint • Low Carbon Construction
Reference to EC Working Doc[t] accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Set up multimodal centres throughout the European transport network and deploy eco-innovations in existing terminals, e.g. new terminal design concepts in ports to facilitate interaction between modes
Scope / Focus	Multimodal Hubs as train stations, rapid transit stations, bus stops, tram stops, airports, ferry slips, seaports, truck terminals… are necessary elements for people and cargo mobility. Along their long life, Multimodal Hubs have relevant positive and negative impacts for the citizenship and the environment. **Green** Multimodal Hubs have to be designed from the very beginning for a **minimum environmental impact** over their entire life cycle. When adequately planned and designed, Multimodal Hubs can be major contributors to reducing energy and CO_2 emissions during construction and **operation**, materials resources and wastes during construction, maintenance and demolition, land occupation during service life, nuisances and environmental impacts (noise, vibrations, pollution...)…
Scientific & Technological objectives / outcomes	Reducing environmental impacts of Multimodal Hubs requires the development and deployment of a Life Cycle Assessment (LCA) approach that considers the specificities of these infrastructures: long life, people and cargo involvement, participation in the urban-territorial development… LCA relies on a multi-criteria approach including the use of natural resources (land, water, energy and construction materials), nuisances – environmental emissions (air, water, soil, noise…) and related impacts (human health, biodiversity, climate change…). In order to weigh up the advantages and disadvantages related to implementing different solutions on Multimodal Hubs, it is necessary to improve and enhance LCA methodologies and develop supporting tools for more accurate predictions of their environmental impacts in terms of, for example: • Integration of global impacts (currently assessed by LCA) and local impacts related to the specific location of Multimodal Hubs (as impacts assessed through an Environmental Risk Assessment for instance). • Development of dynamic LCA methods that distinguish between “elements” constant in time and “elements” which vary with time (impacts related to energy for instance will decrease as more renewable energy will contribute to the energy mix). LCA should involve the assessment of different possible future scenarios and trends (electric vehicles vs. hydrogen vehicles, fossil fuels economy vs renewable based-low carbon economy, for instance). • LCA should be able to be continuously updated through the integration with monitoring data. • In order to promote the use of LCA, LCA supporting tools should be very friendly for the user and very close to design tools; it should be mandatory to obtain a LCA at the Multimodal Hub design phase. • Supporting databases should be available and periodically updated for all users.

	These databases should consider the geographical location. • LCA should be able to assess the development of specific technology solutions needed to decrease negative environmental impacts, such as noise, vibration, air and (ground)water pollution, Green House Gases (GHG) emissions, induced by infrastructure planning, design, construction operation and maintenance. • LCA tools should support eco-labeling schemes in Multimodal Hub construction and maintenance.
Expected Impacts	The application of LCA methods to Multimodal Hubs can be benchmarked against the following impacts: • Reduction of direct energy consumption in Multimodal Hub management and operation by 30% by 2030, and substantial indirect energy consumption related to reduction of congestion, improved interconnection, public transportation promotion… • Reduction of carbon emissions - by 30% by 2030 - related to direct and indirect energy consumption and the increase of renewable energies use (by 30% by 2030). • Drastic reduction in construction, demolition and excavation waste to landfill by 2030. • 20% less noise and 50% less local air pollution by 2050. • 100% of multimodal Hubs will support sustainable vehicles by 2050 (use of electric, hydrogen and hybrid technologies). • Energy related to fossil fuel sources will be reduced by 30% by 2030 in Multimodal Hubs. • Eco-labeling schemes promoted.

Research Topic Title	**Optimising Costs of Infrastructure Networks by Extending their Service Life**
Reference to reFINE Roadmap	Urban Mobility • Optimisation of Costs
Reference to Cross-Modal Roadmap	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Maintenance and Rehabilitation
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Carry out R&D to extend the life-span of existing infrastructures, to achieve a better understanding of degradation and ageing processes and to reduce disruption caused by network congestion
Scope / Focus	A critical challenge of sustainable European cities is to maintain on the very long term ever denser transport infrastructure networks. Replacement of obsolete infrastructure components comes with an extremely high cost, and existing networks must be continuously maintained and updated to cope with today's new service requirements such as accessibility, security, vehicles powered with new sources of energy, increased traffic... In the urban context, these interventions are subjected to difficult constraints such as constricted working sites, sensitive urban environment, and the necessity to maintain continuity of service during works.
Scientific & Technological objectives / outcomes	Fighting obsolescence and continuously upgrading existing urban infrastructure networks is a priority to reduce their social cost. First concern is to continuously adapt the existing infrastructure to new service requirements such as accessibility for all, security, vehicles powered with new sources of energy, increased traffic flow, increased traffic load, adapting to climate change. A second concern is to maintain at all times a full functional capacity of all components of infrastructure. Research can include: • New components and construction processes to minimise 'by design' overall maintenance costs (costs of interventions, number and duration of interventions, costs of service interruptions) while ensuring safety conditions. • New in-situ material reinforcement techniques. • New safe and non-intrusive techniques to create new access routes to existing underground infrastructure. • New non-intrusive techniques to improve, repair and reinforce the capacity of existing infrastructure (surface or underground). • New concepts / components for integrating electric vehicles into existing infrastructure. • New concepts / components for integrating instrumentation and monitoring systems into existing infrastructure. • Integrated monitoring and instrumentation of interventions to control safety and minimise nuisances to the urban environment (vibrations, settlements…).
Expected Impacts	• Existing infrastructure networks to become components of a low-carbon Integrated Transport System by supporting new low-carbon vehicles and transport modes. CO_2 emissions linked to operation / maintenance works are assessed and controlled. • Recycling & reusing of existing infrastructure networks are powerful means to optimise costs and decrease Life Cycle environmental impacts of Integrated Transport Systems. • Urban Mobility Networks are efficient and effectively accessible and safe for all

	users. Cultural Heritage structures are maintained in operation while offering service levels similar to those of new infrastructure. Existing infrastructure becomes resilient to climate changes. • Construction and managements costs of Urban Mobility Networks are optimised and associated risks are controlled. Construction and maintenance of underground networks is as safe and economical than for surface facilities. Construction, upgrade and maintenance works are easy to plan and optimise, because they are industrialised, highly automated and furtive (with no impact on operations).

Research Topic Title	**New solutions to reduce impacts and nuisances related to urban infrastructure construction, upgrade and/or maintenance**
Reference to reFINE Roadmap	Urban Mobility • Minimizing Nuisances of Urban Networks
Reference to Cross-Modal Roadmap	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Maintenance and Rehabilitation
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries
Scope / Focus	A vital component of sustainable European cities is a High Level Service Infrastructure of Urban Mobility Networks. Urban Mobility Networks require continuous improvement, adaptation, maintenance through processes that usually imply impacts and nuisances for citizenship in the form of noise, vibrations, pollution (dust), traffic disruption, congestion... It is therefore necessary to develop new methods, processes, technologies, techniques and products for improving construction processes to make them fully compatible with the urban environment (no damages to existing built environment, no noise, no dust, no vibrations, no congestion of traffic…) and at the same time cost-effective.
Scientific & Technological objectives / outcomes	• Development of new “discreet” methods to build new infrastructure with no interruption of traffic. • Development of new “discreet” methods to maintain or upgrade existing infrastructure network under service conditions (no interruption of traffic). • Development of “green” construction methods and materials reducing transport of materials (lean design, in-situ recycling…). • New or improved technologies and processes to increase productivity and reduce the environmental impact of tunneling (underground construction) in urban areas. • Development of efficient and “discreet” techniques for construction, repair, maintenance, replacement, reinforcement and relocation of utilities networks for transport infrastructure construction / maintenance works. In particular, robotic techniques for inspection and repair, accurate methods for locating existing utilities; new techniques to minimize the size and costs of excavations and backfilling - small-dimensioned trenching with new, mechanized laying techniques; new concepts for integration of utility networks (gas, water, sewer, electricity...) in a single built infrastructure or duct…
Expected Impacts	• 30% less people suffering from noise, pollution and vibrations. Reduction of noise complains. • Reduction of traffic disruption due to construction and maintenance. • Time for developing or upgrading infrastructure to meet new demands reduced by 50%. • Underground operations with zero impact on existing surrounding urban areas by 2050. • Economic losses due to nuisances from construction, maintenance and retrofitting reduced by 50%.

Research Topic Title	**Solutions to preserve the functional use of urban networks in emergency episodes related to natural and man-made hazards and climate change impacts.**
Reference to reFINE Roadmap	Urban Mobility • Increasing Resilience of Urban Networks
Reference to Cross-Modal Roadmap	Resilient Transport infrastructure Operations across Europe • Climate Resilient infrastructure Network
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries
Scope / Focus	Roads, tunnels, bridges, canals, water courses… in urban areas and related energy, water, waste… infrastructures are the backbones of urban connections and urban functions. Man-made and natural hazards and climate change impacts threaten these connections and subsequently urban functions. It is therefore necessary to adapt the urban infrastructures to avoid congestion, service interruption, system breakdown and systemic crisis through reinforcing effects rippling through interconnected infrastructures by network design, asset management strategies, early warning systems, specific solutions…
Scientific & Technological objectives / outcomes	Solutions to be considered for adaptation of urban networks are for instance: • Methods and tools for urban infrastructure planning and design that consider from the very beginning contingency planning through the identification of capacity bottlenecks in the network as well as determining appropriate levels of (local) redundancy, in order to accommodate major intrusions to the steady state such as from maintenance and rehabilitation actions, large events or natural causes, including climate change. For a selection of such major disturbances, vulnerability maps should be developed that can be used for developing adaptation (and mitigation when applicable) strategies. • Early warning systems related to natural and climate change hazards that integrate real-time monitoring data and prediction tools for an early and reliable knowledge of the situation for Emergency Plan development and deployment. • Development of specific adaptation measures for transport infrastructure minimizing the impact on seamless transport operation, and strategies to provide optimal information to urban infrastructure users. These measures could include the application of new materials, techniques and systems for construction, operations and maintenance in order to ensure reliable availability during unfavorable conditions.
Expected Impacts	• No service disruption - services offered by urban infrastructure do not stop during episodes related to natural and man-made hazards and climate change impacts. • Connections offered by urban infrastructure do not break during episodes related to natural and man-made hazards and climate change impacts. • Reduction of cost (insurances, reconstruction...) related to natural and man-made hazards and climate change disasters.

Research Topic Title	**Extending the Life Time of Existing Infrastructure**
Reference to reFINE Roadmap	Long Distance Corridors • Extending the Life Time of Existing Infrastructure • Increasing the Capacity of Existing Infrastructure
Reference to Cross-Modal Roadmap	Safe and Secure Transport Infrastructures and Operations • Advanced Safety Technology • Advanced Safety Management Systems
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Carry out R&D to extend the life-span of existing infrastructures, to achieve a better understanding of degradation and ageing processes and to reduce disruption caused by network congestion
Scope / Focus	With a 50-years design life at an end, we now face 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 structural behavior monitoring? The ensuing reconstruction works will inevitably create an important disturbance of traffic with associated economic consequences. The cost of replacing the existing European infrastructure is astronomical, and massive coordinated investment and funding is necessary.
Scientific & Technological objectives / outcomes	Safety assessment and life time extension of existing structures through: • Development of new advanced methods for characterization and assessment of the safety of existing structures, taking also into account economic considerations and limits for human safety. • Development of performance indicators and performance-based design closely connected to probabilistic modeling and prediction. • Better understanding of structural load, resistance and deterioration mechanisms and their effects on asset performance and residual life. Monitoring plays an important role here: ▪ New sensors, methods and tools for continuous monitoring and assessing (the status) of existing structures, e.g. relatively to structural loading and deterioration potential. This includes new (non-destructive) testing methods (radar, ultrasound, optical fiber, wireless smart sensors...) for diagnostic, early damage detection and maintenance of infrastructure. ▪ Integration of terrestrial and satellite systems for the structural health monitoring of key infrastructure located in a natural risk prone area (earthquakes, landslides, floods…). New concepts and components to extend the capacity and life time of infrastructure: • Development and application of more durable materials and components as well as of processes for enhancement of service life of existing structures / components of structures. • Development of improved tools for determining infrastructure condition and longevity. New smart sensing and communication technologies Integration online hazard assessment techniques. • Composite materials with integrated Structural Health Monitoring. • Metrics to quantify resilience for drafting proper codes and standards. The basis for the definition of acceptable risk under consideration of all societal and

	political circumstances is to be established.
Expected Impacts	• Less maintenance intervals: 50% cost saving. • Life extension of the aged infrastructures by 50%. • Reduced costs and carbon usage compared to construction of new infrastructure; contribution to a 30% reduction in carbon emissions and a 50% reduction in generation of waste by 2030. • Less maintenance requirement and optimal planning of interventions (less cost, less environmental impact). Moreover, indirect costs like economic losses due to nuisances from construction, maintenance and retrofitting, or the ones due to traffic congestion or disruption caused by maintenance and retrofitting can be reduced. • Improved user appreciation through better information, less intrusion and consequent congestion, brought on by optimal planning of necessary interventions. • Better European and global market opportunities for the construction sector. • Considerable improvement of resource efficiency through increased reuse and capability enhancement of components and materials.

Research Topic Title	**Assessing Risks Associated to Long Distance Corridor Structures**
Reference to reFINE Roadmap	Long Distance Corridors • Resilient, Safe and Secure Corridors
Reference to Cross-Modal Roadmap	Resilient Transport Infrastructure Operations across Europe • Climate Resilient Infrastructure Networks
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries • Develop coordination mechanisms and structures that would allow operators to provide seamless services with a minimum number of interruptions. The structures and mechanisms must be sufficiently resilient to handle the impact of these services, using integrated information and communication systems • Find innovative ways to improve safety, such as technologies and infrastructures for informing drivers about road hazards, and road infrastructure that is 'self-explanatory' and 'forgiving'
Scope / Focus	The reliability and predictability of the mobility of goods and passengers is of vital importance within Europe. 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, 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. Over the last years the number of (natural) hazards in relation to infrastructure has increased and reliability and robustness have become key issues.
Scientific & Technological objectives / outcomes	Development of new methods and tools to guarantee the continuity of services in long distance corridors in case of unexpected events like accidents, explosions and other hazards. For instance: • Advanced assessment of tunnel safety to guarantee the continuity of service of the TEN-T network. Methods to quantify safety risks (internal safety, external safety and structural safety). Solutions to mitigate risks. • Tools for providing efficient and fast appropriate measures in case of accidents and reducing their impacts. Development of models, methods and tools for assessing and reducing impacts of seismic events and improved assessment and protection: • Experimental and theoretical studies (design procedures and improvement techniques) on the seismic response of structures. • Setting up of models and criteria to define optimal strategies for the reduction of the global seismic risk. Tools for mitigating risks linked to extreme climatic effects. In particular: • Risk management tools and decision-support systems for assessing flood risks and the safety of hydraulic structures. • Impact and adaptation of infrastructure to sea level rise (e.g. roads as flood defenses).
Expected	• 100% reliable networks during extreme events caused by climate change.

Impacts	• Lower disruption of traffic due to hazards: 30% less traffic disruption by 2030.

Research Topic Title	**Reducing Costs and Disruption of Long Distance Corridors**
Reference to reFINE Roadmap	Long Distance Corridors • Reducing Costs and Disruption
Reference to Cross-Modal Roadmap	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Construction Concepts and Processes • Advanced Maintenance and Rehabilitation
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries
Scope / Focus	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 infrastructures, with higher levels of requirements (new uses, better quality, high serviceability, better sustainability…) and their interconnection with the existing network, but also the maintenance, upgrading and adaptation of existing ones to new needs. The challenge is to keep this huge cost socially acceptable, and maintain funding at adequate level.
Scientific & Technological objectives / outcomes	Development of new methods and techniques to reduce costs, construction time, and impacts on traffic. In particular: • Development of highly industrialised construction means/processes with the objective to minimise life cycle costs. • New methods for on-site construction with prefabricated components. • New solutions (e.g. based on a larger use of prefabricated materials) that allow for a significantly lower disruption of traffic due to road maintenance and upgrading. • Methods and tools for an optimal management of asset maintenance, repair and upgrading, and eventually replacement, with low impact on service and environment.
Expected Impacts	• New high-end calculation methods with monitoring: 20% cost saving. • Innovative construction of upgraded and new structures: 30% cost saving.

Research Topic Title	**Foresighting and roadmapping activities for the generation of the HLSI of the future -** *Coordination & Support Action*
Reference to reFINE Roadmap	Transversal Areas • Foresight and Roadmap
Reference to Cross-Modal Roadmap	All items
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • All items
Scope / Focus	The **Foresight** activity is relying on prediction and forecasting of futuristic needs and breakthrough innovation, towards ***pan-European "HLSI[2] 2040"***. It aims at visionary scenarios including prospective evolution and profound transformations of infrastructure, based on large-scale changes induced by society and sustainability, and influencing on the long term public policy and strategic management and business in companies. The **Roadmapping** activity derives from a need to update views on (especially short-term and medium-term) activities in terms of applied RDI, based on the current state-of-the-art: the Roadmap is to be updated on a regular basis, typically every 2 years.
Scientific & Technological objectives / outcomes	**Extend current infrastructure towards an harmonised and interoperable network of HLSI ("HLSI 2040" vision)**: this requires to continuously work out a permanent community building and comprehensive operating method allowing all affected and relevant communities of actors to act as *breeding and nurturing grounds for innovation* with the purpose of starting up **"innovation cycles in HLSI development and generalisation**" - implying the completion of the following main activities: • Build a **strategic alliance at a European level** to create the required conditions for dialog and consultation between all complementary communities for developing HLSI to be intensively deployed by 2040: companies in building and infrastructure sectors, process engineering specialists, equipment providers, energy companies, ICT software companies, as well as local and regional authorities. Put in place mechanisms to achieve relays in each country through **national strategic alliances**. • Generate a common vision as regards needs for collaborative RDI covering products, systems & services for HLSI development, operation & management – also based on current use cases / best practices. • Develop a shared **vision**, **Strategic Research Agenda** (SRA) and detailed **Implementation Activity Plan** for future RDI – including the establishment of European-scale actions and ambitious (real life) pilots spanning from research to deployment – and the identification of required standardisation needs. • Develop common indicators, methodology and instruments to experiment and evaluate RDI solutions, and for impact assessment. • Establish a detailed plan for **coordination of information exchange and dissemination** between all infrastructure-related RDI projects, initiatives and stakeholders – so as to promote a better understanding, a closer dialogue and a

[2] HLSI : High-Level Service Infrastructure.

	more active cooperation between researchers, end-users/practitioners, facilities owners, infrastructures builders as well as operators, technology-suppliers, software developers…
Expected Impacts	• Comprehensive map of new generation of transport infrastructures to accommodate the predicted changes in travel requirements for passengers and freight including consideration of: ▪ Use of natural resources and legislative requirement to reduce CO_2 – and how can infrastructure contribute to this. ▪ Predicted changes in passenger and freight quantities and routes. ▪ Predicted long-term performance of existing infrastructure facilities. ▪ Climate change impacts. • Innovative technologies and systems leading to smart, green and cost-efficient HLSI, with dissemination of the generated foreground / know-how. • New schemes for HLSI deployment & operation – including provision for exploitation of new business models and new market opportunities, and the contribution to the opening of a market for novel infrastructure operation and maintenance processes and systems (including ICT-based ones). • Establishment of a collaboration framework between academics and research centres, industry and SMEs (from construction, energy, transport and ICT sectors), and public bodies / local authorities. • Continuous improvements in standards & potential regulations – with identification of areas where standardisation work is required. • Facilitation of project generation – thanks to awareness raising of all different kinds of actors, networking coordination, and greater access for industry and research organisations to funding and partnerships.

Research Topic Title	**Information Data Management for Infrastructure**
Reference to reFINE Roadmap	Transversal Areas • Information Systems and ICT
Reference to Cross-Modal Roadmap	Non-Intrusive Construction, Maintenance, Enhancement and Renewal • Advanced Construction Concepts and Processes Decision Making in European transport Infrastructure Investment • Advanced Asset Management Systems Supporting Systems and Services • Integrated Transport Infrastructure Data / Information Systems
Reference to EC Working Doct accompanying COM(2012) 501	Field 5: Smart, green, low-maintenance and climate-resilient infrastructure • Design and create efficient infrastructure networks for improved mobility, specifically targeting transport network systems and stressing the importance of interoperable and inter-modal networks and interfaces across Europe, including interfaces between neighbouring countries
Scope / Focus	Infrastructure networks have to face sustainable challenges such as affordable costs, increasing environmental requirements and high-level service expectations. This requires innovative solutions, partly relying on information systems and ICT. The large progress obtained by the manufacturing industries by using intensively Digital Mock Ups during the whole development process of products is the expected impact of this topic. Some works have been initiated by the sister building industry based on the so-called Building Information Modeling (BIM). But up to now, the reference of the project remains a set of drawings, and when existing, digital mock ups rely on the drawings. The ambition is to place the digital mock up at the centre as the reference of the project and to develop BIM for infrastructure.
Scientific & Technological objectives / outcomes	The main goal of this research is to develop concepts, methods and tools to create and manage product information associated to High-Level Services Infrastructure (HLSI) during the whole life cycle of infrastructure. All involved stakeholders should be able to exchange and share information of the project BIM. The sharing and exchange of information should be in accordance with the contracts binding the different stakeholders with respect to their individual responsibilities and liabilities. Change management is a key process to maintain confidence regarding the information quality. It should address information validation, approval and decision making tracking. Versioning management at entity level instead of drawing level is a key issue. In addition to geometric representation of the different entities describing the project, the model should also include properties allowing numerical simulations and relationships allowing a simulation tool to “understand” the model without human intervention. Interoperability is a key word to allow information exchange between software tools with different proprietary formats according to their discipline domain and capabilities. Infrastructure projects are immersed in existing geographic areas. Therefore the existing data are partly described in Geographic Information Systems (GIS). Exchanging with GIS is also a key issue to validate the consequences of the project against the existing areas from a sustainable development point of view, for

	instance regarding nuisances during construction and operation. Alternative is a key word. Such a BIM for infrastructure should allow simulation of alternative solutions that could be the basis of coordination or communication meetings.
Expected Impacts	• Greater design efficiency, better quality of infrastructure products. • More efficient business processes thanks to better integration and interoperability, and improved communication between stakeholders (in particular with the supply & logistics chain).Wide-spread adoption of standards for data exchange. • Reduction and optimization of environmental impacts of infrastructure during their whole life-cycle, by applying multi-criteria LCA approaches. Better resources utilization. For instance, 30% reduction in CO_2 emissions of construction materials production is targeted by 2030, and noise impact of long-distance corridors is reduced by 20%. • Reduction (up to 30%) of construction and maintenance costs, extension of existing infrastructure lifetime (up to 50%) thanks to appropriate maintenance and management.