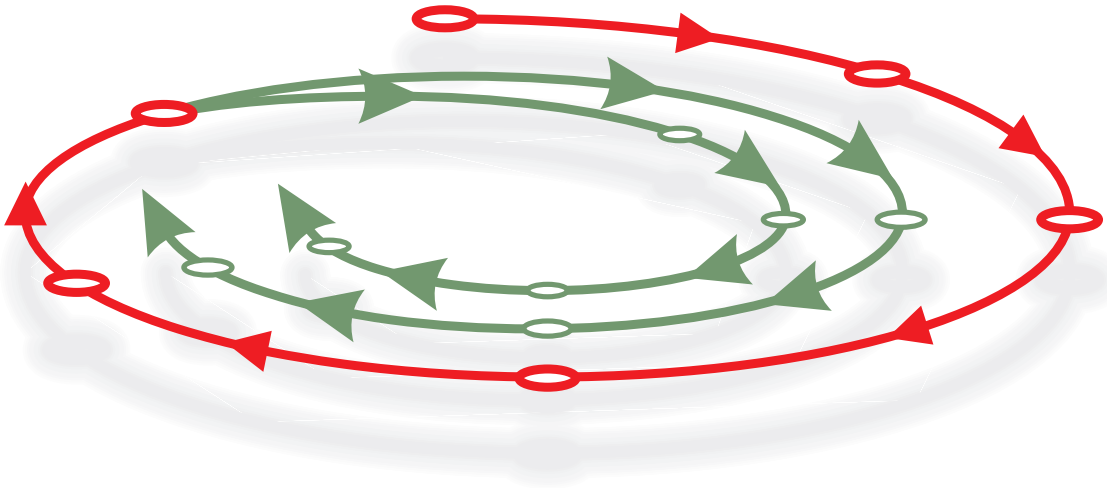
Construction Can!



ENCORD's Programme for RTD&ID

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1 Preface

In 1994 ENCORD - The European Network of Construction Companies for Research and Development - published a report entitled “RTD in the Construction Industry, A Challenge for Europe”. This report defined a great number of RTD projects that have been later successfully executed.

Nevertheless, in our view we still face a challenge and we have produced this new report entitled “Construction Can!” to address it. The construction industry can really meet the challenge!

Other documents have been published in the meantime. These include “FutureConstruct - RTD Strategies for European Construction” published in 1997 (ISBN 951-97676-0-6) and to which members of ENCORD also contributed. However, we still think it is of great value to review ENCORD’s activities, and in particular to present ENCORD’s Programme for Research and Technological Development & Innovation and Demonstration (RTD&ID). Innovation and demonstration are essential for the successful exploitation of RTD results in the market-place for real business.

This report is based on the experience of ENCORD’s member companies that has been gained in 210 European RTD projects and - above all - on the knowledge of the construction process and its consequences that is available in our operating companies.

I am sure that this report will again contribute towards improvement in our industry and I would like to thank all our members and our Secretary-General for their contribution.

Jan MAAT
President of ENCORD

2 Executive Summary

ENCORD - The European Network of Construction Companies for Research and Development is a permanent grouping established in 1989 by several leading European construction companies. *ENCORD's strategic objective is to increase awareness of the potential of industry-led research and development in the construction field to enable European companies to enhance their competitiveness.*

The construction industries are the largest industrial cluster in the European Union (EU), representing 11% of total gross domestic product (GDP), or a quarter of total industrial output. Their 2.7 million enterprises directly and indirectly employ almost 30 million people. There are several successful big European design, manufacturing and construction companies that are world leaders, yet 97% of European construction companies are small and medium-size enterprises (SMEs) with fewer than 20 employees.

A change towards lower costs, sustainability and comfort & quality for citizens can only be achieved through collaborative research and technological development & innovation and demonstration (RTD&ID) at European levels.

For *competitive growth*, procurement and construction processes and technologies must be developed. As construction affects the overheads of other industrial and commercial activities, their international competitiveness can be improved with better construction productivity and efficiency. Networking, partnering, lean management and the increasing use of information and industrialised technologies make lower costs possible.

More efficient and *customer-friendly processes* must be developed to satisfy demanding, individual and changing customer needs and user requirements.

Urban people live in the built environment and spend 90% of their lives indoors. Thus the quality of the living and working *indoor environment* is especially important; for health, comfort, productivity, safety and security. In twenty years, a quarter of the

ageing population will be more than 60 years old. Their special requirements for comfortable and autonomous living must be properly observed.

Sustainability is a matter of satisfying the needs of present generations without compromising the ability of future generations to fulfil their own needs. Sustainable development means sustainability not only ecologically and economically but also socially and culturally. New environmentally friendly technologies must be developed to reduce the environmental impact of buildings and of construction and renovation work. Life-cycle costing (LCC) and environmental life-cycle analysis (LCA) will be essential considerations.

Buildings consume 40% of total *energy* and account for 30% of CO_2 emissions. Major savings are obtainable with energy-oriented design for construction and renovation together with new building services technologies and combined heat and power generation.

Building *products should be reusable and materials recyclable***.** The use of materials and other resources must be minimised and the utilisation of renewable raw materials encouraged. Durability and long service life are environmental priorities.

In accordance with various studies and experiments, ENCORD believes that the following ambitious targets are achievable: *30% more construction at the same cost* and *50% reduction in delivery time*. Assuming a 10% saving in costs, construction volume within the EU could be increased by ECU 70 billion annually.

In order to achieve these targets, sufficient efforts must be made through an integrated RTD&ID programme or project cluster and construction-focused calls. Even RTD&ID alone is not enough; European policies and regulations also need to be changed.

In order to advance these efforts,

ENCORD will

- **promote long-term fundamental research jointly with universities and research institutes**
- **promote medium-term incremental and radical RTD projects jointly with other stakeholders, universities, research centres and companies in the construction cluster**
- **promote short-term incremental RTD&ID intra- and extra-net projects**

- **run technology watch, benchmarking, best practice, demonstration and dissemination intra-net projects, workshops and seminars**

At the end of this book is a list of topics and changes in the European regulatory environment that are deemed necessary for positive change. They concern, in particular, overcoming organisational, institutional, legal and behavioural barriers to the successful application of RTD&ID results, particularly procurement and contracting rules and construction processes and systems.

In order to demonstrate and disseminate the existing and emerging new techniques, ENCORD will establish the following special knowledge enhancement activities:

ENCORD Prize for Innovation

A European competition for innovative construction (a building or structure with innovative characteristics or properties; also, it could be a construction method, some new technological innovation, or even an idea for development). The competition will be held every second year and the prize will be published for the first time in the year 2000. A "People's Panel" will judge the candidates to find a winner that positively reflects the expectations of ordinary people.

ENCORD Summer School

A summer course to instruct students on best practice and on new and emerging construction technologies. The course is to be held in technical universities, departments of architecture, civil engineering, building physics etc, in one country at a time. A trial will be run in 1999 with the first actual course starting in the year 2000.

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4 Vision 2010

Some of the changes expected in the European construction sector in ten years' time are listed below:

Individual Customers

- Individual requirements of demanding customers and end-users will increase; high quality, individuality, lower prices, easy to buy, easy and economical to use, delivery now
- Rising requirements for fittings and finishing and increasingly adapted technical building services.
- Rising requirements for the indoor environment as well as for outdoor infrastructure and services.
- Quality/price ratio will be more favourable.

Changing Society

- Requirements for sustainability and environmentally friendly technologies by market forces will increase and be made mandatory by the authorities.
- Requirements for total quality will increase.
- The European construction market will be further opened to cross-border competition; also competition from outside the EU will increase.
- The market volume will remain stable; yet big changes in different countries and a major improvement in the transition economies of Europe.
- Rapidly developing information and communication technologies make nearworking (teleworking) increasingly popular. This will cut down on daily commuting and decrease the need for office buildings but

increase the need for home building and possibly for near/satellite office facilities. Similarly, electronic trade will limit the need for shops and other commercial buildings.

- The rapidly increasing number of elderly and disabled people will need special attention for their autonomous living.
- The renovation and modernisation of the existing buildings and infrastructure and the preservation of the European cultural heritage is a major challenge.
- *The city of tomorrow will be different from the city of today!*

Advancing Industries

- Competitiveness in relation to other industries will be better.
- The European Union will be the home market for large and specialised top-end enterprises, the rest of Europe a neighbour and the rest of the world a frequently visited and familiar place for business.
- Increased competition in the common market will lead to competitiveness in the global market.
- Productivity will rise.
- New construction processes will be used.
- Cooperative networking between big companies and SMEs as well as the integration of different disciplines will be in use.
- New procurement and contracting processes will be used.
- High-performance materials, products and systems will emerge.

5 Great Potential

In accordance with various studies and experiments, ENCORD believes that the following ambitious targets are achievable. Other industries have been able to do it, why not the construction industries?

- **30% more construction at the same cost**
- **50% reduction in delivery time**
- **50% reduction in maintenance costs**
- **50% reduction in energy consumption**
- **50% reduction in waste & pollution**
- **50% reduction in accidents**

In order to achieve these targets, efforts must be made. *Only an integrated RTD&ID programme or project cluster and construction-focused calls can gain enough synergy, weight and visibility for the successful adoption and exploitation of the results in the market-place.* Even RTD&ID alone is not enough; European policies and regulations also need to be changed.

Assuming a 10% saving in costs, construction volume within the EU could be increased by ECU 70 billion annually.

ENCORD's Profile

Introduction

ENCORD - The European Network of Construction Companies for Research and Development is a permanent grouping established in 1989 by several leading European construction companies. ENCORD's strategic objective is to increase awareness of the potential of industry-led research and development in the construction field to enable European companies to enhance their competitiveness.

ENCORD aims to be a platform for research and technological development & innovation and demonstration (RTD&ID) and an interlocutor with the European Commission, the European Parliament and other European and national decision-makers.

Today, ENCORD has members from Germany (Philipp Holzmann, Hochtief), France (Bouygues, Saint-Gobain), The United Kingdom (BICC/Balfour Beatty, Taylor Woodrow), Spain (Dragados), Italy (Dioguardi), The Netherlands (HBG), Switzerland (ABB), Sweden (Skanska) and Finland (YIT, Addtek)*.

Their combined turnover in 1997 was ECU 100 billion, ie an amount equal to some 13% of the EU's total construction output. These companies use a significant percentage of their turnover for RTD&ID and they represent 210 partnerships in different European RTD projects.

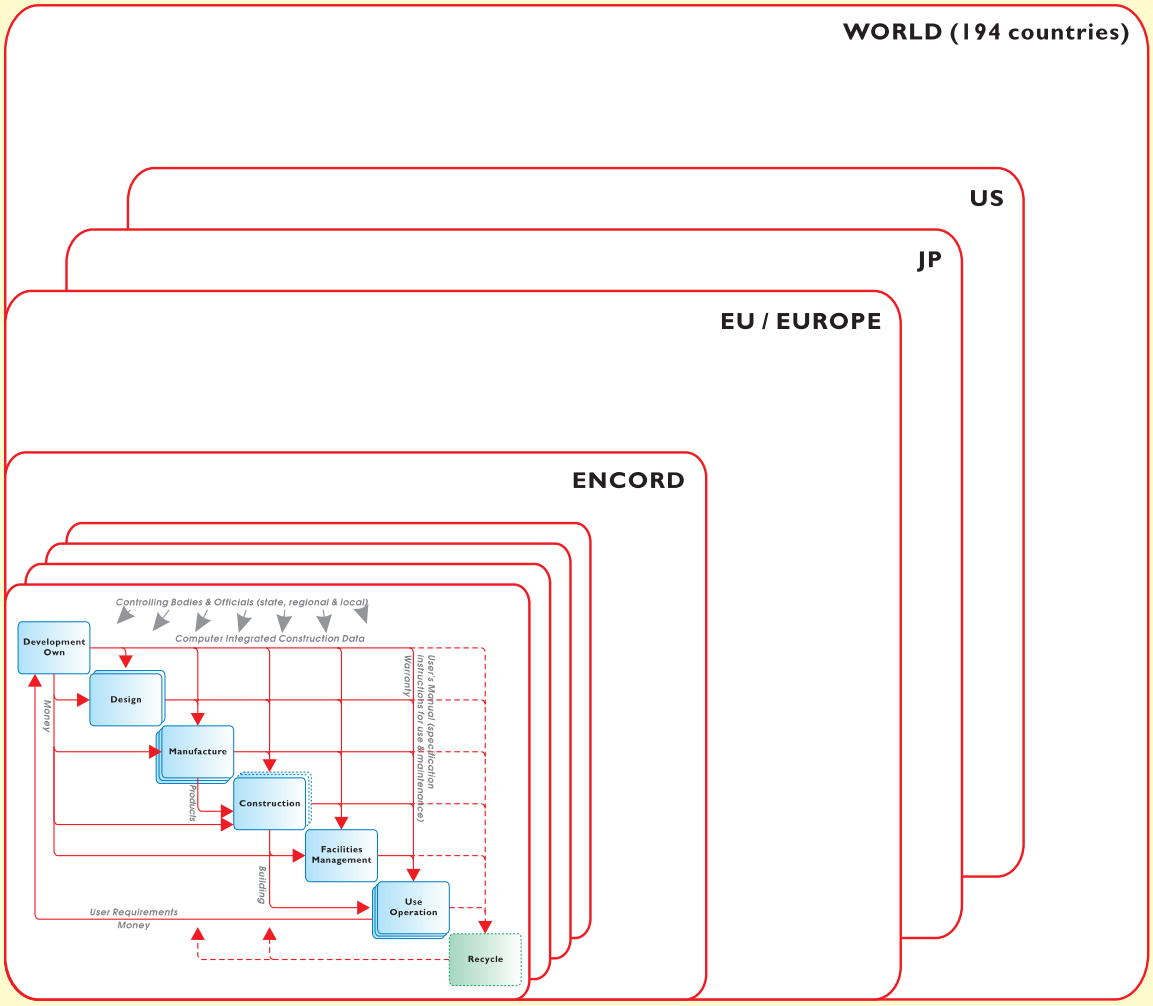
ENCORD is determined to become a well-known and respected body within the European construction cluster and an influential actor on global RTD&ID activities.

*** ENCORD's members feel at home in Europe working altogether in over 30 European countries. The whole world is familiar to them as they are present in all the important markets in over 120 countries.**

Brief descriptions of these companies are at the end of this booklet. If you want to know more about us or want to do business with us, websites and other communication data are there listed. For RTD&ID, there are one or two directors for each company ready to take your call.

ENCORD's communication data are also at the end of this booklet. You might start with our website, http://www.encord.org.

Global Environment / Market-place



What RTD&ID?

In industries, the main objectives of investing in research and technological development (RTD) is to create better products and services to satisfy customers and society and to develop more efficient production and operational methods to cut costs. Eventually this should result in successful business and higher profits in the future. Also, with a targetting RTD strategy new business can be conquered in the global market-place.

To achieve this, innovation is necessary in order to exploit the results of RTD successfully in the market-place. In most cases, also, demonstration is necessary in order to make the results widely known and accepted, also by the regulation makers. Thus we mostly talk about RTD&ID. This also demonstrates the difference between the real needs of industries and the European Union framework programmes for research and technological development (EU RTD).

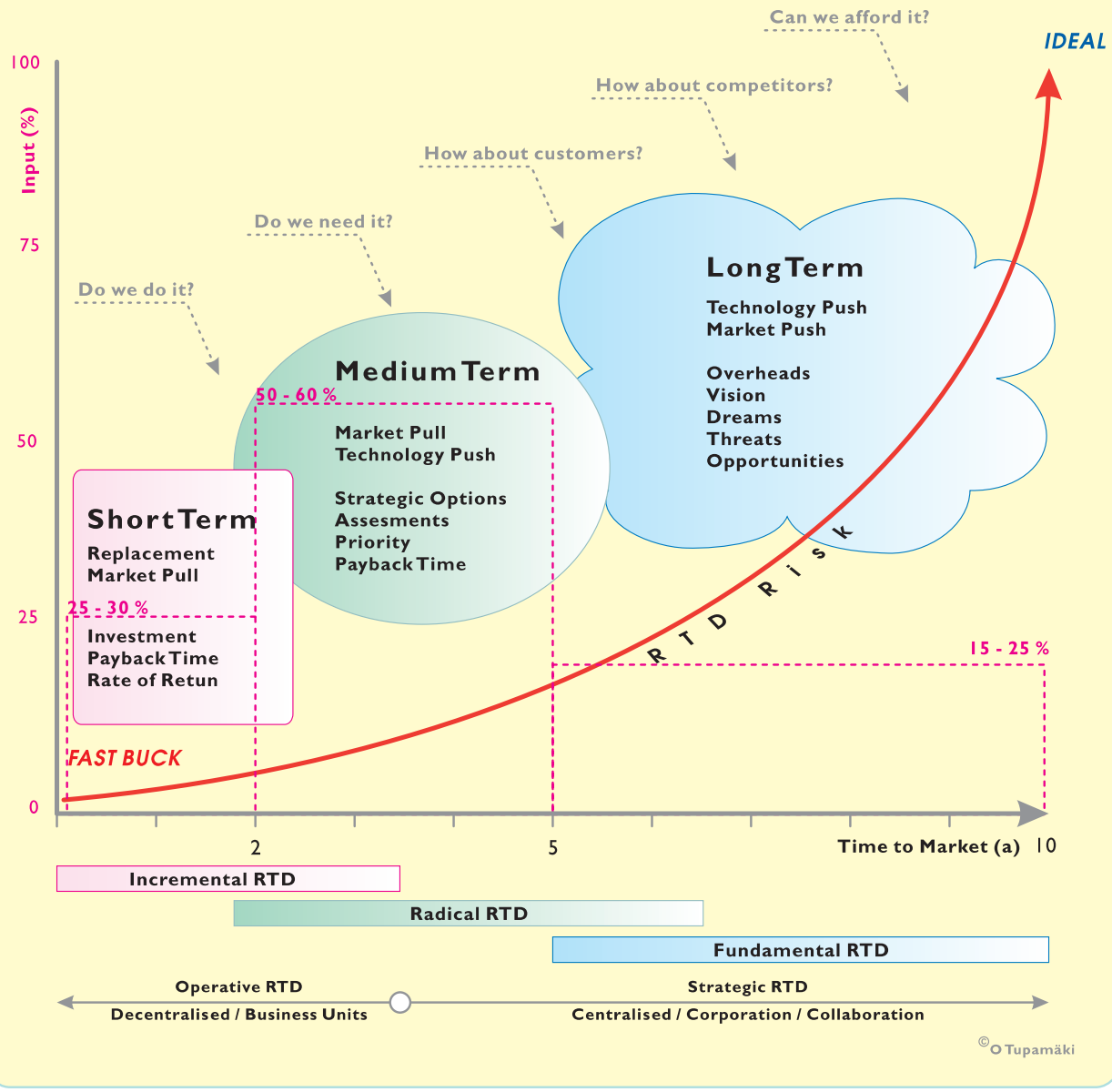
The following diagram presents the different aspects of various RTD actions. Innovation and demonstration should ideally always be an element in all successful RTD.

When applying the above features to ENCORD, we arrive at the following definitions, where within the European and global construction cluster ENCORD will

- **promote long-term fundamental research (5-10 years and more) jointly with universities and research institutes**
- **promote medium-term incremental and radical (2-5 years) RTD projects jointly with other stakeholders, universities, research centres and companies in the construction cluster**
- **promote short-term incremental (1-2 years) RTD&ID intra- and extra-net projects**
- **run technology watch, benchmarking, best practice, demonstration and dissemination intra-net (0-1 year) projects, workshops and seminars.**

Input in RTD&ID

"Most technologies will be replaced & most efforts to replace them will fail"



What to cover?

The construction cluster covers primarily property development, design & engineering, the manufacturing of different materials, products, equipment & systems, actual construction, installation & renovation works and facilities management. We could add construction machinery and equipment manufacturers, transport and suppliers. And there is also the user or consumer of the constructed building and infrastructure - which covers almost all of us. Eventually, there will still be the demolition or dismantling of the building or facility. To illustrate this, the construction value chain is shown in the following diagram.

Conventionally, general contractors are just constructors involved in the actual construction only. Usually 80% of the costs, however, have already been fixed before their involvement. And they can only compete in an open tendering process to use their construction resources, or capacity.

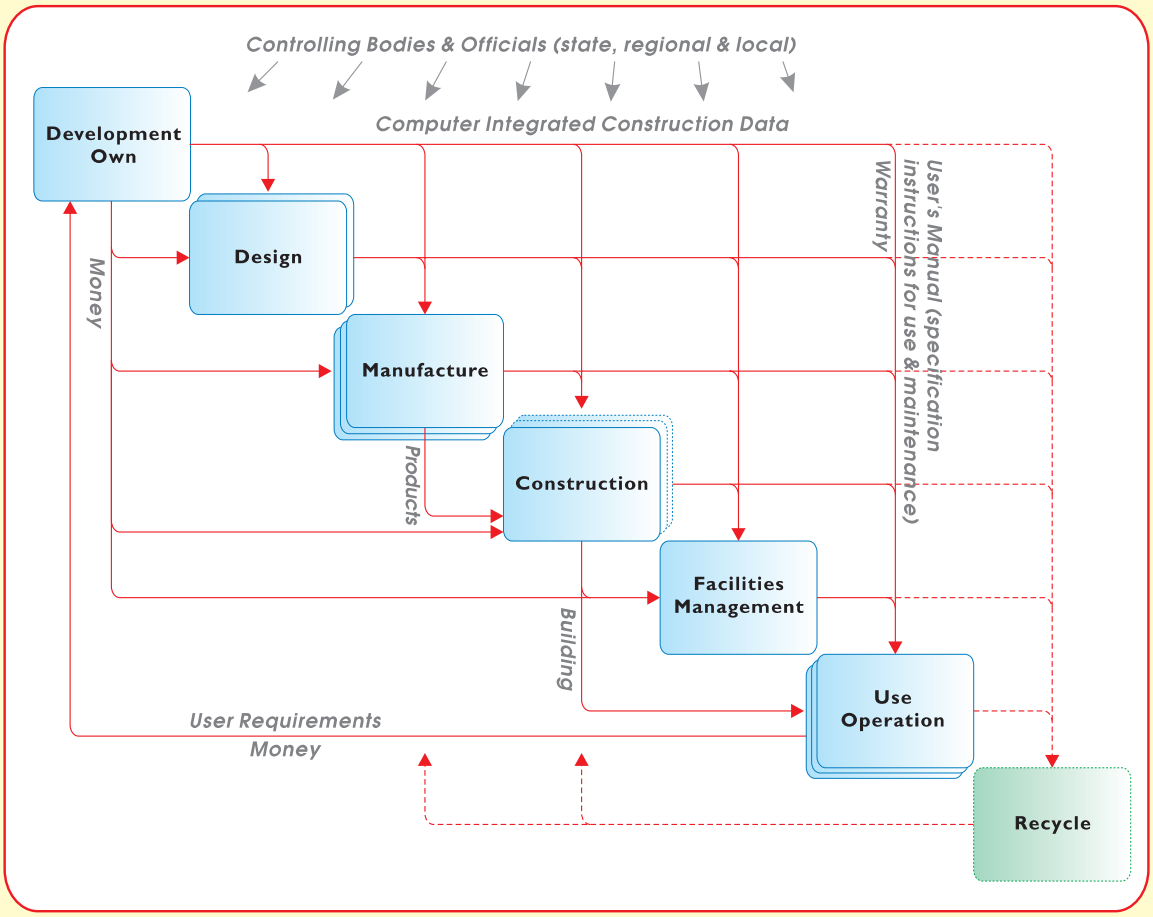
The ambition of ENCORD members is to expand their knowledge and activities towards the early construction phases as well as the post-construction phases.

The next diagram illustrates building materials' life-cycles; from raw material to product, to a building or other structure, to dismantling or demolition and then to the start of the second cycle as a reusable component or material for reprocessing. Not everything can be recycled, so the spiral converges inwards.

The construction cluster's activities cover the life spiral as a whole.

The RTD&ID needs of the construction cluster definitely cover the whole life spiral. Big contractors may be influential actors here that together with other stakeholders - particularly clients ie owners and developers, as well as users or consumers - and networking SMEs can make real progress happen.

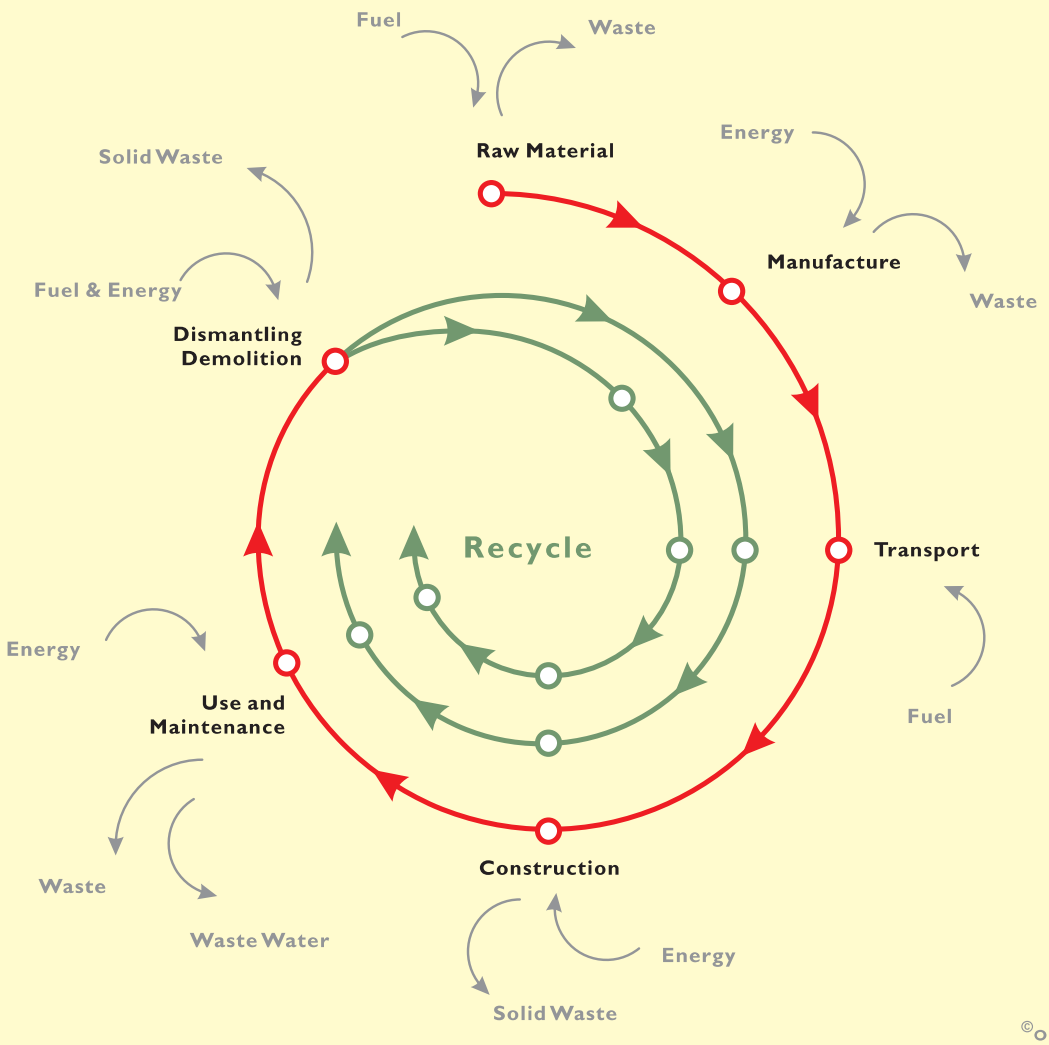
Construction Value Chain



Life Spiral

Environmental Life Cycle Analysis

No re-manufacturing needed for building components to be dismantled and re-installed -> better sustainability



What actions?

In order to achieve its strategic objective, ENCORD may carry out different actions when and where appropriate, as listed below:

- **be a forum for the exchange of information on RTD&ID**
- **share market information in general**
- **contribute to technology foresight and scenarios**
- **promote the overall image of construction; website, members as "ambassadors"**

- **promote long-term fundamental research (5-10 years and more) jointly with universities and research institutes**
- **promote medium-term incremental and radical (2-5 years) RTD projects jointly with other stakeholders, universities, research centres and companies in the construction cluster**
- **promote short-term incremental (1-2 years) RTD&ID intra- and extra-net projects**
- **run technology watch, benchmarking, best practice, demonstration and dissemination intra-net (0-1 year) projects, workshops and seminars**

- **advise European and national decision-makers about the importance and the needs of construction industries**
- **contribute towards the EU's framework programmes for research and technological development (EU RTD) and related specific and work programmes**
- **support the European Commission (EC) with evaluation and assessment of different construction-related activities**

- **support SMEs through working closely with them in RTD&ID projects, thus facilitating technology transfer**
- **promote the exploitation and application of RTD&ID results in real-life construction works**
- **support SMEs through partnering in actual construction projects**

- **participate in all priority construction-related RTD&ID activities**
- **be present in all important construction-related RTD&ID events and activities**
- **cooperate with other bodies active in construction-related RTD&ID in Europe and globally**

7 RTD&ID Programme

7.1 Strategic Objectives

According to the Maastricht Treaty, Part One, Article 2, ***"The Community shall have as its task, by establishing a common market and economic and monetary union and by implementing the common policies or activities ... to promote throughout the Community a harmonious and balanced development of economic activities, sustainable and non-inflationary growth respecting the environment, a high degree of convergence of economic performance, a high level of employment and social protection, the raising of the standard of living and quality of life, and economic and social cohesion and solidarity among Member States."***

The construction cluster, its importance, character, working methods and problems, are linked to the attainment of these aims and influence it to a very great extent. Building a common market in the construction cluster is one of the central objectives.

In order to make the construction market foreseen happen and to achieve some or all of the great potential improvements, the following strategic objectives for the European construction cluster are deemed important:

- **customer-friendly construction (to satisfy individual customer requirements)**
- **performance-based competition (for open competition, new innovations and lower costs)**
- **integrated design & construction (for best constructability, lower costs, shorter lead times and clear liabilities)**
- **networking and partnering (for system deliveries, lower costs and efficient continued collaboration)**
- **sustainability (for environmental requirements)**

Technological advances particularly are foreseen in the following fields:

- **Process re-engineering**
- **Information and communication technologies**
- **Automation in design, manufacture, construction and operation**
- **Technical building services**
- **High-performance materials**
- **Human factors**

Many of the technologies currently considered as new technologies are beyond the stage of basic research. This means that their present status in the chain of technology development may be at the stage of industrial development, innovation, demonstration or dissemination. In certain cases, they only require measures aimed at increasing and accelerating the number of market applications.

The problem here is the prevailing procurement system that focuses mainly on first cost, ie the initial investment only instead of life cycle costs. At the same time new techniques and systems are held back by standards and detailed specifications and also by regulatory requirements and the cultural environment.

The following divides the proposed activities into:

- **five key activities defined as per the principal construction domains**
- **generic technologies covering activities common to, or typical of, all construction or renovation works,**
- **support activities for knowledge dissemination**

7.2 Key activities

The construction industries serve a wide range of types of customers, from individual end-users with an occasional need for home repairs, to multinational owners and developers requiring major projects. Their needs differ and it is appropriate that a range of different types of procurement processes should be available to meet their needs.

Renovation is of great importance, accounting today for half of construction activity. Also do-it-yourself (DIY) needs must be catered for.

The quality of the living and working indoor environments (health, comfort, productivity, safety, security) as well as a healthy and esthetically pleasing outdoor environment largely depend on the construction industries. That is also the case with the preservation of the diversity of European design and cultural heritage.

7.2.1 Office buildings

Buildings can be considered as an overhead cost for industrial, commercial and public activities. The size of this overhead depends on first cost ie the initial construction investment. However, it depends much more on the efficiency of the operation performed in the building. This is particularly true for office buildings where highly paid employees perform their tasks. The more comfortable they feel, the more tasks they perform.

The user, the office building employee, wants a healthy, comfortable, safe, secure and productive, ergonomic and pleasing working environment. These features can be interpreted in measurable user requirements. Safety sets requirements for stability, fire safety and safety in use, and security against human or animal intrusion. Healthiness sets air purity, hygrothermal and hygiene requirements. Comfort sets additional acoustical, visual, tactile and dynamic requirements as well as requirements for roominess and the suitability of spaces for special uses. Also esthetic, cultural and sociological requirements, which may not be expressed quantitatively, are part of comfort.

An improved indoor environment with low-emission and non-toxic materials, zero-radiation structures and proper ventilation as well as low-noise equipment and systems with efficient noise insulation and noise abatement methods are necessities for improving the health, comfort and productivity of the occupants. Temperature and humidity must also be at appropriate levels, of course. Airflow as well as draught

caused by convection, mostly related to windows, should be avoided while natural lighting should be maximised.

The building, its services and the work process all contribute to the well-being and productivity of people. The physical and mental performance of occupants is affected by the entire indoor environment of the building. The WHO estimates that sick-building syndrome affects 30% of all new and renovated buildings.

The owner of an office building wants it to be easily adaptable to the changing needs of the users and, actually, for completely new use. Durability and economic considerations are also important, of course.

The following lists important topics for RTD&ID and some target characteristics.

- **50% reduction in delivery time**
- **comfort and quality for efficiency**
- **indoor environment; air, climate, environment**

- **advanced building components, such as smart glazing, ceiling and wall components with improved thermal, acoustic, lighting and visual characteristics**
- **adaptability for changes; operational, IT, physical**
- **smart offices, distributed intelligence**
- **zero-energy office buildings**

- **satellite offices for nearworking**
- **teleworking**

7.2.2 Housing

The customer, especially the end-user, the owner or tenant of the house or flat, wants a healthy, comfortable, safe and secure living environment. These features can be interpreted in measurable user requirements, as mentioned above for offices. Durability and economic considerations are also important, of course.

Housing in general is too expensive, particularly so now when social housing schemes are nearing the end in more and more communities. Investment in housing has to be made attractive and competitive against other durable or semi-durable goods and, in fact, against consumer merchandise.

The following lists important topics for RTD&ID and some target characteristics.

- **10 years warranty**
- **full care of user's requirements; adoption of individual taste and local culture**
- **documentation for specification and use & maintenance**
- **adaptability for changes; "life cycle house"**
- **improved occupancy**

- **50% reduction in delivery time**
- **30% lower unit costs**
- **simplified planning**
- **economical architecture**
- **open modular industrialised systems**
- **75% standard prefabricated components**
- **simple assembly on site**

- **indoor structures, amenities and services to enable the comfortable and autonomous living of elderly and disabled people**
- **healthy buildings with a good indoor climate dependant on its technical qualities**

- **IT in manufacture, logistics and construction**
- **smart housing; fittings, equipment, communication, broadcasting, entertainment**
- **the Internet**
- **nearworking**
- **teleworking**
- **telecare of elderly and handicapped people**

7.2.3 Infrastructure

Development of infrastructure is required to support economic growth, European integration and internationalisation. It increases the competitiveness of industrial and commercial activities and generates new opportunities for profitable investment. At the same time, the principles of sustainable development must be followed. There is also a need for investment in infrastructure to reduce the cost of transport to European markets from the peripheral regions and to reduce the increasing problems of congestion and air pollution.

The emphasis in the future will be on the completion of trans-European networks, in particular the development of a high-speed railway network. Major new road corridors are needed to link up to Central and East European centres, and the whole of Eastern Europe has huge road building needs.

The ageing infrastructure of Western Europe and decaying and obsolete facilities, especially in the former Soviet Union and Central and Eastern Europe, require massive construction investment. There is a need to develop sustainable construction, renovation and demolition technologies.

Congestion in cities, around and between cities needs to be solved. Multi-modal, interchangeable transport systems for goods and people require new solutions and structures.

The following lists important topics for RTD&ID.

- **integrated urban services networks; water, sewage, gas, electricity, telematics**
- **multi-modal transport techniques**
- **transport fuelling; gas, recharging electric vehicles**
- **light rail systems; elevated, surface, underground**
- **road paving technologies; service life, noise, recycling**
- **rain water penetrable pavements**
- **ice prevention and de-icing; health and environmental issues**
- **high-speed railways; noise, environmental issues**

- **ports and waterways; environmental issues, cultural heritage**
- **airports and airways; congestion, efficiency, safety, environmental issues, airparks with taxiways for private small planes**

- **underground construction**
- **rapid tunnelling**
- **durability of tunnels and linings; lifetime, maintenance**
- **no-dig remote monitoring and inspection; sensors, robotics and multimedia**
- **no-dig renovation and replacement; robotics**
- **more accurate design criteria for foundations**
- **control of noise, dust, harmful air pollutants**

- **smart services distribution**
- **IT and telecommunications; cables/fibre, mobile, wireless, satellite**

- **outdoor structures, amenities and services to enable the comfortable and autonomous living and movement of elderly and disabled people**
- **cultural heritage; total street, road, square, park, block**

7.2.4 Renovation

The renovation market (including maintenance, major repairs, modernisation, rehabilitation) now represents some 50% of all construction activity in Europe. Projects range from the very small to the very large with the type of work varying from basic maintenance to major reconstruction.

The growing role of renovation creates a need for developing special solutions and technologies applicable to existing buildings and structures. The planning and implementation of renovation projects cannot be started from a blank slate; compatibility requirements for materials and products must be taken into account. Special emphasis

should be given to the development of industrialised modular renovation products and respective installation techniques.

The types of structure to be renovated vary from historic monuments to concrete bridges and multi-storey buildings, some of them less than twenty years old. Much of the construction work will continue to be the renovation of existing buildings, structures and infrastructure, albeit within the context of improved functionality and quality of life. There is a need to recognise that much renovation work has excessive environmental impact; measures need to be taken to reduce this.

The need and ability to integrate new technologies into existing buildings is growing as the modernisation part of the renovation process increases in importance. Issues to be addressed include improving communications both within buildings and between buildings, and reducing life-cycle costs.

As well as reducing the environmental impact, construction processes will need to become less dependent on the use of skilled operatives and commensurate with this recognise that in the developed world there is an increasing reluctance to work on construction sites because of the conditions, ie the 3Ds syndrome, dirty, difficult and dangerous. This can be partly addressed by moving to the off-site manufacture of many components and elements and by transforming the construction site into a factory. Achieving these aims in the context of renovation projects will require particular solutions.

Materials development has to take into account the need to reduce maintenance costs and to lengthen maintenance intervals. In the same way that service intervals for cars have been extended considerably over the years, a similar requirement will be set for construction. Allied to this is a need for a better understanding of the causes of deterioration (UV degradation, pollutants, moisture etc) in the indoor climate as well as at the microclimate level around individual buildings.

Renovation of historic monuments and cultural artefacts presents its own unique set of problems requiring the development of special materials.

The re-vitalisation of derelict city centres and other threatened urban areas needs special attention.

The following lists important topics for RTD&ID.

- **rapid renovation technologies, in order to minimise the disturbance caused to the occupants**
- **safe and easy dismantling and demolition techniques**
- **techniques to reduce noise and dust from renovation work**
- **effective separation and recovery of composite products**
- **materials with increased durability to reduce maintenance requirements**
- **methods to transform the construction site into a factory**
- **methods of prefabrication of components and elements including building services, windows, cladding, partitions, ceilings etc**
- **further development of the 'open building' approach to internal and external renovation of buildings.**

- **materials for use in the repair and renovation of historic monuments and cultural artefacts**
- **methodology to assess microclimates around buildings and other structures**
- **accurate, rapid-scan surveying techniques and linking these to CAD to facilitate immediate preparation of detailed renovation drawings**
- **monitoring and assessment of ageing structures**

7.2.5 Environmental construction

In all construction works environmental sustainability will be an issue. Design, manufacture, construction, facilities management and demolition processes need to focus on decreasing waste and environmental impact. Life cycle costing (LCC) and environmental life cycle assessment (LCA) will be increasingly important factors in deciding the winning tender.

Sustainability and environmental requirements nevertheless offer the construction cluster considerable business opportunities, where RTD&ID is much needed.

The following lists important topics for RTD&ID.

- **rational use of water**
- **water / waste-water cleaning and recycling**
- **groundwater remediation and recirculation**
- **direct utilisation of rainwater**
- **sewage treatment producing energy, fertilisers and raw materials**
- **cleaning and usage of surface waters**

- **building decontamination**
- **waste cleanup**
- **waste storage and disposal**

- **land recycling**
- **demolition**
- **land reclamation; physical, chemical, biological**
- **sediment remediation**
- **mining remediation**

- **green buildings and facilities**
- **zero-energy buildings**

- **wind farms**
- **noise barriers and noise abatement**
- **flood control**
- **coastal protection**
- **seismic control**

- **increasing use of wood and other renewable materials**

7.3 Generic activities

Customer-orientation

The customer wants comfort and quality. And wants to get it easily.

The customer, especially the end-user, wants a healthy, comfortable, safe and secure living environment and a productive, ergonomic and pleasing working environment. These features can be interpreted in measurable user requirements. Safety sets requirements for stability, fire safety and safety in use and security against human or animal intrusion. Healthiness sets air purity, hygrothermal and hygiene requirements. Comfort sets additional acoustical, visual, tactile and dynamic requirements as well as requirements for roominess and the suitability of spaces for special uses. Also esthetic, cultural and sociological requirements, which may not be expressed quantitatively, are part of comfort. Durability and economic considerations are also important, of course.

Since quality is defined as conformance to agreed requirements, it is important that the parties concerned are equally aware of what precisely was agreed. This is necessary to avoid the customer's disappointment as well as unnecessary costs on the contractor's part. This does not prevent the contractor from carrying out work with a higher satisfaction factor, ie to fulfil expectations, or exceed expectations or, in deed, delight the customer.

The procurement of a building or renovation works should be much easier and less risky than is the case today. One must not forget that the buyers of a house or a flat are the numerical majority of customers. They are one-time customers, just ordinary people and families with no "system" adaptable to the processes suitable for public procurement agencies, housing corporations, commercial or industrial companies and other big developers.

By the year 2020, over a quarter of the European population will be more than 60 years old. Their special needs for comfortable and autonomous living must be properly observed. Also the special requirements of the handicapped should be catered for indoors and outdoors.

Urban people spend 90% of their lifetime indoors, in dwellings, at work in factories, offices, commercial, service and public buildings etc; most of it at home! An improved indoor environment with low-emission and non-toxic materials, zero-radiation structures and proper ventilation as well as low-noise equipment and systems with efficient noise insulation and noise abatement methods are necessities for improving the health, comfort and productivity of the occupants. Temperature and humidity must also be at appropriate levels, of course. Airflow as well as draught caused by convection, mostly related to windows, should be avoided while natural lighting should be maximised.

Up to 40% of the population are allergic, and allergic illnesses have been increasing rapidly. Usually the cause is believed to be polluted outdoor air, but more and more often there is a causal link to indoor air pollutants.

The proper selection of building materials, products, and interior decoration is extremely important because they are the major building-related sources of pollutants. Selecting building materials on the basis of their emissions when new is not the only criterion which guarantees a healthy building. Some materials are susceptible to chemical degradation reactions caused by humidity. Moisture causes hydrolytic degradation of materials, which gives rise to emissions.

There is no longer any doubt that airborne fungi are indeed more frequent in damp and mouldy buildings. Serious illnesses can be traced to microbe-contaminated buildings, and typical sick-building symptoms are more common in buildings with water damage. Water damage to building materials generally results in microbial growth.

Proper visualisation and documentation using information technology to specify a building or other structure, together with instructions for use, maintenance, repairs, reuse and demolition, should be made available to owners, facilities managers, end-users and consumers.

Finally, it is important to realise that there is demand for different products in construction also. Thus some companies may specialise in building up to quality and class, and some others down to price.

Management & Organisation

For improved competitiveness and productivity all the best methods of management should be used. Benchmarking the best practices and a technology watch on other, more advanced industries gives good pointers.

The following lists important topics for RTD&ID and improvement.

- **flexible customer-driven management**
- **make on demand**
- **lean management**
- **innovation in products, services and processes**
- **alliances - collaborative business efforts**
- **stakeholder symbiosis - customers, employees, shareholders, suppliers, society**

- **team working**
- **multi-disciplinary teams**
- **multi-skilled manpower**
- **preservation of traditional skills**

- **networking and partnering**
- **TQM - total quality management**
- **first time right / zero defects**
- **JIT - just in time, logistics and supply chain**
- **speed**
- **the Internet**
- **distributed systems**
- **(global) virtual enterprises**
- **holonic networks (distributed autonomous systems)**
- **ISO 9000**

Procurement and Contracting

Besides the conventional design-bid-build route, there are alternative new construction delivery methods. These include Construction Management at risk (CM-at-risk), which was established as a means of more efficiently managed design and construction process; Design & Build (D&B), which establishes one entity to provide both design and construction, mostly simultaneously; D&B with extended performance specification, often incorporated with partnering and bridging; and D&B expanded with other players on the design-build team such as financiers, land owners, facility managers, which may add up to the Build, (Own), Operate & Transfer method (B(O)OT). Typical to D&B is a clear liability, a shorter delivery time and lower costs as the best solution for buildability can be freely utilised.

Another emerging technique is the System Delivery method (SD) enabling specialised SMEs to take part directly in the construction process. System Delivery refers to the delivery of an independent functional entity (assembly) of the building with possible variations between systems and hierarchical levels. Here a single organisation, more often an SME, is liable for the design, manufacture or procurement, logistics and assembly of this modular entity, including most of the site equipment and auxiliary construction work needed. The functionality and individuality required by the customer is achieved through varying combinations and accessories of standard components that are part of the system. This provides greater opportunities to apply innovation and systematic learning. This method may also be utilised in intra-deliveries within a large company. However, the benefits have not yet been fully realised and the process necessitates its own culture change.

Construction Process and Systems

Current working conditions on sites do not appeal to workers. This syndrome is characterised by three attributes called the 3Ds; Dirty, Difficult and Dangerous. These are synonymous with the famous Japanese 3Ks; Kitanai, Kitsui and Kiken.

The kind of construction process we have at present is one in which design is separated from production and there is no competitive bidding for the end product or its attributes, performances, quality and price but only for the selling price of productive capacity. Such a process cannot lead to industrial operating methods, is not

based on a market with demanding customers and does not provide motivation or rewards for RTD. This leaves the construction cluster far short of the share of public RTD funds that the size of the cluster merits.

The construction sector should be propelled from its current low-tech/low-productivity image into a technology-focused contributor to Europe's future prosperity. Currently construction is almost always a local activity by nature and there are few or no chances for SMEs to compete internationally and consequently develop their processes, products and systems. If we are unable to supply higher-quality buildings and infrastructure more efficiently and economically, demand in the market mechanisms will increasingly turn to consumer goods. Also, efficiency and effectiveness in construction affect the overheads of all other areas of industrial and commercial activity.

Recruitment is an important aspect in the construction industries, as well as the retention of skills through education and training. Improved training systems contribute to enhancing quality. Training for site skills is very important, especially developing teamwork on site. Accident statistics also show that construction is the most hazardous of all major industries, accountable for some 50% of all serious accidents at work. The construction industries must attract and retain competent people.

Buildings need to be conceived and built to respond easily to the requirements of their owners and users in terms of flexibility and adaptability to subsequent changing needs. This means that flexible and changeable components should be widely used. As different physical parts and sub-systems of a building have different service lives, they should be easily separable. The 'open building' concept, where the distinction between the frame, shell and infill of a building is applied, might be an example to satisfy demanding and changing customer requirements.

There will be a trend towards the industrialisation of building processes, which will usually mean less site construction and more off-site manufacturing under more controlled circumstances. The opportunity to move a significant proportion of construction off-site and into a factory combines the potential for lower cost, improved quality and increased production rates, reduced waste and rework and increased safety with a single change. Following off-site manufacture, which may take place in parallel, the work on site could consist almost exclusively of assembly.

Automation, robotics and information technologies, ie computer-integrated manufacturing (CIM) can be best utilised in a controlled factory environment. Yet there is also a gradual introduction of automation and robotics on building sites, mostly for repetitive and/or dangerous work. Industrialisation in general can also be introduced to all site work, and information and communication technologies put to good use. Here the Internet again can be exploited.

Site conditions must be improved in order to be ecologically competitive. Noise, dust and vibration on construction sites must be reduced. Improved methods of silencing construction machinery and equipment should be developed, as well as methods of driving piles and similar operations that minimise vibration. Also the environmental impact of transportation to the site must be minimised. This could be done by creating a model for predicting the environmental impact of different methods of transportation together with giving consideration to alternative sources of supply which might be closer to the site.

IT in Production / Construction

IT, of course, is going to be applied to all activities in processes, operations, companies and society as a whole. The following lists some important topics for RTD&ID and improvement.

- **networks and communication**
- **planning and design**
- **tendering**
- **logistics**
- **mobile communication on site**
- **computer integrated construction**
- **automation; total and intelligent units, equipment**
- **ERM - enterprise resources management for total operations**

- **the Internet**
- **intranet**
- **extranet**

- multimedia
- expert systems
- simulation, eg for the constructability of design
- virtual reality, eg for the performance of a building
- GPS - global positioning system, GIS - geographical information system

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- IFC - industry foundation classes, object-oriented standards, by the Industry Alliance for Interoperability; STEP
- LonWorks - local operating network with LonTalk protocol for interoperable and interchangeable technical building services

IT in Products

Advanced, miniaturised IT will be an essential part of more and more products in everyday life. The same development will occur in construction. The following lists some important topics for RTD&ID and improvement.

- construction automation
- technical building services
- security
- interoperability
- interchangeability
- distributed intelligence

- object-oriented product and process data, IFC
- LonWorks compatible products; controllers, sensors, detectors, actuators, transmitters, transponders
- intelligent materials and products
- modularity
- miniaturisation
- multifunctionality

Materials

Building products should be reusable and materials recyclable. The aim is more for better properties in existing materials than for completely new materials. Reusability and easy changeability are necessary product properties, in particular for modular products and systems with different service lives.

Future construction materials can be characterised by the following features and properties; to achieve them and to get them into use needs a lot of RTD&ID:

- **recyclability**
- **resources-saving manufacture**
- **increasing use of renewable rawmaterials**

- **enhanced strength, toughness and ductility**
- **enhanced durability and service life**
- **increased resistance to abrasion, corrosion, chemicals and fatigue**
- **zero emission**
- **non-toxic and zero radiation**
- **moisture-safe**
- **improved response in natural disasters and fire**

- **initial and life-cycle cost efficiency**
- **initial and life-cycle energy and CO_2 efficiency**

- **ease of application or installation**
- **ease of use and maintenance**
- **ease of replacement, modularity in products**
- **compatibility with other materials / products**
- **pleasing esthetics**

- **tailor-made materials**
- **ability for self-diagnosis, self-healing and structural control**

Durability and long service life are environmental priorities. It is important to keep in mind that this does not apply only to materials but also to components made of the

materials, assemblies put together from the components, as well as to complete structures.

Design and engineering

Design (architectural and structural, services engineering design etc) technology and practices will have to deal with ever-greater complexity and the compression of time and space that characterises the ways we work and live. Designers must be helped to spend less time on data collection, computation and preparation of design documentation, and more time on problem-solving.

Design must be for buildings and communities with better 4Es, ie ecological, esthetic, efficient and economical features.

The following lists some topics for RTD&ID and improvement

- **integration with the construction value chain**
- **team work from the beginning**
- **ever-increasing utilisation of IT**
- **LCC**
- **LCA**

- **town planning for energy efficiency**
- **zero-energy zones**
- **design for adaptability and maintenance**
- **design for reuse**
- **green design**
- **cultural heritage**

It appears that a 20% improvement in sustainability can be achieved with a modest design input and no increase in capital construction investment. A 50% improvement already requires a considerably higher design input and increase in capital cost as well. To achieve a still higher improvement in sustainability definitely demands development of new technologies.

Design for durability is superior to design for recycling, and recycling is superior to waste.

Facilities Management

Facilities management is an expanding service activity in the construction value chain. The contents can vary from minimal maintenance to full operation; the owner owns - the user carries out normal business operations - and the facilities manager takes care of the rest as agreed.

The following lists some topics for RTD&ID.

- **IT**
- **telecontrol**
- **technical building services**

- **changing requirements**
- **changing users**
- **LCC**
- **LCA**

Sustainability, Energy and Environment

"Sustainable development is a matter of satisfying the needs of present generations without compromising the ability of future generations to fulfil their own needs" [Brundtland report, "Our Common Future", 1987]. Sustainable development means sustainability not only ecologically and economically but also socially and culturally.

New environmentally friendly technologies must be developed to reduce the environmental impact of buildings and of construction and renovation work. Life-cycle costing (LCC) and environmental life-cycle analysis (LCA) will be essential considerations.

In the Kyoto Conference in December 1997, the EU promised to cut greenhouse gases by 8 % by 2008-2012; carbon dioxide, methane and nitrous oxides as measured against the base year 1990 (!) and hydrofluorocarbons, perfluorocarbons and sulphur hexa-fluoride against either a 1990 or 1995 base line. In accordance with the Council's

resolution in June 1998, the 8% total cut would be distributed to the member states as follows:

Austria	-13.0%
Belgium	-7.5%
Denmark	-21.0%
Finland	0.0%
France	0.0%
Germany	-21.0%
Greece	+25.0%
Ireland	+13.0%
Italy	-6.5%
Luxembourg	-28.0%
The Netherlands	-6.0%
Portugal	+27.0%
Spain	+15.0%
Sweden	+4.0%
The United Kingdom	-12.5%

Buildings consume about 40% of total energy (10% for construction and 30% for use) and account for 30% of CO_2 emissions. Major savings are obtainable with energy-oriented design for construction and renovation together with new building services technologies and combined heat and power generation.

The following lists important topics for RTD&ID and some target characteristics.

- **energy-oriented design**
- **energy-efficient structures and building services**
- **maximal use of daylighting**
- **gravitation-based ventilation**
- **utilisation of passive and active solar energy, wind energy and the thermal capacity of the ground**

- **low-consumption fittings and appliances**
- **intelligent appliances; heating, cooling, lighting, domestic**

- **rational use of water**
- **water recirculation**
- **energy recovery and reuse**
- **energy storage**
- **new building services technologies**

- **district heating and cooling**
- **low temperature systems**
- **combined heat and power generation**
- **distributed cogeneration; local mini/micro cogeneration, photovoltaic structures etc**
- **new energy technologies; gas condensing boilers, fuel cells, new technologies for the non-polluting utilisation of renewable biological raw materials**

- **resources-saving manufacture and construction; materials, energy**
- **clean manufacture, zero emission manufacture**
- **zero waste construction site**
- **industrial by-products in manufacture**
- **industrial by-products in construction**
- **replacement of environmentally sensitive materials**
- **recycle; dismantle-reinstall, demolish-reprocess**

- **LCC**
- **LCA**
- **energy audits**
- **EMS / ISO 14000**

In construction, environmental LCA is for assessing the total environmental impact associated with a product's manufacture, use and disposal and with all actions in relation to the construction and use of a building or another constructed facility. When considering sustainable construction, the following definition has been proposed: *"The creation and responsible maintenance of a healthy built environment, based on ecological*

principles, and by means of an efficient use of resources" [Kibert; First International Conference on Sustainable Construction, 1994] or "*The creation and responsible management of a healthy built environment based on resource-efficient and ecological principles*" as modified by CIB W82 in 1998.

LCC offers a practical way of at least comparing different alternatives against each other. A comprehensive simplified formula would be as follows:
LCC = First cost (capital investment) + NPV [(use & maintenance) + (operating costs) + (major repairs + modernisation + rehabilitation) + (salvage value) + (environmental LCA factors) + (occupational LCA factors) + (locational LCA factors)].

Here NPV = net present value of the accumulated future costs over a certain period of time (eg 40 years) at an agreed discount rate (eg 6% pa, dependant on prevailing interest and inflation rates).

Environmental factors refer to different environmental impacts that various materials and actions have; environmental profiles. Occupational factors refer to health, comfort, productivity, safety and security. Environmental and occupational factors are, however, hard to come by and need a lot of RTD at European and international levels to define their features and properties and to give them generally accepted values.

Locational factors refer to the location of a (industrial, commercial, office, school etc) building. We should calculate LCC not for the building alone but also its location in relation to incoming material and outgoing product flows as well as to employees' commuting or school children's daily transport.

In principle, the above formula gives you a figure in money, which is a real thing and easy to understand and compare against other alternatives. The following table gives an idea about the nature of the LCC calculations.

Net Present Value (NPV) of accumulated constant 100ECU annual costs over a 40 year period and of the cost in the 40th year, at different discount rates (rounded figures)

Discount Rate	NPV (40a total)	NPV (40th a)
9% "business economy"	30% = 1,100ECU	3% = 3ECU
6% "state economy"	40% = 1,500ECU	10% = 10ECU
3% "national economy"	60% = 2,300ECU	30% = 30ECU
0% "natural economy"	100% = 4,000ECU	100% = 100ECU

The rate of return available through LCC considerations today is lower than that offered by alternative long-term investment. It can be claimed, however, that future costs will increase due to higher energy prices and new environmental and other regulatory requirements. This development will increase the rate of return and enables market-driven LCC considerations.

Finally, social and cultural factors need to be taken into account.

7.4 Support activities

In order to demonstrate and disseminate the existing and emerging new techniques, ENCORD will establish the following special knowledge enhancement activities:

ENCORD Prize for Innovation

A European competition for innovative construction (a building or structure with innovative characteristics or properties; also, it could be a construction method, some new technological innovation, or even an idea for development). The competition will be held every second year and the prize will be published for the first time in the year 2000.

A "People's Panel" will judge the candidates to find a winner that positively reflects the expectations of ordinary people.

ENCORD Summer School

A summer course to instruct students on best practice and on new and emerging construction technologies. The course will be held in technical universities, departments of architecture, civil engineering, building physics etc, in one country at a time. A trial will be held in 1999 with the first actual course starting in the year 2000.

8 Needs for regulatory changes

The following list shows topics and changes in the European regulatory environment that are deemed necessary to make the aforesaid positive developments possible. They concern, in particular, overcoming organisational, institutional, legal and behavioural barriers to the successful application of RTD&ID results, particularly in procurement and contracting rules and construction processes and systems.

- **clear warranty and liability rules with related insurance policies**
- **qualification and registration of enterprises, professionals and craftsmen**
- **requirement for documentation on specifications and use & maintenance**
- **full use of CE marking with conformity to essential requirement**

- **best practice procurement procedures**
- **competition on quality, LCA and LCC**
- **competition based on design & build, and other "new" processes**
- **performance requirements / specification instead of prescriptive ones**
- **performance-based competition**
- **encouraging public-private partnership**
- **encouraging partnering and alliances, including SMEs**
- **opening up the in-house design in the public / para-public sector**

- **performance standards instead of prescriptive norms**
- **abolishing national restrictive standards and codes of practice**

- **public / para-public sector as educated, ideal clients**
- **warranty and liability rules with related insurance policies for innovative, non-established new technologies**
- **ensuring industrial and intellectual property rights**

1 Characteristics

- The construction industries are the largest industrial cluster in the EU
- It represents 11% of GDP, ie a quarter of total industrial output
- It generates 58% of annual fixed capital formation
- Its 2.7 million enterprises employ directly or indirectly almost 30 million people
- 97% of the companies are SMEs with fewer than 20 employees
- Less than 1% of the turnover (value-added, too) is used for RTD, and even less than 0.1% in some sub-sectors, whereas 2-3% of GDP is generally used
- New construction represents 2% of the existing building stock
- Maintenance costs are 50-100% of first cost, operating costs still much higher
- Buildings consume 42% of total energy and account for 30% of CO_2 emissions; CO_2 emissions represent some 60% of all greenhouse gases
- In line with the Kyoto Conference of December 1997, the EU aims to cut greenhouse gases by 8 % by 2008-2012

2 ENCORD Members

ENCORD´s members are present in over 30 European countries and in over 120 countries world-wide.

Germany

Hochtief AG, vorm. Gebr. Helfmann

Hochtief is one of Europe's leading players in the construction industry. Increasingly, the marketplace is calling for total, turnkey solutions. So the emphasis of Hochtief has shifted correspondingly from a brick-on-brick approach to providing complex systems solutions. And as one of Europe's leading civil engineering companies, Hochtief is expanding continuously into the broader fields of construction-related services. The related range of services comprise design, finance, build and operate for every type of project. As a result, Hochtief is fast establishing a distinctive position for itself as a system leader in national and international marketplaces. More than 40,000 employees world-wide provide the foundations for this all-embracing strategy.

Turnover 1997 = 6,500 MECU

Active world-wide

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Germany

Philipp Holzmann AG

Philipp Holzmann was founded in 1849 and is now the largest German construction company. Holzmann's activities are divided in four inter-related business branches:

1. General Construction, 2. Construction of Transportation Systems and Extraction of Construction Materials, 3. Energy and Environment Technology and 4. Services. The core business is general construction including public, residential and commercial buildings, civil engineering, bridges and prefabricated structures.

Turnover 1997 = 7,000 MECU

Active in 16 European countries and 74 countries world-wide

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France

Saint-Gobain SA

Saint-Gobain is a global leader in Engineered Materials (Glass, Ceramics, Cast Iron, Construction). Applications for Construction, Automotive, Aeronautics, Packaging, Industry, Markets

Turnover 1997 = 16,000 MECU

Active in all European countries and 40 countries world-wide

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France

Bouygues SA

Bouygues' activities are currently divided into two main areas of business: Construction, the Group's core business which includes building/public works, roads and property development, and Service activities which cover communication, telecommunications and management of public utilities.

Turnover 1997 = 13,100 MECU

Active world-wide, permanent locations in 80 countries.

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United Kingdom

Taylor Woodrow Plc

Taylor Woodrow was founded in 1921 and employs 10,525 people working in 25 countries. The group has built a mix of four inter-related businesses in construction, property, housing and trading in building materials and consumables. From a strong UK operational base, the group has carefully developed its presence in selected international markets with over 160 subsidiary companies. Taylor Woodrow's substantial investment property portfolio includes retail, office and industrial assets. This provides a strong rental scheme, which is supplemented by an active programme of development projects.

Turnover 1997 = 1,840 MECU

Active world-wide.

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United Kingdom

BICC Plc

The BICC Group is an international engineering business specialising in cables, cable systems, construction, engineering and contracting. It serves, principally, the world's markets for infrastructure development in communications, power, transport and the built environment.

Turnover 1977 = 6,700 MECU

Active world-wide

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United Kingdom

Balfour Beatty Ltd

Balfour Beatty is a major international engineering and construction company. Its activities encompass civil, railway, and power engineering, building and building services, maintenance and facilities management. It also has a number of specialist manufacturing operations that support its power and railway engineering businesses

Turnover 1997 = 3,300 MECU

Active world-wide

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Spain

Dragados y Construcciones SA

Group of companies first established in 1941, is a general contractor with activities in engineering, hydraulics, transport infrastructure, building construction, restoration, real estate activities, off-shore, Energy, water cycling, community services, environmental control, integral maintenance, social equipment and services (integral services).
Turnover 1997 = 2,700 MECU
Active in 11 European countries, and 38 other countries in all continents

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Italy

Dioguardi SpA

General contracting for civil works including buildings for business (not housing), banks, airports, technical facilities for telephone companies. refurbishment works.

Turnover 1997 = 65 MECU

Active in 2 European countries and in the USA

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The Netherlands

HBG, Hollandsche Beton Groep nv

HBG is a 95 year old group of companies, active in design, engineering and construction. Activities range from housing (8%) and general contracting (39%) to specialised work such as marine construction (29%), and large infrastructural works (10%).

Turnover 1997 = 5,000 MECU

Active world-wide, three quarters of turnover generated outside the Netherlands.

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Switzerland

ABB
Asea Brown Boveri Ltd

ABB is a world leader in electrical engineering comprising more than 1,000 companies with 213,000 employees.
Its Industrial and Building Systems segment provides engineering, procurement and construction services for oil, gas and petrochemical industries, design and installation of electrical, ventilation and refrigeration systems, complete infrastructure systems for industrial and commercial buildings and areas as well as operation and maintenance of building systems. Business Unit Contracting operates within the electrical and mechanical installations and building services with 23,000 employees.
Turnover 1997 = 30,000 MECU for ABB total, 14,000 MECU for Industrial and Building Systems and 3,100 MECU for BU Contracting
Active in over 100 countries world-wide, BU Contracting in 20 European countries and 30 countries world-wide

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Sweden

Skanska AB

General construction, engineering services, property development and related industries.
Turnover 1997 = 6,500 MECU
Active world-wide.

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Finland

YIT Corporation Plc

Building construction, mechanical and steel construction, infrastructure.
Turnover 1997 = 940 MECU
Active in 12 European countries and 33 countries world-wide

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Finland

Addtek International Oy Ab

Precast concrete products for the construction of residential and commercial buildings,

bridges, tunnels, car parks and railway sleepers

Turnover 1997 = 350 MECU

Active in precast concrete business in seven European countries and precast concrete technology sales world-wide

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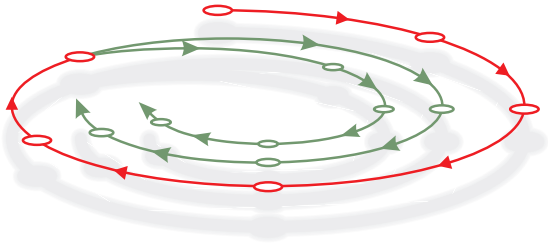

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