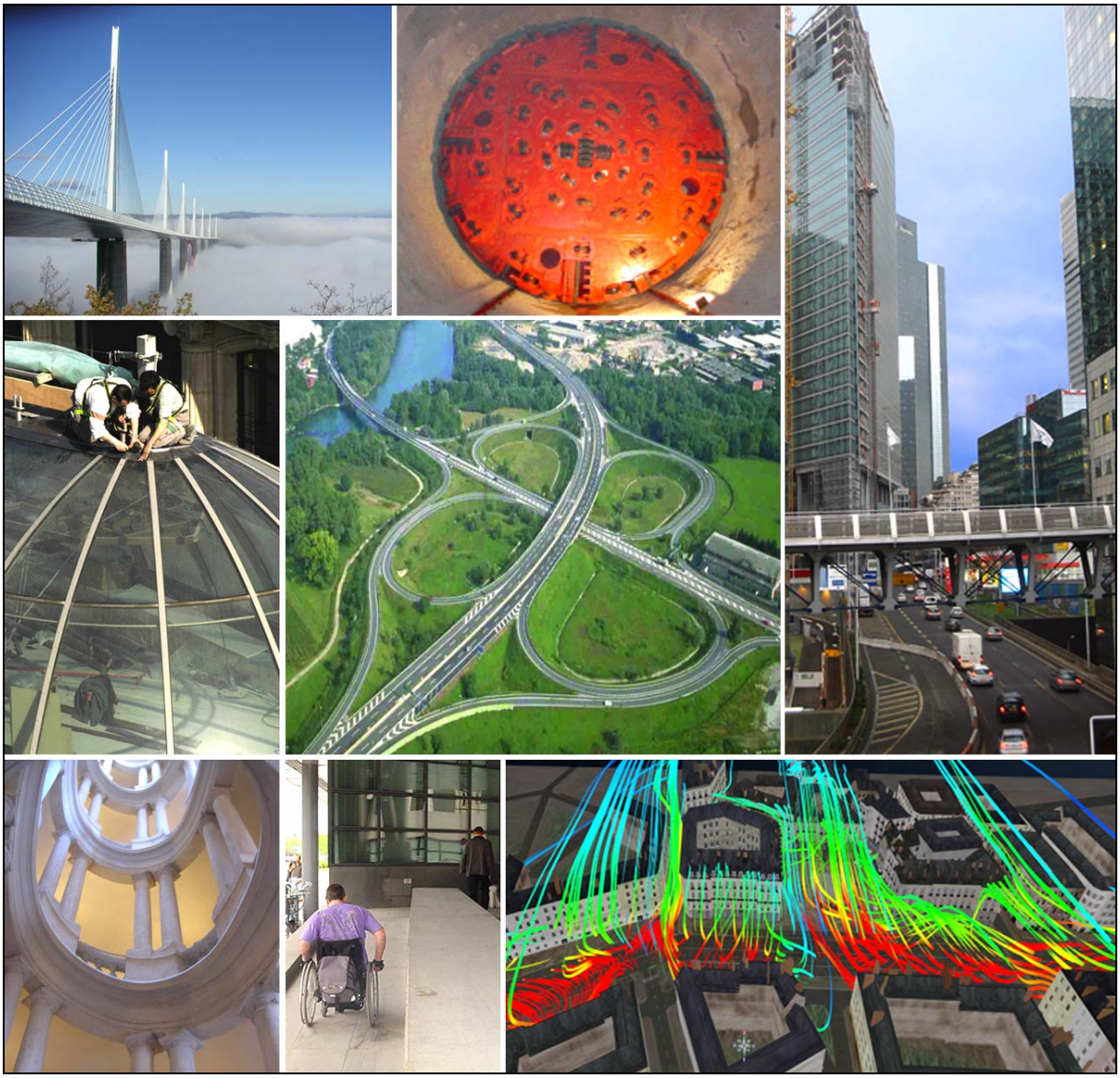
EUROPEAN CONSTRUCTION TECHNOLOGY PLATFORM



Strategic Research Agenda for the European Construction Sector

Achieving a sustainable and competitive construction sector by 2030

Draft Version, June 1st , 2005

European Construction Technology Platform (ECTP)
www.ectp.org

Preamble

This document is the first draft version of the Strategic Research Agenda (SRA) established by the European Construction Technology Platform (ECTP) that addresses the research needs of Europe in the field of Construction over the next 25 years, and sets out the likely directions of technological and organisational changes that will need to be converted into specific research programmes over the coming years.

Background to this SRA was the report on a vision for a sustainable and competitive sector by 2030 "Challenging and Changing Europe's Built Environment", endorsed by the High Level Group of the ECTP on the 1st of March 2005.

The Vision 2030 recommends the design and construction sector to engage towards a sustainable and competitive Europe. It sees construction to be increasingly client-driven, sustainable and knowledge-based, and proposes two inter-linked key goals :
- *meeting client requirements;*
- *becoming sustainable.*

These two goals are detailed through an objective to be reached and typical research targets gathered under main research domains such as:
- *process, product, infrastructure, cultural heritage, hazards, social sustainability for the goal of meeting client requirements;*
- *interaction of built and natural environments, interaction of built environment with citizens, production, existing buildings and infrastructure for the goal of becoming sustainable.*

These two key goals are supported by strategic research themes dealing with materials and technology, industry transformation, and service.

This Strategic Research Agenda is based on the preparatory elements of the Vision 2030. Purpose is to guide and stimulate all those interested with the relevant research programmes, whether from a governmental, industrial, social, funding, policy or regulatory perspective. It is not to list specific research programmes or collaborating actors, it is to pave the way for future research by clear sets of directions and priorities.

This SRA proposes Research Priorities organised along the two main goals of the Vision 2030: meeting client requirements and becoming sustainable. An additional goal on the needed transformation of the construction sector has been singled out. Under each goal, detailed research topics derived from research domains presented in the Vision have been sorted out according to major strategic research priorities agreed by the Focus Areas of the ECTP.

This draft Agenda is the first of a series of agenda documents aimed at delivering and updating a long-term view of research priorities and needs. It has been prepared by the ECTP with relevant contributions from the Support Group and Focus Area Members. It is still provisional, far from perfect, but already makes an important contribution towards organisation and optimisation of research efforts in the Construction Sector, from which discussion can start at European level to reach a large consensus on the ways and means to achieve the objectives of the Vision 2030. This Agenda is being presented to the High Level Group of the ECTP and will be revised according to its guidelines. It will also be complemented by some other documents prepared by the Focus Areas.

CONTENTS

1. Introduction

The Construction Industry of the previous century was oriented towards the construction of products: dramatic improvements were obtained in terms of industrialisation and efficiency of the construction process, and the performance of construction materials. For example, skyscrapers reaching 500 m; magnificent viaducts and bridges, spanning more than 1400 m; record tunnels reaching 56 km length; and record deep foundations, reaching 120 m. All these remarkable achievements were driven by technology and set the pace of innovation for the Construction Sector of the XXth century.

At the dawn of the XXIst century, European Society is facing an overwhelming number of challenges: demography changes, climate change, globalisation, and the gloomy perspectives of declining natural resources such as drinking water and oil. And yet, European Society is still relying on the Construction Sector to obtain better living and working conditions from its built environment: accessible and comfortable for all, durably enjoyable, efficient and flexible to changing demands, available and affordable.

For the Construction Sector, this represents a dramatic upturn: to convert a technology-push industry into a demand-driven sector. Race for performance is not the objective any more. The new key for development is sustainability: building durable structures, which do not impact on the environment, and instead, which consume a minimum of resources. The new criteria for success is the ability to satisfy customer's needs – all customers' needs.

This Strategic Research Agenda is presented by the European Construction Technology Platform (ECTP) . It follows a previous document, "*Challenging and Changing Europe's Built Environment - A vision for a sustainable and competitive construction sector by 2030*" which drafted and published a "vision" for the construction sector in Europe covering the period up to 2030, marking a new departure in the approach to research and development activities. This document was officially endorsed by the High Level Group of the ECTP at its first meeting on March 1st, 2005 in Brussels.

In the real world the demand for Research and Development is, quite correctly, driven by market forces of today, rather than by the need to turn into reality the visions for tomorrow. Essence of the Strategic Research Agenda is to establish long-term research objectives, and to organise research actions corresponding with both market driven innovation and the long-term vision. A well crafted Strategic Research Agenda will closely maintain the balance with both of these objectives: by creating a consensus between stakeholders on priority objectives, and by organising the progression from today's reality towards the vision's objectives.

This Strategic Research Agenda document is the result of quite a complex elaboration process, aiming at reaching the best possible consensus of all stakeholders of the Construction Sector on a reduced set of priorities. The Vision for 2030 should remain globally unchanged with time, but all main drivers for research will change continuously: the global context, technology, market forces. Therefore, this SRA is not crafted for ever: role of the ECTP will be to keep this document regularly updated.

2. The context of the European Construction Sector

2.1. Societal needs

The current picture of the European built environment presents a stark contrast between the best technological achievements like the recently completed Viaduc de Millau or the most beautiful examples of cultural heritage, co-existing with huge amounts of sub-standard housing and infrastructure, abandoned brownfield sites and neglected waste lands.

Our built environment shapes our society, the way we live, work, entertain and move around. The development of a sustainable built environment for all is essential for the realisation of a society based on equal rights and opportunities. Many persons in the society of today depend on an accessible built environment in order to live autonomous and active social and economic lives. This number will increase significantly with the demographic changes in Europe, making a "design for all" approach of particular relevance.

Maintaining, upgrading to a common standard, re-inventing this huge asset accumulated over past history is one of the main challenges confronting the enlarged European Union. Taking care of an omnipresent heritage while building a new society with high quality standards is a specific challenge of the new Europe, which places on the built environment a number of unavoidable and urgent social demands:

- **Creating a built environment accessible and usable for all:** action is urgent and necessary to cater for diverse needs of all, including persons with disabilities, persons with reduced mobility, young persons etc. Centuries of neglect and discrimination by design need to be compensated in existing and new built environment;
- **Improving health, safety and security of the built environment**: low indoor air quality, will continue to cause health problems and loss of productivity at work unless improved technology is introduced. As regards safety, special consideration has to be given to persons with impaired orientation capacity. The possibility for all, including persons with reduced mobility, to evacuate buildings in case of fire or any other emergency situation needs to be ensured. Earthquakes, fires and other accidents will continue to cause significant losses of life and property unless buildings are made safer.. The threat of crime and terrorism will hamper the well-being of people unless protective measures are taken into account in the design and maintenance of the built environment;
- **Contributing to objectives of the Kyoto Protocol**: action is urgent and necessary in order to dramatically reduce greenhouse gas emissions and the huge amounts of energy produced in an unsustainable manner from fossil fuels which are needed today for heating and lighting buildings which account for some 42% of all energy consumed, whereas construction activities account for about 5% of energy used including construction related transport;
- **Preserving the natural environment**: if no action is taken, the green field areas will continue to shrink, bio-diversity will be increasingly threatened, brown-fields will continue to spread and vital water resources will be increasingly at risk from contamination;
- **Preserving the natural resources**: . billions of tons of natural materials are used each year for construction. Construction and demolition waste is increasingly recycled, but still amounts to about 22% of all waste measured by weight, although most of it is inert. It is increasingly urgent to conserve non-renewable assets and increase the Sector's efforts to reduce environmental impacts;

- **Adapting to climate change**: urgent action is required to address the growing threat of disastrous damage expected to be caused by floods and storms arising as a direct consequence of climate change. Rising temperatures are expected to increase the demand for air-conditioning in buildings, the majority of which are ill-adapted to accommodate it. This tendency will further increase the demand for energy and if not urgently addressed will lead to even more greenhouse gas emissions, thus aggravating an already precarious situation;
- **Protecting against rising sea levels**: if no action is taken, huge and densely populated areas adjacent to low-lying coast lines in Europe will be threatened;
- **Preserving our cultural heritage**: if no action is taken, a further 10% of our tangible cultural heritage may have been lost by 2030;
- **Enhancing the urban environment**: if no action is taken, traffic congestion of main European cities will progressively reach breaking point and seriously hamper the economic and social development of Europe;
- **Maintaining at a high level of efficiency and service the patrimony of infrastructure systems:** it is necessary to meet the increasing and demanding needs of transport of persons, goods, energy, supply and information matching the need of new constructions against the preservation and upgrading of existing assets. If no action is taken, congestion will spread along major roads and railways; infrastructure will reach the end of their service life, requiring unbearable level of investment in particular in new Member States; systems for water supply and wastewater networks and installations will be dilapidating all over Europe; security and continuity of energy supply will be impaired throughout Europe;
- **Optimising the life-cycle cost of the built environment**: the demand is for a high quality of built environment, but the next imperative is to closely control its costs. If no action is taken, housing costs risk increasing to the point that affordable accommodation will be increasingly beyond the reach of growing numbers of citizens;
- **Improving its Health and Safety conditions**: although tangible progress has been made in recent years towards reducing the incidence of accidents on construction sites, unless pressure and initiatives to reduce them further are continually maintained, further progress will be elusive, the image of the sector will fail to improve, and recruitment difficulties will worsen.

The dimension and number of constructed facilities, the duration of their life time make a huge impact on European society, on its quality of life and on its economy. The Construction Sector involves all stages of the life cycle of these facilities: design, planning, material production, construction, facilities management, refurbishing, demolition and replacement. Its performance has an instrumental role to play in meeting these pressing social demands and direct and crucial impact on the European economy

Final demand of the society is for the Construction Sector to contribute to a competitive European industry. As the largest cluster employer in the EU, it accounts for 10% of the gross domestic product (GDP) and 50% of the gross fixed capital formation (GFCF); it has the capacity to provide employment for all levels of skills. This gives the Sector the responsibility to **ensure good working conditions for all its employees**. Due to declining birth rate and ageing of the population, shortages in competent work force become more and more evident. More attractive work places, and an improved productivity will be major challenges of the Construction Sector.

Moreover, poverty is strongly linked to the quality of the existing built environment. In many instances it is the unemployed or poorly trained members of our society who live in

sub-standard accommodation that in turn blights the built environment. Carefully crafted policies providing construction skills training for the unemployed and/or the unskilled, can simultaneously combat poverty through using those skills to improve the quality of the built environment.

The Construction Sector must also develop for itself a sustainable economy. It must maintain its technical leadership, which is a critical condition to keep ahead of a fierce and growing international competition, to preserve its internal market shares, to consolidate its international positions, especially in relation to the US, China and India. It must face persistent challenges in transforming and modernising itself. It must continue to strive for sustainability while addressing daunting and complex issues arising from climate change and the demographic evolution of Europe's society. In responding to these changing demands, carefully planned and targeted research and development efforts have a major role to play.

2.2. The European policies

First requirement to the Construction Sector is to take its share of the strategic goals of the European Policy:

- The **Lisbon strategic goal** (2000) to become by 2010 "the most competitive and dynamic knowledge-based economy in the world";
- The **Barcelona goal** (2002) of raising Europe's overall level of research investment from its current level of 1.95 % of GDP to 3 % by 2010, of which two-thirds should be from private sources.

Furthermore, the social demands must be placed in the perspective of the enlargement of the European Union and development of the single market. They are taken in account in European policy, which imposes many new requirements on the Construction Sector. Table 1 is a tentative to identify the principal legislative acts affecting the Construction Sector. This impressive list also reflects the social impact of construction activities.

Taking into account the continuous evolution of the European regulatory framework is an important consideration for any research actions undertaken, in order to anticipate the application of the directives in the context of the sector's activities, to prepare the new products and processes which are called for. Moreover, despite the large number of directives, Member States still have significantly different construction regulations. To a large extent, the differences have no rational technical basis and thus cause unnecessary barriers to trade within the European Economic Area. RTD actions undertaken by the Sector can be assigned the role of assisting the implementation of this regulatory framework in a truly European way, harmonised and homogeneous in all Member States.

HEALTH, HYGIENE AND SAFETY AT WORK	
Framework - health and safety at work	Council Directive 89/391/EEC of 12/06/1989
Proposal for a Regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)	SEC 2003 - 1171
Community strategy on health and safety at work (2002-2006)	Commission Communication of 11/03/2002
Use of work equipment	Directive 2001/45/EC
Temporary and mobile work sites	Council Directive 92/57/EEC
Exposure to noise	Directive 2003/10/EC
Exposure to mechanical vibration	Directive 2002/44/EC
Exposure to electromagnetic fields	Directive 2004/40/EC
SOCIAL MEASURES FOR TARGET GROUPS: DISABILITY AND OLD AGE	
Equal opportunities for people with disabilities: a European action plan	Communication of 30/10/2003
SUSTAINABLE DEVELOPMENT	
The energy dimension of climate change	Commission Communication of 14/05/1997
Strategy for sustainable development	Commission Communication of 15/05/2001
Integrating the environmental dimension into the urban environment	Decision No 1411/2001/EC
Strategy on Urban Environment	Commission Communication of 11/02/2004
ENERGY	
Energy efficiency: energy performance of buildings	Directive 2002/91/EC
Eco-design for energy-using appliances	Proposal for a Directive amending Council Directive 92/42/EEC
Energy Services Directive	COM(2003) 739 final, currently in co-decision procedure
New guidelines for trans-European energy networks	Decision No 1229/2003/EC
Scheme for greenhouse gas emission allowance trading within the Community in respect of the Kyoto Protocol's project mechanisms	Directive 2004/101/EC
CONSTRUCTION	
Construction products	Council Directive 89/106/EEC
Noise emission by equipment used outdoors	Directive 2000/14/EC
WASTE MANAGEMENT	
Framework Directive on waste disposal	Council Directive 75/442/EEC of 15/07/1975 on waste
Landfill of waste	Council Directive 99/31/EC of 26/04/1999
Strategy on the prevention and recycling of waste	Commission Communication of 27/05/2003
NOISE POLLUTION	
Assessment and management of environmental noise	Directive 2002/49/EC
CLIMATE CHANGE	
Implementation of the European Climate Change Programme (ECCP)	Communication from the Commission of 23/10/2001
Community post-Kyoto strategy	Communication of 19/05/1999
ENVIRONMENT	
Framework Directive in the field of water policy	Directive 2000/60/EC
Protection of groundwater against pollution	Proposal for a Directive
Strategic Environmental Assessment Directive	Directive adopted in 2004
Strategy for soil protection	Communication of 16/04/2002
CIVIL PROTECTION	
Flood risk management	Commission Communication of 12/07/2004
TRANSPORT	
Satellite navigation: Galileo	Commission Communication of 10/02/1999
Minimum levels of safety in European road tunnels	Directive 2004/54/EC

Table 1 Most Relevant Decisions of the European Institutions Affecting the Construction Sector

2.3. New Opportunities for Change Offered by Technology

The constant and fast evolution of technology imposes another pressure on the Construction Sector. Keeping ahead of international competition calls for the rapid integration of the most recent technological advances. This pressure must be seized as another opportunity to transform the Sector into a knowledge-intensive industry :

- Introduction of more human sciences to develop new business models based on customer focus, to develop human-oriented innovative construction processes ;
- Introduction of information technologies at all levels of the construction process and of the life cycle of structures: advanced design based on modelling and simulation; automation of construction plant and equipment, including advanced embedded electronics; advanced possibilities offered by wireless or mobile communication technology; advanced monitoring techniques and wireless intelligent sensors; integrated demand and asset management;
- Introduction of nano- and bio-technologies to develop new advanced multifunctional materials and re-engineer the corresponding components and construction processes;
- Implementation of communication technologies at all levels of the construction processes, with the objective of streamlining the flow of information and irrigating knowledge amongst all actors of the construction sites;
- Introduction of new services offered by satellites for positioning construction equipment, for monitoring works and their impact;
- Adaptation of new concepts developed by other manufacturing industries like car or aerospace : just in time production, Design for Disassembly and Design for Recycling.

3. Europe 2030: A vision for the Future of Construction

In a previous document, the European Construction Technology Platform drafted and published a "vision" for the construction sector in Europe covering the period up to 2030, marking a new departure in the approach to research and development activities. This vision was officially endorsed by the High Level Group of the ECTP at its first meeting on March 1st, 2005 in Brussels. Significantly, this document fulfils an important need for long term prospective on research needs and sets ambitious objectives to the sector :

Challenging and Changing Europe's Built Environment.
A vision for a sustainable and competitive construction sector by 2030

"In the year 2030, Europe's built environment is designed, built and maintained by a successful knowledge- and demand- driven sector, well known for its ability to satisfy all the needs of its clients and society, providing a high quality of life and demonstrating its long-term responsibility to the mankind's environment. Diversity in age, ability and culture is embraced. Equalisation of opportunities for all is an overarching principle; construction has a good reputation as an attractive sector to work in, is deeply involved in research and development, and whose companies are well known for their competitiveness on the local and regional as well as global levels."

The "vision" for the ECTP identifies a number of important and desirable objectives that should potentially lead on to developing better technologies, and to raising the level of "sustainability" in the sector both in terms of the characteristics of buildings themselves as well as in the processes of actually carrying out construction works.

In order to reach this vision, objectives and typical research targets are specified for two key aspects of construction: Meeting client requirements and Reaching sustainability.

Meeting Client Requirements

"Europe provides a variety of attractive, healthy, safe, accessible, useable and sustainable environments in which a diversity of social and cultural values are welcomed and fostered; places where significant economic prosperity is underpinned by social cohesion.

Advanced techniques and know-how for urban design and building enhance the competitiveness of the European construction industry. The construction sector is based on client- and user-driven complete life-cycle processes. Cost reduction of the overall value chain results in increased competitiveness, new business opportunities, new investments and in economically viable services to the largest possible client base. Optimal allocation of available economic resources is met.

New research focuses on how technology can address human sciences and socio-economics, and how the sector can profit from exploring the current design gap. Inclusion of diversity and the equalisation of opportunities for all are overarching principles that strengthen the sector by enabling it to reach new users and make contacts in many different communities. The design and construction sector is recognised by the public as indispensable to development of the built environment."

Becoming Sustainable

"Europe combines 'high tech' with 'high culture', and is a natural leader in creating a sustainable built environment. The built environment links nature and citizens in a sustainable way. The built indoor environment enables health and comfort in living, moving and working. The negative impacts of construction's whole life-cycle on the environment are radically reduced, thereby substantially improving the sustainability of the construction sector in Europe, with policies such as aiming for zero-waste construction and an efficient use of all resources. Environmental life-cycle approaches are adopted for design, construction works, maintenance and operation, as well as product development."

4. Strategic Research Priorities

In the real world the demand for R&D is, quite correctly, driven by market forces of today, rather than by the need to turn into reality the visions for tomorrow. It is important - the existence of the vision notwithstanding - that this remains substantially the case. Essence of the Strategic Research Agenda is to establish long-term research objectives, and to organise research actions corresponding with both market driven innovation and the long-term vision. A well crafted Strategic Research Agenda will closely maintain the balance with both of these objectives.

The SRA defines the research that needs to be carried out to achieve the vision whilst at the same time taking account of market forces. It is for these reasons that the SRA is inherently difficult to get "right" and at the same time a document of crucial importance. Ultimately, the success of the document will be judged on just two criteria, by two very different stakeholders:

- The users will expect to see the realisation of the vision, while
- The researchers will look for a framework where their talents can contribute and respond to the needs of the market place.

Construction is a huge industrial sector which involves more than 2.5 million enterprises. Furthermore, the dimensions of the social demand are multiple , which makes the selection of a coherent set of priorities quite a difficult task. Table 2 below gives the list which is proposed by the ECTP:

Meeting Client Requirements

1. Healthy, Safe and Accessible Built Environment for All
2. A New Image of Cities
3. Unlimited Underground Spaces
4. Mobility and Supply through Efficient Networks

Becoming Sustainable

1. Reduce Resource Consumption (energy, water, materials)
   - Cost-effective and Eco-efficient Built Environment
   - Efficient and Environmentally Friendly Building Materials
2. Reduce Environmental and Anthropogenic Impacts
   - Protecting Land and Water
   - Impact of Infrastructure on the Environment
3. Sustainable Management on European Assets
   - Transports and Utilities: a European Asset
   - A Living Culture for an Attractive Europe
4. Improve Safety and Security
   - Mastering Natural and Man-made Hazards
   - Safety and Security of Infrastructure Against Natural and Anthropogenic Hazards

Transformation of the Construction Sector

1. A New Knowledge-Based Construction Process
2. ICT and Automation
3. High Added-value Construction Materials
4. Attractive Workplaces

Table 2 List of Strategic Research Priorities

4.1. Meeting Client Requirements

4.1.1. Healthy, Safe and Accessible Built Environment for All

4.1.1.1 Introduction

The well-being of people is largely affected by health and comfort conditions during the main activities of living, working and transportation in an enclosed space, in which they spend more than 90% of their time. In more than 40% of the enclosed spaces people suffer health and comfort related complaints and illnesses. Improving health and comfort of the European population in those spaces has consequently a huge potential for economic and societal benefits obtained by increased productivity, reduced sick leave and medical costs, but also by the prevention of potential liabilities. New concepts, technologies, materials and processes to design, build and upgrade the built environment, to be inherently safe, attractive, environmentally friendly, healthy, comfortable and accessible for all, in a cost effective way and with regard taken to human behaviour should be developed.

Many people are today excluded from using parts of the built environment because of a design that did not consider the different needs of persons. Accessible built environments allow persons with disabilities and persons with reduced mobility, including many elderly persons, to live a more independent life and to stay autonomous longer. This is important not only for the social sustainability, but it would equally be economically beneficial for the society.

4.1.1.2 Research Areas

Medium-term

- Methods and strategies to ensure the design-for-all approach to retrofit of existing constructions and to new constructions, including the possibility for all, including persons with reduced mobility, to evacuate in case of a fire or any other emergency situation;
- Better understanding of the impact of the built indoor environment on health, comfort and feeling of safety. This understanding has two aspects:
  - Understanding the demands and desires of all occupants, expressed in harmonised performance indicators for health, comfort and feeling of safety
  - Understanding the information chain required and improving the information transfer
- Development of harmonised assessment methods from the human point of view (holistic approach), focused on:
  - Objective relations between stimulus and perceptual behaviour;
  - Sensors, actuators and systems that anticipate human perception;
- Improved knowledge of relevant needs for different groups:
  - Requirements for persons with impaired cognitive capacity, with mental illness or with vision impairment.
  - Requirements for persons with reduced mobility. Existing guidelines are to a great extent based on old ergonomic studies or simply on estimations. New types of technical aid, like new models of wheelchairs or lifting devices, will make it essential to adapt the requirements.
  - Optimised solutions and concepts to combine the requirements for different groups.
- Development of energy efficient systems and of innovative building materials providing healthy and comfortable indoor air quality and climate into new and existing buildings through:

- Temperature and humidity control
- Zero emissions and degradation of air pollutants

- Innovative concepts for safe, comfortable and healthy indoor environments with full participation of all stakeholders in environment and health, comprising of
  - New inter-relationship between demand and supply
  - Matching demand and supply

Long-term

- Realisation of healthy, comfortable and safe indoor environments, making use of the above and of:
  - innovative sustainable and smart materials and systems accessible to all people
  - new construction, operation and maintenance processes

4.1.1.3 Targets for 2030

- Accessible and safe for all built environment
- Reduction of the number of accidents at home due to poor indoor environment by 50%
- Improved feeling of safety and security at home, at work and on the way
- Improved awareness of people to sudden events (terrorist attacks, fire…)
- Improved general well-being of people through creating a better indoor environment (lighting conditions, air quality. acoustical quality, thermal comfort, accessibility, usability) by at least 20%
- Increase of productivity at the work place by 20%
- Reduction of Sick Building Syndrome by at least 20%
- Reduction in the number of people suffering from asthma, allergies and other respiratory diseases due to unacceptable indoor environmental conditions, by at least 20%
- Reduction in the need for air conditioning in new and existing buildings.

4.1.2. A New Image of Cities

4.1.2.1 Introduction

Cities should be developed through sustainable urban policies that ensure the holistic development with significant involvement of citizens in decision-making. A new understanding of the city as a system of buildings and other urban elements must be developed. This must be accompanied by a systematic adoption of holistic approaches together with mechanisms for the appropriate engagement of all actors in the process of city development in a way that builds consensus for a new image of cities: the most desirable places to live and work.

Cities are made up of buildings, streets, squares, parks and the spaces between them and they are supported by services and transport infrastructures. The inter-relationship, or architecture, of these various elements gives character to a city. The quality of this architecture has a fundamental impact on the well-being of those who live and work in cities. There is a need to better understand these interrelationships and the various ways in which their impacts are felt in urban situations. The challenge will then be to integrate the resulting conclusions into development policies, planning decisions and the design of cities and their components

The success of European society largely rests on the quality of the urban environment. This has been recognised by the European Commission by its undertaking work to develop a thematic strategy on the Urban Environment. This has been underpinned by the official recognition of the strategic role of cities in the achievement of the Lisbon Objectives of the European Union. In order to underpin this emerging political recognition, a wide range of research must be undertaken.

4.1.2.2 Research Areas

- The Behaviour and Flows of People, Energy and Materials in Cities
  - Developing indicators that assist in assessing the attractiveness of cities in economic, social and culture terms
  - Devising tools for the measurement of how a city consumes resources
  - Developing a deeper understanding of the city as a system
  - Developing tools for the integration of "green" practices in procurement by cities

- Policy Development to Ensure that Capacities are Harnessed and Organised
  - Developing models of tenure to inform approaches to spatial planning policy
  - Devising indicators to measure the extent of "path dependency" in policy formation at city level
  - Mapping policy development processes in order to draw on experiences across the EU
  - Assessing the impact and effectiveness of existing indicators and benchmarks for city development and regeneration

- Designing Cities Accessible and Useable for All Regardless of Age, Ability or Social Group
  - Mapping of existing urban strategies in the field of accessibility
  - Developing indicators for assessment of accessibility appropriateness of spatial development plans and policies
  - Developing tools for the integration of accessibility in all policies

- Mechanisms for Engagement with all Actors
  - Mapping existing models for participation in city development and policy making
  - Developing indicators to measure how projects can benefit through participation?
  - Developing new models for cross-actor participation in city processes

- State of the Art Techniques and Their Applicability
  - Mapping of the techniques and technologies that need to be harnessed in order to make cities more desirable places in which to live and work
  - Benchmarking of existing models for the integration of research results into policy formation and city development

- Governance Models – their Successes and Failures
  - Developing an in-depth understanding of existing governance models and their impact on political decision making
  - Mapping emerging governance approaches and benchmarking them for the benefit of cities across the EU

- Path Dependency in Planning Policy and new Models to Address Urban Sprawl

- Developing indicators that expose to what extent new planning policies are based on historical models
- Mapping of existing models of urban sprawl that contribute most to a sustainable and creative city for all
- Developing a deep understanding of the functional and policy relationship between a parent city and its suburbs and other nearby towns

- Territorial Regeneration and Cohesion
  - Devising tools that show how territorial infrastructures and services can be optimised
  - Developing indicators on city complementarities, within territories and regions, showing how these can be articulated and harnessed
  - Developing 3-d geographical information systems (GIS) that improve public management, private investments, citizen's integration and participation

- Integration Techniques for Technological, Process and Governance Innovations
  - Setting out of models, roadmaps and indicators that demonstrate how the various divergent aspects of research can be brought together to form truly holistic approaches to the creation and maintenance of our cities and urban areas

4.1.2.3 Targets for 2030

- By 2030 cities have become the most desirable places in which to live and work.

4.1.3. Unlimited Underground Spaces

4.1.3.1 Introduction

The traditional construction model is to develop cities in elevation and horizontally: ever higher buildings, ever sprawling across the countryside. On the opposite, underground space is largely available: it must be employed now to provide congested European cities with the space they need for their harmonious development. To achieve this challenge the underground built facilities must be safe, sustainable, with minimum impact on the environment and competitive when compared to above ground solutions. New construction concepts must be invented to support this radically new model proposed for the development of cities:

- Cities extend downwards in an unlimited ground space, limited only by the borders of technology and imagination;
- A human-friendly underground infrastructure is closely interconnected to a surface living space with a better environment;
- Underground cities are linked together or to the airports by high velocity and high capacity transportation lines for passengers and freight , offering an efficient alternative to road transport.

A whole new concept of underground construction is needed: the whole supply chain must be reviewed to cope with the constraints of an enclosed space - new contractual arrangements for a new world, new services industries to work underground, new underground architecture, new specialised vehicles; new technologies for excavation, new social business, new concepts for the safety and security industry, for the supervising and protection, for hazards and risks mitigation.

4.1.3.2 Research Areas

Medium -term

- Social and Human relations for a new environment; developing psychological and social acceptance of the underground environment;
- Improved understanding of human behaviour for long periods below the surface, to adapt the minds to 3D movements in a vertical city, instead of 2D movements in today's horizontal cities.
- Architectural design for the unlimited conquest of deep available space , playing with voids, filling spaces and caverns with new inverted concepts of buildings , interacting with surface buildings, human-friendly and designed for all;
- Materials technology for waterproof and self-caulking, insulation, fire safety, are strong enough to withstand ground pressures, flexible enough to absorb ground movements and with high durability in an underground environment;
- Construction Processes for large underground spaces below cities and interurban connections :
  - New tunnelling technologies: long tunnels, air-tight lining, specific materials;
  - ICT controlled, fully automated excavation procedures with low impact and flexible equipment, for any size and shapes of excavations;
  - Fibre ground support with re-absorption, modular and flexible ground anchors, sustainable grouting, lining;
  - New techniques for ground treatment, recycling of materials;
  - Ground conditioning special devices, ventilation, air regeneration and conditioning, exhaust absorption, communications, transport systems, ground water treatment;
- Specific training and education to adapt the users to the new social circumstances deriving from new environment;
- Life cycle assessment of underground built assets under existing premises;
- Development of new standards and codes for the new environment.

Long-term

- New concepts for the comfort of underground spaces: air-conditioning, artificial sun, etc;
- Perfect knowledge of surrounding soil condition and its evolution along the life cycle of the projects;
- Life cycle assessment of underground built assets under existing premises;
- Development of new standards and codes for the new environment.

4.1.3.3 Targets for 2030

- Price of underground space competes positively with real estate at the surface, providing affordable new underground square meters and cubic meters to integrate facilities which are today dispersed in cities, and to improve the comfort and quality of today's cities;
- Areas facing difficult conditions at the surface find in underground space a new resource to create missing social facilities and economic activities;
- Underground space has the same level of comfort, safety and security as does surface space. It is the preferred method of creating new social facilities accessible to all in congested cities, extended local transport networks and fast transport links between cities;
- Underground space contributes to the protection of environment and of Cultural Heritage;

- Underground space contributes to the energetic balance and to the development of new energy sources.

4.1.4. Mobility and Supply through Efficient Networks

4.1.4.1 Introduction

The network systems of highways, railways, waterways, and of utilities (water, sewage, gas, electricity) represent a huge investment and are essential to the economic and social well-being of society. They are expected to provide reliable service for very long periods of time, spanning several generations, covering dramatic evolutions of technology and of the individual and collective aspirations for quality of life. The increasing demand for mobility and supply is driven not only by demographic growth, but mostly by a number of factors like urbanisation or macro economic development. Climate is another major driver that determines the intensity and the overall pattern of energy, supply and transport. All these factors converge towards critical saturation of infrastructure lines and nodes.

Efficient networks at the service of society should aim at enhancing the level of service offered to European citizens in terms of demand for mobility and supply while meeting social, environmental and economical objectives, and achieving inter-operability of lines and information.

The competitiveness and the social and economical development of Europe depend heavily on the full integration - within, between and across Member States borders- of networked systems providing a quick and safe exchange of mobility, goods and supply. The impact in the urban context must be reduced. Minimum levels of service, reliability, security, information even under critical conditions must be pushed to higher efficiency level.

4.1.4.2 Research Areas

- New models to stimulate transportation use and cost/benefit;
- New concepts of design and construction of infrastructural nodes for high speed transport and highways;
- New concepts of design and construction of multiple choice/multiple speed infrastructural systems near roads;
- Points of interoperability and inter-modality: new ways to exchange goods and passengers among nodes and among modes in urban and extra-urban environment
- Technical-economical reliability and feasibility of new concepts of multimodal infrastructure design for shared structures
- Setting of multimodal centres allocated through the European Network system, and the coordination of the different means of transport converging in a multimodal centre, including their timetables, allowing user to easily plan a trip, avoiding dead-times
- New information system between modes of transport and new coordination requirements for exchanging information among infrastructure and operators
- Exchange of information between modes of transport and other networks
- Systems for the management of risk and emergencies and partial functionality of the networked system.
- Smart and Safe Utility concept : new concepts and models based on integrated sensors and information technologies for real time control of network operation

- Study, implementation and application of ICT systems to optimise the traffic, serviceability and security of networks, integrating fleet and freight management, traffic monitoring, tolling, information to users, incident and crisis management, transport of hazardous goods, service in adverse climate conditions.

4.1.4.3 Targets for 2030

- European networks offer the highest level of service;
- Reduction of incidents
- Improved fluidity of traffic
- The trans-European network of transport and utilities as a whole with new habits of users and citizens:
  - Interoperability and inter-modality to assure fast and safe mobility in a competitive Europe in urban and extra-urban environments
  - Utility networks with ease of access and minimal impact on users, quality of life, roads and other adjacent apparatus
- New logistic, transport and quick exchange people traffic system;
- New nodal infrastructural systems, junctions and urbanisation;
- New multimodal networks optimise the use of infrastructure and shared facilities.
- Improved coordination among operators, including procedures and regulations, to assure an enhanced service such as a reduced number of interruptions;
- European networks are interoperable and supported by integrated information and communication systems;
- Information to drivers
- Integrated solutions to improve communication between users, infrastructure and operators, improving mobility and purveying
- Reduced impact of new techniques and technologies on the structural components of the infrastructure whose design and production will change, when implemented in practice in a logic of plug and play.

4.2. Becoming Sustainable

4.2.1. Reduce Resource Consumption (energy, water, materials)

4.2.1.1 Introduction

As much as 50% of all materials extracted from the earth's crust are transformed into construction materials and products. Including energy in use, the built environment accounts for as much as 40% of all energy use. Moreover, these same materials, when they enter the waste stream, account for some 22 % of all final waste. The amounts of raw material and energy used in construction therefore needs to be reduced. The energy content of construction materials must also be reduced. Buildings and the built environment in general need to be progressively transformed from elements with a negative environmental balance (particularly energy and water consumption) towards a neutral or positive environmental balance. The approach of "Design for Disassembly" and "Design for Recycling" developed by the automotive industry can inspire a similar approach to the building process.New concepts, technologies, materials and processes optimising the life cycle costs of (new and existing) buildings and infrastructures and minimising the overall environmental impact through drastically reducing the demand for raw material, energy and water while reducing waste should be developed.

4.2.1.2 Research Areas

- Cost-effective and Eco-efficient Built Environment

Medium -term

- Creation of resource consumption performance indicators and rating systems for buildings
- Energy savings
    - new processes for design and construction of affordable new buildings with very low energy demand
    - new processes to implement energy saving techniques for refurbishment of the building stock
- Development and improvement of manufacturing technologies focused on the reduction of embodied energy and resource consumption in construction materials and components
- Improvement of energy efficiency in buildings through new conceptual designs of cities and buildings; the development of new building envelope systems capable of generating energy, the development of new and improved materials with high heat storage capacity and release on demand, the development of smaller and more efficient power generation and storage units, the implementation of ICTs for an efficient management of buildings and cities, etc.
- Innovative technologies for the reuse and recycling of rainwater and waste water and for the reclamation of natural wastewater
- Innovative materials and technologies for the recycling/ reuse of construction wastes and incorporation of other waste streams in building materials
- Integrated life-cycle process for flexible buildings:
    - integration of the processes of design, planning, procurement, construction management and management during use
    - new logistics management systems.

- Development of building components and processes with the objective of optimising the deconstruction processes.

Long-term

- Development of materials and concepts for retrofitting of existing buildings with high rates of energy efficiency (low energy consumption) able to produce net CO2-free energy from renewable resources (incl. tools for design, technical solutions for retrofitting,
    - Tools for design,
    - Technical solutions for retrofitting,
    - Economy and building sector business
    - Social sciences.
- Develop specific solutions for new energy efficient buildings able to produce net CO2-free energy from renewable resources (incl. tools for design, technical solution for construction, new energy solutions using underground storage capacity)
    - Tools for design
    - Technical solutions for construction
    - Economy and building sector business
    - Social sciences
    - New energy solutions using underground storage capacity.
- Common solutions for the two markets (existing and new buildings) have to be developed, taking into account experience and various situations of European countries (a real pan-European vision is needed), education, training and dissemination.

➢ Efficient and Environmentally Friendly Building Materials

Medium-term

- Creation of environmental performance indicators and performance rating systems for materials and buildings
- Understanding and control of degradation phenomena to improve the service life of building materials.
- New manufacturing processes of building materials with high performance at reduced environmental impact through reduced energy, reduced raw material demand and use of large quantities of residual products and waste
- Optimised use of light and heavy building materials to reduce the energy used for heating and cooling in buildings
- Improvement and development of durable materials with prolonged and predictable service life under aggressive conditions including self-assessment and innovative non-intrusive in-situ inspection techniques.

Long-term

- New logistic concepts and manufacturing technologies for full utilisation of construction and demolition waste.

4.2.1.3 Targets for 2030

➢ Cost-effective and Eco-efficient Built Environment

- 30% reduction of the embodied energy in construction materials and components of equal performance
- 40% waste reduction in the manufacturing processes for construction materials and components

- 50 % decrease in energy consumption and CO_2 emissions from new buildings
- 30 % decrease in energy consumption and CO_2 emissions from existing buildings
- Substantial reduction of water consumption and wastewater generation of buildings and the urban environment
- Construction and building activities are zero-waste generating.

➢ Efficient and Environmentally Friendly Building Materials

- 30 % reduction of the specific raw material and energy consumption of building material production
- Total energy consumption and emissions reduced by 50 % during the life cycle of new buildings
- Striving towards 100 % re-utilization of construction and demolition waste
- 30 % specific reduction in CO_2-emission of building material production
- Improvement of production quality to 100 % of 1st choice products with high flexibility and reduced production batches.

4.2.2. Reduce Environmental and Anthropogenic Impacts

4.2.2.1 Introduction

The Communication from the Commission "Towards a Thematic Strategy for Soil Protection establishes 8 threats to soil in the EU and Candidate countries: Erosion, decline in organic matter, soil contamination, soil sealing, soil compaction, decline in soil biodiversity, salinisation, and floods and landslide.

It is vital that the construction sector, as one sector with a high relationship with land use, develops specific construction concepts for the construction of surface and underground structures which are necessary to face and to solve these threats to soil and water resources. In the end, construction activities have to increase the different soil functions: food and biomass production; storing, filtering (soil is a natural filter for groundwater, the main source for drinking water) and transformation; habitat and gene pool; physical and cultural environment for mankind; and source of raw materials.

Some examples of the influence of the construction sector on the natural environment are set out below :

- The covering of soil for housing, roads or other land developments is know as soil sealing. When land is sealed, the area for soil to carry out its functions including the absorption of rainwater for infiltration and filtering is reduced. In addition sealed areas may have a great impact on surrounding soils by changing water flow patterns and by increasing the fragmentation of biodiversity. Soil sealing is almost irreversible. Soil can play a valuable role in food production, nature conservation, flood control or any other key function, and the consequences of sealing are damaging to sustainable development.

- Large surfaces of natural European land are used every year for construction of buildings, transport, infrastructure. The amount of urban soil increases exponentially and the amount of natural land which can perform more sensitive functions than "built" land is consequently being reduced. In order to protect the remaining greenfield areas a combination of measures must be adopted: increase the density of urban patterns, re-use "brownfield" land, develop underground construction, etc. The main issue associated

with brownfield redevelopment is the lack of safe, predictable and cost-effective tools to assess the content and nature of the pollution remaining in the soil, to elaborate a mitigation strategy, and finally treat the pollution.

- The anthropogenic environments, the environments made by the mankind, have to maintain soil functions during its whole life cycle and to improve them where they have been drastically reduced. New concepts, materials and processes should be developed for the optimised use of the land, for the re-use of brownfields, for the protection and for the remediation of water resources. For instance: Development of underground spaces will lead to solve specific problems of waste collection, treatment and management; cities and roads have to avoid the problem of soil sealing; construction activities have to avoid compaction of natural soils; contaminated soils and contaminated groundwater have to be remediated in order to prevent contamination spreading and to reuse these resources; etc.

- The largest resources of drinkable water in Europe are located underground in aquifers. In coastal areas, the majority of these aquifers are salinated by seawater encroachment, further exacerbated by over-exploitation. Remediation of these polluted aquifers is an extremely long process with very slow rate of progress, and many aquifers are left practically unsuitable for pumping drinking water. It is necessary to develop specific construction concepts for the construction of surface and underground structures to optimise the exploitation of water resources.

Decreasing the impact of infrastructure on the Environment will imply to manage efficiently the construction /maintenance/ re-construction of a large number of new infrastructure for transport and services in order to cope with funding and environment constraints, to reduce the use of natural resources, to increase the use of alternative forms of energy, and to reduce the environmental impact of networks operation on users and populations: pollution, vibration, noise, etc.

4.2.2.2 Research Areas

- Protecting Land and Water

Medium-term

- Development of monitoring tools and especially reliable in-situ chemical sensors for the real time monitoring of groundwater quality
- Development of methodologies and tools for the risk assessment of contaminated soils and their impact on human health and ecosystems
- Development of new cost-effective materials and technologies for the remediation and containment of contaminated soils and groundwater
- Development of new cost-effective materials and technologies for the protection and for an optimised exploitation of water resources
- Innovative materials and technologies for the reduction of damage to natural land and/or the restoration of natural land during construction and management processes.
- Technologies for reduction of soil erosion.
- Development of prediction methodologies and tools for the assessment of the construction process on the system soil-water-atmosphere-biodiversity

- Development of prediction methodologies and tools for the assessment of short, medium and long term affection from the anthropogenic environments to the system soil-water-atmosphere-biodiversity
- Development of new, cost-effective in-situ and on-site soil remediation technologies in order to decrease the price of brownfield reuse, and prevent the use of external landfills (which leads to additional truck traffic in cities and accelerates use of landfill resource).
- New materials and concepts for a construction that allow a maintenance-improvement of the soil functions (permeable cover materials, non soil-compaction construction methods, etc.)

Long-term

- Development of new integrated services for the regeneration and re-development of brownfield sites, supported by holistic decision taking tools (environmental-economic-social).
- Integrated monitoring-remediation technologies focused on the protection of land and water resources against emergencies or drastic changes.

➢ Impact of Infrastructure on the Environment

- Eco-technical infrastructure by using systems solutions for traffic noise, vibration, air & water pollution, gas venting control and by including new maintenance and re-cycling techniques and the integration of composite materials
- Design for environment (including cost/effectiveness performance analysis) to integrate innovative systems solutions
- Reduce impact of accidents involving dangerous and hazardous goods by appropriate measures and procedures.
- Reduce the use of natural resources and minimise pollution of the environment (i.e by decontaminating soil or by new materials)
- New concepts for construction and maintenance of infrastructure, for a better integration of transport infrastructure in the landscape
- Energy recovery, use of alternative energy sources.
- Waste collection, waste treatment in the new environment of underground spaces
- Technologies for impact reduction of underground spaces on groundwater flows and underground hydrogeology
- Waste management, recycling of water, and air conditioning in a large scale for underground spaces

4.2.2.3 Targets for 2030

➢ Protecting Land and Water

- By 2030, brownfield sites are reused and preferred to greenfield sites
- By 2030, decontamination techniques are available and cost effective on all pollutants and are a preferred technology to dumping in landfills
- By 2030, reliable monitoring systems are available for public health protection.
- By 2030, Land occupancy has reversed its growing tendency
- By 2030, All new developments considers measures to minimize soil threats: Erosion, decline in organic matter, soil contamination, soil sealing, soil compaction, decline in soil biodiversity, salinisation, and floods and landslide.

- Impact of Infrastructure on the Environment

- Reduced negative effects on users and communities
- Innovative techniques and technologies to ensure maximised recycling (>50%)
- Very high percentage of 'no-dig' interventions
- Full adequacy to environmental and sustainable standards
- Radically innovative approaches to gas and water network installation, maintenance and repair which minimise environmental impacts on communities.
- Improved relation of networks with the territory. Avoidance of new environmental conflicts between networks and sensitive land uses
- Insertion of new networks in the environment minimising consumption of natural non-reproducible resources
- Preservation of resource environment and reduction of consumption of natural resources
- Increased competitiveness.

4.2.3. Sustainable Management of European Assets

4.2.3.1 Introduction

The European built environment results from centuries of construction activities having led to invaluable assets which need to be continuously maintained, upgraded, retrofitted while available economic resources are extremely limited compared to their values. RTD should contribute highly to improve the efficiency of the efforts through developing new methods and new technologies.

To manage transport networks and utilities it is necessary to maintain and upgrade existing assets, at a minimum affordable cost, to extend the life span and to improve the understanding of degradation and ageing processes, to reduce networks jamming and disruptions and their associated costs to transport, energy, trade, and to improve management and operation of the networks.

Functional networks of transport and services responding to the needs of users and clients: New constructions matching the need of preserving existing patrimony, by adopting materials, construction rehabilitation and maintenance concepts and management tools that extend life-cycle, increase capacity and durability with low impact on operation and high standards of safety and security.

The concepts of Sustainable Development must be translated in a specific way when dealing with Cultural Heritage. The need is here to develop a "consequence-based approach", by which any intervention on Cultural Heritage would not do any harm to its future *behaviour* (in response to decay, accidental actions, man-made damages) or *functions* (accessibility and usability, energy efficient use, maintenance. management and exploitation for tourism or any other purposes). We are building now the Cultural Heritage of next European generations: consequence-based advanced technologies and practices must be used to maintain our Cultural Heritage alive in more attractive cities. New materials, concepts and techniques for intervention in the cultural heritage should be developed that implement the consequence-based approach, and for increasing the attractiveness of cities and buildings.

RTD activities should be accompanied by communication and public participation to develop a European citizen interaction and the re-establishment of the preservation of cultural heritage as a priority in city management.

4.2.3.2 Research Areas

- Transport and Utilities; a European Asset

a. Modelling the performance of the infrastructure

- New theoretical and numerical models to assess, follow and predict the long-term performance of structures and components (bridges, tunnels, foundations, embankments, pavements, pipelines, water mains and sewers, etc) subject to ageing and deterioration
- New concepts to extend the life time of structures, increase their capacity with no reduction in safety and with positive impact on maintenance, or to improve their response to natural and man-made hazards
- New models to predict and manage the demand in terms of volumes and intensity
- European standards for structural assessment

b. Monitoring performance

- Identification and integration of minimum number of significant parameters and their measurement
- Innovative, cost-efficient wireless sensors based on bio or nano-technologies for the long-term monitoring of new and existing infrastructures
- Integration of monitoring, materials and components
- Development of integrated life-cycle assessment systems : combining cost-efficient and easy to maintain sensors, monitoring and performance prediction systems ; to be used all along the structure life-cycle : control of the construction stage, asset management, optimisation of maintenance.
- Risk-based inspection regimes for low impact on demand and costs
- New non-destructive, automated, inspection/testing techniques to control / identify / localise / monitor structures and infrastructures, even buried, with minimal impact on traffic and supply.

c. To improve the performance of the network

- New construction, maintenance or upgrade technologies
    - Optimizing the use of added-value materials,
    - using industrialised or precast elements with value added service for demand management, flexible plant equipment, etc.
    - with reduced construction and installation time (incl. equipment), with reduced number of interventions and time, with enhanced safety conditions for carrying them out in safety conditions and with low environmental impact(i.e. repairing with no loss of gas).
- New techniques of demolition that allows recycling and reuse of materials (considering internal re-use or towards other applications), even more than one time. New techniques for dismantling, decommissioning and re-employment of components
- New concepts and technologies for the integration of new utility networks (gas, water, sewer, electricity, etc) in a single built infrastructure or duct.

- Develop, design, build and operate with new or non-conventional materials of multifunctional characteristics or with traditional existing materials of enhanced performances with with low environmental impact, high durability and resistance to environment aggression, reduced maintenance and operation costs, and increased comfort for users and citizens

d. Enhanced management

- New concepts for network-wide management and operations, with an emphasis on customers in the provision of services
- New asset management systems integrating all important infrastructure components, related activities and constraints (data management, inspection, planning and realisation procedures, cost-benefit analysis procedures,) for all types and scales of networks.
- New methodologies for the optimal and comprehensive management of operation, maintenance and upgrading of transportation infrastructures in the urban and extra-urban context; high pressure transmission pipelines; gas, water and sewerage networks, to reduce impact on service
- Management procedures tailored for all types and scale of networks.

➢ A Living Culture for an Attractive Europe

The aim is to set up Culturally holistic planning and management systems available for safeguarding, regeneration and development of the Historic European Urbanized Environment, based on research supported development and implementation of standardised modular hard and soft tools, technologies and systems for monitoring, survey, documentation, evaluation, sustainable maintenance, public participation, communication and networking of units with cultural and natural heritage territorial values.

Six main research topics must be developed to support this aim. In medium term the research has to be focused on new assessment and management tools, and new safeguarding and maintenance projects have to be set up; in the long term new applications should ensure implementation of the research results.

a. Assessment, monitoring and diagnosis

Integration of technologies for building diagnostics and monitoring in the safeguarding; development of embedded intelligent wireless sensors suitable for a long life cycle in the environment of heritage structures.

Medium Term

- Setting up databases and standard protocols for an integral structural assessment;
- Optimisation of monitoring and diagnosis methods, adaptation to new materials.

Long Term

- Development of strategies of assessment and larger databases, education of civil engineers, architects, restorers about application of NDT and monitoring technologies.

b. Materials

Assessment of the degree of decay of heritage buildings due to the degradation of modern or historic materials, development of new materials by way of nanotechnologies. Research leitmotiv for this area is the compatibility of conservation materials.

Medium Term

- Demonstration and dissemination of the knowledge accumulated during the last thirty years, about materials used for repair and develop methodologies for testing their suitability and their performance through
    - Built-up and networked specialised laboratories;
    - Development of "easy to use and "highly efficient" materials for strengthening-reinforcing of structures;
- Development of smart materials with flexible physicochemical properties adapted to specific technical requests;

Long Term

- Utilisation of intelligent materials structures.

c. Intervention and Techniques

Development of new process solutions and low intrusive retrofit techniques, to reduce interventions in cultural heritage with the objective of no consequences of the interventions:

Medium Term

- Development of performance criteria based on experiences gained from past interventions and observation of their efficiency, cataloguing and definition of techniques;
- New low-impact and easy-to-operate technologies and conditions for execution for reduction of damage environment impact execution.

d. Energy and environment

Medium Term

- Development of special measures for climate control of the various cultural heritage units.

e. Management, exploitation and maintenance

Rational and long term management process of Cultural Heritage to enable sustainable and cost efficient maintenance :

Medium Term

- Creation of new economic models for an interactive and flexible cultural heritage management;
- Setting up of a complete catalogue of European Cultural Heritage;

Long Term

- Setting up an integral management of Cultural Heritage based on its sustainable interaction with its environment.

f. Cities and Territorial Aspects

Research on new tools to improve the communication and the public participation in cultural heritage to develop an European citizen interaction:

Medium Term

- Developing indicators to measure the impact of cultural tourism on economical and social development in Europe;

- Setting up research works on the interaction between Cultural Heritage and European identity, social cohesion and creation;

  Long Term

- Development of networks and databases to set up global practices in territories for the safeguarding and the enhancement of Cultural Heritage linked to social, environmental and economical objectives.

4.2.3.3 Targets for 2030

➢ Transport and Utilities; a European Asset

- Reduction in service failures and mitigation of consequences
- Reduction in number of accidents and mitigation of consequences
- Reduction in number, size and duration of maintenance interventions (congestions and interruptions)
- Enhanced efficiency
- Full asset management
- Extension life cycle and improved knowledge
- Cost optimisation
- Increase in recycling and re-use of materials and reduction in waste materials
- Reduction space used/territorial impact
- Reduction of construction time
- Increased competitiveness of the sector toward non-EU countries.

➢ A Living Culture for an Attractive Europe

- All information generated during the study, restoration and maintenance process will be available and used for appropriate management
- Service life of Cultural Heritage materials and structures could be predicted with 20% error and will be used to prepare predictive maintenance plan
- 25 important EU cultural heritage sites should be assessed using new specifications between 2010 and 2030
- Cultural Heritage accessible for all
- Reducing the decay of Cultural Heritage by 95%.

4.2.4. Improve Safety and Security

4.2.4.1 Introduction

Since natural and man-made hazards do not respect national boundaries, coordinated and collaborative research is required at the European level to eliminate the uncertainty, the unpredictability and the consequences of natural and man-made hazards and to achieve timely and appropriate holistic solutions so that losses and disruption by natural and man-made hazards become marginal, acceptable and insurable. Mitigation of natural and man-made hazards should be reached by the development of integrated assessment, management and prevention methods, new materials and technologies.

Safety and security of all infrastructure must also be ensured as any disruption of service may result in large socio economic consequences for the European citizens. Safety of users and supply must be assured (i.e. road accidents, gas supply). Security of mobility and supply must be guaranteed under critical condition (i.e. climate conditions), but especially against man-made hazards. Interruption of service must be avoided also after seismic and other natural hazards as the functionality of the networks is paramount for rescue and emergency operations. ICT must be implemented for a better safety, efficiency, information, travel comfort and environment to a more and more demanding client/user.

Efficiency of fire safety design and engineering is also particularly needed.

4.2.4.2 Research Areas

- Mastering Natural and Man-made Hazards

- Develop risk assessment, management methods and insurability
  - Advanced Hazards mapping and monitoring systems
  - Event specific vulnerability mapping
  - Innovative risk assessment improving safety of people from man-made hazards. New models and tools for risk and safety management integrating issues such as safety culture, business processes, roles and responsibilities, training and competency, quality and performance management
  - Decision Support Systems for priorities and impacts of risk mitigation.

- Development and harmonisation of European guidelines for performance based and innovative design relating to
  - Earthquake prone structures
  - Flood defence systems(rivers and coasts)
  - Landslides (on shore and off shore)
  - Terrorist threats to industrial facilities and especially exposed buildings and infrastructure
  - Fire safety design of buildings and underground premises.

- Prediction and simulation tools for hazards impacts to the built environment
  - Engineering tools for multiple threat scenarios and design options
  - Programs for calamity simulation and training

- Advanced constitutive equations for soils and building materials
- Prediction and development of mitigation strategies for structural vibrations (e.g. windstorms, explosion, traffic).

- Development of protection systems, techniques and materials
  - Simple and easy to handle seismic strategies to retrofit existing buildings, particularly residential houses and cultural heritage
  - To retrofit existing hazard defence systems to accommodate for climate changes and land use
  - Unobtrusive and aesthetic protection structures against man-made hazards (e.g. impact, blast, fire)
  - Development and application of innovative construction methods
  - Developing methods to improve the resistance of existing buildings against extreme weather conditions
  - Extensive soil stabilisation using bio-technology (cementation)

- Remedial measures
  - Develop specific warning systems
  - Develop post-disaster strategies according to specific risks
  - Training.

- Consequences of climate change on the built environment
  - Understanding of increasing effects of floods, windstorms, coastal erosion etc. on actions induced on structures.

➢ <u>Safety and Security of Infrastructure Against Natural and Anthropogenic Hazards</u>

- Safety and Security tools for underground premises to guarantee trouble free activities in the event of natural phenomena such as floods, poisonous gases, earthquakes, etc. or anthropogenic threats such as fire, terrorism, vandalism, crime, etc. (MT)
- Reliable and long life systems to supervise and control all parameters of underground spaces (MT)
- Tools for risk and safety management, risk perception and risk modelling (including safety culture, roles, competency…)
- Reduction of the vulnerability of networks from natural or man-made hazards by new risk assessment systems
- Monitoring and assessment methods to evaluate consequences and prove accessibility and availability of infrastructure of transport and supply after damage
- Mitigation of consequences by innovative materials, components, design, construction and retrofitting techniques
- Incident reaction in order to mitigate the effects of an attack on people and infrastructure
- Definition of a common EU regulatory framework on security and institutional continuity.

4.2.4.3. Targets for 2030

- Mastering Natural and Man-made Hazards

- Proven advances in predictability and insurability of natural hazards
- Reliable vulnerability mapping (pre-disaster) and damage assessment (post-disaster) methods are applicable
- Operational alert systems for natural hazards all over Europe
- People living in risk areas are prepared to counter act against hazards and their consequences by dedicated continued work placement
- Practical computer simulation methods for the determination of load conditions, global and local damage as well as progressive damage assessment are available. Simplified computer-aided design tools based on comprehensive computer simulations are widely available
- Technologically improved, aesthetic protection materials and structures at reasonable costs for extreme actions
- European design guidelines for buildings and structures subjected to natural and man-made hazards are available, defining load scenarios and a minimum standard of hazard protection.

- Safety and Security of Infrastructure Against Natural and Anthropogenic Hazards

- Achieving full protection from seismic risk and natural hazards, also according to standards
- Security and protection of networked systems -(transportation facilities, utilities):security of use-vulnerabilities-interdependencies;
- Efficiency in case of natural hazards and enhanced crisis management (evacuation)
- Risk and emergencies are managed;
- European networks of transport and supply are safe and secure;
- Risk mitigation
- Identification of critical road transportation infrastructures, such as main road corridors, freight terminals, and critical elements like bridges and tunnels
- An integrated pipeline protection system incorporating e.g. remote monitoring, inspection, telemetry and communication to achieve optimum levels of security, safety of networked systems, and ensuring security of supply into the EU.

4.3. Transformation of the Construction Sector

Previous chapters concern the demands of the European customers and the European Society in terms of products and functions to be provided by the Construction Sector. But all these demands can be summarised in a more global objective: the Construction Sector must be at the service of society, a key actor to improve the competitivity of European industry.

The challenge here is to **re-engineer the construction process**, to transform a technology-driven sector, slow to integrate innovation, into a sustainable demand-driven sector, creative, flexible, innovative, knowledge-based, offering new business opportunities and attractive work places. Another important challenge is to incorporate the myriad of small and medium-sized enterprises (SMEs) into this global innovation process.

4.3.1. A New Knowledge-based Construction Process

4.3.1.1 Introduction

The progressive reduction of waste (not only wasted materials, but also and particularly wasted design resources, wasted communications resources, wasted labour input on site,) becomes the guiding principle in seeking change within the construction process. RTD can support the realisation of a 'lean', waste minimising, value-maximising perspective of the construction process through enhancing understanding of the process and the development of tools and techniques. Concepts such as whole life thinking, lean production, industrialisation, integrated delivery (notably through the development of partnership relationships and of integrated ICT system), performance, improvement of the working environment need to be developed and assessed.

New business and site construction process, including increasing off-site manufacture and production, on-site automation, knowledge-based communicating teamwork, adapted materials,… for an inherently safe, efficient and human-friendly production of buildings and infrastructure should be developed.

Industrialisation of the construction processes (industrialisation changes from an on-site construction process to a more controlled factory construction process) should be looked for: new manufacturing methods, new architectural typology based on 2D and 3D components, new components, new connections and interfaces, new on-site assembly methods…

4.3.1.2 Research Areas

- Knowledge based construction processes and products, using Knowledge Management tools and new models based on Human Science principles, linking the value and supply chain in construction together, bridging the gap between "knowledge production" and "knowledge use": supply and logistics processes in the conceptual design stage, procedures for continued development in strategic business relationships…
- Service oriented business and systems: from "design for the customer" to "design by the customer" : new business models and new managing relationships to establish world-class customer and supplier networks.
- The development of an industrialised construction process: process theories adapted from the manufacturing industry to the construction sector, production technologies, development of the component industrial market-place…

- Develop new sustainable models, design and building techniques, that increase the design possibilities, efficiency and safety and reduce the risks for users and citizens from hazards, focusing on the whole life-cycle cost.
- Develop standards that are performance based and inherently open to innovation: suggestions for performance-based legislation, including performance indicators based on demonstration projects.

Develop the architectural knowledge-base and its implementation in construction: addressing the interaction between architecture and technology, production and economy in the conceptual design stage, mechanisms for mobilising architectural good-practice in construction.

4.3.2. ICT and Automation

4.3.2.1 Introduction

Advances in information and communications technology (ICT) will result in 'intelligent products', capable of communicating location, orientation and condition. RFID chips represent the first generation of cheap identification devices which can be incorporated in any product. MEMs will soon represent the new generation of miniature intelligent networked wireless sensors and actuators which can be dispersed in large numbers in the built environment to monitor the condition of structures. The continued reduction in the cost of communications and data processing will enable construction processes to be fully monitored, and to incorporate all actors of the site in the same chain of information. ICT will provide the means to empower the new paradigm of a knowledge-based Construction sector.

On the other hand, automation and robotics offer many and important possibilities to improve construction processes. It must be said that the Construction Sector has been too slow to integrate these possibilities. The recent trends for miniaturisation and for mass production of robots open the way to a larger implementation of these concepts in the construction workplace.

4.3.2.2 Research Areas

Medium-term

- ICT tools for the efficient connection of all actors of mobile sites to corporate information networks, and to develop ubiquitous access to H&S knowledge;
- Mechanisation / automation / robotisation of construction processes;
- ICT, sensor technologies and micro-mechanics to monitor and control the built facilities and their environment, including wireless communications and new communication channels between the underground and the surface.

Long-term

- Radically advanced construction concepts such as programmable nano-materials and nano-constructors, bio-mimetic materials, structures and facility systems;

4.3.2.3 Targets for 2030

- All mobile sites are effectively connected to corporate information networks.

4.3.3. High Added-value Construction Materials

4.3.3.1 Introduction

Materials for construction projects are usually considered and classified as having traditional functionalities (structural, covering, etc.) and, as a consequence, they are used by constructors only in a traditional way. This poses limitations to the development of new ideas and concepts in the building, cities, construction projects and networks of the future.

Successful technological solutions have to be sought more and more upstream in the design and production processes; new materials and development of traditional materials will together with other research approaches such as *nano-technologies, sensor technologies and information technologies* have a crucial role to play in this respect, as drivers of innovation.

The possibility of having materials with new and improved functionalities opens up new potential in the way construction projects are conceived from the design stage up to their ultimate use and occupation. For example, important innovations can be achieved in the indoor quality, and comfort by using smart, sensing, "active" or ergonomic materials, which can be integrated into our daily life. On the other hand, new functionalities will also bring innovation to construction processes.

New "high value" construction materials, manufacturing technologies and processes for new materials with new multi-functional properties, which improve the comfort of living, are easy to install and optimised for industrial pre-fabrication should be developed.

4.3.3.2 Research Areas

Medium-term

- Development of materials with new functionalities and improved properties and comfort (resistance against aggressive environment, hygienic and easy to clean, moisture control, thermal, electro-magnetic and acoustic isolation, heat storage and climatic functionality, "warm feeling" and aesthetic appearance)
- Exploration of the potential for application of biological technology in the production of building materials
- Development of simulation tools for predictable and multi-functional products and manufacturing processes (innovative automated manufacturing, control and measurement strategies) for reduced production time and costs
- Development of "easy to use & install" building materials for friendly and safe construction processes
- Life cycle analysis of products with new functionalities addressing durability of new building products.
- Development of materials with smart and sensing capabilities for self-assessment of integrity, functionality control and self-maintenance, improved structural and aesthetical properties
- Active, multi-functional materials, which improve indoor climate and energy consumption of buildings by nano, sensor and information technology
- Development of new materials based on bio technologies, e.g. embedded bio electronics, active surface properties, natural process technologies
- Improve predictability and efficiency of new building materials production processes by innovation in manufacturing, control and measurement processes to ensure quality along all the production batch, manufacturing flexibility.

Long-term

- Tailor-made materials, which can fulfil any demand on durability, strength, active responses, heat storage and aesthetics
- Development of virtual design / construction programs based on service-oriented materials that drastically increase the range of utilization ("design by the customer")
- New, integrated concepts and networks from material producers to facility management suppliers and clients exploiting the full benefit of multi-functional materials.

4.3.3 Targets for 2030

- Building materials capable to adapt 100 % indoor environmental conditions depending on changing use requirements (temperature, odours, hygienic properties, depending on destination of use, level of occupation, etc.)
- Insulation and storage (thermal, acoustic, electro-magnetic) capabilities increased by 20 % compared to current building materials
- Knowledge-based control of properties of building materials (such as porosity, microstructure and behaviour at a nano scale) are 100 % under control to allow total architectural freedom in structural design and design of surface appearance
- New and innovative building materials and production technologies are compatible with the application of ICT technologies in the building (sensoring, monitoring, etc.)
- Production time and costs reduced by 30 % through innovative, efficient and predictable manufacturing processes
- Reduction of assembly, repair and maintenance costs by at least 20 %.

4.3.4. Attractive Workplaces

4.3.4.1 Introduction

The Sector must acknowledge and respond to society's '3D' perception of the industry - dirty, difficult and dangerous - with technology and skills that transform the working conditions and skill base of its workforce. Efforts are absolutely necessary to make the Construction Sector attractive for the most competent and skilled young people it needs: shortages in workforce are already the reality in several Member States.

A major difficulty is that construction sites are by evolutionary context inherently dangerous places. Uncertainty is always present however detailed the risk assessment studies. This feature is quite specific to this industry and not present in manufacturing or chemical industries for example. It calls for specific RTD programmes.

One approach to improving the workplace is to remove workers from tasks which expose them to risk or which take place in arduous and demanding conditions. If the number of people required to work in the relatively exposed and uncontrolled environment of a construction site can be reduced, overall risks to health and safety will also reduce and the conditions and rewards for those still required can be suitably enhanced. Labour requirements can be significantly reduced by mechanisation and by greater use of off-site production. ICT and Automation can provide progressively more sophisticated monitoring and control systems for construction equipment. The goal will be the complete replacement of human labour in all hazardous conditions, such as the construction of tunnels.

Complete automation may not be necessary, nor possible for the increasing proportion of construction concerned with repair and refurbishment, when there is imperfect knowledge of the condition of the structure and the exact tasks required may not be fully determined until the works commence. However, the application of technologies for remote

operation, assisted by progressively more intelligent systems for capturing and interpreting visual data, will serve to reduce direct exposure to risk. The 'site control room' comparable to the control centre of a production plant and with similar controls and displays, can become a feature of construction.

Another approach is to develop a culture for Health and Safety on construction sites Site construction teams are always the potential victims but have also the necessary practical knowledge to analyse situations. They are the sole actors with the capacity to re-engineer – on a real time basis – their work processes. "Joined-up thinking" and coherent collaboration by all the parties involved – but centred around the site workforce and management and integrating individual and collective dimensions - is essential from the initial design stage right through to completion.

It is therefore essential that human science based on a global approach encompassing all relevant scientific disciplines (psychology, organisation, sociology, occupational medicine, ergonomics etc.) develops a new model for putting together site construction teams beginning with site teams and progressively enlarging them to project construction teams which will then have the capacity to re-engineer on a permanent basis the complete supply and construction chain. This new modus operandi will have to be developed "in situ" through the application of "intervention research". Within such a renewed business model, increasing off-site manufacture with new 2D and 3D components, on-site automation, new on-site assembling methods, knowledge-based communication and teamwork, selected use of materials will play an important role in making the construction process health and safety friendly and the sites attractive and empowering work places for the workforce.

This approach must include personal development, teamwork and knowledge access. Beyond its positive effect on attractivity and workforce well-being, knowledge flow and management is also a fundamental element of any business process and of project development. It must be approached in accordance with existing roadmaps already addressing this issue such as ROADCON or FIATECH.

4.3.4.2 Research Areas

Medium-term

- Development of tools for collaborative work on construction sites
  - Unified H&S assessment system
  - Free and voluntary H&S certification label
  - Collaborative working and training methods for inherently safe site construction teams, balancing individual aspirations and a collective sense of responsibility
  - Safe and healthy work processes and materials.
- Construction technologies
  - Erection and assembly processes: new, lightweight, high-strength materials and components, innovative assembly and joining methods applied by new generations of automated, smart tools, equipment and systems
  - Knowledge based construction processes and products, using Knowledge Management tools and new models based on Human Science principles.

Long-term

- Construction technologies

- Knowledge based construction processes and products, using Knowledge Management tools and new models based on Human Science principles

- Service oriented business and systems: from "design for the customer" to "design by the customer" : new business models and new managing relationships to establish world-class customer and supplier networks.

4.3.4.3 Targets for 2030

- Construction processes have been re-engineered from the H&S point of view
- All dangerous occupations have been transformed by remote control or replaced by automation.

5. Making the Vision a Reality

5.1. Role of the ECTP and the National Technology Platforms

The European Construction Technology Platform (ECTP) is the response of the Construction Sector to the demands of European society . It is an open industry-driven action, which acts as an umbrella of the research initiatives in Europe. This initiative is bringing together more than 300 partners today, and it is supported by committed stakeholders at all levels of the supply chain (users, clients, contractors, authorities, architects and designers, purchase, material producers, all kinds of suppliers).

The ambition of the ECTP is to play a major role in creating a better synergy between European and national initiatives, between public and private efforts. Its target is to identify and structure the research needs, in order to elaborate an efficient response. By putting together all stakeholders of the Construction Sector around a clearly specified set of priorities, it aims at optimising investment in innovation. The strong commitment from the industry is a guarantee that innovation will find its way to practical implementation and market penetration.

The dimension of the Construction Sector and its impact on the society, give the ECTP an important European dimension. Addressing research needs and coordinating research efforts at European level, involving all stakeholders requires huge efforts. For this reason, the ECTP promoted from the beginning the creation of a network of National Platforms (18 NTPs are currently gathered in this network). The ECTP is now supported by a strong network covering nearly all Member States and some Accession States, acting on the principle of subsidiarity. These Platforms provide vital resources to the ECTP: a direct link to the reality of each of the national construction sectors, a direct link with national authorities, standardisation committees, the possibility to establish a synergy between European and National projects, and – last but not least – an efficient link with the many SMEs which form the largest number of construction companies.

The creation of such a powerful European network is an impressive achievement for such a large Sector which is usually driven by relentless competition. It already creates a significant momentum and renewed interest for research in the Construction industry.

5.2. Removing barriers to innovation

The classical structure of procurement can be a major obstacle to innovation:

- the tender policy is based on the lowest cost favouring well-known and well-managed techniques;
- the precautionary principle generally prevails;
- tenders require references that cannot be provided by innovative techniques;
- project design is generally based and optimised from well-known techniques. Alternatives that could magnify the innovative techniques are often not accepted.

New approaches must be developed and encouraged to help in promoting innovative results such as :

- the development of Public Private Partnership;
- the development of risk assessment techniques, such as the Observational Method.

But certainly the greatest barrier of all to innovation lies in national liability regimes in many EU member states and the way in which they are insured. All efforts must be undertaken to develop the legal framework of a cooperative teamwork between consulting architects, engineers and contractors to rationalise the design, to develop innovative solutions that actually reduce costs, and ultimately offer their clients better value for money. Whenever possible, contactors should be encouraged to propose alternative technical solutions ("variants" in the wording of the public procurement directives) that offer clients better value for money while maintaining equivalent quality in the resulting project.

Such procedures will encourage all stakeholders to innovate, thus liberating the most effective driver for innovation (as well as the research and development that underlies it), namely increased financial returns. There are however two essential ingredients that are necessary to facilitate this process:

- That contractors take advantage of the new provisions in the public procurement directives for the confidentiality of alternative technical solutions (i.e. they cannot be used by the client as the basis for re-tendering a construction project);
- That clients are encouraged to make use of single point liability insurance arrangements under which all actors in the construction process are insured under a single policy of insurance, which effectively covers the contractor against liability risks linked to his proposed alternative technical design solutions, while also dramatically reducing the sources of conflict between the various actors in the construction process which leads in turn to integration of the supply chain its resulting economies

Moreover, in addition to existing collaborative research instruments, a framework for Experimental Projects is necessary to provide an opportunity of creating the necessary references for deployment of innovative construction processes in Europe and on the international markets.

5.3. Developing a Single European Construction Market

Further integration of the sector across Europe can be expected to continue to evolve over time. The ECTP will promote research at European level, but the underlying infrastructure of a single European market calls for further initiatives to promote harmonisation. of the national construction processes, the liability regimes and the national legal systems. There is a need to learn from one another through exchanges of best practices, and to encourage cross border collaboration for large infrastructure projects.

Many national practices and regulations will continue to remain, creating barriers to the take-up of new products and processes at European level. Specific actions are necessary to overcome these barriers, for instance :

- **Eurocodes:** the deployment of the European construction codes is far from complete. Many of their provisions still remain at national level. Efforts must be continued to arrive at a truly European set of construction codes which do not require national application documents unless specifically foreseen in the Eurocodes.
- **Environmental impact of construction materials:** there is a clear need for a harmonised and realistic set of specifications regarding the impact of construction materials on human health, and on air, soil, underground water, etc… There is a clear need also to assess in a harmonised way the content of all raw materials and to collect this information in databases accessible to all actors of the Sector. The foreseen development of Environmental Product Declarations should address this aspect in due time.

- **Health and Safety**: H&S reporting is not harmonised in Europe, making benchmarking and comparisons difficult at European level. The development of harmonised H&S standards and reporting will be beneficial for the future multi-national, multi-lingual European construction sites.

5.4. Implementing the Research

The implementation of this Research Strategy will involve a combination of collaborative research instruments and of Joint Technology Initiatives. The European Construction Technology Platform has the capacity to generate Joint Technology Initiatives. An initiative is today already under preparation.

The construction of very large infrastructure projects could provide an excellent opportunity to develop Joint Technology Initiatives in the Construction Sector. Past examples such as the construction of the Channel Tunnel demonstrate that such large projects combine many characters of the JTIs :

- Based on private funding
- Association of a very large number of stakeholders
- Size and ambition of the project, responding to a major social need
- Innovative character of the technology employed
- Large impact on the competitiveness and public image of the Construction Sector.

5.5. Training and Education

The Sector is already facing a shortage of skilled young people, partly due to demographics and partly due to the reduced attractiveness of industrial activities, when compared to other activities such as finance and services.

First action is to engage the Sector in massive research efforts to change the Sector profile towards a knowledge-based, demand-driven sector, and to base these efforts on cooperation with academic partners.

Research in the Sector combines a wide scope of technologies with environmental, economic and social issues ; it requires a careful cross-disciplinary critical analysis of the construction process from both builder's and user's perspectives. It will also require to define with academic partners the best suitable sets of training programmes with a suitable dosage of specialisation and multi-disciplinarity.

Training the personnel is another priority, a necessity of any knowledge-based process. The objective is to bring high level knowledge to the closest point of its application – ideally, on the construction site itself. New training methods, new training tools must be developed with cooperation of academic partners to reach this goal.

5.6. Linking with other Technology Platforms

Many concepts which are now considered by the Sector have been the subject of previous research, or have been already applied by other industrial sectors; example, the "Design for Disassembly" concept developed by the automotive industry. Still, significant effort is still necessary to adjust these concepts to the specific needs of Construction.

Ambition of the ECTP is to organise an efficient dialogue with the other Sectors wherever a fruitful synergy can be identified, by developing active and living links with other Technology Platforms. A number of relevant Technology Platforms have been already identified :

Manufacturing Technologies ("Manufuture")
Steel
Road Transport (ERTRAC)
Rail Transport (ERRAC)
Industrial Safety
Water Supply and Sanitation…

The network of National Construction Technology Platforms will provide more opportunities to link efficiently to the other sectors and their Technology Platforms, be it at the European level, or at the level of their respective National Platforms.

6. The Way Forward

The European Construction Sector has a tradition in pioneering. Construction techniques invented and developed yesterday in Europe form the basis of our built environment and the core business of today's construction over the world.

The Sector is facing today the impressive challenges of an enlarged European Union in a global market: adapting to a single market and keeping ahead of international competition. A new approach is necessary, mobilising all resources to satisfy all customers needs and to strive for sustainability.

The European Construction Sector must be a pioneer and the leader of this new approach.

The ECTP is committed to coordinate this effort. It benefits from a large support of all stakeholders and of a European network covering most Member States. The impressive momentum it already created towards RTD provides the best guarantee it has the capacity to make the Vision a reality and to "fully exploit the knowledge triangle: the creation, transmission and use of knowledge, through research, education and training and innovation." [1]. This Strategic Research Agenda is only the first step.

[1] Lecture given by EU Commissioner J Potocnik to the ECTP High Level Group Meeting, 1/03/2005