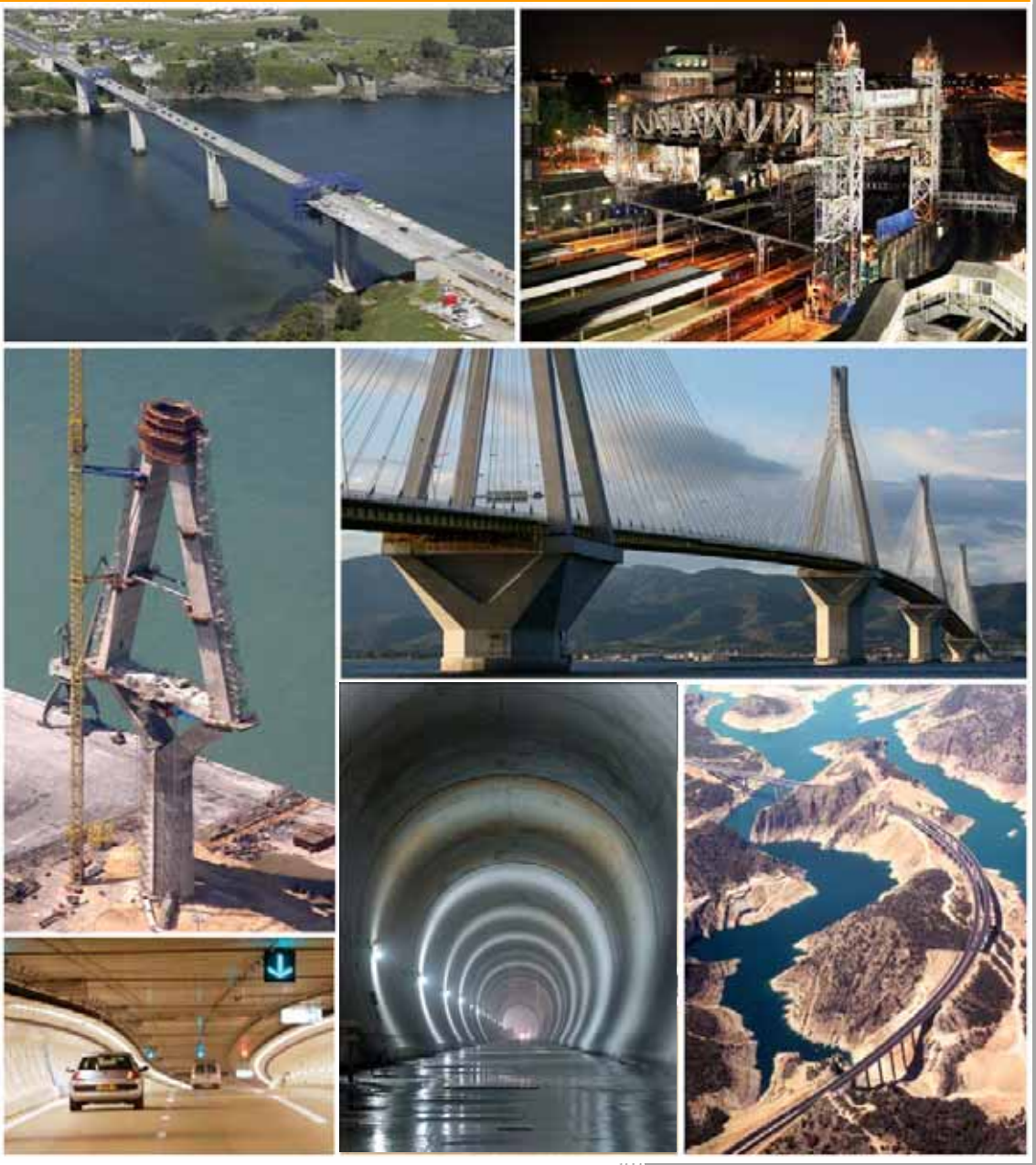
An initiative of the European Construction Technology Platform

Research for Future Infrastructures in Europe

reFINE

Building Up Infrastructure Networks of a Sustainable Europe



From left to right:

Los Santos Bridge. *Paddington Bridge.* ***Cádiz Bridge.***

Rion Antirion Bridge. ***Tunnel in A-86.*** *Ferden Tunnel.*

Viaducts and Tunnels in A-3

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1. Introduction

Infrastructure networks provide transport for people and goods. They are fundamental lifelines of today's society. The quality of services they offer and their condition affects the competitiveness of the European industry and the quality of life of European citizens. However, in the coming years, numerous challenges are expected to put the current system under pressure. On the internal market demographic changes, the inevitable adaptation to climate change, increasing energy costs and the need to minimise impact of human activities on the environment all present new challenges that need to be addressed within our lifetimes. On the external dimension, the process of globalisation will offer increasing opportunities for the European industry provided constraints and barriers will be removed.

Urgent action is necessary to transform our infrastructure networks into an accessible, efficient integrated and sustainable transport system to support European economic growth and human and social development, by upgrading and developing the infrastructure at reduced, affordable and controllable costs.

The European Construction Sector is the largest single sector responsible for the shaping of our built environment; it is proud to introduce with this document a new initiative, **reFINE** (research for Future Infrastructure Networks of Europe)**,** proposed by the European Construction Technology Platform (ECTP) with the objective to present necessary research actions for tomorrow's Infrastructure Networks of a sustainable Europe.

Normandie Bridge

2. Transport Infrastructure Networks - Lifelines of European Society

By the year 2050, 84%[1] of the world's population will be living in urban and suburban areas[2] as a result of demographic developments – an aging population, migration and internal mobility. Provision must be made for this continuous urban population growth to enhance the economics of European cities and reduce their environmental impact. Concurrently, deeper integration of countries and regions into an emerging global system of production and trading is expected to reshape transport, trade and supply patterns towards larger hubs which are connected through a dense web of links.

When considering the services necessary for this growing and changing population, infrastructure networks will form the arterial system of our society. They cover a wide range of social needs – mobility of people, distribution of water, electricity, gas, transport of freight and trade of industrial and agricultural products. Not having good access to transport and good internal networks at local, regional and national levels makes it difficult to maintain links between production, distribution and consumption. Europe will lose business without modern communications and connections to the international economic hubs and markets. In the global economic market, financial and human capital moves to the most competitive locations offering the best combination of work and living standards: human skill, quality of life, good transport links, production costs. Moreover, infrastructure networks are expected to provide reliable service for very long periods of time, covering major technology advances, spanning several generations and constantly evolving to enhance the quality of life of users.

Europe currently possesses one of the densest and most developed infrastructure networks in the world, a huge legacy and cumulated investment inherited throughout its long history. It possesses the oldest road networks, the first ever subways and railway network links to the seaports and airports, along with magnificent new transport links such as the Millau Viaduct[3] in France. Europe's prosperity stemmed from this, and now depends on it.

The impressive magnitude of Europe's infrastructure

Roads: More than 60,000 kilometres of motorways out of a total road network of approximately 5 million kilometres in the 27 European Union member states (EU 27). By 2020, TEN-T will include 95,700 km of motorways.

Railways: the total length of railway lines is approximately 215,000 kilometres, out of which 107,400 kilometres are electrified. By 2020, TEN-T will include 106,000 new kilometres of railway lines linking the main European cities.

Waterways: 41.000 km of navigable inland waterways

Total investment on Transport infrastructure in the period 2000-2006 was € 859 billion [4]

[1] COM(2009) 279 final - A sustainable future for transport: Towards an integrated, technology-led and user
friendly system.
[2]Population Reference Bureau : http://www.prb.org/Educators/TeachersGuides/HumanPopulation/urbanization.aspx
[3] It is a multi-spanned cable-stayed road-bridge in southern France opened to traffic on December 2004.
[4] First Intermediate Report "Evaluation of cohesion policy programme 2000-2006, work package transport", August 2009

Large variations exist in infrastructure within the different Member States and even though new lines have been built or are planned to complete the TEN-T network, it is true that they are often strained beyond their intended capacities in terms of traffic rate and traffic load. Large parts of the network already require significant refurbishment.

Moreover, the demographic growth and other factors like urbanisation and macro economic development impose an increasing demand on infrastructure networks, leading to critical saturation of infrastructure lines and nodes. It is necessary to increase their capacity and to extend their service life, while coping with new demands for safety, quality of service and sustainability.

Within the constraints of current funding, the construction of a large number of new infrastructure is not feasible, so efforts will have to be concentrated on rehabilitation, strengthening and monitoring of existing assets.

Solutions must aim at assuring the same level of service for both new and existing infrastructure, throughout Europe, by:

- the development of new projects integrating with and complementing the existing networks;
- the maintenance and upgrading of a huge existing asset of networks.

Upgrading of Los Santos Bridge

Furthermore, the global scenario imposes a series of new challenges:

- **A paradigm shift towards increased environmental awareness**: Infrastructure networks must be designed, built, operated and maintained in a sustainable way, reducing resource and material consumption, with a reduced environmental impact and with increased level of safety;
- **New concern about the availability and cost of energy**: new types of equipment will be developed, new uses of infrastructure will require new concepts, new products and new regulations to existing and new infrastructure;
- **An ageing society**: a new concern on the variety of users needs will necessitate a new approach to the design of infrastructure;
- **New conditions caused by climate change** : infrastructure networks must be adapted to cope with new and increased risks from natural hazards, including extreme events such as floods, droughts and rising sea levels;
- **Increasing economic constraints**: global competition obliges to optimise construction and maintenance costs and favours larger application of ICT solutions.

Roads of Elefsina Patras

3. Future Infrastructure Networks of Europe

Addressing these challenges in an efficient and cost-effective way is a huge task, requiring structured and coordinated investment and funding, along with new processes, new concepts and new products. It must draw from a common vision of the requirements for future infrastructure networks of Europe, to be shared by all stakeholders at European level: from public authorities to network owners, contractors, suppliers, users and also investors and insurance companies.

Infrastructure networks support the European social and territorial cohesion. They guarantee Europe's integration with the international and intercontinental market, while complying with the principle of sustainable development.

Infrastructure networks are accessible and well connected. They 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.

Infrastructure networks are integrated and efficient. They support a **competitive European economy** by providing fast means to develop European trade in a sustainable way: inside urban centres, between city centres and along major routes connecting Europe with the rest of the world.

Infrastructure networks are designed and improved to have a **minimised environmental impact** over their entire life cycle from design and construction stage to service, maintenance and final recycling. Continuous, efficient and reliable quality of service makes infrastructure a major contributor to reducing consumption of energy and natural resources by the European economy.

Smart and resilient infrastructure networks provide a high quality level, even ensuring a continuous and safe service throughout natural and man-made hazards and through climate change.

Quality of services provided by infrastructure networks is visible and recognised by users and by society. Infrastructure networks are commonly regarded as a shared heritage of great economic value; their **maintenance and upgrade costs are optimised and managed** as a necessity to preserve a continued quality of life for the future generations of European citizens.

Cádiz Bridge

4. Coping with the challenges

The development of transport networks is a priority of the European Commission. This priority was recently acknowledged by the European Commission in "A strategy for smart, sustainable and inclusive growth"[4]. In the second priority; "Sustainable growth", the "Resource efficient Europe" Flagship Initiative largely refers to the need for a better infrastructure to "modernise and decarbonise the transport sector", to accelerate implementation of strategic projects such as "cross-border sections and intermodal nodes (cities, ports, logistic platforms)" and "to develop smart, upgraded and fully interconnected transport and energy infrastructures and make full use of ICT".

EUROPEAN CONSTRUCTION SECTOR

Turnover of Construction Companies : (EU 27 - 2009) :
- 1,173 billion €
- 9,9 % of GDP
- 51,4 % of Gross fixed Capital Formation

3,1 million enterprises (EU 27), of which 95% are companies with fewer than 20 operatives.
14.874 million operatives 7 % of Europe`s total employment 29 % of industrial employment.
45 million workers in the EU27 depend, directly or indirectly, on the construction sector.
Exports : 71 billion € outside Europe.

Comparison with other countrie
- USA = 673 billion €, 6 million operatives;
- Japan = 557 billion €, 5.2 million operatives.
- China (2007) = 560 billion €, 31.3 million operatives

EUROPE - CONSTRUCTION OF INFRASTRUCTURE
Civil Engineering represents 22% of total Construction activities, or
258 billion €, and about 3 million operatives.

Facts and Figures on Construction Companies in 2009[5]

Eiffel's Viaduc Garabit

[4] Brussels, 3.3.2010 COM(2010) 2020 ; COMMUNICATION FROM THE COMMISSION ;EUROPE 2020 A strategy for smart, sustainable and inclusive growth.
[5] source : All figures from : FIEC *Construction In Europe, Key Figures | Activity 2009 – - May 2010 Edition*; except for Chinese statistics (2007), coming from an independent sudy.

The Construction Sector plays a prominent role in most infrastructure activities, integrating a great variety of technologies and processes as well as vast fields of expertise. It is also the biggest employer in Europe; with nearly 15 million operatives. If it were a country, it would rank at the 9th position in the EU 27. Infrastructure construction, also frequently referred as Public Works, accounts for about 22% of its activities. This puts major responsibility on the Construction Sector to face up to the challenges of Infrastructure Networks.

The sector also has to fight for its own sustainability, and to prepare for increasing threats from its own market and social environment:

- Increasing scale and complexity of large projects;
- Increasing international competition, especially from Asian countries, boosted by their dynamic local development, developing a very powerful Construction Industry (engineers, contractors, equipment manufacturers) already challenging Europe's position in the overseas market and soon due to spread over Europe's internal market;
- Increasing competition to attract new talents in more recent business activities such as finance, information technology and multimedia offering easier working conditions.

The challenges posed by the need of modernising and creating a unique integrated sustainable system of infrastructure networks must be regarded as an opportunity, for EU Construction Sector and related value chain, to expand their markets and increase their competitiveness

The Construction Sector has already set up a major initiative focussing on energy efficiency in buildings and districts as a response to the challenges presented by energy consumption in buildings. This initiative, called E2B (Energy Efficient Building) already gathers a very strong group of more than 130 stakeholders driven by industry and plays an instrumental role by ensuring critical mass, continuity in the implementation of research and long-term industry investment plans. However, in order to meet European targets for a comprehensive approach of the needs of European society in the construction domain, it is not enough to adapt buildings. It is also necessary to adapt another major component of our built environment – Infrastructure.

To face the new societal challenges described above, a large scale effort of research, development and innovation is needed at European level, targeting the specific activities linked to design, construction, operation and maintenance of Europe's critical Infrastructure Networks.

The urgency of the needs and the relative scarcity of available resources (competences, research staff, funding) oblige to prioritise and schedule the more strategic research activities. **reFINE** is the response proposed by the European Construction Sector, through its Technology Platform – ECTP – to take the lead and to mobilise resources in this area.

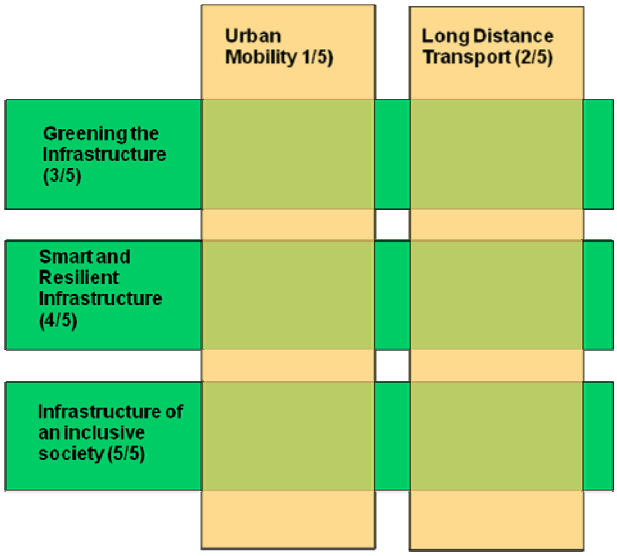
M-30 Tunnel

5. Priorities and research needs

It is proposed to divide research needs into five priorities:

- Two priorities addressing infrastructure types with different requirements: infrastructure for urban mobility and infrastructure for long distance transport.
- Three priorities addressing the major technical challenges posed by the new requirements of sustainability, safety / security, inclusiveness.

Vasco de Gama Bridge



5.1. Infrastructure for a sustainable urban mobility

Cities all over Europe must ensure a sustainable growth within their current limits. They must deal with a continuous increase of their population and their activities and try at the same time to improve quality of life. The challenges are to create efficient, accessible and less congested **urban infrastructure networks** well connected to interurban links, to service the new suburbs, and to upgrade and maintain the existing networks in the city centres.

Research topics include:

- *Cost effective underground construction in all ground conditions.*
- *Deeper and longer tunnels;*
- *Maintenance of urban infrastructure without interruption of traffic;*
- *Retrofit of old underground facilities under traffic and in constrained environments;*
- *Techniques and products for the interoperability of infrastructure and providing reliable multimodal links in an urban setting;*

- *Optimising transport modes, including rapid transport, personal public transport and mass-transit, integrated and / or dedicated freight distribution infrastructure linked with e-services;*
- *Use of underground and above-ground infrastructure for urban renewal including developing green spaces and reducing community isolation;*
- *Reduce environmental impact (noise, settlements) of infrastructure works;*
- *Safe underground construction under the built environment including heritage buildings of cultural importance.*

5.2. Infrastructure for a sustainable competitive economy

If Europe is to fulfil its economic and social potential in the global and internal market place, it is essential to create an interconnected seamless system, where existing infrastructure are as smart as new ones, with identical levels of safety and standards of service. Missing links have to be filled and bottlenecks and congestions removed. The TEN-T network has to be completed and maintenance and enhancement of the existing transport system, with no impact on operation, has to be prioritised over new works. Furthermore, environmental protection requirements need to be integrated with a view to promoting sustainable development.

A-19 Eco - Autoroute

Research topics include:

- *Reliable networks through a systematic approach to maintenance, operations and management that provide users and operators with predictable services levels;*
- *Preserving and improving existing infrastructure by adopting new technologies, techniques and materials that extend the lifecycle and increase capacity and durability;*
- *Adaptability of infrastructure for changing requirements and challenges;*
- *Industrialised construction; fast and long lasting techniques for maintenance and upgrade works under traffic (including bridges, locks, etc);*
- *Infrastructure with lower environmental impacts including less noise, less vibration, less energy consumption and less air pollution;*
- *Integration of transport infrastructure with terminals and intermodal connections;*

- *Service life models for durability and techniques to predict and monitor the long-term performance of structures and components subject to ageing and deterioration;*
- *Application of technologies and solutions for safer infrastructure through cost-effective forgiving road systems, safer road systems (including lower-spray, skid resistant surfaces).*

Channel Tunnel

5.3. Greening Infrastructure Networks

The primary objective here is to implement a new model of sustainable development. Infrastructure networks have a long life span, taking in centuries and generations of users and transport systems. A new approach is needed to promote the concepts of life cycle analysis and management. New developments are necessary in order to implement more flexible infrastructure design, which tackles multipurpose and multimodal aspects. New research is necessary to radically increase the service life of infrastructure beyond the current limits.

Research topics include:

- *Reducing the environmental impact (including visual impact) of Infrastructure Networks on users and residents in rural, urban and suburban areas.*
- *Protecting and increasing the value of an area by further development of planning, design, construction and upgrading, by using environmentally-friendly materials and technologies and by decreasing the impacts of rehabilitation works on traffic congestion.*
- *Adapting the infrastructure to cope with climate change, taking into account the need for cost effective methods.*
- *Tools and technologies to make infrastructure more climate-proof by prevention and protection in order to prevent delays, economic losses and accidents due to instability, unpredictability and loss of service.*
- *Minimising consumption of resources by using alternative forms of energy and by infrastructure re-use and recycling. This requires extensive investigation, performance modelling and testing in order to develop new environmentally friendly concepts and techniques for construction, operation, maintenance and dismantling.*
- *Energy recovery and energy harvesting techniques.*

5.4.Towards a smart and resilient infrastructure

Logistic networks are interconnected worldwide. The increasing traffic volume and complex interconnections make the system vulnerable during times of disruption. Solutions are needed to guarantee that the impacts of natural and man-made events are

systematically evaluated and mitigated, that monitoring systems are operational and that efficient support, crisis management and rescue operations are functioning. The vulnerability of the built environment that depends on the presence and operation of transport infrastructures must also be guaranteed. Smart and resilient infrastructure is needed to bring transparency and organisation given the increased complexity.

Research topics include:

- *Making infrastructure safer against terrorism and compatible with new sources of energies (e.g. fuel cells);*
- *System engineering;*
- *Risk analysis;*
- *Intelligent surveying systems, e.g. use of sensor systems and non destructive testing.*
- *Decision support and expert systems.*

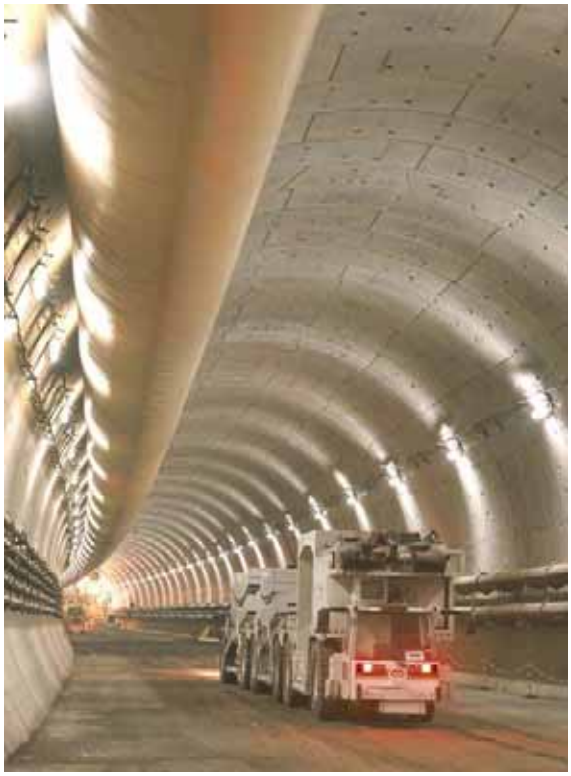
5.5. Infrastructure of an inclusive society

An ageing society is presenting new requirements for European infrastructure. For example one in every three road users in the future will be over 65 years old, will be used to driving a car and will want to continue to do so. The infrastructure network will have to accommodate this, ensuring more accessible and safer transportation means for all citizens.

Infrastructure construction sites rank among the most exposed work places, with accident rates twice as high as other industrial activities. A review of the construction process is required given these reports, taking Health and Safety as an important starting point.

Research topics include:

- *Integration of the requirements of various users;.*
- *Organisation at work;*
- *Automation / assistance at work;*
- *Site monitoring;*
- *Specific equipment to protect workers.*



Groene Hart tunnel

6. Generation and Implementation of RD&I

reFINE is a European Initiative proposed by the ECTP (European Construction Technology Platform). It is fully supported by the ECTP High Level Group;

Inside ECTP, **reFINE** is supported by major industry members including - Autostrade per l'Italia, Ballast Nedam, Royal Bam Group, Bouygues Construction, Dragados, Fcc Construcción, Ferrovial Agromán, Hochtief, OHL, Soletanche Bachy, Vinci and Züblin.

reFINE is supported by major research organisations in this area including - FEHRL (Forum of European National Highway Research Laboratories), IFSTTAR, Deltares, TNO, Danish Technological Institute, Tecnalia, ZUS (Technical and Test Institute for Construction Prague), Bundesanstalt für Wasserbau (BAW, Germany) University College Cork and CSIC Consorzio Tre (Italy).

reFINE has many interactions other other ETPs such as ERTRAC, ERRAC, WssTP, European Technology Platform on Industrial Safety, SusChem and Steel. Contacts with these platforms are underway.

reFINE is supported by professional associations including – ENCORD (European Network of Construction Companies for Research and Development) and FNTP (Federation Nationale des Travaux Publics – France).

Grande Ravine Viaduct