Strategic Research Agenda for the European Construction Sector

Implementation Action Plan

Version 1, July 20th, 2007

European Construction Technology Platform (ECTP)
www.ectp.org
Priority A: Technologies for Healthy, Safe, Accessible and Stimulating Indoor Environments for All

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Item E3: New concepts to extend the life time of structures or increase their capacity, with no reduction in safety and with positive impact on maintenance

Item E4: New testing methods for early detection of damages for structures and infrastructures, even buried, with minimal impact on traffic and supply

Item E5: Develop, design, build and operate, with new or non-conventional multifunctional materials or with traditional materials of enhanced performances, with low environmental impact, high durability, reduced maintenance and operation costs, and increased comfort for users and citizens

Item E6: Integrated life-cycle assessment systems combining cost-efficient and easy-to-maintain sensors, monitoring and performance prediction systems, and covering all stages of construction control, asset management, and optimisation of maintenance

Item E7: ICT and ITS systems to optimise traffic, serviceability and security of networks integrating traffic and transport monitoring and management, information to users, tolling, incident and crisis management

Involvement of SMEs

Budget and scheduling

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Brief description of the priority and rationale

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Introduction

The European Construction Technology Platform (ECTP) officially endorsed its Vision for a sustainable and competitive sector by 2030 “Challenging and Changing Europe’s Built Environment” through its High Level Group meeting held on March 1st, 2005 in Brussels. This Vision fulfilled an important need for a long-term perspective on research needs and set ambitious objectives for the sector.

"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 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."

A vision for a sustainable and competitive construction sector by 2030: “Challenging and Changing Europe’s Built Environment”

This Vision identified a number of important and desirable objectives that should enable the development of better technologies, and to raising the level of “sustainability” in the sector. This would occur both in terms of the characteristics of the buildings and infrastructures themselves, as well as in the processes of actually carrying out construction works.

The Strategic Research Agenda (SRA) of ECTP was endorsed in December 2005. Based on the objectives set up in the Vision 2030, this SRA was a first attempt to identify a set of Research Priorities organised along three main goals clearly singled out: meeting clients/users requirements, becoming sustainable and transforming the construction sector. Under each goal, detailed research areas have been sorted out according to the major strategic research priorities agreed by the Focus Areas of the ECTP in liaison with several National Technology Platforms already active at that time;

The Implementation Action Plan (IAP) of this Strategic Research Agenda constitutes the third step towards a practical mid-term organisation of research needs and activities in Europe in the Construction Sector. After having defined the Vision for the future and the SRA focusing on goals and research areas, the next logical step was to explain how exactly the research themes defined in the SRA should be implemented in the coming years and to describe how ECTP and its stakeholders would facilitate this process, and which parties to involve. Therefore, the IAP focuses on activities and actions.

The IAP of the ECTP SRA is based on a selection of the most important and urgent research areas of the SRA which should be strategically dealt with in the period 2007-2013. This selection resulted from a prioritization process organised in the framework of the ECTP and its comprehensive Network of National Technology Platforms. It enabled to identify a set of 9 major Priorities with a limited number of well agreed research items.

SRA Summary

The SRA defines the research that need to be carried out to achieve the vision whilst at the same time taking into account market forces. It is for these reasons that the SRA is inherently difficult to get right and at the same time is a document of crucial importance. Construction in Europe is a huge industrial sector that represents more than 10% of GDP, involves more than 2.5 million enterprises and employs more than 13 million operatives. Furthermore, the dimensions of the social demand are multiple, which makes the selection of a coherent set of priorities quite a difficult task. The list of elementary priorities which have been agreed by the ECTP can be gathered in 13 main areas grouped in 3 pillars as it follows.

A. Meeting Client/User Requirements

Society is at the same time the end-user and the client of the Construction Sector. It is in permanent evolution, now confronted with an ageing and growing population, with new and more diversified demands for more equity, more comfort, more safety and security, better health, better mobility. The demand of Society is for a new approach to our built environment: houses, cities, transport infrastructures and networks. The challenge of the Construction Sector is to meet this demand not only by new constructions but even
more by renovation and by upgrading of existing structures. Four main sets of R&D needs have been identified in this area:

- Healthy, Safe, Accessible and Stimulating Indoor Environments for All
- A New Image of Cities
- Efficient Use of Underground City Space
- Mobility and Supply through Efficient Networks

B. Becoming Sustainable

Our built environment is intimately linked with nature and its natural resources, and should make the most of our interface with the natural environment. The impact of our built environment on nature is considerable through the resources it consumes, through the land it occupies and transforms, and through the nuisances it imposes. It is therefore vital to strive for a sustainable built environment. Emphasis has to be put on the following domains:

- Reduce Resource Consumption (energy, water, materials)
  i. Energy Efficient Buildings
  ii. Efficient and Environmentally Friendly Construction Materials
- Reduce Environmental and Man-made Impacts
  i. Protecting Land and Water
  ii. Impact of Infrastructure on the Environment
- Sustainable Management of Transport and Utilities Networks
- A Living Cultural Heritage for an Attractive Europe
- Improve Safety and Security

C. Transformation of the Construction Sector

Previous chapters have explored the demands of European customers and European Society both in terms of products and functions to be provided by the Construction Sector. But all of these demands can be placed in a more universal objective: the Construction Sector must be at the service of society, a key player in improving the competitiveness of European industry.

Innovation is needed to support the growing trend towards integrated construction teams and long-term supply chain collaboration. Although off-site techniques are not applicable in all cases, advanced manufacturing techniques must be introduced either on- or off-site to enable suppliers and manufacturers to undertake the following: to reduce costs; to enable mass customisation; to reduce installation problems and health and safety risks; to facilitate design; and finally, to improve quality and consistency. The challenge here is to reengineer the construction process, to transform a technology-driven sector, one that is slow to integrate innovation, into a sustainable demand-driven sector, one that is creative, flexible, innovative, knowledge-based, and which offers new business opportunities and attractive work places to all.

Another important challenge is to incorporate the myriad of small and medium-sized enterprises (SMEs) into this global innovation process, a necessary move to increase the impact and application of new ideas in construction. A knowledge-based construction process will sustain the importance of the sector for our economies, both in urban and rural areas.

The built environment will be of growing value and comfort for people in our cities and villages. There will be a shift away from new construction to renovation and refurbishment, always following the target of improving comfort for consumers, sustainability and value for investors. The construction sector will maintain its importance as an employer of people with a range of skills from both urban and rural areas. Construction will diversify to embrace entirely new performances and methods, but will also remain a craftsman-oriented business for SMEs.

Four main areas of R&D needs have been identified on this topic:

- A New Client-driven, Knowledge-based Construction Process
Prioritization Process

The selection of the most important and urgent research areas of the SRA, which should be strategically dealt with in the period 2007-2013, was carried out through a prioritization process organised from November 2005 to September 2006) in the framework of the ECTP and its comprehensive Network of National Technology Platforms.

The process was based on a voting exercise carried out through 15 participating National Technology Platforms and through the ECTP Support Group itself.

From the 13 main areas of the SRA, a set of 9 major Priorities, with a limited number of well agreed research items (around 60, instead of 160 in the SRA), was selected for implementation in the period 2007-2013.
These nine priorities are following. They are presented according to their appearance order in the SRA and the sections of the SRA document relating to each priority are indicated between brackets.

A. Technologies for Healthy, Safe, Accessible and Stimulating Indoor Environments for All (SRA §1.1)
B. Innovative Use of Underground Space (SRA §1.3)
C. New Technologies, Concepts and High-tech Materials for Efficient and Clean Buildings (SRA §2.1)
D. Reduce Environmental and Man-made Impacts of Built Environment and Cities (SRA §2.2-1.2)
E. Sustainable Management of Transports and Utilities Networks (SRA §2.3-1.4)
F. A Living Cultural Heritage for an Attractive Europe (SRA §2.4)
G. Improve Safety and Security within the Construction Sector (SRA §2.5)
H. New Integrated Processes for the Construction Sector (SRA §3.2-3.1-3.4)
I. High Added Value Construction Materials (SRA §3.3)

Priorities A and B focus on the "meeting client requirements" research area of the SRA, addressing the basic building block of indoor spaces plus the special situation of underground spaces. Priorities C-G are orientated around the "becoming sustainable" research area of the SRA, moving from buildings, to built environments/cities, and then to the level of transport and utilities networks. In addition there are two cross-cutting priorities areas of heritage and safety/security. At last, Priorities H and I concern the "transformation of the construction sector" research area of the SRA and, logically for an assembly industry, focus on integrated processes and innovative materials.

Implementation of the R&D Priorities

The Implementation Action Plan of the Strategic Research Agenda of ECTP explains how the research themes defined in the SRA should be implemented in the period 2007-2013 and describes how ECTP and its stakeholders would facilitate this process, and which parties to involve.

It gives information on:

- the scope of each priority and its rationale,
- the main development issues, mainly in terms of foreseen innovations,
• the expected impact,
• the state of the art,
• the vision and the objectives,
• the synergies with other priorities and/or other European Technology Platforms,
• the list of the research items foreseen in each priority, introducing the main steps of the roadmap of the priority,
• the expected costs\(^1\) of the research activities needed to fulfil out the objectives of each research item during the period, together with the expected timing,
• which kind of instruments is mainly needed (basic research, applied research, demonstration, dissemination, infrastructure, standardisation, networking of stakeholders…) and which programmes may be concerned (FP7 priorities, national programmes, multi-national schemes such as Eranet, EUREKA, COST, private programs…),
• which family of stakeholders is mainly concerned by the research activities and the implementation of the results (academia/research institutes, industry (eventually SMEs), authorities…),
• some major recent projects in each priority.

The IAP is written from today’s perspective and sets a time horizon (2013) which is shorter than the SRA horizon (2030). So the progress of this plan will have to be monitored through some indicators and the plan itself to be revised from time to time taking into account the progress of the research activities and amending the research items and their content if needed.

With a total turnover of nearly 1000 billions Euros, which represents 10% of the EU GDP, the construction sector is vital to the European economy. The impact on the citizen will be enormous. Actually less than 1% of the construction turnover is invested in R&D and this should clearly be improved if we want it to become more knowledge based and competitive as means to fulfill user’s needs and requirements.

\[^1\] All figures mentioned in the various tables of this document have been estimated starting from an evaluation of the budget needed to carry out the research activities related to the considered items/priorities. All figures are in M€ and correspond to the total costs of the projects to be carried out under the considered item/priority. Internal industrial private projects are not included. No assumption of the respective public and private contributions has been made. The order of magnitude of the costs of the FP7-supported projects is coherent with previous Framework programmes.
Priority A: Technologies for Healthy, Safe, Accessible and Stimulating Indoor Environments for All

Brief description of the priority and rationale
People in Europe spent approximately 90% of their time indoors. The health and well-being of people is largely affected by the indoor air quality in the building and the perception of comfort experienced by the building occupants, living and working in the enclosed (and semi-enclosed) environments including transports.

In a free society based on equal rights of people, it is important for all people to be able to access and move safely into building premises and other facilities.

Main development issues
Firstly, research is necessary to understand the effects of the various environmental factors (including indoor air) on the users with diverse needs. Then, new concepts, methodologies and tools must be developed to enable the building of a healthy, safe, comfortable, accessible and stimulating indoor environment for all people.

In order to realise these objectives the following steps need to be undertaken:

Medium-term
1. Better understanding of the impact of the indoor built environment on health, comfort and perception of safety of occupants. There are two aspects to this understanding:
   a. understanding the demands, desires and needs of all occupants, expressed in harmonised performance indicators for evaluating the perception of health, comfort and safety,
   b. understanding the information chain required and improving the information transfer.
2. Development of harmonised assessment methods from the human point of view (holistic approach), focusing on:
   a. objective relations between stimulus and perceptual behaviour,
   b. sensors, actuators and systems that anticipate human perception.
3. Improve and update knowledge of relevant needs for various groups of people (persons with reduced mobility or other disabilities or other users with special needs), by applying a comprehensive approach considering:
   a. their specific requirements,
   b. their interaction with the different environments.

Long-term
4. Development of innovative concepts for safe, comfortable and healthy indoor environments with full participation of all stakeholders in environment and health, comprising of:
   a. new alliances between demand and supply,
   b. matching demand and supply.
5. Building healthy, safe, comfortable, accessible and stimulating indoor environments, making use of the above including:
   a. innovative sustainable and smart materials and systems accessible to all people,
   b. modern method of construction and new operation and maintenance processes of building and network services.
**Expected impact**

The impact on the citizen will be enormous. European citizens spend more than 90% of their time indoors. In more than 40% of the enclosed spaces, people suffer health- and comfort-related symptoms and illnesses. The quality of the indoor environment can also affect the efficient working of people, with a direct consequence on all economical sectors. Consequently, improving the health and comfort of the European population working in these environments will create a huge potential for economic and social benefits, such as increased productivity, reduced sick leave absences and medical costs, and also prevent potential liabilities.

Recent research undertaken by the Association for Higher Education for Access and Disability (AHEAD 2004) finds that 80% of secondary schools are not accessible to children with physical disabilities. A study carried out for the Disability Agenda of the National Disability Authority demonstrates that 30% of homes in Ireland are not accessible for people with reduced mobility (AHEAD, 2003). In Spain the White book of accessibility stated that 100% of the home buildings considered by their study were not accessible to disabled people, since they failed to meet at least one of the accessibility requirements. On the other hand demographic trends show that by year 2020, about one third of the European population will be age over 60, affected by disabilities strongly linked with age. The strong desire of older people to remain independent and spend time in their own home will further increase demand for accessible built environment. Improving accessibility will improve their quality of life, and also enhance the building values for the owners. It will also increase turnover of services by broadening the number of potential customers and it will increase the overall efficiency of services by facilitating everyone’s use of the facilities.

**State of the art**

State of the art is largely dominated by the lack of understanding of the impact of the indoor built environment on perception of health, comfort, safety and positive stimulation.

In the fields of evaluation and design, existing methods and tools are of limited applicability and there is a general lack of specific tools that will take into account the use of the buildings/networks and the user’s population as well as the existing possibilities in terms of materials, construction and ICT.

Current processes are mostly focused on the addition of individual components, which together create a building. Evaluation of each component is based on its individual performance. A real integrated approach is required to create a safe, attractive, environmentally friendly, healthy, comfortable and accessible environment for all. New concepts, technologies, materials and processes need to be developed to design, build and upgrade the existing built environment.

Regardless of the European objective of social inclusion, the implementation of the design for all and universal access in construction still shows today wide differences among local, regional and national legislations. One reason is the lack of scientific foundations of the rules of accessibility. Besides, most of the requisites are constrained to dimensions and general requirements with a lack of assessment methods to quantify other aspects such as usability of devices and materials properties. On another hand, there is a lack of knowledge of users’ needs of populations (such as people with Alzheimer).

Acceptability of construction solutions with regard to many specific aspects such as rescue in case of emergency is also not developed enough. Under these circumstances European policies of social inclusion and free movement of citizens are compromised and the offer for “design for all”, accessibility, devices and materials will lag well behind the need for better service to all people.

**Vision/targets**

- Accessible and safe indoor environment for all (“indoor environment” here and after also includes semi-enclosed spaces such as train stations, football stadium and areas in and around buildings…)
- 50% reduction of the number of accidents at home due to poor indoor environment
- Improved perception of safety and comfort at home, at work and during travelling to and from these places
• Improved general well-being of people through creating a better indoor environment (e.g. lighting conditions, air quality, acoustics, thermal comfort, accessibility and usability)

• Increased productivity in the workplace through spaces that support effective and efficient working of individuals, groups and virtual communities.

**Synergies with other priorities and ETPs**

Synergies must be organised with the proposed JTI on Energy Efficient Buildings (in Priority C of this SRA). Other identified synergies are with:

- Priority H on the development of ICT,
- the European Technology Platform on Industrial Safety,
- the European Technology Platform on Smart Systems Integration.

**Research Items**

**Item A1: Improved Knowledge of Users Needs**

Short Description

To improve the knowledge of relevant (including future) demands, needs and desires for different groups of people in a range of work, home, leisure and care settings (including those with impaired capacity for cognitive, sensorial or motor function). To develop harmonised performance indicators, to determine the effects of indoor environmental conditions and indoor air pollutants on human health.

**Item A2: Harmonised Assessment Methods**

Short Description

To develop harmonised assessment methods from the human point of view (holistic approach) based particularly on sensors, actuators and systems that can anticipate human perceptions, for example, of indoor air quality including all the relevant variables such as outdoor air pollution, indoor sources, building environmental characteristics, occupants' behaviour, etc.

**Item A3: Ensuring a Design-for-all**

Short Description

To develop new methods, new products (automation, ICT, air quality), tools and strategies to support the “design-for-all” approach for new constructions and for refurbishment of existing buildings and networks.

**Involvement of SMEs**

Item 2 “Harmonised assessment methods” is anticipated to raise a strong interest from SMEs, mainly service providers or specialists in sensor or detector instrumentation systems, strongly contributing to the development and exploitation of the research activities, and acting also as final users of the technology.

Item 3: “Ensuring a Design-for-all” is anticipated to raise a medium to strong interest from SMEs, mainly service providers or providers of new products for accessibility.

**Budget and scheduling**

The tentative planning and budget of Priority A in FP7 calls is summarised in the table below. But in fact research needs are much more important, and additional funding will have to be covered by other European (EUREKA, COST…) or National Programmes.
<table>
<thead>
<tr>
<th>Research Items</th>
<th>Planned FP7 Scheduling and Projects Costs</th>
<th>Other Programmes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td>A1 Improved knowledge of users needs</td>
<td>5</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>A2 Harmonised Assessment Methods</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>A3 Ensuring a Design-for-all</td>
<td></td>
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</tr>
</tbody>
</table>

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included. 430

**List of some major recent projects**

UNIACCESS: Design of Universal Accessibility Systems for Public Transport (FP6-SUSTDEV)

SYSPAQ: Innovative Sensor System for Measuring Perceived Air Quality and Brand Specific Odours (FP6-NEST)

ENVIE: Co-ordination action on Indoor Air Quality and Health Effects (FP6-POLICIES)

POLIS: Decision support tools and policy initiatives in support of a universal design of buildings (FP6-POLICIES)

BAS: Building Accessible Services EC Employment and Social Affairs DG Project

LENSE: Methodology Development towards a Label for Environmental, Social and Economic Buildings

BUMA: the aim of this project is to create a reference database about emissions of building materials into indoor air (DG SANCO)
Priority B: Innovative Use of Underground Space

**Brief description of the priority and rationale**

Safety, health and convenience of public life in Europe depend widely on the construction sector. Transport, utility and communication systems below ground-level contribute greatly to the arteries and lifelines of our modern society.

The European Underground Construction Industry is mainly responsible for constructing, refurbishing and maintaining these complex systems.

Increasing societal demands - larger cities, reliable and safe transport of people and supply, need for green and recreational areas, better emission control of CO₂ and particulate matter - call for continuous improvement of sustainable and resource efficient urban planning and development.

Underground Construction (UC) is a key sector to offer solutions for pivotal societal challenges through developing innovative new underground facilities, refurbishing existing underground structures and exploiting their potential for renewable and readily available energy. UC technologies can drastically impact the needed effort to improve the quality of surface space by e.g. transferring air and noise polluting traffic infrastructures and hazardous facilities, such as waste plants, storehouses etc. below ground level.

Cutting edge underground construction technologies (UCT) are needed to maintain and refurbish the existing underground infrastructures and facilities during their safe and secure operation. Advanced UCT are thus able to initialize and provide design and operative solutions for traffic congestion problems and pollution (transport of people and/or supplies through tunnels), and in addition for the issue of energy efficiency (reduced traffic congestion, shorter travelling times, use of geothermal energy) sharing its responsible effort to finding answers for coping with the climate change.

**Main development issues**

A highly mechanized, technology driven underground construction sector is pivotal in providing transport and/or supply solutions for a sustainable and high quality of life in urban and inter-urban areas, which are particularly environmentally strained.

This will include the development of new and better traffic and/or infrastructure systems and the optimization of existing structures through their holistic integration with new and existing subsurface infrastructures - for example transport of goods - and feature longer and safer life cycles.

Milestones are:

- improvement of public acceptance of underground construction,
- reduction of environmental impact and risks during construction (e.g. monitoring system developments; use of new materials and innovative/improved use of conventional ones),
- increasing of safety during construction and security during operation,
- finding solutions to link new and retrofitted structures to energy efficiency
- new business fields due synergy of underground construction and energy supply
- automated or highly-assisted retrofitting technologies,
- development of automated or highly assisted mechanized tunnelling,
- improvement of ground reconnaissance technologies in order to produce the least negative environmental impact,
- new concepts for funding of large projects (such as TEN-T), risk assessment by insurance companies, cost reduction through standardisation.

Much of this work will largely be based on ICT, such as virtual construction through which underground construction takes up a pioneering role. Facing heavy competition from the United States and Asia requires the most advanced solutions in terms of models, materials and recycling, monitoring and decision support systems, components, design, construction, and maintenance as well as replacement technologies.
**Expected impact**

Underground Construction technologies highly influence the realisation of fundamental targets that are beneficial to the society. These are adopted in the Strategic Research Agenda, and primarily focus on urban and inter-urban areas.

Economic and social life depends heavily on the advances and performance of the construction sector. Infrastructures - roads, railways, airports, ports, pipelines, electricity and water networks, sewers, telecommunication systems, etc – are our life-lines and rely increasingly on underground construction technology and performance.

Three activity fields have been identified to be relevant for UC expertise. As they are interlinked and tied to activities of other stakeholders, the obtained impact can be significant due to synergetic potential.

<table>
<thead>
<tr>
<th>Field</th>
<th>Impact</th>
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</table>
| Technology| • automated / highly assisted tunnelling  
• revisiting tunnelling processes in order to take into account technology breakthroughs  
• safety and security (no worker in hazardous areas, for instance near tunnel face)  
• developing technological solution by reconciling subsurface infrastructures of any kind with energy/heat production |
| Resources | • reduction of primary energy sources  
• minimizing use of surface space  
• minimizing environmental impact through e.g. emissions, noise and particulate matter  
• … |
| Society   | • maximizing use of surface space for societal well-being (quality of urban life)  
• improving acceptability of wide-spread underground infrastructures  
• improving (reliability, safety, security) high speed traffic between and within large urban areas by use of shortest possible underground connections  
• traffic impact is minimized at the surface by the use of underground space  
• effective use of existing underground space for different traffic systems (for instance metro lines for goods transport during the night)  
• … |
State of the art

In order to cope with an increasing traffic congestion, European countries and cities are designing ambitious improvements of their transportation systems, relocating appropriate infrastructures underground and providing the basis for a more harmonious and sustainable development.

The competitiveness of Europe and its social and economical development depend heavily on the comprehensive integration of infrastructure systems aiming towards a quick and safe transportation of people, goods and supply, eventually across the borders of the Member States (TEN-T).

Underground construction is to this day a high risk activity, and bears a large number of unknowns and uncertainties, despite being the most mechanised construction activity.

The current R&D state-of-the-Art can be summarised through the TUNCONSTRUCT project.

TUNCONSTRUCT is a multi-disciplinary research project (2005-2009) that promotes the development and implementation of European technological innovation in underground construction. The objectives are strategically targeted on multi-faceted aspects of innovation that can be classified into four specific areas:

Design: the improved prediction and underground engineering design capabilities, based on an expert-knowledge basis, will be a factor in lowering costs while reducing construction time and risk in underground operations. In addition, virtual underground construction through computer simulation, integrated optimization platforms and risk-oriented fuzzy logic design will have an impact on industry productivity, economic competitiveness, bottom-line performance and future opportunities.

Technologies: to develop innovative underground construction technologies such as new TBMs, with larger diameters and suitable for any ground condition, the use of robots in construction, automatic shot-creting machines, road headers, and similar. The research will also focus on increasing quality of the final construction by developing efficient, durable materials for lining and ground treatment, and on exploring construction procedures that minimize long-term impact on the environment.

Processes: to improve construction processes using an integrated platform for process optimization, expediting their effective introduction into practice; to promote the exchange of information by providing a web-based data system that can supply relevant and reliable information throughout the lifetime of an underground facility. The research will include an efficient monitoring during construction and visualization of geological data based on augmented virtual reality.

Services: to significantly improve performance and reduce the costs of maintenance and repair by means of state-of-the-art technology, such as specialized sensors, integrated robotic inspection and service systems, post-construction monitoring and inspection devices, management and service-life analysis systems, and other related repair and service methods.

The current state-of-the-Art regarding safety and security in Underground Construction can be summarised through the L-SURF project.

Research on safety and security in enclosed underground spaces is of outstanding importance as current incidents (tunnel fires, terror motivated attacks in metros etc) have shown. However currently the EU competence related to safety and security is largely unstructured, fragmented and mostly national oriented. Especially missing is a large scale research facility and the coordination and synergy of existing facilities. The necessity for a European wide initiative in these respects also was identified and clearly expressed during the 1st International Symposium on safe and reliable tunnels, held in Prague in February 2004.

Vision/targets

Underground Construction has the following vision for Europe:

- Significant contribution towards sustainable and safer urban networks.
- Transforming underground construction and space into competitive alternative to surface construction (in terms of price, safety and quality).
- Platform for new construction concepts and new business models adopted by city planners and decision makers to foster the development of sustainable cities.
- Tunnelling equipment for any type of ground, for instance TBMs capable of working in any type of ground without stopping.
- Innovative methods and equipment for geological exploration, monitoring and decision support system.
- New cutting technologies.
- Active control to minimise environmental impact.
- Include renewable/geothermal energy for underground construction and structures.
- To become an attractive technology-driven, skills demanding industrial sector, through educational/outreach programmes.
- Novel underground transport system for supplies and goods, supplementary to existing infrastructures.

**Synergies with other priorities and ETPs**

Priority B can unfold an essential impact using a holistic approach to tap a significant synergy potential. That would include:

- The technical and design support of infrastructure (roads and highways, railways, water distribution and sewage) as well as underground facilities.
- A substantial integration of ICT.
- Innovative contributions to the energy sector and/or supply lines.
- Close collaboration with clients that wish to exploit synergetic potential such as reconciling underground mass transportation and cargo supply.

This holistic approach includes a strong link with other priorities of this Implementation Action Plan, in particular:

- Priority D: Impact on Environment
- Priority E: Management of Networks
- Priority F: Safety and Security
- Priority G: Processes and ICT
- Priority H: High Added Value Materials.

Regarding the needs in the frame of safety and security in Underground Construction (as summarised in the L-SURF project), a link with Research Infrastructures has to be established.

Such a holistic approach requires also a link with platforms dealing with the system (infrastructure cannot be separated from the supported system), for instance with the European Technology Platforms on Rail (ERRAD), Road Transport (ERTRAC) and Industrial Safety (ETPIS).

Finally this need of a holistic approach could also be addressed in the frame of a Joint Technology Initiative. Such a proposal is actually under discussion between the stakeholders of UC, with an expected budget of 100 M€.

**Research Items**

In order to maximize the impact potential for the above listed challenges, Priority B has identified various relevant research topics within the activity fields, which are listed below according to their realisation potential, i.e. what is a realistic time frame for their exploitation. These topics should be tackled using appropriate R&D tools, such as FP7, JTI, EurekaBuild and/or National projects.

**Item B1: New Concepts: Integration Underground Functions**

**Short Description**

New concepts regarding underground logistics can upgrade the urban environment also making better use of already existing underground logistics. Living space will benefit from this as well as inner-city transport processes. Regained new urban space can be returned to the city and its inhabitants.
Concepts consider:

- Exploration of synergies with existing underground infrastructures; for example metro systems supplying the inner-city at night, temporary use of tunnel parts or underground parking spaces for emergency storage in rain overflow situations, putting underground of inner urban railway links and upgrading them to backbone logistic supplies with free access for suppliers, etc.
- Development of new concepts like integrated underground distribution channels, for example integrated pipelining for energy, data, sewage, packages, etc in urban underground.

Deliverables include the development of these concepts and a piloting in an urban construction project.

**Instruments:** Large-scale integrated projects.

**Item B2: Retrofit and Upgrade of Existing Underground Structures**

**Short Description**

The main targets are: new concepts, technologies, tools for retrofitting and upgrading existing underground structures. The aim is to address the increasing need of retrofitting and upgrading with regards to new regulations, requirements regarding larger dimensions, traffic volume increase, commuter needs, and changed boundaries needs (cities above ground have changed in the meantime). Developments will target also retrofitting and rehabilitation technologies, as well as related equipment. These have to take account of higher security and safety levels, during operation and monitoring. Deliverables include the development, integration and demonstration of the above concepts, technologies and tools.

**Instruments:** Large-scale integrated projects.

**Item B3: New Tunnelling technologies**

**Short Description**

TUNCONSTRUCT is developing innovative technologies including new TBM’s (larger diameter, suitable for any ground conditions, automated steering), automatic shot-creting machines and/or road headers…

Nevertheless construction projects are more and more ambitious: deeper, longer, larger, less overburden, higher water pressure… Squeezing is an unsolved problem. In such difficult conditions, maintenance and replacement of cutting tools become a critical issue. Breakthrough in rock cutting technology is expected: on one hand regarding a radical advance in cutting tools; on the other hand regarding robots to help maintenance of existing tools and therefore avoid human intervention in hazardous areas.

The targets are: new concepts, technologies, tools enabling automated excavation in any type of ground for long, large and deep tunnels. Hence, developments are also required in automation and remote control of equipment and processes necessary to operate in highly difficult conditions, intelligent and modular machines. Deliverables include the development, integration and demonstration of the above concepts, technologies and tools.

**Instruments:** Large-scale integrated projects.

**Item B4: Processes and ICT**

**Short Description**

TUNCONSTRUCT is initiating virtual construction in underground construction including design, monitoring and decision support systems. Ambitious and difficult, this topic opens the path towards larger applications.

A big issue is the transfer of this technology to the tunnel site. The processes have to be revisited taking into account two axes: business and technology.

The main objective of the item is to apply ICT for fully integrated process optimization and automated equipment. The main development issues and targets are: technologies to monitor, to reduce and manage risks and environmental impact of underground constructions as well as costs during their entire life-cycle.
Deliverables include the development, integration and demonstration of embedded monitoring systems, expert and decision support systems.

**Instruments:** Large-scale integrated projects.

**Item B5: Transparent Underground for 3-D Urban Planning**

**Short Description**

The main objective of the item is to make the underground conditions (with all its natural and man-made structures) visible in a way that can be used in every sector of urban planning and building. Opportunities will increase and risks will be reduced. The main developments will include a method (or methods) to collect interdisciplinary data on pipes, cables, foundations, geological conditions, etc and merge it into a dedicated GIS system. These methods and tools should be demonstrated in pilot studies in different urban areas. Deliverables include both an operative method to collect, evaluate and store data and a set of GIS applications that can give an integrated 3-D picture of “the city under the city” at any relevant scale.

**Instruments:** Large-scale integrated projects.

**Item B6: n-D Modelling in Tunnelling**

**Short Description**

TUNCONSTRUCT has shown the way and demonstrated that it is possible. The needs are large and the technology is moving quickly.

The main objective of the item is to apply digital models and simulation tools (Underground Information Model) in order to reduce risks, environmental impacts and costs during the whole life cycle of underground spaces. The main development and issues are related to safety and security, social acceptance, risk management based on simulations and decisions support systems. Developments are also required to address the new challenges of going deeper. Deliverables include the development, integration and demonstration of the above concepts, hardware and software package.

**Instruments:** Large-scale integrated projects.

**Item B7: New Materials**

**Short Description**

The main objective is to apply new material technologies and developments in order to reduce risks, environmental impacts and costs during the whole life cycle of underground spaces. Main developments and issues are related to fire resistance, waterproofing, self caulking, pressure resistance in order to cope with safety and environmental impacts. Developments are also required to address the new challenges of going deeper and using excavated materials form the construction of tunnels. Deliverables include the development, integration and demonstration of the concepts and materials.

**Instruments:** Large-scale integrated projects.

**Involvement of SMEs**

Underground Construction is a more risky and industrialized activity than in general in the construction sector. Companies active in that field are not numerous. SMEs do not act as main contractors, but they participate more and more often as associated contractors.

Their added value stands in specific fields, linked to small markets (“niches”) where this is no room for bigger players. These related fields are linked to ICT (monitoring systems, software development…) or Electrical & Mechanical (systems, embedded software…).

Consequently, if dedicated SME-targeted projects are not suggested, SME participation is definitively recommended due to their flexibility and agility to address high-tech fields. The final project results will benefit SMEs in the frame of “niches” activities, but also other industrial companies.
**Budget and scheduling**

The tentative planning and budget of Priority B in FP7 calls is summarised in the table below. But in fact research needs are much more important, and additional funding will have to be covered by other European (EUREKA, COST…) or National Programmes.

<table>
<thead>
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<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>2007</td>
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<td>2009</td>
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<tr>
<td>B1 New Concepts: Integration Underground Functions</td>
<td>10</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>B2 Retrofit and Upgrade of Existing Underground Structures</td>
<td>15</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>B3 New Tunnelling Technologies in any type of ground for long, large and deep tunnels</td>
<td>25</td>
<td></td>
<td>125</td>
</tr>
<tr>
<td>B4 Processes and ICT</td>
<td></td>
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<tr>
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<tr>
<td>B7 New Materials</td>
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</tbody>
</table>

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.

**List of some major recent projects**

- TUNCONSTRUCT (IP) Advancing the European underground construction industry through technology innovation ([http://www.tunconstruct.org](http://www.tunconstruct.org))
- UPTUN (FP5): it is the acronym for Cost-effective, Sustainable and Innovative Upgrading Methods for Fire Safety in Existing Tunnels. Its main objectives are: a) to develop innovative technologies where appropriate and where relevant comparing to and the assessment of existing technologies for tunnel application; b) to develop, demonstrate and promote procedures for rational safety level evaluation, including decision support models; and knowledge transfer ([http://www.uptun.net](http://www.uptun.net))
- FIT (FP5): it is a European Thematic Network on Fire in Tunnels. FIT provides a European platform for dissemination and information of up-to-date knowledge and research on Fire & Tunnels ([http://www.etnfit.net](http://www.etnfit.net))
- DARTS (FP5): it stands for Durable and Reliable Tunnel Structures. Its objective was to develop operational methods and supporting practical tools for the best pro-active decision-making process for choosing, in each individual case, the cost optimal tunnel type and construction procedures regarding environmental conditions, technical qualities, safety precautions, service life ([http://www.dartsproject.net](http://www.dartsproject.net))
- SafeT (FP5): it is a "Safety in Tunnels" Thematic Network on development of European guidelines for upgrading tunnel safety ([http://www.safetunnel.net](http://www.safetunnel.net))
- VIRTUALFIRES (FP5): its main objectives were: a) the development of efficient methods for handling large datasets to visualize fire disasters in real time; b) the comparative study of the impact of various fire-fighting methods; c) the comparison of the simulation results with real fire scenarios in order to verify the quality of the computed results.
• SIRTAKI (FP5) stands for Safety Improvement in Road&rail Tunnels using Advanced ICT and Knowledge Intensive DSS. The strategic goal of SIRTAKI is the development and assessment of an advanced tunnel management system that specifically tackles safety issues and emergencies and the integration within the overall network management (http://www.sirtakiproject.com)

• SWOP (FP6-Strep) stands for Semantic Web-based Open information Platform (http://www.swop-project.eu)

• SCOUT (FP6-Strep) : Sustainable Construction of Underground Transport infrastructure, with the objective to define a new approach to cut and cover tunnel projects.

Brief description of the priority and rationale
Our built environment is intimately linked with nature and its natural resources, and should make the most of our interface with the natural environment. The impact of our built environment on nature is considerable through the resources it consumes, through the land it occupies and transforms, and through the nuisances it imposes. It is therefore vital to strive for a sustainable built environment.

Main development issues
Energy supports vital services and societal comfort, which are the main components of the European way of life. But energy consumption also has major impacts on the environment and the European economy. The European energy policy is dominated by two main concerns:

- Reducing greenhouse gas emissions in order to reduce global warming and the damaging economic and ecological consequences.
- Reducing Europe’s reliance on imported energy.

Expected impact
Consumption of energy for heating, cooling and lighting the built environment represents about 42% of the total consumption of energy in Europe. Energy performance of the built environment has therefore a huge impact on the capacity of Europe to meet objectives to reduce the CO₂ emissions by a factor 4 before 2050.

The decrease of our energy consumption is recognized as well by Europe as by all Member States as a major challenge for the future. All other economical sectors are affected by energy performance of the built environment. The impact of a large reduction of the energy consumption shall automatically also be important on the air pollution (CO₂ / NOₓ /SOₓ/…). The impact shall also have a big effect on the employment in Europe, mainly in SMES involved in renovation of existing buildings.

Concerning the environmental impact of building materials, it should be noted that 180 millions tons of waste are produced annually and in many countries the amount of C&DW which is reused and recycled is yet below 20 %. The challenge increases with new materials and material combinations.

State of the art
As a major industrial sector, the construction sector must contribute to reduce the consumption of natural resources, especially energy, water and materials. Although not visible, energy supports vital services and societal comfort, which are the main components of the European way of life. But energy consumption also has major impact on the environment and the European economy. As far as the construction sector is concerned, European buildings are deeply affected by these two main factors:

- In 2002, the domestic and service sectors accounted for 41% of all final energy consumption in the EU-15.
- Households and services are the third largest source of CO₂ emissions in the EU-15 if electric power generation is considered as an alone item (Electric Power: 31%, Transport: 29%, Buildings: 18% in 2001). It becomes the first emitter of CO₂ if the respective parts of electricity are included into final sectors (Buildings: 36%, Industry: 33%, Transport: 27%).

In today’s context, 80% of energy consumed during the whole life-cycle of a building is consumed during its service life (20% is consumed for materials production and construction and demolition works). The first priority is then to reduce energy consumption of buildings during their lifetime. Annual energy consumption in residential buildings is 100-250 kWh/m². In Eastern and Central Europe, heating energy consumption...
reaches approximately 250-400 kWh/m², that is to say about 2 times more than for similar buildings in Western Europe. In Northern European countries, well insulated buildings only consume 50-100 kWh/m² per year. About 20000 passive houses have been built in Europe, mainly in Germany and Austria and consume less than 20 kWh/m² per year. The energy consumption of the built environment in the next 50 years is mainly determined by the existing building stock.

Vision/targets

In 2030 it is waited that a minimum of 30% of existing buildings will have been upgraded to a high level of energy efficiency. The average decrease of energy consumption will be around 50%. New highly efficient buildings will be affordable and represent a significant part of this market.

By 2050, the majority of new EU buildings will produce nearly zero CO₂ emissions and produce by themselves the main part of their energy demand. 100% of 2050 building stock will be retrofitted. Energy consumption and CO₂ emissions of the Construction Sector will be decreased drastically (more than 2/3).

- Total potential CO2 emissions reduction:
  - For EU-25: 450 Mtoe by 2010 – Source Euroace 2005
    - Thermal insulation – (up to 200 Mtoe reduction)
    - Glazing – (up to 120 Mtoe reduction)
    - Control Systems – (up to 80 Mtoe reduction)
    - Lighting – (up to 50 Mtoe reduction)

Concerning the reduction in natural resources consumption, the targets are:

- 50% reduction of the embodied energy in construction materials and components of equal performance
- More than 30% reduction of the specific raw materials
- More than 40% waste reduction in the manufacturing processes for construction materials and components
- Provision of on-site storage and segregation of waste
- <1% of construction waste going to landfill disposal
- Striving towards 100% of new construction materials which are recyclable and towards 100% re-utilization of construction and demolition waste
- Substantial reduction of water consumption
- Substantial contribution of renewable energy sources.

In order to ensure the coordination of all needed actions, a JTI (Joint Technology Initiative) E2B (Energy Efficient Building) should be set up and is under preparation.

Synergies with other priorities and ETPs

Priority C covers a broad scope of technologies, concepts and materials that the Priority would like to integrate in order to fulfill its goal which is to provide end-users with a final product: efficient and clean buildings. It is recommended to look at the building as a global system, with first an optimization of the thermal envelope, followed by the optimization of the energy equipments and the increase of the renewable energy supply. As a consequence, contacts and links have been established with all these other sector-oriented European Platforms (such as Sustainable Chemistry, Steel, Forestry, PV, Hydrogen...) dedicated to the development of technologies and/or materials that the Construction sector, as the assembling stakeholder, will have to implement to carry out its goal.
**Research Items**

Priority C has been detailed in 5 research items that are briefly described in the following paragraphs.

However a proposal to set up a JTI E2B (Energy Efficient Buildings) to coordinate the priority is in preparation. The JTI expected budget should be more than 350 M€ starting as early as possible before 2011.

The overall objective of E2B JTI, through a systemic approach, is to deliver and implement building and district concepts that have the technical, economic and societal potential to cut the energy consumption in existing and new buildings by 50 % within 2030, thereby contributing to improve the energy independence of EU.

Reaching this goal will imply:

- A strong identification and development of the new technologies and materials that are needed to realise the building concepts. This will include, through a systemic approach, the integration of results issued from the work of related technological platforms.

- The development of new business models, services and partnerships in the value chain, allowing putting the building concepts into practice.

- The proof by demonstrators that these concepts, business models and value chain partnerships actually allow to deliver energy efficient buildings in a more satisfactory way.

E2B JTI will then contribute to a significant reduction of the environmental impact of the building sector in terms of emissions and resource consumption.

**Item C1: New concepts, technologies, design tools and business models**

**Short Description**

New concepts, technologies, design tools and business models (based on users’ and investors’ motivation for investing in sustainable building solutions) for the retrofit of existing buildings and for large scale development of affordable and attractive new buildings able to meet their own energy consumption through renewable energy sources, to reduce their energy needs and lower their CO2 emissions. The concept of "intelligent building" will embed new technologies in order to improve the building energy management (cladding and ventilation technologies, sensors and pervasive computing systems...) at building and district level.
Item C2: New and improved materials and structures

Short Description
Development of new and improved materials and structures to improve indoor climate, energy consumption and heat storage capacities of buildings (including underground), and fulfil users requirements, especially but not only by means of nanotechnologies, sensor and information technology and life cycle assessment.

Item C3: Integrated design tools

Short Description
Integrated design tools based on whole-life value in order to identify the best concepts and technologies to make old and new buildings highly resource efficient (energy, raw materials, water, low energy industrial processes), as well as fulfilling users needs in terms of comfort, design, accessibility and price. Appropriate simulation systems for evaluation and optimization.

Item C4: New information systems

Short Description
New information systems for old and new buildings to monitor and manage the resource efficiency and to predict and manage service life at building and district levels.

Item C5: Environmentally friendly building material production

Short Description
Development and improvement of construction materials manufacturing processes with high performances and reduced environmental impact (energy and resource consumption), optimisation of materials and components transportation and assembly processes focused on the reduction of energy consumption; use of large quantities of secondary (and local resources), residual products and waste (Environmentally friendly building material production).

Involvement of SMEs

SMEs are vital for Europe and the construction sector involves more that 2.5 million enterprises mainly SMEs. This sector provides the framework (in terms of product and services) to support all other activities whether commercial or not. Its leverage effect is tremendous: attractive employment opportunities shall be created by the new technologies and applications linked to efficient and clean buildings.

In all projects, a large involvement of SMEs shall be needed for the demonstration and dissemination stages. A large implementation of a new technology or a new product in new and existing buildings is not possible without the involvement of SMEs.

Another kind of SMEs are very innovative and are at the origin of a large amount of new ideas needed to develop new technologies and applications. Some special construction materials and products developers, involved in precast manufacturing, recycling, etc., as well as sensor developers are SME’s. Consequently, item 2: New and improved materials and structures and item 3: Integrated design tools are highly relevant for SMEs.

SMEs are also major players of integral services to monitor and manage efficient and clean buildings, especially for the retrofitting of existing buildings. For this reason, item 1: New concepts, technologies, design tools and business models, and item 4: New information systems could be addressed to specific calls for SMEs.
**Budget and scheduling**

The tentative planning and budget of Priority C in FP7 calls is summarised in the table below. But in fact research needs are much more important, and additional funding will have to be covered by other European (EUREKA, COST…) or National Programmes.

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<tr>
<td>C1 New concepts, technologies, design</td>
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<tr>
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<td>material production</td>
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</tbody>
</table>

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included. **780**

**List of some major recent projects**

- Eco-buildings and Concerto Projects dealing with the demonstration of energy-efficient buildings and communities
  - DEMOHOUSE. Design and Management Options for Improving the Energy Performance in Housing ([http://www.demohouse.net](http://www.demohouse.net))
  - MULTISOLAR. Development of an integrated Solar System for Buildings
  - POLYSMART. POLYgeneration with advanced Small and Medium Scale thermally driven Airconditioning and Refrigeration Technology ([http://www.polysmart.org](http://www.polysmart.org))
  - SARA. Sustainable Architecture Applied to Replicable Public-Access Buildings ([http://www.sara-project.net](http://www.sara-project.net))
  - ACT2 Nantes Island Project. Urban sustainable development projects
  - BIPV-CIS. Improved building integration of PV by using thin film modules in CIS Technology ([http://www.aramis-research.ch/d/18791.html](http://www.aramis-research.ch/d/18791.html))
  - CAMELIA. Concerted Action Multigeneration Energy Systems with Locally Integrated Applications
  - POLYCITY. Energy Networks in Sustainable Cities

- Intelligent Energy Europe Projects dealing with the dissemination of energy-efficiency measures towards stakeholders and communities
- AUDITAC. Field benchmarking and market development for audit methods in air conditioning (http://www.energyagency.at/(en)/projekte/auditac.htm)
- BESTFACADE. Best practice for double skin facades (http://www.bestfacade.com)
- BUDI. Pilot actions to develop a functioning market for energy performance certificates (http://www.buildingdirective.org)
- CLEAN-E. Clean Energy network for Europe (http://www.eugenestandard.org/clean-e)
- DEEP. Dissemination of energy efficiency measures in the public buildings sector (http://www.iclei-europe.org/?deep)
- EARTH. Extend accredited renewables training for heating (http://www.earth-net.info/)
- ELVA. Establishing local value chains for res heat in local communities (http://www.bioheat.info/)
- ENERinTOWN. Monitoring and control of energy consumption in municipal public buildings over the Internet (http://europa.eu.int/comm/energy/intelligent/projects/doc/factsheets/enerintown.pdf)
- EPBD. European Building Performance Concerted Action
- EPLABEL. A programme to deliver energy certificates for display in Public buildings across Europe within a harmonising framework (http://www.eplabel.org)
- E-TOOL. Energy Toolset for improving the energy performance of existing buildings
- EULEB. European high quality low energy buildings (http://www.euleb.info)
- IMPACT. Improving energy performance assessment and certification schemes by tests (http://www.senternovem.nl/impact/index.asp)
- INTELLIGENT METERING. Energy savings from intelligent metering and behavioral change
- ...
Priority D: Reduce Environmental and Man-made Impacts of Built Environment and Cities

Brief description of the priority and rationale
The objective is to reduce the impacts of construction and operation of infrastructure networks and of building on natural and urban environment during their whole life cycle. The success of the European society depends on the quality of her urban environment, and this has been acknowledged by the European Commission setting out the European thematic strategy on Urban Environment.

For the Construction Sector, this requires a global vision of the future based on environment-friendly concepts that will provide a high quality service level, reduce construction/maintenance costs, improve health, safety and environmental criteria such as a more sustainable use of resources (materials, energy, water, land…), a better valorisation of waste materials and reduce the emissions of pollutions to air, water, and soil.

Main development issues
The main development issues for improving the knowledge and development of technologies and materials to reduce the impacts of pollution, on water, energy, raw material consumptions, land use, soil fixing, noise and vibration are:

- Urban planning and management: urban environment must be planned and adequately constructed and maintained, incorporating a consideration of its whole life performance, at several levels: city, town, district and individual building.
- Regeneration of brownfield sites: the use of brownfield sites must be encouraged to reduce further demand on greenfield sites.
- Environmental impact of the construction processes by disruption and pollution must be reduced. Construction works must be adequately planned to be better integrated in the cities. Infrastructure of transport and service networks must be better integrated in the landscape.
- Environmental profile of materials: construction materials must reduce their consumption of resources, embodied energy and production of by-product wastes. This requires an improvement in the manufacturing processes and the properties of construction materials and components.
- Resource management: the construction process must include an end-of life strategy for the building. The demolition processes must optimise the reuse and recycling of materials and components recovered during the de-construction of buildings. This requires a consideration of the demolition-deconstruction processes at the early stages of the design for the building.
- Efficient use of energy and reduction of CO₂ emissions: research must focused on reversing the energy balance of buildings and built environments, from a negative energy balance to a more neutral or positive energy balance.
- Efficient use of water: there is a need to reduce the consumption of treated water and production of wastewater. There is also a need to develop technology to reuse-recycling of natural waters (rainwater, for instance) and waste waters.

Expected impact
In Europe, some 80% of its citizens live and work in the cities. Therefore, environmental performance of the Construction sector has a huge impact on the quality of life in Europe. It also impacts the performance of European economical sectors, all tightly depending on the performances of buildings, transport infrastructures (road, railways, airport, seaports), and service networks (gas, electricity, water, sewers, telephone).
Urban environment should be planned and constructed in a way that includes consideration of users and population demands such as living, working, pursuing leisure and travelling, and that ensures a vibrant economy and a healthy, equitable society which are major goals for sustainable development.

Reducing the impact of infrastructures on the environment is paramount to meet users and population demands and needs for a better quality of life.

The current exponential growth of natural land consumption should be ceased to allow citizens to enjoy natural green land. Urban centres should be revitalized to reduce the movement of people to the edge of the cities and subsequently increasing the demand for Greenfield developments.

As much as 50% of all materials extracted from the earth's crust are transformed into construction materials and products. Moreover, these same materials, when they enter the waste stream, account for some 50% of all waste generated prior to recovery. Construction & Demolition wastes (C&DW) amount to around 180 million tonnes in the EU every year. About 65% of this is recycled or re-used across the EU-15. A high proportion of the construction wastes are concrete, bricks and tiles, can be crushed and recycled as alternatives for newly quarried aggregates for certain lower grade applications. The percentage of the recycled or reuse materials can be substantially increase by having a better resource consumption strategies, producing new materials based on waste recycling-reuse technologies and new design strategies to include the end-of-life consideration of buildings.

Heating and lighting of buildings accounts for the largest single share of energy use (42%; of which 70% for heating) and contributes to about 35% of all greenhouse gas emissions in the global atmosphere. Poor design and construction can have a significant effect on the health of building occupants and can produce buildings that are too expensive to maintain, heat and cool. The effects can disproportionately affect the elderly and less affluent social groups in the society. Changing the ways that buildings and the built environment are designed, constructed, refurbished and demolished can enable significant improvements of the environmental and economic performance of towns and cities and the quality of life of urban citizens.

A sustainable environmental management plan aims to reduce the amount of treated water used in the building and the reduction of the wastewater passing to the treatment plants. Implementation of new technologies and “intelligent” management strategies will lead to a higher reduction of water consumption and wastewater generation.

State of the art

Each and every function or element of the city contributes in a different way to the overall environmental impact of urban areas. The accumulation of buildings and other hard surfaces has several negative effects on the environment, including: soil sealing that enhances the likelihood of flooding, creation of “heat island” effects, glare pollution, pollution concentration and noise, dust and vibration disturbance. At present, the environmental implications of the policy decisions are often not sufficiently considered. There is a need to develop integrated tools for the evaluation of the environmental impact of urban planning decisions and the whole life performance of the urban environment.

Additionally, large surfaces of "Greenfield" – or natural land - are used for new builds, transportation infrastructure in Europe every year. The amount of urban land increase exponentially, which is causing a dramatic impact on biodiversity and reducing the amount of natural land available for other purposes.

Construction works are associated to disruption and nuisances. Construction processes must be optimised to reduce disruptions by reducing the volume of on-site activities or using less disturbing equipment and processes. There could be obvious benefits from minimising the amount of work-sites for maintenance of networks infrastructure (gas, water & sewerage, roads, railways, waterways) taking place in cities and in rural environment.

Increasing the degree of off-site manufacture and assembly is another means to effectively reducing the impact of construction works. Moreover the impact of transport of components must also be considered. More accurate control of the works and better information will also help; for example, by optimising the efficiency of the works and reducing the incidence of accidents that could extend the duration of works.

The amounts of raw material and energy used in construction have to be minimised, to reduce pollution and wastes. Careful choice of materials and components can greatly reduce the embodied impact of construction. Construction materials, components and systems will condition the buildings and the urban...
environments. High performance materials will enable efficient and low environmental impact management and use during construction, use and the end-of-life of buildings.

The nature of C&DW is directly linked to techniques used during construction. Increasing variety of materials found in C&DW, adds up to the complexity for management of wastes from demolition activities. Reusing and recycling construction wastes would significantly reduce the need for landfill sites and further mineral extraction. The demolition plays an important role here: it must be carefully planned and organised to enable maximum reuse and recycling of materials and components. This is likely to be cost-neutral or even generate costs savings. Another important issue relates to waste reduction from the design, through approaches such as using standardised components, or providing space for the recycling bins in the completed buildings. The building process has to be planned and managed in a way that minimises the production of wastes during all stages of the construction process.

The Directive on the energy performance of buildings is expected to make a significant step forward in highlighting the very real shortcomings of the generally unsatisfactory energy performance of existing buildings. The objective is to minimise the energy consumption (or even to produce energy) without loss of comfort for the occupants. Several alternatives could be considered, such as working on the building envelope by insulation, on more efficient and responsive heating and lighting controls, on appropriate glazing and shading to avoid over heating in the summer, on higher natural ventilation, on generating energy by using renewable resources. Customised and intelligent work- and living space offers important opportunities to reduce energy use.

A sustainable management of water resource in built environment aims to reduce the amount of treated water used in the building whilst reducing the amount of wastewater discharged to treatment plants. This can be achieved by using more water efficient fittings, control devices, grey-water recycling treatment systems, rain water collection for toilet flushing and irrigation, or even black water recycling, implementation of a Building Management System (BMS), etc.

**Vision/targets**

Construction activities can have a significant impact on the environment: resource consumption, energy consumption, emissions to air, to soil and water, etc. This impact also affects the whole life performance of buildings and urban environments.

The Construction sector must radically reduce this impact by efficient management of resources and waste throughout the service life of the buildings and built environment.

Reduction of environmental impact can be measured in terms of:

- **Reduction of the environmental impacts of manufacturing of materials and components.** Targets for 2030 are:
  - 50% decrease in embodied energy of new building materials and components;
  - 40% waste reduction.

- **Reduction of the environmental impacts of hazardous construction materials.** Targets for 2030 are:
  - Use of Hazardous construction materials phased out.

- **Regeneration and remediation of land.** Targets for 2030 are:
  - Brownfield sites used in preference to greenfield sites.

- **Sustainable use of the built environment by reduction of energy consumption, reduction of water consumption, reduction of wastewater generation.** Targets for 2030 are:
  - 50% decrease in energy consumption;
  - 50% decrease in CO₂ emissions from new buildings;
  - 30% decrease in energy consumption and CO₂ emissions from existing structures.

- **Reduction of the environmental impacts of construction, demolition, deconstruction and transport processes.** Targets for 2030 are:
- Humans, ecosystems and biodiversity are not affected by the construction process;
- Construction and building activities have an overall net zero waste generation;
- 50% decrease in energy consumption in construction & deconstruction works;
- Safety of users and supply, as well as continuity of service, are ensured at all times during construction and maintenance works;
- Time lost in traffic congestion caused by worksites is reduced;
- Mitigation of consequences on the environment of transport and supply accidents.

**Synergies with other priorities and ETPs**
Synergies must be organised:
- with Priority B, on underground construction;
- with Priority E, on the management of transport and utilities networks
- with Priority H, on the development of ICT;
- with the European Technology Platforms on Industrial Safety (ETPIS), on Rail (ERRAC) and Road Transport (ERTRAC);

**Research Items**
Priority D has been detailed in 8 research items that are briefly described in the following paragraph.

**Item D1: New concepts, processes and components for the reduction of damage to environment**
Short Description

**Item D2: Sustainable design, construction, demolition and recycling process**
Short Description
New conceptual design of buildings, neighbourhoods and cities incorporating the concept of whole life performance of buildings. Implementation of methodologies and tools for the environmental design and further management of buildings quarters and cities that consider their whole life cycle. Planning and simulation tools to predict short, medium and long term environmental, social and economical impacts. New integral management systems involving facilities design, planning, environmental impact and disturbance assessments.

**Item D3: Knowledge of energy and materials flows**
Short Description
Creation of performance indicators for materials and buildings; development of performance rating systems for materials and buildings, Harmonised Environmental Product Assessment, Application of ICT for the development of databases and tools for the environmental assessment of construction products, Declaration of content of all building materials.
**Item D4: Reduction of impact of transport and utility networks**

New technologies for the construction and maintenance of infrastructure, reducing impact, costs and delays: solutions include reducing construction and traffic noise, vibration, air and water pollution, and trenchless construction or using small size trenches.

**Short Description**

Infrastructure use must be expanded, repaired, replaced and optimised, leading to disruption of service, and resulting in significant socioeconomic consequences for the European citizens. The vision for the infrastructure of the future is aimed at selecting in particular environment-friendly and suitable concepts striking a compromise between reduced global construction/maintenance costs on one side, safety and environmental criteria on the other side.

Impact on the environment must be drastically reduced, not only by reducing the consumption of natural resources and by using alternative forms of energy, but also by reducing the impact of operation (such as pollution, groundwater pollution, vibration, noise, radiation, frequent work disruptions, traffic congestions, etc) on users and resident population both in rural, urban and suburban areas.

Existing transport and utility networks will have to be modified and/or new infrastructures will have to be built, with minimal disturbance to the living environment and this will require extensive investigation, extensive safety modelling and testing and development of new construction and maintenance techniques.

**Item D5: Reducing impact of accidents involving dangerous and hazardous goods**

**Short Description**

Reduction of risks in transport of hazardous materials in densely populated or environmentally sensitive areas or transport of exceptional loads by locating and monitoring transport and providing efficient and fast appropriate measures in case of accident. It will finally provide input for maintenance and rehabilitation of infrastructure, impacting the life cycle assessment of the infrastructure itself. Organisational architecture has to be deeply studied due to different competencies of intervention in case of emergencies. Good technical monitoring applications for Goods and Vehicles are needed, but this is not enough for a correct management of emergencies, because priorities of interventions are decided by responsible bodies which are different from country to country. Uniform goods classification criteria are needed in order to distinguish different categories of hazardous materials.

*(Priority to be considered in conjunction with DG TREN)*

**Item D6: Remediation and mitigation of contaminated soils and groundwater**

**Short Description**

Development of methodologies and tools for the risk assessment of contaminated soils for the assessment of the impact on human health and ecosystems. Development of new services and new cost-effective in-situ and on-site technologies for the remediation and/or containment of contaminated soils and groundwater, in order to decrease the cost of brownfield reuse, and prevent the use of external landfills. Integration of construction techniques in redevelopment and remediation of brownfields to come to an integrated risk reduction versus land use approach.

**Item D7: Re-using and re-cycling demolition debris and waste**

**Short Description**

Development of innovative technologies for reuse and recycling of debris and waste materials issued from demolition and brownfield redevelopment activities. Development and improvement of manufacturing technologies that use recycled materials instead of raw materials and/or generate less waste during manufacturing process. Tools (based on LC methods) to aid decision making on recycling.
Item D8: Construction technologies for the protection and exploitation of water resources

Short Description

Development of new approach and concepts for the improvement of underground water quality in urban or greenfield context and for optimised exploitation of water resources. Implementation of new distributed waste and wastewater treatment and management systems. New permeable (porous) materials for urban construction (foundations, etc.) and motorways.

Involvement of SMEs

All research items are anticipated to be relevant to SMEs at various levels. As a matter of fact SMEs cover a huge area regarding activities related to design, demolition and recycling processes, as well as the production of specific environmentally friendly materials and industrialized products.

Specific relevant items for SMEs are Item 1 “New concepts, processes and components for the reduction of damage to environment”, Item 2 “Sustainable design, construction, demolition and recycling processes”, Item 3 “Knowledge of energy and materials flows”, Item 6 “Remediation and mitigation of contaminated soils and groundwater”, and Item 7 “Re-using and re-cycling demolition debris and waste”.

Budget and scheduling

The tentative planning and budget of Priority D in FP7 calls is summarised in the table below. But in fact research needs are much more important, and additional funding will have to be covered by other European (EUREKA, COST...) or National Programmes.

<table>
<thead>
<tr>
<th>Research Items</th>
<th>Planned FP7 Scheduling and Projects Costs</th>
<th>Other Programmes</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>2007 2008 2009 2010 2011 2012 2013</td>
<td></td>
<td></td>
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<tr>
<td>D1 New concepts, processes and components for the reduction of damage to environment</td>
<td>5 5</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>D2 Sustainable design, construction, demolition process</td>
<td>5 5 5</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>D3 Knowledge of energy and materials flows</td>
<td>5</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>D4 Reduction of impact of transport and utility networks</td>
<td>5 5</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>D5 Reducing impact of accidents involving dangerous and hazardous goods</td>
<td>5 5 5</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>D6 Remediation and mitigation of contaminated soils and groundwater</td>
<td>5 10 10</td>
<td>125</td>
<td>150</td>
</tr>
<tr>
<td>D7 Re-using and re-cycling demolition debris and waste</td>
<td>5 5 5</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>D8 Construction technologies for the protection and exploitation of water resources</td>
<td>5 5 5</td>
<td>50</td>
<td>65</td>
</tr>
</tbody>
</table>

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.

List of some major recent projects

Brownfields

- RESCUE: Regeneration of European sites in cities and urban environments.
- NORISC: Network oriented risk-assessment by in-situ screening of contaminated sites.
- HYGIEIA: Hybrid geophysical technology for the evaluation of insidious contaminated.
- Concerted action on brownfield and economic regeneration network.
- CLARINET: Contaminated Land Rehabilitation Network for Environmental.
- REGENTIF: Network for enhancing innovation in regenerating old industrial facilities.

### Soil remediation

- PHYTODEC: A decision support system to quantify cost/benefit relationships of the use of vegetation in the management of heavy metal polluted soils and dredged sediments.
- STRESOIL: In situ stimulation and remediation of contaminated fractured soils.
- COST: Biotechnology of soil: monitoring, conservation and remediation.
- INDEX: Indicators and thresholds for desertification, soil quality, and remediation.
- An integrated approach for the phytoremediation of organic pollutants in the rhizosphere.
- Liquefied gas injection technology to increase efficiency and control of in-situ soil remediation techniques.
- COSART: Contaminated soil - assessment and remediation technologies to protect the groundwater.
- HELM, JANA: Stimulation of in situ microbial remediation of polluted soils by electrokinetics.
- PURE: Protection of groundwater resources at industrially contaminated sites.
- IMSIS: In situ monitoring of landfill related contaminants in soil and water by infrared sensing.
- CLEANSOIL: An innovative method for the on-site remediation of polluted soil under existing infrastructures.
- BIOORGANOCLAY: Use of organoclays in bioremediation of contaminated soils and groundwater.
- TRESOR: Technique for remediation of steel-works polluted sites.
- SNOWMAN: Sustainable management of soil and groundwater under the pressure of soil pollution and soil contamination.
- ECO-SOIL: Innovative process for the on-site decontamination of soils.
- PHYTAC: Development of systems to improve phytoremediation of metal.
- INCORE: Integrated concept for groundwater remediation.

### Waste recycling in construction

- RECYPULPE: Demonstration project for the recycling of pulp waste from the paper recycling industry.
- Valorisation des machefers par la fabrication de blocs de construction.
- Demonstration of possibilities for use of recycled materials in the construction sector.
- Recycling of low performance glass waste in road construction and in building materials (CRAFT).
- RECLAIM: Reduction of construction debris in landfill by the application of innovative methods.
- Optimization of the waste recycling sector: when clinkers become road materials.
- New construction components from recycled waste timber.
- ECObRICKS: Ceramic building materials with improved insulation characteristics using waste substances from urban sewage treatment plants.
- Specific facilities for grouping together and treating waste materials from construction sites for optimum recycling.
- Development of demolition waste recycling.
- Industrial wastewater treatment with reuse of treated water.
- KYRIACOS NEOCLEOUS: Waste fibre recycling in concrete; development of design guidelines.
- ASHREC: Ash recycling technologies.
- Radiological aspects of recycling concrete debris from dismantling of nuclear installations.
- Cork wastes recycling in high performance isolation composite panels.
- Development of new materials by means of controlled vitrification and crystallization of inorganic wastes from urban incinerations.
- Environmental management for refurbishment integrated with construction project management.
- UPCYCLE: Treatment of fly ash for sound material utilization.
- Demonstration of possibilities for use of recycled materials in the construction sector.
- Materials recycling from bricks production rejects and from buildings demolition.
- Use of Recycled Materials as Aggregates in the Construction Industry.
- Development of a process to produce construction materials from contaminated wastes by inertisation in stable mineral phases.

**High performance materials**
- Development of fireproof coatings and paints with long term performance.
- THICKOMP: Manufacturing thick section composites for structural applications.
- COSIMB: Composite column and wall systems for impact and blast resistance.
- Development of high durability and performance concrete by using pozzolans and optimum material synthesis.
- Usage of amorphous silica and hydrous alumino-silicates for the production of building materials with improved mechanical properties.
- The Development of Improved Techniques for the Installation of Reinforcing for Concrete Structures.
- Understanding & improvement of ultra high performance cementitious materials resistance to long term water aggression.
- Construction Recycling Technologies for High Quality Cement and Concrete.
- ANCHR: Anchorages in normal and high performance concretes subjected to medium and high strain rates.
- The development of improved techniques for the installation of reinforcing for concrete structures.
- Utilisation of wastes from ceramic industries for low costs and high performance of concrete.
- DURANET: Prefabricated enduring composite beams based on innovative shear transmission.
- High performance materials derived from industrial-waste gypsum.
- Innovative Material for the Next Generation of the European Bridges.
- TESCOP: Cleaner technology solutions in the life cycle of concrete products.
Demolition

- New building materials by recycling of wastes of foundry moulding sands, and demolition scraps.
- Treatment, Disposal, Re-Use of Building Demolition and Site Cleaning Wastes from Nuclear Facilities.
- Development of demolition waste recycling.
- Recycling of blasted grit in solid construction materials.
- Automated sorting system for advanced waste disposal.
- TURBOWASH: Construction and Demolition Waste Washing System with Increased Mobility through Rapid Coagulation of Turbid Water.
- IRMA: Integrated decontamination and rehabilitation of buildings, structures and materials in urban renewal.
- Socio-technological-commercial framework and decision support systems for building refurbishment.
- Semi-active passive control of the dynamic behaviour of structures subjected to earthquake, wind and vibration.
- NOVPOL: A new concept for the recycling of incompatible polymers allowing the creation of new polymeric materials with enhanced properties.

Sustainability assessment – environmental indicators

- PRESCO: European thematic network on practical recommendations for sustainable construction.
- MATISSE: Methods and Tools for Integrated Sustainability Assessment.
- RAISE: Raising citizens’ and stakeholders’ awareness, acceptance and use of new regional and urban sustainability approaches in Europe.
- ATLAS: Action for Training in Land use And Sustainability.
- SIAMETHOD: Development of methodologies and tools to assess links between trade, environment and policies.
- Development of a method for environmental assessment of building materials and component.
- LCA-IWM: The use of life cycle assessment tools for the development of integrated waste management strategies for cities and regions with rapid growing economies.
- Environmental management for refurbishment integrated with construction project management.
- Research in support of standardisation in construction and construction products (FP6-JRC).
- European construction in service of society.
- ECO-SERVE

Water protection

- SOWA: Integrated soil and water protection.
- WATER MONITOR: Water management system based on innovative monitoring equipment and DSS.
- EUROLAKES: Integrated water resource management for important deep European lakes and their catchments areas.

Wastewater management

- EOLI: Efficient operation of urban wastewater treatment plants.
- CD4WC: Cost-effective development of urban wastewater systems for water framework directive compliance.
- Reducing the pollution of rivers through rain water: introduction of a global pollution/flood management strategy for sewage systems.
- Optimised urban waste water management.
- Pumps, electromechanical devices and systems applied to urban water management.
- Integrated expert system for waste water management efficiency control.

**Urban management (including water management)**
- CITYNET: the network of European research projects on integrated urban water management.
- Demonstration of a municipal contribution to a sustainable urban technology: land use planning, household water and bio-installations (Stroomdal-Life).
- AISUWRS: Assessing and improving sustainability of urban water resources and systems.
- Integrated planning and management of urban drainage, wastewater treatment and receiving water systems.
- Sustainable development at local and regional levels: methods and techniques to support Ecosites and monitor urban sustainability.
- URBEM: Urban river basin enhancement methods.
- Communicating urban growth and green: assessment of planning concepts and policy instruments for sustainable development of the urban landscape.
- WATERTIME: improving the quality of urban life through sustainable decision-making on city water system reform.
- Metropolitan cities and sustainable use of water.
- DAYWATER: Adaptive decision support system for storm water pollution control.
- CLOCWISE: Constraint logic for operational control of water systems.
- Zaragoza: water saving city. Small steps, big solutions.
- RENA: Saline-Ostia Antica. Urban planning of a social area in the suburbs of Rome maximizing the use of renewable energies, respecting the environment and with the objective of reaching the "zero-emission town".
- Enhancement of integrated water management strategies with water reuse at catchments scale.
- INTERMEDIARIES: New intermediary services and the transformation of urban water supply and wastewater disposal systems in Europe.
- Integrated management of urban water systems.
Priority E: Sustainable Management of Transports and Utilities Networks

Brief description of the priority and rationale
European transport and utility networks grew over centuries to become the arteries and lifelines of our society. These assets have to be well maintained, modernized and adjusted at best quality and practice as well as extended for the increasing demands of a growing and demographically changing society with an urge towards increasing mobility and demand. Better technologies and processes have to reduce maintenance and works and increase durability and safety to reduce network failures and out-of-service conditions. This in turn means reducing their impact on transport, energy and trade, both in the urban and extra-urban context. The increasing demand for mobility/supply requires new network systems that are carefully implemented within the existing ones.

Main development issues
Infrastructural systems of transport with expected longer service life integrating the most advanced solutions in terms of models, materials and recycling, monitoring and control systems, components, design, construction, maintenance and replacement techniques.

Safe, integrated service systems with increased longevity, capable of rapid maintenance/repair, with minimal disruption incorporating new materials, new technologies and capable of carrying wide ranges of supply

Highly efficient management and operation of networks, with the use of the latest technologies, to reduce costs, without compromising safety, security and the environment.

Integrated solutions to improve communication between users, infrastructure and operators, improving mobility and purveying.

Expected impact
Current infrastructure is massive asset, and over billions of euros are spent annually on its maintenance and operation. Networks are used by all Europeans, both for their personal travel as for their access to essential services. Even incremental improvements in this area would lead to savings which are order of magnitude larger that the research investment, for example:

- Reduction in user delays on Europe's transportation networks. Transport of people and goods still is a far too large cause of injuries and deaths, particularly for road transport. Improved operation and management of transportation networks will support the Commission's policy on halving the number of fatalities by the year 2010.

- Guaranteed reductions in traffic disruption and congestion as the reliability of services are ensured. Owners and operators are expecting considerable increases in the use of their networks, as demand for natural gas will grow to around 28% by 2020 and demand for water and waste water will experience an overall growth rate of 60% by 2010. This in turn will be met by building new infrastructure or by upgrading the existing infrastructure so that it can be used more effectively.

State of the art
Functional networks of transport and services must respond to the needs of users and clients, while maintaining a good balance between the needs for new infrastructure and the need to preserve the already existing infrastructure. This requires the industry to adopt new materials, new construction techniques, rehabilitation and maintenance concepts, new management tools that are capable to extend the life-cycle, to increase capacity and durability and at the same time present high standards of safety and security and demonstrate a low impact on operations both in the urban and extra-urban environment.
The challenge is to ensure that existing infrastructure can be inspected, assessed, maintained, repaired or renewed, integrated by new construction, at minimal cost and with the minimum of disruption to traffic, quality of life and the environment, set against a background where safety of users and workers is paramount.

**Vision/targets**

Enhancing the level of service offered to all European citizens without discrimination in terms of demand for mobility and supply, and to achieve the inter-operability of lines and information. The aim is to favour the economic growth and to increase the social cohesion and on the other side to meet public objectives on, for example, economic and territorial development, health and social issues, due to the strategic role played by the infrastructures.

Impact of R&D activities may be measured in terms of:

- Reduction in service failures, number of accidents and mitigation of consequences;
- Reduction in number, size and duration of construction and maintenance interventions (time, congestions, emissions and interruptions) both in urban and extra urban context;
- Enhanced efficiency and higher level of management and service; cost optimisation
- Extension of life cycle and improved knowledge;
- Increase in recycling and re-use of materials and reduction in waste materials;
- Interoperability of infrastructure and information;
- Increased competitiveness of the Sector toward non-EU countries.

Integration of all stakeholders in the implementation is strongly pursued: users, owners and operators, contractors, material and technology suppliers, research institutions and SMEs.

More specifically, operators and owners, being the natural interface between the needs of the users and communities, political and governmental agencies, and authorities, can guarantee the implementation and effective application of research results.

Contractors and suppliers can benefit from the quick industrialisation and marketing of technical and technological solutions that are aligned with the needs of clients and users.

SMEs will benefit from the technological implementation and technological compatibility of the developed solutions increasing their competitiveness in high-tech specialised market segments and on the other hand they will increase their know-how and knowledge in traditional activities where a lack of training is actually experienced.

**Synergies with other priorities and ETPs**

As the infrastructure in itself is an integrated product or system including different functions and answering to different needs throughout its life-cycle, Priority E has developed a multimodal integrated approach covering roads and highways, railways, water distribution and sewerage, gas and waterways. As a consequence, contacts and links have been established with other relevant European Platforms, such as ERTRAC, ERRAC and WSSTP and efforts have been put into establishing complementarities.

**Synergy with ERTRAC:** ERTRAC main stakeholder is the vehicle industry, and ERA-NET ROAD represents the public side of R&D investment in road operations research. SMEs and the construction industry are most prominent in ECTP. The basic outcome of this is that construction of the road infrastructure is part of the ECTP-SRA, whereas the systemic elements of the road transport system are dealt with by ERTRAC.

**Synchronisation:** The private sector/vehicle industry driven ERTRAC work will start under the first Call of FP7. At the same time, the public sector ERA-NET ROAD work will commence. To ensure a systemic approach to the road transport issues and to support the alignment of the full private and public R&D funding in the sector, it is of the essence that the ECTP Priority E is also addressed in the early Calls of FP7.

**Synergy with ERRAC:** The ERRAC SRA has been updated taking into account the potential synergy effects with ECTP. High relevance to the railway sector is mainly regarding design, construction and maintenance of
the infrastructure, topics not covered by ERRAC SRA and it is expected that the potential of construction industry within ECTP will focus on achieving these objectives.

Synchronisation: To strengthen the need for innovative and cost-efficient solutions for improving the performance of railway infrastructure, ERRAC complementary issues will be dealt by since the first Calls.

Synergy with WSSTP: The WSSTP major goal is to assess the status of the water infrastructure, design and implement mitigation solutions to minimise health and safety hazards and optimise the cost of delivering the needed service of quality water to all categories of users. ECTP will deal with the construction and rehabilitation of buried pipelines and WSSTP will focus on the detection and repair of leakage from these systems and the development and application of the concept of smart pipes with embedded intelligence.

Synchronisation: Issues addressed by ECTP and WSSTP are part of a whole such as the Urban Pilot Theme complimentary programme of R&D as they are interdependent and reliable upon one another for the improvement of Europe’s utility services.

Possible synergies with FP7 Theme 7 – Transport are therefore envisaged whenever a research item may be relevant for this Theme according to the criteria of use and technology.

Possible synergies with the work carried out in other DGs, such as DG TREN, have been explored and the results are clearly shown in the list of items identified for R&D. As a consequence of the EU enlargement issues on road construction and data exchange (cross border) will be probably called in 2008 the 2007 call being limited to issues on safety (signals) and security (of data transmission).

Finally, as far as it concerns the synergies with other Priorities within the ECTP, specific topics relevant for infrastructures of transport and service are covered under Priority D “Reduce Environmental and Man –made Impacts of Built Environment” and Priority 7 “Improve Safety And Security within the Construction Sector”.

Research Items

This priority has been detailed in 7 research items that are briefly described in the following paragraphs.

**Item E1: New methods/tools for the comprehensive management of transport and utilities infrastructure in urban and extra-urban context to reduce impact on service**

Infrastructure systems represent a huge public and private investment and are essential to the economic and social well-being of society. Unlike many other engineered systems, civil infrastructure is expected to provide reliable service for very long periods of time, spanning several generations during which society will experience dramatic changes in terms of available technology, as well as individual and collective aspirations with regard to life quality indices. As a consequence infrastructure must be seen as an integrated, pre-arranged product, able to receive and deliver a number of services in response to a precise demand of the users and of public at large. The aim is to develop systems for network-wide management and operations, with an emphasis on customers in the provision of services.

**Item E2: Standards, models and databases to assess, follow and predict the long-term performance of structures and components subject to ageing and deterioration**

Infrastructure systems comprise structural components and assemblies as well as mechanical and electrical equipment. In contrast to the latter, the former are often more difficult to inspect, repair or replace, in particular for the utilities. Their assessment involves processes which are subject to considerable variations resulting from limited knowledge, variable levels of experience and judgement, and subjective evaluations of the factors that may lead to unacceptable performance. In view of the above, research has, over the past twenty or so years, moved rapidly in exploring methods that can capture elements of uncertainty, imprecision and fuzziness for decision support. Methods for structural reliability assessment are now well developed and can be used for practical applications, even though progress in dealing with deteriorating, time-variant complex systems is still urgently required. Quantitative methods for risk analysis are also needed to deal with hazard identification, scenario representation and risk evaluation in many situations.
**Item E3: New concepts to extend the life time of structures or increase their capacity, with no reduction in safety and with positive impact on maintenance**

The majority of the decisions required during the process of assessment, maintenance and management of ageing civil infrastructure are made under conditions of uncertainty. Uncertainties are associated with mechanical loadings, environmental stressors, material properties, simplifications and idealisations required for modelling to list some of the major areas of influence. Moreover, these sources of uncertainty are compounded by human and organisational factors that are an indispensable part of the processes employed by the profession. Most importantly, these uncertainties are not fixed but change considerably over time and space, even when considering one structural element in a single structural system. The aim is to identify and select models and tools able to provide an overall holistic approach to the description of life cycle of existing assets that will still be in use for the next decades.

**Item E4: New testing methods for early detection of damages for structures and infrastructures, even buried, with minimal impact on traffic and supply**

Most of the existing assets will be in use in the next 50 years. This means that effort must be directed at developing and improving diagnostic tools, including system identification, inspection techniques, testing methods, sensing and monitoring methods, and their interpretation for decision making. Information technology is having a large impact on both the acquisition and processing of the information that can be obtained from these systems. In this respect, our ability to model, analyse, predict and manage infrastructure systems is, in principle, growing at an increasing rate. However, dealing with vastly more data and information, and turning this into knowledge and wisdom poses formidable challenges for researchers, owners and regulatory bodies.

**Item E5: Develop, design, build and operate, with new or non-conventional multifunctional materials or with traditional materials of enhanced performances, with low environmental impact, high durability, reduced maintenance and operation costs, and increased comfort for users and citizens**

A large increase in the use of networks for transport and service is expected over the next thirty years. The network industry will only be able to respond to this challenge by either building new infrastructure, increasingly reducing bottlenecks, and by incrementing the capacity or mobility.

Within the constraints of current funding, the construction of a large number of new arteries is not feasible, so efforts will have to be concentrated on maintaining and upgrading existing assets. The challenge to the construction industry is to ensure that existing infrastructure can be maintained and renewed without unduly disrupting the traffic and without prejudicing the levels of safety currently necessary to guarantee a good level of service. The aim is to select environment-friendly and suitable concepts in order to strike a compromise between reduced global construction/maintenance costs, safety and environmental criteria.

**Item E6: Integrated life-cycle assessment systems combining cost-efficient and easy-to-maintain sensors, monitoring and performance prediction systems, and covering all stages of construction control, asset management, and optimisation of maintenance**

An integrated holistic approach is needed in order to understand and quantify the effect of complex technological, environmental, economical, social and political interactions on the life-cycle performance of civil infrastructure systems. Concerted effort is required on many different fronts, including materials, construction and maintenance techniques, structural analysis and simulation, risk and reliability, information technology, life-cycle and systems engineering. The objective is to push civil infrastructure systems to higher levels of efficiency under both normal and critical conditions, yet balance this against socio-economic and political constraints.
**Item E7: ICT and ITS systems to optimise traffic, serviceability and security of networks integrating traffic and transport monitoring and management, information to users, tolling, incident and crisis management**

Road infrastructure is already congested if not rapidly reaching saturation. This is true not only along Trans European corridors and major highways, but also in urban areas where access of commuters and freight transport is causing serious problems. Traffic demand is expected to grow at least by 30% in the next 10 years, while transport network investment by only 5%. Management of networks at their optimal capacity is becoming a must.

ITS implementation will result in better safety, efficiency, travel comfort and environment. Commercial vehicle operators, individual drivers and public transport users alike are already benefiting from ITS not to mention the infrastructure operators and public authorities.

ITS will allow infrastructure operators to expand and to optimise the use of the infrastructure. The implementation of ITS systems will impact on the way planning and design, realisation and operation of the network is done, in logic of “plug and play”. Further, ITS allows for interoperability in different environments (e.g. motorway and urban networks) with the use of well acknowledged services (easily extended to new applications) and systems (whose technology can be easily integrated in existing ones).

*(Priority to be considered in conjunction with DG TREN)*

**Involvement of SMEs**

Although “transport and networks” is not a clear business for SMEs, SMEs will benefit from the technological implementation and technological compatibility of the developed solutions increasing their competitiveness in high-tech specialised market segments. They will also increase their know-how and knowledge in traditional activities where a lack of training is actually experienced.

SMEs could be especially involved in all the activities related to quality control, consulting and maintenance, services related to management, etc. For this reason, Item 6 “Integrated life-cycle assessment, systems combining cost-efficient and easy-to-maintain sensors, monitoring and performance prediction systems, and covering all stages of construction control, asset management and optimisation and maintenance”, is especially relevant for SMEs.

**Budget and scheduling**

The tentative planning and budget of Priority E in FP7 calls is summarised in the table below. But in fact research needs are much more important, and additional funding will have to be covered by other European (EUREKA, COST…) or National Programmes.

<table>
<thead>
<tr>
<th>Research Items</th>
<th>Planned FP7 Scheduling and Projects Costs</th>
<th>Other Programmes</th>
<th>Total</th>
</tr>
</thead>
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<tr>
<td></td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
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<tr>
<td>E1 New methods/tools for the comprehensive management of transport and utilities infrastructure in urban and extra urban context to reduce impact on service</td>
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<td>10</td>
<td>10</td>
</tr>
<tr>
<td>E2 Standards, models and databases to assess, follow and predict the long-term performance of structures and components subject to ageing and deterioration</td>
<td>15</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>E3 New concepts to extend the life time of structures or increase their capacity, with no reduction in safety and with positive impact on maintenance</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>E4 New testing methods for early detection of damage for structures and infrastructures, even buried, with minimal impact on traffic and supply</td>
<td>5</td>
<td>15</td>
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ICT and ITS systems to optimize traffic, serviceability and security of networks integrating traffic and transport monitoring and management, information to users, tolling, incident and crisis management.

List of some major recent projects

SAMARIS “Sustainable and Advanced MAterials for Road InfraStructure” is a RTD and Demonstration research project from the Growth programme of the 5th Framework Programme. It was divided into two streams. The first one dealt with pavements and the second one with highway structures.

NR2C “New Road Construction Concepts”. The project provides future-oriented initiatives for the road infrastructure, in dialogue and cooperation with external partners such as special interest groups, experts and users. NR2C develops long-term perspectives and physical trial projects and demonstrations, in which long-term visions and ideas are linked to short-term action.

Rankers “Ranking for European Road Safety”. The overall objective of RANKERS is to develop scientifically researched guidelines on road infrastructure safety enabling optimal decision-making by road authorities in their efforts to promote safer roads and eradicate dangerous road sections.

Spens “Sustainable Pavements for European New member States”. The objective of this project is to develop appropriate tools and procedures for the rapid and cost-effective rehabilitation and maintenance of roads in the EU New Member States (NMS). The materials and technologies for road pavement construction and rehabilitation will: behave satisfactorily in a typical climate; have an acceptable environmental impact; be easy to incorporate within existing technologies; and be cost-effective and easy to maintain.

Silence. The aim of the Integrated Project SILENCE is to develop holistic methodologies and technologies for improved control of surface transport noise in urban areas. Issues that will be covered, include noise control at the source, noise propagation, noise emission, and the human perception of noise.

Arches “Assessment and Rehabilitation of Central Europe Highway Bridges”. The strategic objective of the project is to reduce the gap in the standard of highway structures between the Central and Eastern European Countries (CEEC), including New Members States (NMS), and the rest of the EU, in a sustainable way. This will be achieved by developing appropriate tools and procedures for a more efficient assessment, and faster, cost-effective, and long lasting rehabilitation (repair or strengthening) of substandard highway structures.

Sustainable bridges “Sustainable Bridges” (IP) is an EU-project which handles the question if the railway bridges of today can meet the new demands of higher loads and speeds of tomorrow’s trains.

SAMCO “ Structural Assessment, Monitoring and Control” is a network for industries (especially for small and medium sized enterprises), consultants and other organisations interested in the transfer of knowledge and technology in the field of assessment, monitoring and control of structures of relevant civil and industrial interest, in particular the transportation infrastructure.

Saferelnet “Safety and Reliability of Industrial Products, Systems and Structures”. The scope of the Network is the integrated treatment of the important aspects of design, production, operation of industrial products and systems. The main emphasis is on the use of reliability-based methods for the optimal design of products, production facilities, industrial systems and structures from the point of view of balancing the economic aspects associated with providing predefined safety levels, with the associated costs of maintenance and availability.

Future Bridge: The overall objective of the project is the development of a new high performance and cost effective construction concept for bridges based on the application of Fibre Reinforced Polymers (FRP) for rapid renewal and long life service infrastructures in the NMS.
Priority F: A living Cultural Heritage for an Attractive Europe

Brief description of the priority and rationale

European cultural heritage is the testimony of our shared past and the root of our identity. It enriches the collective memory, which will make the future of Europe more humane and civil for its population, so it needs to be conserved with great care. We are now building for the cultural heritage of future European generations: a strong knowledge-based approach must be used to protect and promote our cultural heritage to keep it alive in an attractive Europe.

The wide area of cultural heritage safeguarding can be covered by interdisciplinary approach where the construction sector serve as an environment that helps in achieving synergy among the stakeholders involved in heritage protection. The main priorities of heritage protection can be summarized in the form of a matrix formed by six main pillars and six ties that crosslink the pillars.

Main development issues

The global objective is to promote new sustainable and preventive strategies, concepts, methodologies and techniques for conservation and restoration of cultural heritage in order to improve the quality of life of citizens and the attractiveness of Europe, particularly its cities, buildings, monuments and landscapes.

The challenge of the application of special techniques, materials and processes to maintain Europe’s rich cultural heritage is of great importance for all players involved in these vital activities for the maintenance and preservation of European cultural identity in today’s global processes. In addition, new strategies for management are needed to reinforce and recognise the added value Cultural Heritage gives to cities and landscapes.

Expected impact

The importance of cultural heritage for Europe can be measured in economic and social terms, such as growth in employment, job creation and unified communities, and it has a considerable impact in many areas such as the environment, construction, tourism and regional development to enhance European competitiveness and skills through technical innovation and traditional skills. The European construction industry will achieve greater competitiveness and the ability to satisfy societal needs through research, development and innovations oriented towards protecting and enhancing cultural heritage, and adaptive re-use of existing buildings. Today, about 40 % of construction activities are devoted to adaptive re-use, repair and maintenance. Beyond that, Cultural Heritage is the key issue to enhance the sustainability of the
Construction Sector, ensuring that Cultural Heritage is added to the three basic pillars of sustainability: Environment, Society and Economy.

**State of the art**

Following the recent enlargement of the European Union, the need for strengthening collaborative efforts on the protection of our common European cultural heritage is now greater than ever. Cultural Heritage (CH) enriches the collective memory; this makes the future of Europe human and friendly to its population. It is also the basic asset on which tourism is built.

In this new century, European Society is facing an overwhelming number of challenges: demography changes, climate change, globalization, and the gloomy perspectives of declining natural resources. And yet, European Society is still relying on the Construction Sector to obtain better living and working conditions from its built environment. For the Construction Sector, this represents a dramatic upturn: to convert a technology-push industry into a demand-driving sector. The new key for development is sustainability transforming industry and society from resources-based into knowledge-based. Cultural Heritage is now an essential topic to reach a new dimension (Culture), added to the three basic pillars of sustainability: Environmental, Societal and Economic aspects.

To emphasize the importance of Cultural Heritage, based on its importance as a social resource, including its contribution to economy, employment and wellness, on February 6 2006, the European Parliament organized a Hearing on “Cultural Heritage, research and sustainable development” for supporting CH research in the EU. The participants in the hearing request “a strong and firm support on basic research, scientific and technical, applied to every branch of the Cultural Heritage whether immovable or movable, tangible or intangible, cultural and natural heritage, including archaeology, plastic arts, history of art and iconology.”

Furthermore, the future FP7 work programme research will consider the future refurbishment, rehabilitation and maintenance of the built heritage as an essential objective to meet two fundamental drivers: Lisbon goals (policy) and achieving greater sustainability (values).

**Vision/targets**

Main targets of the sector are specified as follows:

- **Approaching citizens**: European cultural heritage is the testimony of our common past and the base of our identity, it enriches the collective memory what makes the future of Europe more human and friendly for its population and increases quality of life. Its conservation could contribute to the creation of a new image of cities, where Cultural Heritage is a valuable element that should be accessible for all.

- **Maintaining cultural values**: The interventions of the European construction industry in cultural heritage should be guided by conservation experts knowledgeable in the application of recognized ethical principles of conservation which seek to preserve not only the material cultural heritage but to the retain the ‘meaning of place’ associated with it. A “consequence based approach” should be applied in order to avoid damage caused by inappropriate interventions in heritage objects and to ensure protection from the environment and human causes of destruction. Therefore, new integrated knowledge-based conservation processes are needed that will preserve both the tangible and intangible cultural heritage through the application of appropriate methods of construction or refurbishment of buildings associated with both moveable and immovable Cultural Heritage. These include ICT and automation of diagnosis and monitoring, the design and application of high added-value materials and structural systems in restoration processes, in order to provide distinctive and attractive work and living places in EU cities rich in cultural heritage.

- **Meeting socio-economic and environmental requirements**: Cultural heritage enriches the collective memory what makes the future of Europe human and friendly to its population. Environmental friendly interventions to reduce resource consumption and environmental impact, sustainable management of a living cultural heritage for an attractive Europe, and improving safety and security against natural and man-made hazards have to be considered.

Impact of R&D activities may be measured in terms of:
• 100% of the information generated during the study, restoration and maintenance process will be available and used for appropriate management and increase of knowledge transferred through the life-long education schemes.

• Service life of Cultural Heritage materials and structures could be predicted with 20% error and will be used to prepare predictive maintenance plan.

• Understanding change in composite materials applied in the forthcoming wider applications in heritage retrofitting over time should be improved by 50% between 2010 and 2030.

• At least 25 important EU cultural heritage sites should be assessed using the knowledge gained from FP7 projects and new specifications between 2010 and 2030.

• Enhance the accessibility for citizens to Cultural Heritage of 50%.

• Implementation and awareness strategies to Cultural Heritage preservation addressed to European citizens especially young generations will be achieved at 100%.

• Resolving the decay of Cultural Heritage about 95%.

**Synergies with other priorities and ETPs**

Apart from ECTP, Cultural Heritage is also related to other European Technology Platforms that can cover other aspects (such as movable heritage), not enough considered in ECTP, such as:

• Sustainable Chemistry Technology Platform: all aspects related to materials analysis, mostly related to Movable Heritage conservation.

• eMobility Technology Platform: approaching of Cultural Heritage to the citizen, by means of development and use of ICT.


• Manufuture Technology platform: training for traditional and new restoration processes.

Therefore interrelations among ECTP and other European Technology Platforms should be established to cover the whole Cultural Heritage scope, how might it fit and in what extend within the ECTP or other European Technology Platforms.

**Research Items**

Priority F has been detailed in 8 research items that are briefly described in the following paragraphs.

**Item F1: Building assessment, diagnosis and monitoring**

Integration of technologies for building assessment, diagnostics and monitoring in the safeguarding; development of efficient assessment tools, standardisation of advanced diagnostic methods and development of embedded intelligent wireless sensors suitable for a long life cycle in the environment of heritage structures.

Short Description

To integrate technologies for building diagnostics based on non-destructive testing techniques, monitoring, computational assessment and interdisciplinary research in the safeguarding and long term management process of the heritage buildings to enable sustainable and cost efficient maintenance. Innovative imaging and 3D-surveying techniques together with adapted theoretical models for long-term simulation of structural and physical properties of relevant elements are used to predict the impact of natural decay and of interventions and to plan strengthening processes.
Item F2: Assessment of material decay and development of Cultural Heritage compatible materials

Assessment of the degree of decay of heritage buildings due to the degradation of historic or/and contemporary materials, development of new materials based on nano and other emerging technologies. Research leitmotiv for this area is the long term compatibility of conservation materials.

Short Description

Understanding of degradation mechanisms is a basis for the development of more durable and adaptable materials and treatments to be used for conservation interventions. Design development and production of smart, memory-capable, self-adjusting, self-cleaning and self-healing materials. Development of strategies for compatible and more durable materials is needed, to influence on structures’ durability and resistance to environmental deteriorative impacts. Improvement of existing materials and techniques for conservation.

Item F3: Low-intrusive retrofit and conservation 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.

Short Description

All steps of intervention should be guided by continual attention to long-term consequences of interventions using interdisciplinary competences and aiming at preserving the authenticity of the cultural heritage, be it single buildings or complex city fabrics. Appropriate intervention strategies will be developed using less invasive techniques applying the possibly removable structural elements in order to improve performance and long-term resistance of the existing buildings. Application of suitable new high-tech materials for attractive and heritage compatible structural solutions is foreseen.

Item F4: Integration in urban and natural environment

Care for integration in urban and natural environment of cultural heritage, and development of special measures for indoor climate control.

Short Description

To integrate new environmental challenges by assessing, predicting and managing the impacts of climate change, energy use and pollutant damage to safeguard cultural heritage assets in urban and natural areas. To develop prediction models, environmental impact assessment methodologies and risk assessment and risk preparedness studies. To set up information management systems and to introduce the appropriate preventive measures and suitable interventions for the improved care of the cultural assets in relation with their environment and contents. To improve the use of traditional materials and skills, renewable forms of energy, water conservation and the implementation of recycling of materials for sustainable and cost-effective strategies in the adaptive re-use (new usage) of Cultural Heritage.

Item F5: Rational and long term management processes

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

Short Description

To set up sustainable strategies for the preservation of cultural heritage assets by developing new management and monitoring tools to ensure their added value for European cities and the local environment; this will enhance the European Society’s knowledge and understanding, and promote a reliable predictive and cost effective maintenance. To develop pan-European model and strategy for tracking of changes of Heritage building due to natural impacts and maintenance interventions (Heritage Building Identity Card). The model is the starting point for development of maintenance plans for organizing of the long term management process.
**Item F6: New tools for European citizens interaction**

New tools to improve the communication and the public participation in cultural heritage to develop a European citizen interaction.

Short Description

To improve and sustain the integration of cultural heritage in the urban and rural settings through remedial territorial planning and rational resource management, using historical urban grid systems, while taking into account the characteristics of historic settlements and cultural assets. To develop communication and public participation strategies to set up an European citizen interaction and improve the safeguarding of the most substantial European cultural heritage linked to urban development.

**Item F7: Knowledge transfer to construction sector and demonstration of the best-practice cases**

Proper training of technical and implementing staff as well as planners and building owners will be decisive for the success of an of the intervention needed in the field of restoration.

Short Description

The negative impact to CH is often generated by the inappropriate interventions and maintenance. The main reasons are lack of basic knowledge and carelessness. The basic courses can radically change the attitude of persons engaged in the simple but important CH protection works. The professionals involved in CH preservations have a different formal education. The knowledge that is basic for one profession is often not offered to another profession through its formal education. The special courses combining lectures and practical training in laboratories and on-site should be organized. Lectures should include not only local but wider European perspective. The formal education is in principle oriented to understanding of principles and thus includes a limited amount of the applicable knowledge. The early period of professional activities is a critical one when the transfer of knowledge gained from solving of problems is needed. The development of the profession generated by research and innovations should be properly transferred to brothels, less and more experienced professionals. The importance of lifelong education of specialized professionals in SMEs can be easily justified by the market success of SME. Specific support actions for dissemination, education in order to increase knowledge transfer are needed.

**Item F8: Demonstration of knowledge gained from FP7 and other research projects in selected typical CH sites across the EU**

The knowledge and technology development gained from the EU supported research should contribute to the efficiency of investment in immovable cultural heritage protection.

Short Description

The knowledge and technologies gained from the first five years of FP7 projects and FP5/FP6 financed projects will be demonstrated in solving the restoration problems in selected sites across the EU member states. Application of new materials, monitoring devices, assessment methods and innovative strengthening techniques will be put in force. The careful documentation of restoration process will help in solving of restoration processes in other cases. Comparing the experiences gained from selected demonstration cases common conclusions will be searched in order to generalize as many as possible conclusions.

**Involvement of SMEs**

Cultural heritage is a sector clearly dominated by SMEs. Major restoration companies, as well as other type of companies related to specific areas of activity and creative business within the cultural sector are SMEs. Other players, such as sensor developers, monitoring, assessment, architects, engineering companies, ICT tools developers, etc, that also play an important role in Cultural Heritage, are also SMEs.

For this reason, SMEs should be involved in all items established in this priority, as they should normally act as end users of the technology. This is especially the case of Item 2 “Assessment of material decay and development of Cultural Heritage compatible materials”.
Together with other actors, such as big companies, universities, etc, SMEs could develop many technologies for diagnosis and monitoring for efficient maintenance of buildings, included in Item 1 “Building assessment, diagnosis and monitoring”, and Item 5 “Rational and long term management processes”.

Moreover, some of the items presented in this priority are mostly developed by SMEs, and are also addressed to SMEs as main end-users of the developed technologies. Item 3 deals with the development of low-intrusive retrofit and conservation techniques. Specific interventions in cultural heritage, using new techniques and restoration systems, constitute a clear SME business, and SMEs will mostly receive the benefits of these developments. Item 7 “Knowledge transfer to construction sector and demonstration of best-practice cases” is also clearly addressed to SMEs, as the main receptors of the knowledge transfer.

**Budget and scheduling**

The tentative planning and budget of Priority F in FP7 calls is summarised in the table below. But in fact research needs are much more important, and additional funding will have to be covered by other European (EUREKA, COST…) or National Programmes.

<table>
<thead>
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<th>Research Items</th>
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<tr>
<td></td>
<td>2007</td>
<td>2008</td>
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<tr>
<td>F1 Building assessment, diagnosis and monitoring</td>
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<td>F2 Assessment of material decay and development of Cultural Heritage compatible materials</td>
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<td>F3 Low intrusive retrofit and conservation techniques</td>
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<td>F4 Integration in urban and natural environment</td>
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<tr>
<td>F5 Rational and long term management processes</td>
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<tr>
<td>F6 New tools for European citizens interaction</td>
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<td>F7 Knowledge transfer and demonstration of the best-practice cases</td>
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<td>F8 Demonstration of knowledge gained from FP7 and other research projects in selected typical CH sites across the EU</td>
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<tr>
<td>TOTAL</td>
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<td>30</td>
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</tbody>
</table>

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.

**List of some major recent projects**

Within the 5th Framework Programme 141 projects widely related to cultural heritage was financed. In the 6th Framework Programme the significant drop of number of financed projects was evident. Before the last call of FP6 only 48 projects in domain of cultural heritage were contracted. The last call in 2006 added several
projects to the FP6 score.

During FP5, the cultural heritage related projects were covered by several programmes. Environment and sustainable development, key action 4: "City of Tomorrow and Cultural Heritage" where 58 projects were launched was a part of EESD Programme. Within IST Programme 73 projects were financed. They were submitted in one of four key actions: “Systems and services for the citizen”; “New methods of work and electronic commerce”; “Multimedia content and tools” and “Essential technology and infrastructure”. One project was financed to promote research by SMEs within the horizontal action of CRAFT. There were also other two programmes covering cultural heritage: INCO 2 (10 projects) and Human Potential (9 projects).

Within FP6, three main programmes cover the cultural heritage: Policies, Objective 3.6: “The protection of Cultural Heritage and associated conservation strategies” (13 projects before the last call); INCO-MED that identifies RTD activities in cultural heritage for cooperation with Mediterranean Countries (19 projects) and IST - Technology-enhanced learning and access to cultural heritage (9 projects before the last call). Besides in these programmes, projects were financed also to support SMEs (2 projects) and MOBILITY (5 projects). Several other European programmes as RECITE followed by INTERREG I, II and III, COST, EUREKA, CULTURE 2000, and other with international co-operation such as Asia-Urbs and MEDA

List of FP6 Projects related to immovable heritage (without the projects contracted upon the last call in 2006)

CORRLOG - Automated corrosion sensors as on-line real time process control tools, Institut De La Corrosion SAS, France
SALTCONTROL- Prevention of salt damage to the built cultural heritage by the use of crystallisation inhibitors, Univ.Gent-Dept. Geology and Soil Science, Belgium
CULT-STRAT-Assessment of air pollution effects on cultural heritage-management strategies, Korrosionsinstitutet SCI AB, Sweden
Global climate change impact on built heritage and cultural landscapes,CNR. Istituto Di Scienze atmosfera e del Clima,Italy
PICTURE-Pro-active management of the Impact of Cultural Tourism upon Urban Resources and Economies Univ.Liege/ Ulg.Département d'Architecture et d'Urbanisme’,Belgium
SURVENIR-Near Infrared Spectroscopy Tool for Collection Surveying, University of Ljubljana, Slovenia
SUSTAINING HERITAGE- Sustaining Europe’s cultural heritage: from research to policy, Univ. College London,United Kingdom
CONSIST -Comparison of conservation materials and strategies for sustainable exploitation of immovable industrial cultural heritage, FGH Foerderung Der Angewandten Forschung E.V.,Germany
GRAFITAGE- Development of a new antigraffiti system, based on tradicional concepts, preventing damage of architectural heritage materials.Fundación Labein, Spain
Fingerprinting art and cultural heritage - in situ 3d non contact microscale documentation and identification of paintings and polychrome objects, Spain
NOAHSARK Defending cultural heritage against climate change, CNR, Instituto di Scienze dell’Atmosfera e del Clima. ISAC,Italy
SAUVEUR-Safeguarded cultural heritage-understanding and viability for the enlarged Europe, Inst. Theoretical and Applied Mechanics of the Czech Academy of Sciences,Czech Republic
KT-DIGICULT-BG-Knowledge Transfer for Digitisation of Cultural and Scientific Heritage in Bulgaria,Inst of mathematics and informatics -Bulgarian Academy of Sciences,Bulgaria
REPROCITY-Research and training on restoration and protection of the city environment in industrial regions, Engineering, Silesian Univ. of Technology,Poland
CULTURAL HERITAGE- Advanced Research Training on the Conservation of Cultural Heritage, CSIC. Inst. de Recursos Naturales y Agrobiologia de Sevilla,Spain
WIND-CHIME -Wide-range non-intrusive devices towards conservation of historical monuments in the Mediterranean area, CENS,Estonia
PATINE DU DESERT - Re-creation de la patine des gres sahariens porteurs d oeuvres gravees ou peintes, temoins de 15 000 ans de changements climatiques, Frei Universitat Berlin, Germany

SHADUF - Traditional water techniques: cultural heritage for a sustainable future, EJTN GEIE, Italy

PROHITECH - Seismic protection of historical buildings by reversible mixed technologies, University of Naples Federico II – Eng., Italy

PROMET - Developing new analytical techniques and materials for monitoring and protecting metal artefacts and monuments from the Mediterranean region, Technological educational institute of Athens, Greece

MEDISTONE - Preservation of ancient Mediterranean sites in terms of their ornamental and building stone: from determining stone provenance to proposing conservation/restoration, BRGM, France

QUARRYSCAPES - Conservation of ancient stone quarry landscapes in the eastern Mediterranean, Geological Survey of Norway. Natural stone team, Norway

OPERHA - Open and fully compatible next generation of strengthening system for the rehabilitation of Mediterranean cultural heritage, Fundación Labein, Spain.
Priority G: Improve Safety and Security within the Construction Sector

**Brief description of the priority and rationale**

Coordinated and collaborative research is required at the European level to reduce the uncertainty, the unpredictability and the consequences of natural and man-made hazards. Safety and security of all infrastructures must be ensured, as any disruption of service may result in large socio-economic consequences. Safety of users of buildings and infrastructures must also be assured, including safety of workers involved during the construction process. The ultimate goal is to achieve timely and appropriate holistic solutions so that losses and disruptions by natural and man-made hazards become marginal, acceptable and insurable.

**Main development issues**

Mitigation of natural and man-made hazards should be reached by the development of integrated assessment, management and prevention methods, new materials and structural systems, new technologies and ICT. The disproportionate risk of loss and damage by natural and man-made hazards such as earthquake, flooding, fire, storm, landslide, blast are considered as well as their impact on carrying out economic activities and work.

Qualification and simulation of structural and system behaviour up to residual strength and failure.

Strategies to reduce accidents and occupational diseases in the work environments of the construction sector.

**Expected impact**

During the last decade, total average cost of natural and man-made hazards is estimated at 7.35 billion €/year, with the following repartition: floods, 5 billion €/year; earthquakes, 0.25 billion €/year; severe wind storms, 0.1 billion €/year; industrial accidents, 2 billion €/year; which demonstrates the large economic lever effect of rational protection and prevention measures. This lever effect is even higher when only most vulnerable areas are considered, and if we consider necessary protection against extreme events with longer return periods. Moreover, potential loss of life is not incorporated in these figures. This is especially significant for earthquakes, which have cost more than 7000 lives in Europe in the last 50 years. Also, hazards impose threats that have a significant impact on the quality of life and economy, e.g., through reduced incentive to invest in flood prone areas or near hazardous industries.

A study estimates that economic costs of bad working conditions in the sector represent 8.5% of the costs of the construction project, which means some 75 billion euros annually in the whole European Union.

The aims are to:

- create a sound state of emergency preparedness and risk awareness in societies, and to achieve timely, appropriate and internationally accepted holistic solutions, qualifications and procedures, by which disproportionate risk of loss and damage by natural and man-made hazards are mitigated and do not develop progressively, but become manageable, acceptable and insurable and by which the impact on rescue operations and normal socio-economic activities are minimal;
- reduce the number of accidents and number and duration of congestions and increase availability and accessibility of transport and supply infrastructure;
- reduce the economic costs of bad working conditions in the sector.

Safety in the built environment is a fundamental right (Art 25, UN Universal Declaration of Human Rights). European politics and societies will be enriched by covering vulnerability of the built environment by new protocols, legislation and standards for mitigation.
State of the art

In Europe, because of anticipated climate changes, increased land occupation, and eastwards expansion of the EU, increasing numbers of natural hazards are predicted over the next 50 years, which associated with the ageing of infrastructure, will lead to considerable economic losses and fatalities. Safety and security against natural and man-made hazards must be guaranteed for people to work and live. No activity (including emergencies and rescue operations) can be carried out with an interruption of supply and transport or the loss of key buildings and facilities. The public acceptance of terrorist threats is decreasing, whilst the impact magnitude is increasing. In densely populated areas of Europe people work and live near industrial facilities and industrial accidents are recognised as potential serious hazards for employees and neighbouring offices and dwellings. Improving safety and security has been classified in the high-medium priorities of the ECTP.

There is a great variety of flood protection policies and the safety offered by flood defence systems varies quite a lot in the different European states. Available codes of practice include only simple and mainly empirical methods. In many countries in Europe no safety levels are prescribed and indicated safety levels range from a return period of extreme water levels less than 100 to 1000 years. In the Netherlands legally prescribed safety levels range from 2000 to 10000 years. Current flood risk assessment only focus on structure height versus water level and possible flood consequences, whereas structural failures due to mechanisms like strength, erosion and human interventions are hardly considered. Proper maintenance is rarely performed in time. Each country facing the threat of floods has developed its own system of protection measures according to local conditions, the core of which consists of construction and maintenance of flood defence structures.

At present the predictability of landslides occurrence is weak and the current status of landslide inventory is far from being satisfactorily, with the exception of Italy. Soil conditions vary widely all over Europe and standardisation, though started in the late nineties, has only partly been achieved, with many national varieties remaining not assessed. Expanding populations, people have settled in areas vulnerable to landslides without any awareness. The relation of land sliding with ground water levels is understood, but the influence of climate changes triggering landslides is unknown. Applied diversion and stabilisation works are usually fairly simple and there are only a few specific and sophisticated early warning systems in operation (avalanches).

New buildings and civil structures, which are designed according to the present state-of-the-art seismic codes are supposed to resist the assumed design earthquakes. However, recent earthquakes have also revealed that some building construction practices are not necessarily safe. For example non-ductile reinforced concrete construction, often with masonry infill – a construction method that is quite popular throughout Europe - is a proven “serial killer” during earthquakes. For the large stock of existing buildings and civil structures, effective vulnerability assessment methods as well as affordable retrofit strategies remain an urgent target for research. Innovative concepts for seismic design of new and retrofit of existing buildings, dams, networks and infrastructures are needed to protect the built environment.

At present comprehensive engineering knowledge is available on the design for normal wind conditions. However, recent extreme winds will require further data acquisition and possibly higher design values, especially for the envelope of buildings.

An overview of European research on Natural Hazards can be found in the catalogue of selected FP5 and FP6 projects, volume 1, EUR 21936, ISBN 92-79-00443, European Communities 2006.

Comprehensive threat and vulnerability analysis and risk assessment helps to rationally grasp potential threats, vulnerabilities and risks and prevents expensive piecemeal responses to extraordinary events. Available protection structures are often quite heavy and massive, utilising traditional and bulky materials such as soil and reinforced concrete and often designed on an element by element basis instead of looking on systems in a holistic way (mitigation).

Presently, it is not uncommon to spend millions of euros on perceived risks whilst statistically significant risks may go unaddressed. Especially for man-made hazards (terrorist threats and industrial hazards), considering randomness and independence of occurrence as well as the limited opportunity to obtain experimental data to make informed decisions, risk assessment methods will be a rational way of improving safety and security of people in the built environment. For years, the airline and the nuclear industries have used formal risk assessment tools to improve design and safety margins. At this time, few risk- and vulnerability-assessment tools have been designed specially for buildings and civil structures.
Finally, construction is one of the sectors with greatest occupational risk in Europe and has a higher number of fatal accidents, injuries and occupational illnesses than any other sector. Each year more than a thousand fatal accidents are caused and more than 800,000 workers are injured, many seriously; these figures represent 18% of non-fatal accidents and 24% of fatal accidents at work recorded in the EU. This situation creates the need for a specific research in the sector.

**Vision/targets**

The impact of natural and man-made hazards on built environment are recognized, quantified and managed in a safe and reliable manner at the European level, risks can be rationally evaluated and mitigated and the built environment in Europe accordingly protected.

European transport and supply networks are safe and secure from natural and man-made hazards: security, safety, mobility and supply are guaranteed under critical circumstances. Interruption of networks service is avoided as their functionality is fundamental to rescue and emergency activities. Monitoring systems are operational and efficient, and support crisis management and risk mitigation.

**Synergies with other priorities and ETPs**

This priority should be tackled in coordination with the following European Technology Platforms:

- European Rail Research Advisory Council – ERRAC
- European Road Transport Research Advisory Council – ERTRAC
- European Steel Technology Platform – ESTEP
- Industrial Safety ETP
- Water Supply and Sanitation Technology Platform – WSSTP

**Research Items**

**Item G1: Harmonised design rules**

**Short Description**

Development and harmonisation of European guidelines and codes for performance-based and innovative design, relating to:

- Earthquake resistant structures (new and existing) and common methodologies for hazard evaluation;
- Flood, Tsunami and erosion defence systems (rivers and coasts);
- Landslides prevention (on-shore and off-shore);
- Terrorist threats to industrial facilities, and especially exposed buildings and infrastructure;
- Fire-safety design of buildings and underground premises.
- Technological hazards:

**Item G2: Risk and Safety Management Systems**

**Short Description**

Safety of use and supply as well as security from natural and man-made threats is among users’ and communities’ prime concern.

These challenges must be addressed by the development of innovative systems, models and tools for risk and safety management of infrastructure and defence systems against natural and man-made hazards, integrating issues such as safety culture, business processes, economic impacts, roles and responsibilities,
training and competency, quality and performance management, accessibility and partial functionality of hazard defence systems, infrastructure, key buildings and facilities after damage.

**Item G3: Systems for the management of risk and emergencies and partial functionality of the networked system**

**Short Description**

(Priority to be considered in conjunction with DG TREN)

Any interruption – even if momentary - of service and supply can compromise the overall networks functionality, i.e. impeding the connections between the fundamental nodes of the network for the rescue operations and for the transportation of the first aid supplies, and results in an overburden for the others, because of the interdependencies. Systems for communication between users and operators as well as between different operators and authorities are needed in order to react promptly and effectively in order to mitigate the effects of an attack on people and infrastructures, to evaluate consequences, to prove accessibility and availability of infrastructure of transport and supply and to restore service. Suitable European legal framework (where possible) is needed to support the creation of a common playground especially for hazardous materials issues.

**Item G4: Reliable and long-life systems to monitor and control all security/safety parameters of infrastructures**

**Short Description**

(Priority to be considered in conjunction with DG TREN)

Security has become a global challenge. Europe needs to invest in this field in order to effectively and innovatively address existing and future security challenges. Infrastructures, particular for land transport and supply, may be subject to hazards, such as earthquakes, that are likely to occur during their lifetime, and to which they are not resistant according to current standards.

Scientific and technological advances have been and can be further made to drastically reduce risks by defining models, criteria, and optimal strategies and by implementing systems for risk reduction (i.e. seismic risk) on the basis of available data and new targeted.

Recent advance in measurement and telecommunication technologies open new avenues to develop monitoring systems dedicated to continuously control any type of construction, in order to check the structural effectiveness in any moment, to evaluate its response and its subsequent damage state after any event.

**Item G5: Mitigation of natural and technical risks**

**Short Description**

In densely populated areas of Europe people work and live near industrial facilities, and industrial accidents are recognised as potential serious hazards not only for employees but also for neighbouring offices and housing areas. The acceptance of threats of natural and man-made hazards is decreasing whilst the impact of these hazards is increasing. Vulnerable buildings and networks must be assessed and protected to meet new defined safety standards, and new construction and retrofit methods must be developed to mitigate natural and technical risks, such as:

- Simple and easy to handle seismic strategies to retrofit existing buildings, particularly residential houses and cultural heritage
- Approaches and materials to retrofit existing hazard mitigation systems to accommodate for climate change and land use
- Unobtrusive and aesthetic protection structures (including anti-seismic materials) against natural hazards and man-made hazards (e.g. impact, blast or fire)
- New methods to improve the resistance of existing buildings against extreme weather conditions
• New methods to improve the resistance of foundation soil.

The development of these new concepts must be complemented by the development of specific warning systems; specific post-disaster strategies corresponding to risk category and source, and ultimately by raising awareness and alertness of the public.

**Item G6: Safety on construction work places**

**Short Description**

Strategies to improve human and organizational factors on the Construction sites. To reduce accidents and occupational diseases in the work environments of the Construction sector, improving human and organizational factors affecting the design of the most representative workplaces, tools, machinery and industrial vehicles, the required personal protective equipment (PPE) and collaborative and participative culture in working and training methods. New materials and building systems to improve working environment (e.g. light materials, self-compacting materials...).

**Involvement of SMEs**

All research items are anticipated relevant to SMEs at various levels. However, the most relevant items are Item 2 “Risk and safety management systems”, where SMEs can partially develop and exploit the technologies needed to achieve innovative systems, models and tools for risk and safety management. Item 6 “Safety on construction work places”, and Item 4 “Reliable and long-life systems to monitor and control all security/safety parameters of infrastructures” concerning the development and use of new monitoring systems.

**Budget and scheduling**

The tentative planning and budget of Priority G “Improve Safety and Security within the Construction Sector” in FP7 calls is summarised in the table below, assuming that every priority will be called over two years. Year 2 (2008) means “call opening end 2007 for proposals to be submitted beginning 2008”.

But in fact research needs are much more important and additional funding will have to be covered by other European (EUREKA, COST…) or National Programmes.

<table>
<thead>
<tr>
<th>Research Items</th>
<th>Planned FP7 Scheduling and Projects Costs</th>
<th>Other Programs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td>G1 Harmonised Design Rules</td>
<td></td>
<td>10</td>
<td>10</td>
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<tr>
<td>G2 Risk and Safety Management Systems</td>
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<td>5</td>
<td>5</td>
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<tr>
<td>G3 Systems for the management of risk and emergencies and partial functionality of the networked system</td>
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<td>5</td>
<td>5</td>
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<tr>
<td>G4 Reliable and long-life systems to monitor and control all security/safety parameters of infrastructures</td>
<td>5</td>
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<tr>
<td>G5 Mitigation of natural and technical risks</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>G6 Safety on construction work places</td>
<td></td>
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<td>20</td>
</tr>
</tbody>
</table>

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.

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This priority should be tackled in coordination with the following priorities of FP7:

- Environment (Natural hazards within the Climate change, pollution and risks activity and Cultural Heritage)
- ICT to some degree (in support of environment within the ICT meeting societal challenges research application)
- Nanosciences, Nanotechnologies, Materials and new Production Technologies (Material activity)
- Security and Space (security of infrastructures and utilities)
- Transport (Improving safety and security within the sustainable surface transport activity),

As well as with DG TREN to promote sustainable, efficient and safe mobility reducing negative effects on environment.

**List of some major recent projects**

- European research on Natural Hazards, see catalogue of selected FP5 and FP6 projects, volume 1, EUR 21936, ISBN 92-79-00443, European Communities 2006.
Priority H: New Integrated Processes for the Construction Sector

**Brief description of the priority and rationale**

Information and Communication Technology is the main innovation driver in most industries and core enabler of economic growth in the 21st century (NESSI 2006). Process renewal, supported by ICT, is one of the main vehicles towards the vision of the ECTP.

Consequently this priority proposes 8 items aligned with the 3 pillars of the SRA of the ECTP:


**Main development issues**

This section describes the RTD priorities established in the field of Processes & ICT. It sets out the likely directions of technological and organisational changes that will need to be converted into specific research programmes over the coming years.

The document presents research priorities in four important areas of attention. Each area is divided into two complementary aspects: processes: (H1) business and (H2) production, products: (H3) digital models and (H4) intelligent constructions, projects: (H5) interoperability of ICT systems and (H6) team collaboration, enterprises: (H7) knowledge sharing and reuse for (H8) new business models.
**Expected impact**

Some major examples of impacts of the eight above mentioned research themes are:


H5. **Interoperability** – Availability of existing information for new purposes without re-entering. Integration and effectiveness of the supply network. Reduced errors and rework. Cost and time savings.

H6. **Collaboration support** – Information availability to all, any time, anywhere. Trust, confidence and social integration of dispersed stakeholders.

H7. **Knowledge sharing** – Industrialisation of engineering, production and service provision. High-tech image of construction. Increased productivity.


**State of the art**

Main elements of the state of the art for the eight above mentioned research themes are:

H1. **Value-driven business processes** – Business processes are driven by lowest investment cost rather than value to customers and end-users.

H2. **Industrialised production** – Construction site is an ICT island where mobile phones provide the only ICT connection.

H3. **Digital models** – Applications are dedicated to specific engineering functions and traditional sequential and discipline-specific process phases. Document based ICT augments the creation and sharing of human-interpretable information only. Many ICT systems need to be customised for each user organisation and require continuous re-configuration and maintenance. Low semantics does not allow re-use of information.

H4. **Intelligent constructions** – Buildings and products are at best equipped with isolated intelligence using vendor specific platforms and protocols.

H5. **Interoperability** – Data exchange between different applications and companies is file-based using proprietary formats at low semantic level.

H6. **Collaboration support** – Teamwork between distributed project participants is supported by web-enabled file and document management systems. These allow peer-to-peer collaboration but are not integrated with internal ICT systems of participating organisations.

H7. **Knowledge sharing** – Experience and previous solutions are available in personal / department archives but new solutions are regularly re-invented. Some re-usable knowledge is available from solution providers in proprietary digital formats.

H8. **ICT enabled business models** – Business models are bound to historical disciplines of stakeholders, based on geographic proximity and rigid contractual practices, sub-optimisation and antagonistic relationships.
**Vision/targets**

The Vision in that field is that Construction is a highly information intensive industry which uses state-of-the-art technologies in all processes and products in order to satisfy client’s expectations in a sustainable way. As a knowledge-based industry it offers attractive workplaces for skilled and well educated personnel. European construction industry works competitively on the open global market supported by flexible SME-based supply networks.

Aiming at this vision, the objectives of the proposed R&D are to develop:

H1. Processes and ICT to support sustainable value creation for customers and users

H2. ICT for automated and industrialised production

H3. Model based applications to support all stakeholders with semantic, re-usable information

H4. Embedded intelligence of products and systems to support use and life cycle management

H5. Interoperable ICT tools, systems and infrastructures

H6. Infrastructures and services for collaborative cross-organisational and distributed teams

H7. Tools for capturing, consolidating and disseminating project experiences and knowledge

H8. New business models and enabling ICT infrastructures

**Synergies with other priorities and ETPs**

<table>
<thead>
<tr>
<th>Other ECTP priorities</th>
<th>Prior. H</th>
<th>H1 BP</th>
<th>H2 IP</th>
<th>H3 DM</th>
<th>H4 IC</th>
<th>H5 IO</th>
<th>H6 CS</th>
<th>H7 KS</th>
<th>H8 BM</th>
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</thead>
<tbody>
<tr>
<td>A. Indoor Environment</td>
<td>Medium</td>
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<tr>
<td>B. Underground Space</td>
<td>Medium</td>
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<td>H</td>
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<tr>
<td>C. Efficient and Clean Buildings</td>
<td>High</td>
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<tr>
<td>D. Impacts on Environment</td>
<td>Medium</td>
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<tr>
<td>E. Management of Networks</td>
<td>Medium</td>
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<td>F. Cultural Heritage</td>
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<td>G. Safety and Security</td>
<td>Low</td>
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<tr>
<td>I. High Added Value Materials</td>
<td>Low</td>
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</table>

**Other European Technology Platforms**

<table>
<thead>
<tr>
<th>Other European Technology Platforms</th>
<th>Prior. H</th>
<th>H1 BP</th>
<th>H2 IP</th>
<th>H3 DM</th>
<th>H4 IC</th>
<th>H5 IO</th>
<th>H6 CS</th>
<th>H7 KS</th>
<th>H8 BM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTEMIS – Embedded intelligence and systems</td>
<td>High</td>
<td>-</td>
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<td>-</td>
<td>H</td>
<td>H</td>
<td>H</td>
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<tr>
<td>E-MOBILITY – Mobile and wireless communications</td>
<td>Medium</td>
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<tr>
<td>EPOSS – Smart systems integration (RFID, …)</td>
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<td>ERRAC – Rail</td>
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<td>ERTRAC – Road transport</td>
<td>High</td>
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<td>ESteP – Steel</td>
<td>Medium</td>
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<tr>
<td>ESTTP – European Solar Thermal Technology Platform</td>
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<td>SRA not yet available</td>
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<tr>
<td>ETPIS – Industrial safety</td>
<td>Low</td>
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<tr>
<td>EuMAT – Engineering materials and technologies</td>
<td>Low</td>
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<td></td>
</tr>
</tbody>
</table>
Research Items

**Item H1: Value-driven business processes**

<table>
<thead>
<tr>
<th>Main drivers:</th>
<th>Performance-driven process, value to customer, total life-cycle support, product and service customisation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>Performance-driven processes, process orchestration, metrics, indicators, requirement engineering, mass customisation, life cycle performance assessment.</td>
</tr>
</tbody>
</table>

ICT should allow dealing with customer-centric definition of products and services, management of requirements being instrumental in providing what the end users want (especially how functional requirements are translated into design and production requirements), support for capturing and fulfilling predefined performance criteria. ICT should also support scheduling & planning with information transfer between applications used in different stages of the construction process.

Short term:
- Development of performance classification systems
- Methods for capturing customer needs in “tangible” form (e.g. these requirements could be based on product/process performance)
- Methods, models and tools for product and service lifecycle simulation
- Development and use of modular product and service concepts

Medium term:
- Tools to support performance based procurement and contracting.
- Tools for the engineering and management of customer requirements
- Tools for product and service performance assessment
- Tools for customised product design and service configuration

Long term:
- Model based tools for performance verification
- Tools for real-time conformity assessment of customer needs
- Tools for product/service lifecycle optimisation
- Tools for mass customisation of products and services

**Item H2: Industrialised production**

<table>
<thead>
<tr>
<th>Main drivers:</th>
<th>Effective manufacturing and construction. Supply network management; Open market.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>ICT support for modular provision of customised constructions, logistics, on-site production and assembly. Integration of construction site in the process.</td>
</tr>
</tbody>
</table>
The RTD targeting Industrialised Production is driven by two main trends:

- evolving EU-wide open market in constructions,
- increasing productivity throughout the supply network including the construction site,

as well as the challenge to be able to produce individually and tailor-made industrialised construction elements.

The main research areas are:

- **Short term**: Tools for supply network and logistics management. Flexible manufacturing. On-site communication.
- **Medium term**: Standards for supply network integration. Customer oriented configuration design & management using manufactured components. On site production and assembly methods.
- **Long term**: Customised product & service integration. Manufacturing level on-site production and information management. Fully virtual production.

### Item H3: Digital models

<table>
<thead>
<tr>
<th>Main drivers:</th>
<th>Semantics and interoperability ➔ User and lifecycle orientation ➔ Real-time adaptive models.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>nD models providing access to life time information for all stakeholders anywhere anytime. ICT applications for design, configuration, analysis, simulation, and visualisation.</td>
</tr>
</tbody>
</table>

ICT should support scheduling & planning with information transfer between applications used in different stages of the construction process.

**Short term:**
- Take up of existing process paradigms: performance based procurement, open building etc.
- Development and standardisation of value metrics and indicators.

**Medium term:**
- Methods and tools for capturing value requirements, and transforming and validating them between stakeholders throughout the process.
- Re-engineering business processes for dynamic supply networks, driven by customer-perceived value and sustainability.
- Models and tools for performance-based contracting, customer involvement, partnering and system integration.

**Long term:**
- Integrated theory and related methodologies for modelling and rapid engineering of dynamic project-based business processes and networks.
- Configuration tools for consortium formation, contract preparation and ICT integration.

### Item H4: Intelligent constructions

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>Smart embedded systems &amp; devices for monitoring and control, embedded learning &amp; user support.</td>
</tr>
</tbody>
</table>

The R&D targeting the intelligent constructions and smart buildings is to be developed around three fundamental pillars:

- **The “intelligent” objects**: these objects (including multi-functional materials) must have embedded electronic chips, as well as the appropriate resources to achieve local computing and interact with the outside, therefore being able to manage appropriate protocol(s) so as to acquire and supply information.
• The **communications**; these must allow sensors, actuators, indeed all intelligent objects to communicate among them and with services over the network. They have to be based on protocols that are standardised and open.

• The **multimodal interactive interfaces**; the ultimate objective of those interfaces is to make the in-house network as simple to use as possible, thanks to a right combination of intelligent and interoperable services, new techniques of man-machine interactions (wearable computing, robots, …), and learning technologies for all communicating objects. These interfaces should also be means to share ambient information spaces or ambient working environments thanks to personal advanced communication devices.

**Short term**: the R&D is devoted to achieving full integrated automation and control (e.g. eHOME – the electronic home). This is mainly about:

• All objects / components in the built environment integrating elements for a given degree of intelligence: RFID tags, chipsets, embedded micro-systems, etc, including the opportunity for humans to wear such devices or chips with embedded intelligence.

• Application of sensor technologies for distributed monitoring, control, end-user support and services, thanks to all “intelligent” communicating objects being able to mutually identify in the network, connect and interact with each other according to various communication models and channels.

**Medium term**: the R&D is devoted to the generalisation of network-based services accessible from the built environment (e.g. iHOME – the interactive home). This is about considering the built environment being naturally considered as a node (or set of nodes) of the Internet backbone, therefore providing and requesting services over the network:

• Smart products and systems with embedded devices, and embedded learning support to users, operators and maintenance staff.

• Software tools for tracking, logistics, diagnostics, monitoring and control.

• Modular integrated automation, monitoring and control of all subsystems with holistic optimisation and support to service provision.

**Long term**: the R&D eventually is targeting a full understanding and adaptability of the built environment for its users (e.g. uHOME – the ubiquitous home. This includes user and context aware, self-optimising intelligent built environments, with potential for dynamic re-configuration, and providing access to interactive spaces and personalised services.

**Item H5: Interoperability**

<table>
<thead>
<tr>
<th>Main drivers:</th>
<th>Migrate from data/file exchange to data sharing and ultimately to flexible interoperability.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>Model servers; Distributed adaptive components; Ontologies &amp; open ICT standards for semantic communication; ICT infrastructures.</td>
</tr>
</tbody>
</table>

R&D is required to transform the current eBusiness processes environment(s) into fully integrated / interoperable innovative semantical eServices supporting structured and harmonised processes in Construction, with a focus on all ICT technologies and tools that may support such an evolution. This includes:

• Providing seamless semantic (forward and backward) communication (object exchange and sharing), to support both interfacing and synchronisation between actors;

• Integrating (open and standardised) nD modelling technologies, Semantic Knowledge Technologies (SKT), Grid-based Computing, and Global Optimisation methods, along with intuitive visual and interactive user interfaces;

• Developing and refining architectures for construction product/service life-cycles and their associated supply chains, that are adapted to the Construction sector (especially SMEs), with easy methods and techniques for specialisation;

• Offering flexible access to IT-based business services, semantic information resources and Content repositories / libraries of re-usable solutions, with standardized global identification of construction objects;


• Offering capability to provide services for installing, maintaining and monitoring these advanced systems (strengthening the role of system integrators in construction).

**Item H6: Collaboration support**

<table>
<thead>
<tr>
<th>Main drivers:</th>
<th>Rapid and easy connectivity → robust team interaction → seamless inter-enterprise integration.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>ICT tools for information sharing, project steering, negotiations, decision support, risk mitigation, etc.</td>
</tr>
</tbody>
</table>

Short term:
• Take up of existing collaboration tools (CSCW, EDM/PDM).

Medium term:
• ICT infrastructures and tools to support project collaboration of temporary multi-organisational teams.
• Integration of (internal) engineering & enterprise systems (CAE, ERP etc.) with (external) project collaboration environments in a transparent way including authentication, authorization and audit trail.
• Collaborative inter-enterprise ICT infrastructures including model and catalogue servers.
• Standardisation of the interfaces between enterprise systems and project collaboration environments.
• Collaborative ICT tools for information sharing change management, project steering, negotiations, decision support, risk mitigation, on-site monitoring etc.
• Low entry tools for efficient integration of SMEs in project collaboration.

Long term:
• Ubiquitous access interfaces for communication and information sharing with all stakeholders towards the merging of: "digital site" + "virtual project office" + "virtual control room" + "virtual service centre".
• Legal & contractual governance of shared object data.

**Item H7: Knowledge sharing**

<table>
<thead>
<tr>
<th>Main drivers:</th>
<th>Access to knowledge → sharing structured knowledge → context-aware knowledge.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>ICT for transforming project experiences into corporate assets. Object repositories. IPR protection of complex shared data. Context aware applications.</td>
</tr>
</tbody>
</table>

A wide range of different ICT based tools and services necessary for moving an organization towards a dynamic knowledge management will be developed in the next years. ICT should be essential not only for the storage of tacit and explicit knowledge in web based repositories but also as a communication device allowing ubiquitous access to organizational knowledge anywhere, anytime.

Short term:
• Benchmarking and best practice advisory tools
• Online knowledge repositories
• Shared ontologies
• Distributed content management systems

Medium term:
• Semantic tools
• Knowledge management services, models, and frameworks
• Advanced decision support systems

Long term:
• Knowledge mining and semantic search services and tools
• Adaptive and context aware applications
**Item H8: ICT enabled business models**

<table>
<thead>
<tr>
<th>Main drivers:</th>
<th>Business networking, customer orientation &amp; sustainability, system integration, specialisation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key R&amp;D topics:</td>
<td>New ways for sustainable exploitation of ICT as a key part of business strategy in the open European / global construction marketplace. Management tools and services to support inter-organisational collaboration across products and services</td>
</tr>
</tbody>
</table>

The ICT-based solutions should be, among others:

- Innovative e-Business solutions, especially for SMEs, supported by open, interoperable, modular and adaptive ICT-based platforms that would also allow integration of enterprise applications.
- Pan-European multi-lingual “information resource points” accessible and “valuable” all across Europe. This will be done through the promotion of the semantic web and its related technologies applied to the Construction needs.
- Solutions for Sustainability management, through optimised management of multi-constraints systems, and improved cooperative development towards “sustainable construction model(s)”.

**Short term:**

- Tools for managing inter-functional and inter-organisational e-Commerce, supply chain management, and logistics
- Tools that support product, process and service visualisation
- Tools that support management and integration of products, processes, and site models
- Tools for managing (digital) product and service catalogues

**Medium term:**

- Tools for managing change management, audit trailing, and flexible interoperability in inter-organisational settings
- Tools for managing life-cycle performance assessment
- Tools for managing product and process simulation
- Tools for managing parametric products and services

**Long term:**

- Tools for managing partnering, collaboration support, and ICT based contracts in inter-organisational settings
- Tools supporting both design and service configuration and management
- Tools for managing intelligent product and service integration
- Tools supporting product and service customisation.

**Involvement of SMEs**

SMEs are key technology providers and developers especially in topics: H3 “Digital models”, H4 “Intelligent constructions”, H5 “Interoperability” and H6 “Collaboration support”.

As end-users SMEs are potential forerunners especially in topics: H1 “Value-driven business processes”, H2 “Industrialised production”, H7 “Knowledge sharing” and H8 “ICT enabled business models”.

**Budget and scheduling**

The budget is tentatively estimated assuming: industry 60%, FP7 10%, other programmes 30%. Each of the 8 items is in itself a wide area for R&D covering a plenitude of applications and technologies. Thereby many topics will need to be addressed both in the context of other priorities in addition to narrowly focused R&D.
### Planned FP7 Scheduling and Projects Costs

<table>
<thead>
<tr>
<th>Research Items</th>
<th>Planned FP7 Scheduling and Projects Costs</th>
<th>Other Programs</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td>H1 Value-driven business processes</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>H2 Industrialised production</td>
<td>7</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>H3 Digital models</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>H4 Intelligent constructions</td>
<td>7</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>H5 Interoperability</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>H6 Collaboration support</td>
<td></td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>H7 Knowledge sharing - Knowledge contents to be addressed as part of most calls and tools in specific calls (SSA + CP).</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>H8 ICT enabled business models</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total**

|                       |     |     |     |     |     |     |     | 16  35  30  36  40  30  23 | FP7 total: 210 |

*All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.*

The above tentatively proposed funding from FP7 is at similar level as in previous Framework Programmes. Other funding is available from various sources, mainly national programmes.

### List of some major recent projects

<table>
<thead>
<tr>
<th>Synergies with major projects and programmes</th>
<th>Item</th>
<th>1 BP</th>
<th>2 IP</th>
<th>3 DM</th>
<th>4 IC</th>
<th>5 IO</th>
<th>6 CS</th>
<th>7 KS</th>
<th>8 BM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BICT - Evaluation of benefits of ICT for the industrialization of processes in construction (ERABUILD)</strong></td>
<td>Medium</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>BUILDNOVA - Building innovation in the European Construction Sector (Innovation SSA)</strong></td>
<td>Low</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>CABA – Continental Automated Buildings Association (USA)</strong></td>
<td>Medium</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>CEN – European Committee for Standardization (standards)</strong></td>
<td>Medium</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>COMPETITIVE BUILDING (Sweden)</strong></td>
<td>Medium</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>CoSPACES – Innovative Collaborative Work Environments for Engineering (IST IP)</strong></td>
<td>High</td>
<td></td>
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</tr>
<tr>
<td><strong>CoVES - Collaborative Virtual Engineering for SMEs (NMP/IST ST)</strong></td>
<td>High</td>
<td>X</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><strong>CRC-CI – Construction Innovation (Australia)</strong></td>
<td>Medium</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CUBE – Building services technologies (Finland)</strong></td>
<td>High</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DIGITAL BUILDING (Denmark)</strong></td>
<td>High</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E-NVISION – A New Vision for the participation of European SMEs in the future e-Business (??ST)</strong></td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ERABUILD – Sustainable development in the construction &amp; operation of buildings ERA)</strong></td>
<td>Potential</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*All topics*
<table>
<thead>
<tr>
<th>Project Name</th>
<th>Potential</th>
<th>All topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUREKABUILD – Umbrella project for launching research projects under the EUREKA programme (EUREKA)</td>
<td>High</td>
<td>X X X X</td>
</tr>
<tr>
<td>I3CON – Integrated, Intelligent &amp; Industrialized (NMP IP)</td>
<td>High</td>
<td>X X X X</td>
</tr>
<tr>
<td>IAI – International Alliance for Interoperability (IFC, Industry Foundation Classes standard)</td>
<td>High</td>
<td>X X</td>
</tr>
<tr>
<td>IEEE – Institute of Electrical and Electronic Engineers (standard)</td>
<td>Low</td>
<td>X X</td>
</tr>
<tr>
<td>INPRO – Open information environment for knowledge-based collaborative processes … building (NMP IP)</td>
<td>High</td>
<td>X X X X</td>
</tr>
<tr>
<td>INTELCITIES – Intelligent Cities (IST IP)</td>
<td>Medium</td>
<td>X X</td>
</tr>
<tr>
<td>INTELGRT – Interoperability of Virtual Organizations on Complex Semantic Grid (IST ST)</td>
<td>Medium</td>
<td>X X</td>
</tr>
<tr>
<td>ISCSIS - Integrated Supply Chain Information (ERAbuild)</td>
<td>Low</td>
<td>X X</td>
</tr>
<tr>
<td>ISO – International Standardisation Organisation (standards)</td>
<td>Low</td>
<td>X</td>
</tr>
<tr>
<td>I-STONE – Integrated Natural Stone Production and (NMP IP)</td>
<td>Low</td>
<td>X</td>
</tr>
<tr>
<td>KNOWCONSTRUCT (IST SME)</td>
<td>Medium</td>
<td>X X</td>
</tr>
<tr>
<td>MANUBUILD – Open Building Manufacturing (NMP IP)</td>
<td>High</td>
<td>X X X X</td>
</tr>
<tr>
<td>OMG – Object Management Group (standards)</td>
<td>Low</td>
<td>X</td>
</tr>
<tr>
<td>PLUG&amp;PLAY – Managing Information in Construction (ERAbuild)</td>
<td>Medium</td>
<td>X X X X</td>
</tr>
<tr>
<td>PSIBOW – Process and System innovation in Building sector (Netherlands)</td>
<td>Medium</td>
<td>X X</td>
</tr>
<tr>
<td>REVALUING CONSTRUCTION (CIB)</td>
<td>Medium</td>
<td>X X</td>
</tr>
<tr>
<td>ROBOT@CWE – Advanced robotic systems in future collaborative working environment</td>
<td>Low</td>
<td>X X</td>
</tr>
<tr>
<td>SARA – Towards value networking in construction (Finland)</td>
<td>High</td>
<td>X X X X</td>
</tr>
<tr>
<td>STAND-INN – Integration of performance based building standards into business processes … (IST CA)</td>
<td>High</td>
<td>X</td>
</tr>
<tr>
<td>STRAT-CON – R&amp;D strategies for ICT in construction (ERAbuild)</td>
<td>High</td>
<td>X X X X X X X X</td>
</tr>
<tr>
<td>SWOP – Semantic Web-based Open engineering Platform (IST ST)</td>
<td>High</td>
<td>X X</td>
</tr>
<tr>
<td>TISSUE – Trends and Indicators for Monitoring Urban Environment (SSPI ST)</td>
<td>Low</td>
<td>X</td>
</tr>
<tr>
<td>TUNCONSTRUCT – Technology innovation in underground construction (NMP IP)</td>
<td>Low</td>
<td>X</td>
</tr>
</tbody>
</table>
Priority I: High Added Value Construction Materials

Brief description of the priority and rationale

Development of new materials and improvement of traditional materials is one of the key aspects to achieve new developments in the construction sector. At the state of the art, in many cases materials are produced trying to minimise costs but keeping reasonable performances. The current market situation and the competition from the Far East make this situation no more sustainable. The prospect for innovation must be considered according to new drivers, which will allow the European industry to maintain a leading position.

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

The point of view must therefore be changed and a strong research activity initiated to generate new high added value construction materials able to contribute to real innovation in the sector. For example, nanotechnologies open up new important possibilities to improve performances of building materials, as demonstrated in other industrial fields, so that the built environment and the quality of life can benefit of the latest developments in nano-materials and nano-structure research.

Main development issues

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

Currently nano-technologies are not effectively utilised in the production of building materials. This was mainly due to the difficulties in efficiently importing these technologies into production. Therefore industrial production of novel materials is the direction building material industry should go. Development of new materials for use within networks, cities and buildings, underground construction and as remediation measures against natural and man-made hazards, with other research approaches such as biotechnology and geochemistry offer a wide field for innovation. Toxicological studies for these new materials should also be performed.

Expected impact

Building materials form the basis of any kind of construction. Due to the volumes needed, the construction sector is the largest raw material consuming industry. In Europe, the volume of building materials used exceeds two billion tons per year. At the same time, the properties and combinations of materials also determine the energy demand of buildings, thus further increasing their environmental significance. This demonstrates that even small improvements in the environmental performance of building materials would have a huge overall beneficial impact.

Today about 50 % of all construction costs are devoted to maintenance, repair and rehabilitation. Improvements in functional durability would therefore have significant economical relevance.

State of the art

The current situation and main challenges have to be systematically analysed according to the life cycle of building materials: ranging from the production phase (energy and raw material demand, emissions), application (automation, safety) and the use phase (structural and aesthetic function, comfort, resource efficiency) through to the demolition phase, material recovery and/or safe disposal.

It is estimated that today less than 2 % of building materials application benefit from nano-technologies, with a related limited R&D expenditure. Important benefits of nanotechnologies are therefore not exploited and
can be expected in the improvement of structural properties, superficial functionality, durability, aesthetics, etc.

One key problem often is the scale up. Even if improved performances can be achieved at the laboratory level, in many cases it is not feasible to exploit them in the large scale. Also in traditional materials the prediction of long-term behaviour remains a problem limiting the possibilities for an optimized life cycle design. Main reason is the end of understanding in the underlying deterioration mechanisms. Application of nano-technological analytical tools offers the chance to better understand these mechanisms and subsequently form the basis for improvement.

**Vision/targets**

European building materials producers should be recognized worldwide as innovative and competitive companies. They will develop knowledge-based materials and applications with predictable and multi-functional characteristics. Their tailor-made products will create a comfortable living environment and serve the customers' needs while minimizing environmental impact throughout their entire lifecycle. The result will be a leading position of European building materials producers and the construction sector on the global market place and an industry that attracts and employs well-educated people.

To live up to this Vision, the following main objectives need to be accomplished:

- Reduce the environmental impact of building material production and of demolition.
- Improve the predictability and efficiency of building material production processes.
- Improve the resource efficiency of buildings and infrastructure in use through improved materials, tailored to the specific application.
- Reduce lifecycle costs for building materials.
- Improve comfort of living, health, hygiene, safety and aesthetics.
- Improve working conditions in production and construction (ease of application and maintenance, workers' safety).
- Develop new, multi-functional, knowledge-based materials and construction systems adjusted to customer needs.

**Synergies with other priorities and ETPs**

Materials are studied in many industrial fields and sectors. Therefore a lot of synergies can be found, in basic research technologies and also final applications. As a consequence, links have to be established and reinforced with a lot of other European Platforms. In particular, it is suggested that the closest ETPs can be EUMAT (European Technology Platform on Advanced Engineering Materials and Technologies), Steel ETP, Wood ETP, MANUFUTURE. Many of these contacts have been already activated.

In addition material research is also of high relevance in several other priorities of the ECTP (esp. priorities B to F).

**Research Items**

From the invention of new materials to their final application: a precise sequential research priority approach is proposed to improve the future situation of building materials:

- 1st step: new functionalities are needed to improve applicability and attractiveness of building materials;
- 2nd step: production processes have to be improved to include the new functionalities at the industrial scale and to optimize the production of traditional materials;
- 3rd step: traditional properties (as durability and reliability) of the new or traditional materials have to be improved;
• 4th step: once developed, the new materials (together with the traditional once) have to be optimized in terms of applicability using new solutions;

• 5th step: the life cycle of the materials and their behaviour in service must be predicted and managed by innovative tools.

More detailed descriptions are given in the following paragraphs.

**Item I1: Multifunctional construction materials**

Short Description

Development of materials with new functionalities and improved properties and comfort (resistance against an aggressive environment, that are hygienic and easy to clean, self-cleaning, biocides, with moisture control, thermal, electro-magnetic and acoustic isolation, heat storage and climatic functionality, creating a “warm feeling” and aesthetic appearance, low intrusive new materials for rehabilitation of buildings, surface functionalities, etc.) essentially by means of nano, sensor and information technology. Also functionalities related to energy consumption (e.g. thermal and acoustic insulation) and heat storage capacities of buildings should be considered.

**Item I2: Predictable, flexible and efficient building material production**

Short Description

Improve the predictability and efficiency of production processes for new building materials by innovation in manufacturing, control and measurement processes and introduction of ICT tools: this is to ensure quality throughout the production batch, with manufacturing flexibility. Development of tools for new processes simulation and prediction.

**Item I3: Improve durability and reliability of construction materials**

Short Description

Improvement of durability and reliability of construction: generate fundamental understanding of mechanisms that influence the durability of the different properties of building materials, products and components. Methods to generate improved durability, including reliable test methods. Development of new and improved nano-materials and nano-structures to improve structural resistance, reparability and durability. Know how can help designers and construction companies to define more exactly the materials really needed to fulfill the needs of the construction through serve life modeling and design.

**Item I4: Improve usability and applicability of materials**

Short Description

Development of “easy to use and install” building materials for friendly and safe construction processes. This includes for example lighter materials, prefabricated elements. Development of new materials and solutions for improved industrial applications (e.g. through improved rheological properties, optimized jointing materials and technology, improved reinforcement, etc.). Development of new tools to facilitate materials application in the building processes (e.g. virtual tools for material design linked to the specific building under development, measurement systems for testing materials in arrival and in use at the building site, etc.). Simplify building process and building costs by using multipurpose materials that can fulfill several requirements (i.e. surface finish without adding new layers and materials, sound insulation, heat storage etc).
**Item I5: Prediction and management of building material behaviour in service**

**Short Description**

Prediction and management of building material behaviour in service: develop tools and models to predict structural behaviour and service life of materials and elements to optimize life cycle costs of buildings. Development of reliable sensors and suitable models to predict processes and material behaviour through all phases of its service life. Development of non-destructive testing techniques for structural health and installation monitoring with minimal intrusively for the building life. This forms the first step towards the long-term objective of performance based design.

**Involvement of SMEs**

In principal, the involvement of SMEs is possible in all items. Although cement, concrete, ceramic producers, etc are mostly big companies, also a huge number of material producers are SMEs, specially all these related to special materials, pre-cast elements and materials reusing different types of waste. Also some nano-material producers are SMEs. Another group of SMEs involved in this field is the sensor and quality control developers.

Considering this scenario, it is envisaged that SME involvement will be highest in Item 4 “Improve usability and applicability of materials” and Item 5 “Prediction and management of building material behaviour in service”, where SMEs can act as technology providers and key developers.

**Budget and scheduling**

The tentative planning and budget of Priority I in FP7 calls is summarised in the table below. But in fact research needs are much more important, and additional funding will have to be covered by other European (EUREKA, COST…) or National Programmes.

<table>
<thead>
<tr>
<th>Research Items</th>
<th>Planned FP7 Scheduling and Projects Costs</th>
<th>Other Programmes Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2008</td>
</tr>
<tr>
<td>I1 Multifunctional construction materials</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>I2 Predictable, flexible and efficient building</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>material production</td>
<td></td>
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</tr>
<tr>
<td>I3 Improve durability and reliability of construction materials</td>
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<td>I4 Improve usability and applicability of materials</td>
<td>5</td>
<td>10</td>
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<td>I5 Prediction and management of building</td>
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<td>15</td>
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<tr>
<td>material behavior in service</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.

**List of some major recent projects**

**I-STONE:** Re-engineering of natural stone production chain through knowledge based processes, eco-innovation and new organisational paradigms

**HOLIWOOD:** Holistic Implementation of European thermal treated hard wood in the sector of construction industry and noise protection by sustainable, knowledge-based and value added products.
GLASCOAT: High-performance, glass-based coatings

SELF-CLEANING GLASS: Nano-structured self-cleaning coated glasses: modelling and laboratory tests for fundamental knowledge on thin film coatings, EC normalisation and customer benefits

4M: Multi-Material Micro Manufacture: technologies and applications

NENAMAT: Network for Nano-structured Materials of ACC

IP NANOKER: Structural ceramic nano-composites for top-end functional applications

MASMICRO: Integration of manufacturing systems for mass-manufacture of miniature/micro-products

FUSION: Fundamental studies of transport in Inorganic Nanostructures

AIMS: Advanced Interactive Materials by Design

NANOFIRE: Environmentally friendly multifunctional fire retardant polymer hybrids and nano-composites

INMAR: Intelligent Materials for Active Noise Reduction
Transversal Issues

Clients and Users

It is clear that construction projects – whether procured through traditional systems or through long-term ‘service’ contracts – have to meet the needs of stakeholders and in particular the needs of users and the needs of clients as the representative of users and owners. Equally, research aimed at improving construction performance should also enhance the benefits of construction to its stakeholders, including users and clients. Even ‘technological’ research, which appears to be only of relevance to designers and contractors, needs to have client input in order to generate understanding and confidence in the outputs. Therefore the following user/client roles in relation to construction projects need to be undertaken:

- identifying the users’ (and other stakeholders’) requirements,
- communicating these to potential suppliers,
- arranging for the requirements to be met through appropriate procurement actions,
- maintaining communication channels throughout the project,
- taking delivery of the final project output,
- over-seeing initial use and arranging for performance monitoring.

In order to achieve these objectives, the following roles and responsibilities in relation to future research are essential:

- User and client perspectives to be incorporated in the formulation and assessment of research proposals
- Research to have the active participation of users and/or client interests in both execution and the dissemination and application of outputs (this may be best achieved through inputs to projects currently at design or construction stage)
- Research that addresses topics and issues of particular relevance to clients and users.

This has implications for both the management and content of research programmes in construction. One of the most significant implications is that research cannot be purely technological – it must seek to explore and improve the relationships and organisational arrangements through which clients interact with supply interests and the ways in which users interact with buildings and other networks and with public spaces, so that the value to users of the built environment steadily increases. These aspects of research will call upon the expertise of social scientists, architects and other design interests, complementing the established inputs of physical scientists and engineers to the development of construction technologies.

In summary, the following steps should be undertaken in the research proposals:

- Be formulated with clear user/client involvement
- Be interdisciplinary, in that social scientists should be working alongside technical experts on issues of management, organisation and implementation
- Be assessed by experts who can bring user and client perspectives to the evaluation
- Be steered by groupings that include representatives of user and client interests
- Have dissemination and implementation strategies that clearly involve user and client interests.

An efficient way to achieve the necessary user/client involvement in a project is through a specific task for user/client activities in a research project as well as including a user/client in the high level management team for the project.

R&D Infrastructures

The availability of experimental facilities is essential to meet the objectives of ECTP and progress towards enabling the development of better technologies and raising the level of “sustainability” in the construction sector. Such facilities allow studying a large variety of structures and systems, and constitute an indispensable tool to calibrate the numerical models developed for analysis and design. In particular, some of these facilities, which fall into the category of large-scale infrastructures, allow the handling of near to full-scale models of complex structures, helping to improve the understanding of the global response of buildings, bridges and underground structures, and the effects of real phenomena.
Europe counts with a large number of experimental test facilities distributed among the different Member States which support research in different fields of civil engineering: structural, earthquake, fire, wind, hydraulic and geotechnical, as well as in areas of energy efficiency and user comfort, including acoustic and thermal insulation. Examples of such facilities are: shaking tables, reaction walls, centrifuges, wind tunnels, fire pits and furnaces, underground test facilities, material test laboratories, etc. The optimal use and networking of all these facilities, including the setting up of common data repositories, constitute an important step towards generating and making available the necessary data to support the innovation and progress in the field of construction.

Different experimental facilities and research institutions in Europe have been collaborating since the early 90’s in specific disciplines relevant to the construction sector with the financial support of the European Commission across several Research Framework Programmes. The various research projects and contracts aimed at the implementation of three types of activities: networking among the existing facilities and research institutions, providing access to researchers and industry to the experimental infrastructures, and carrying out research activities to improve and enhance the quality and capabilities of the existing facilities.

It is very important for Europe to have the financial support and vision to enhance the collaboration between the existing facilities with the aim of maximizing efficiency, improving quality, enhancing communication and providing access to all Member States and stakeholders. The future development of European distributed databases, distributed testing capabilities and virtual laboratories would be important steps forward in achieving these objectives.

More generally, a long-term plan at EU level for upgrading existing / opening new facilities, developing networking and the associated testing technology is needed in order to optimize research, reach excellence, and structure the civil engineering community.

Both the operators of the European testing facilities and their users’ community feel the need to integrate their research activities and make a coherent use and development of the existing infrastructures. A coordinated and collaborative research strategy has to be adopted to take full advantage of the continuous advance of IT technologies. The latter allow evolution towards global connectivity to support interoperability, to ensure remote access of the laboratories and to provide access to a common data base of experiments and results. Such evolution will greatly facilitate international collaboration and provide industry and SMEs easier access to perform tests at the infrastructures.

The vision of a strategy for FP7 on research infrastructures aims at promoting education and training by providing an adequate level of access, supporting research activities to maintain and upgrade the existing facilities, and improving efficiency by enhancing communication through the setting up of a common protocol for exchanging experimental results (distributed database) and the development of distributed testing capabilities and virtual laboratories. The activities should also promote the integration of the New Member States, as well as the Neighbourhood Countries, into a comprehensive and highly effective network of research infrastructures in Europe.

Under its “Capacities” priority, FP7 provides specific instruments, which could be used at best to achieve such objectives:

- The integrated projects (I3) to support in an integrated way the research activities in the existing large facilities.
- The design studies to investigate the possible creation of new infrastructures with European dimension and interest.
- The e-Infrastructures to build upon the ICT capabilities of existing to provide an easy-to-use controlled access to unique or distributed scientific facilities, regardless of their type and location.

At last, it must be added that specific efforts on developing adequate R&D human resources in the Sector are needed in order to build and synergize the research capacity embodied in individuals.

**Standards**

Although it is often claimed that standardization might hamper innovation, which has a tendency of being true if the standards are prescriptive instead of performance based, standards can also be a powerful instrument allowing driving forwards the uptake of technology and technology improvements. The latter is
especially true in the construction sector where the long service-life-time of structures requires that materials deliver the required performance over long time spans and accurate proof thereof be available at the onset of the construction stage. Also for spreading new practice amongst SMEs, standards, guidelines, approvals and regulations are very often important instruments driving further process and management innovation in the companies.

A consistent approach in tackling the different dimensions of the sustainable development in construction is needed as well as to respond to the recent and foreseeable market developments. To achieve this goal, pre-normative research and development works in close cooperation with all stakeholders are necessary to prepare the background for an integrated set of standards.

Some objectives of the research work on standards for construction are:

- To provide support for further harmonization and development of the existing rules so as to improve consistency between design rules and product specifications.
- To develop various aspects of sustainability (e.g. durability, robustness to natural and man-made hazards, acoustic and thermal performances, fire resistance and strength…).
- To propose updates of the rules and specifications according to the state of the art.
- To develop European guidance in various fields.
- To develop standards related to information management and exchange.
- …

It is believed that in all the priorities of the ECTP the components dealing with standards and transfer of technology to SME should get special attention.
# Roadmap Summary

The following table gives an overview of the scheduling and total costs of all Items introduced in each of the 9 Priorities A to I detailed in this SRA IAP document. All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.

<table>
<thead>
<tr>
<th>Research Items</th>
<th>Planned FP7 Scheduling and Projects Costs</th>
<th>All Other Programmes</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td>A1</td>
<td>Improved knowledge of users needs</td>
<td></td>
<td></td>
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<tr>
<td>A2</td>
<td>Harmonised Assessment Methods</td>
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<td>A3</td>
<td>Ensuring a Design-for-all</td>
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<tr>
<td></td>
<td>Technologies for Healthy, Safe, Accessible and Stimulating Indoor Environments for All</td>
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</tr>
<tr>
<td>B1</td>
<td>New Concepts: Integration Underground Functions</td>
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<td></td>
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<tr>
<td>B2</td>
<td>Retrofit and Upgrade of Existing Underground Structures</td>
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<tr>
<td>B3</td>
<td>New Tunnelling Technologies in any type of ground for long, large and deep tunnels</td>
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<tr>
<td>B4</td>
<td>Processes and ICT</td>
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<tr>
<td>B5</td>
<td>Transparent Underground for 3-DUrban Planning</td>
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<tr>
<td>B6</td>
<td>n-D Modelling in Tunnelling</td>
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<td>B7</td>
<td>New Materials</td>
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<td></td>
<td>Innovative Use of Underground Space</td>
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<tr>
<td>C1</td>
<td>New concepts, technologies, design tools and business models</td>
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<tr>
<td>C2</td>
<td>New and improved materials and structures</td>
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<td></td>
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<tr>
<td>C3</td>
<td>Integrated design tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>New information systems</td>
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<td></td>
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<tr>
<td>C5</td>
<td>Environmentally friendly building material production</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>New Technologies, Concepts and High-tech Materials for Efficient and Clean Buildings</td>
<td></td>
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</tr>
<tr>
<td>D1</td>
<td>New concepts, processes and components for the reduction of damage to environment</td>
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<tr>
<td>D2</td>
<td>Sustainable design, construction, demolition and recycling process</td>
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<td></td>
</tr>
<tr>
<td>D3</td>
<td>Knowledge of energy and materials flows</td>
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<td></td>
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<tr>
<td>D4</td>
<td>Reduction of impact of transport and utility networks</td>
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</table>

<table>
<thead>
<tr>
<th>Total Costs</th>
</tr>
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<tr>
<td>430</td>
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<tr>
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<td>780</td>
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<tr>
<td>30</td>
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<tr>
<td>60</td>
</tr>
</tbody>
</table>
|   | Description                                                                 | Rating | Impact | Total cost | Impact  
|---|------------------------------------------------------------------------------|--------|--------|------------|--------
| D5 | Reducing impact of accidents involving dangerous and hazardous goods        | 5      | 5      | 5          | 75     |
| D6 | Remediation and mitigation of contaminated soils and groundwater             | 5      | 10     | 10         | 125    |
| D7 | Re-using and re-cycling demolition debris and waste                          | 5      | 5      | 5          | 85     |
| D8 | Construction technologies for the protection and exploitation of water resources | 5      | 5      | 5          | 50     |

*Reduce Environmental and Man-made Impacts of Built Environment and Cities*  
\[ T_{FP7} = 110 \]  
655

|   | Description                                                                 | Rating | Impact | Total cost | Impact  
|---|------------------------------------------------------------------------------|--------|--------|------------|--------
| E1 | New methods/tools for the comprehensive management of transport and utilities infrastructure in urban and extra urban context to reduce impact on service | 15     | 10     | 10         | 175    |
| E2 | Standards, models and databases to assess, follow and predict the long-term performance of structures and components subject to ageing and deterioration |        | 15     |            | 75     |
| E3 | New concepts to extend the life time of structures or increase their capacity, with no reduction in safety and with positive impact on maintenance | 10     | 10     | 10         | 150    |
| E4 | New testing methods for early detection of damage for structures and infrastructures, even buried, with minimal impact on traffic and supply | 5      | 15     |            | 100    |
| E5 | Develop, design, build and operate, with new or non-conventional multifunctional materials or with traditional materials of enhanced performances, with low environmental impact, high durability, reduced maintenance and operation costs, and increased comfort for users and citizens |        | 10     | 15         | 125    |
| E6 | Integrated life-cycle assessment systems combining cost-efficient and easy-to-maintain sensors, monitoring and performance prediction systems, and covering all stages of construction control, asset management, and optimization of maintenance | 15     | 10     | 10         | 175    |
| E7 | ICT and ITS systems to optimize traffic, serviceability and security of networks integrating traffic and transport monitoring and management, information to users, tolling, incident and crisis management | 5      | 5      | 5          | 75     |

*Sustainable Management of Transports and Utilities Networks*  
\[ T_{FP7} = 175 \]  
1050

|   | Description                                                                 | Rating | Impact | Total cost | Impact  
|---|------------------------------------------------------------------------------|--------|--------|------------|--------
<p>| F1 | Building assessment, diagnosis and monitoring                                | 5      | 15     |            | 40     |
| F2 | Assessment of material decay and development of Cultural Heritage compatible materials | 10     | 10     |            | 40     |
| F3 | Low intrusive retrofit and conservation techniques                           | 8      | 12     | 15         | 50     |
| F4 | Integration in urban and natural environment                                | 5      | 5      |            | 20     |</p>
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Costs (M€)</th>
</tr>
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<tbody>
<tr>
<td>F5</td>
<td>Rational and long term management processes</td>
<td>5 5 5 10 40 65</td>
</tr>
<tr>
<td>F6</td>
<td>New tools for European citizens interaction</td>
<td>10 5 30 45</td>
</tr>
<tr>
<td>F7</td>
<td>Knowledge transfer and demonstration of the best-practice cases</td>
<td>2 3 2 3 20 30</td>
</tr>
<tr>
<td>F8</td>
<td>Demonstration of knowledge gained from FP7 and other research projects in selected typical CH sites across the EU</td>
<td>45 45 60 150</td>
</tr>
</tbody>
</table>

**A Living Cultural Heritage for an Attractive Europe**

\[ T_{FP7} = 225 \] 525

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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<tbody>
<tr>
<td>G1</td>
<td>Harmonised Design Rules</td>
<td>10 10 100 120</td>
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<tr>
<td>G2</td>
<td>Risk and Safety Management Systems</td>
<td>5 5 5 75 90</td>
</tr>
<tr>
<td>G3</td>
<td>Systems for the management of risk and emergencies and partial functionality of the networked system</td>
<td>5 5 5 75 90</td>
</tr>
<tr>
<td>G4</td>
<td>Reliable and long-life systems to monitor and control all security/safety parameters of infrastructures</td>
<td>5 25 30</td>
</tr>
<tr>
<td>G5</td>
<td>Mitigation of natural and technical risks</td>
<td>10 10 10 150 180</td>
</tr>
<tr>
<td>G6</td>
<td>Safety on construction work places</td>
<td>20 100 120</td>
</tr>
</tbody>
</table>

**Improve Safety and Security within the Construction Sector**

\[ T_{FP7} = 105 \] 630

<table>
<thead>
<tr>
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<tr>
<td>H1</td>
<td>Value-driven business processes</td>
<td>1 1 1 1 1 1 1 63 70</td>
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<tr>
<td>H2</td>
<td>Industrialised production</td>
<td>7 14 189 210</td>
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<td>H3</td>
<td>Digital models</td>
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<tr>
<td>H4</td>
<td>Intelligent constructions</td>
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<td>H5</td>
<td>Interoperability</td>
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<tr>
<td>H6</td>
<td>Collaboration support</td>
<td>4 24 252 280</td>
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<tr>
<td>H7</td>
<td>Knowledge sharing</td>
<td>1 2 1 14 1 1 89 210</td>
</tr>
<tr>
<td>H8</td>
<td>ICT enabled business models</td>
<td>7 63 70 210</td>
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</table>

**New Integrated Processes for the Construction Sector**

\[ T_{FP7} = 210 \] 2100

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Costs (M€)</th>
</tr>
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<tbody>
<tr>
<td>I1</td>
<td>Multifunctional construction materials</td>
<td>10 35 30 300 375</td>
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<tr>
<td>I2</td>
<td>Predictable, flexible and efficient building material production</td>
<td>15 20 20 245 300</td>
</tr>
<tr>
<td>I3</td>
<td>Improve durability and reliability of construction materials</td>
<td>15 20 25 240 300</td>
</tr>
<tr>
<td>I4</td>
<td>Improve usability and applicability of materials</td>
<td>5 10 15 270 300</td>
</tr>
<tr>
<td>I5</td>
<td>Prediction and management of building material behavior in service</td>
<td>5 15 20 185 225</td>
</tr>
</tbody>
</table>

**High Added Value Construction Materials**

\[ T_{FP7} = 260 \] 1500

All figures are in M€ and correspond to total costs of projects. Internal industrial private projects are not included.