Michael Balak
Wolfgang Kippes
Vienna, February 2007

Austrian Construction Technology Platform (ACTP)
Focus Area Cultural Heritage (FACH)
Strategic Research Agenda (SRA)

MMM
Monitoring Maintenance Management

Contents:

1. Objective and Particulars:

The objective is to add an Austrian contribution to the Strategic Research Agenda (SRA) of the European Construction Technology Platform (ECTP) which is

- embedded in both national and international research networks;
- represents an Austrian contribution to the newly installed research community in Europe (Seventh Framework Programme of the European Community for Research, Technology Platforms); and
- offers a substantial contribution to achieving the political goals set forth in Lisbon.

The general frame of reference is the political guideline set forth by the European Commission (EC) in the so-called Lisbon goals for the economic development in Europe. Accordingly, Europe is to become the world's most innovative and strongest economy by investing 3% of the Gross National Product (including private sector contributions) in research, development and innovation. The European building industry – because of its importance from a purely historical point of view but also because of its size – will have to play a key role as an economic driving force in this development process.

What's striking about the currently 29[1] European Industrial Research Platforms is that on a global scale the largest European companies are ranked in 4th place and further down. It is only in construction where the world's four leading companies are based in Europe. These are: Vinci and Bouygues in France, Hochtief in Germany and Grupo ACS (Dragados) in Spain. The Swedish Skanska Group is currently the world's No. 6 while Austria's leading construction group (FIMAG, or „Haselsteiner Group") is ranked No. 20.[2] Since the building industry (in particular the great number of small and medium sized companies) is considered slow in terms of innovation, the Lisbon goals can only be achieved if innovation is adequately promoted throughout the building sector. In case of the Austrian building industry the relevant research proportion is estimated at 0.2% of overall turnover!

If, as a consequence, considerations are also based on the specific niche market of research in the field of cultural heritage, one aspect which needs to always be taken into account as well is that this niche presents not only a specific Austrian strength (based on good traditions) but that at the same time it secures research and development for the entire building industry. Cultural heritage as a basis for research and development must be understood as a 'show-room' representative for the entire industry.

The proposal to direct the ACTP's SRA towards **„MMM – Monitoring, Maintenance, Management"** is based on the fact that the research currently promoted in Europe concentrates exclusively on technology (see also ECTP, Calls for the Sixth Framework Programme of the EC) with a particular focus on material research. The focus on MMM presented here is to address a complementary aspect still underrated in Europe.

Although the SRA presented here was developed for specific Austrian interests it has been repeatedly discussed and adapted on the international level in order to take on as much as possible both the structure and contents of the SRA on the European level (ECTP/FACH). The aim was to create multinational platforms and for other national building platforms to take on parts of MMM and/or the entire concept.

Any strategic effort for increased innovation must include training. Intelligent innovation is only feasible by improving the qualifications and skills of each and every member of staff.

---

[1] The number of industrial research platforms in Europe is constantly growing. The number quoted here could already be higher.

[2] See also: Jesus Rodriguez: European Construction Technology Platform, Presentation in Paris, Oct. 2005

The development of a training programme with a particular focus on unqualified or under-qualified construction workers must therefore be part of any innovation strategy if the broad impact aimed at is to be achieved.

A note to the structure of the contents:
In order to illustrate the fields of Monitoring, Maintenance and Management, several exemplary fields of research were selected for a more detailed description. The list is not complete but the examples included show how closely interconnected the three topics are. The chapter Horizontal Issues[3] provides a detailed account of risk management, energy efficiency of buildings, basic alternatives to standardisation, the disability-friendly adaptation of structures, quality assurance in monument conservation and "Culture Counts"[4]. The final chapter places particular emphasis on the importance of training to ensure proper implementation of the innovations.

[3] Called ‚Horizontal Issues' by ECTP/FACH.
[4] In European technical discussions this term is used for macro and micro economic issues which illustrate the particular contribution of cultural heritage conservation to the overall economy and to sustainable growth. See also: Terje Nypan: Cultural Heritage Monuments and Historic Buildings as Value Generators in a Post-Industrial Economy; Oslo 2003

2. Strategic Research Areas

2.1. Monitoring

2.1.1 Remote Sensing, in particular Laser Scanning

The following considerations are based on the interesting partial results of the research carried out by the Christian Doppler Laboratory "Spatial Data from Laser Scanning and Remote Sensing" established at the Vienna University of Technology. In cooperation with 11 industrial partners, two large areas of research are investigated: Three dimensional data for hydrological applications and object modelling for cities, buildings and infrastructure facilities.

Laser scanning has become one of the most important techniques for the acquisition of three dimensional data. The data is either acquired from airborne platforms (helicopter, aeroplane or satellite) or from the ground. While the exact research tasks are defined by the partner companies, there are also several overlapping areas of basic research.
Full-waveform laser scanning is a relatively new data acquisition method and still requires additional studies and further development both in terms of the hard and software. It involves analysing the echo waveform and allows obtaining information about the scanned object's geometry and surface properties. A typical application would be the determination of the vegetation's structural profile from the top of the canopy down to the solid ground. Laser scanners provide more or less structured scatter diagrams of object surfaces. An important research issue is therefore the development of adequate geometrical data structures and the establishment of efficient three-dimensional data bases.

Sensor orientation, the precondition for achieving highly exact final results, is an often neglected but very important field. Exact 3D coordinates of the recorded objects are increasingly gaining in importance as they can serve as the basis for a great variety of problem definitions ranging from object re-construction to monitoring.

Other issues refer to the deduction of terrain models and their further processing for hydraulic and hydrological applications, the registration of urban space for automated productions of city models and the recording from mobile platforms of street landscapes in densely built areas in order to reconstruct both façades and visible infrastructure facilities. Of interest with regard to interurban areas is the modelling of power lines in which by way of determining three dimensional chain lines it should be possible to recognise danger potentials and initiate the necessary servicing. Future application potentials for automated modelling are bound to range from orchard catasters to the monitoring of vegetation (in connection with false colour images and orthogonal photographs).

One research focus deals with the recording of historic buildings for the purpose of Cultural Heritage Facility Management which in terms of monitoring, conservation and promotion (visualisation, communication) sets forth very specific demands. Here, one of the focal points in the immediate future will be the utilisation of the data gained for promotion and marketing activities in tourism.

As to Facility Management – going far beyond the application to the limited area of monument conservation – it is conceivable to apply laser scanning methods to the monitoring of roof areas, façades and sites, the latter application being bound to gain in significance in large-scale risk assessment procedures (e.g. urban and landscape planning, security).

In general it can be said that the task-settings of the above Christian Doppler Laboratory originate from the virtual and real worlds and their correlation, from monitoring of the environmental situation and change detection and from risk management and facility management.

In a next step the topics of research/development could be a combination of city model technologies, geo-information and facility management systems in order to arrive at a more efficient management of listed building complexes. It is to be expected that the research scope will be extended to the fields of augmented reality, documentation, visualisation and training in details of millimetres and less.

2.1.2. Emission Monitoring – Biomass Furnaces

Austria plays a leading role in Europe in the field of small scale biomass furnaces. Decades of experience coupled with an innovation drive unparalleled in Europe have placed the Austrian economy in a technological pioneering role in this particular field. But in spite of the positive general framework calling for a shift to renewable energy sources, the current discussions of fine particulates against the background of hardly usable data represent a serious challenge to all small scale biomass furnaces. The tiled stove for instance, which has been refined and optimised for centuries, would allow an emission monitoring capable of also monitoring and detecting other biogenic and fossil emitters of fine particulates.

At the same time, however, the attention must be drawn to the broad discussion of fine particulates emissions already taking place in Central Europe. Because of a lack of adequate objective data – in particular from the automotive industry – political decisions still tend to be based on the wrong arguments with the ecological debate falling short. Unless all emission effects – from fine particulates to greenhouse gasses including energy and emission records throughout the life cycle – are taken into account, it will not be possible to achieve an ecologically sound future and to preserve the traditional craftsmanship.

A close link to our cultural heritage results from the goal of maintaining its authenticity. This must include the conservation of traditional heating systems by taking into account up to date ecological risks and saving a highly qualified craftsmanship.

2.1.3. Indoor Climate Monitoring and Alternative Heating Methods

The type of heat emission of a heating and/or tempering system has immediate effects on both indoor climatic parameters as well as on human health. In this respect, heating systems emitting primarily radiant heat have advantages over convection heating systems because they cause very little dust transport (no air draft) and produce a constant indoor climate. One goal should be the application of such systems not only to historic building structures and museum collections but also to individual households with a view to the residents' wellness and wellbeing (see also Chapter 2.4.2, Energy Efficiency of Buildings).

The impacts of a heating system on buildings and on human health are not always immediately apparent but tend to take their effect through continuous exposure over a longer period of time. This exposure can be very well detected by comparing for instance households with radiant heating systems (e.g. tiled stoves) with households heated with convection heating systems. Relevant long term studies examining the conservatory advantages of tempering systems in museums have already been carried out; the expertise for studies of this kind is available in Austria.[5]

What needs to be studied in greater depth is the correlation of radiant heating systems and building diagnostics, life cycle costs, simulation and planning tools or of energy saving potentials and natural ventilation.

---

[5] See also: F.Boody / H. Großeschmidt / W. Kippes / M. Kotterer (Editors): Klima in Museen und historischen Gebäuden: Die Temperierung; Wiss. Reihe Schönbrunn, Bd.9, Wien 2004

2.1.4. Old Building Monitoring:

Non-destructive testing and monitoring and their practical application need to be developed further:

- Non-destructive testing procedures for two-dimensional control of masonry consolidations;
- Historic building monitoring by means of an optical transmission technology applied to statically endangered building components;
- Vibration tests and measurements for assessment of earthquake risks;
- Roof area monitoring (static reinforcement of old roof constructions);
- Geometric surface control on interior and exterior walls (crack initiation, foundations and environmental changes, etc.).

2.1.5. Photonics and Laser Technology

The search for advanced techniques in diagnostics and conservation methods consider as ideal the techniques typically associated with light. On the other hand optical photography and optical microscopy are well known examples. Photons are ideal sampling and testing tools to investigate the material with a not invasive method. The evolution of photon emission and photon detection devices has grown considerably after the invention of the Laser, and this sector of science has been worth of the specific term “Photonics” as a parallel of the previous term Electronics. Europe is very strong in the field, with research centres, components producers and systems producers. Today the sector is having a significant growth because of the many fields of applications for LEDS, Lasers, photo detectors, sensors and systems.

Photonics covers a number of techniques to investigate the material with many possible tasks:

- Composition analysis, by optical and laser spectroscopy (reflectance, Raman, laser-breakdown spectroscopy, laser induced fluorescence, non-linear, time-resolved).
- Surface analysis and texture, by fluorescence imaging, laser rugosimetry, speckle analysis.
- Stratigraphy, by IR multispectral imaging, optical coherent tomography.
- Outside imaging, by 3D laser scanning and digital documentation.
- Endoscopy.
- Defects detection, by double-pulse interferometry, laser Doppler vibrometry, speckle interferometry.
- Authentication and dating, by thermoluminescence.
- Provenience and antique processing techniques interpretation, by luminescence and thermoluminescence.
- Deterioration process monitoring, by optical fibre sensors, passive photo-sensors, LIDAR systems.

At higher power level, capable by laser techniques, the induced process may become crucial part of a restoration intervention with several tasks:

- very precise removal of deteriorated layers in the delicate phase of cleaning;
- very precise welding of gold artefacts.

Knowledge and Conservation of CH will benefit of photonics in the future, with many possible applications. New low-cost and compact solid state emitters and detectors are expected to come out from investments in important production sectors, such as microelectronics, military applications and biomedics. They will make available more advanced and very compact laser emitters based on solid state technology, new detectors with improved capability to investigate inside the artefact, new imaging systems for unprecedented resolution in information and documentation. Evaluating these perspectives on the basis of the fast evolution of photonics in recent years, it is easy to predict that this field of technology has a very high probability to generate new potentially low-cost devices to be integrated in the methods and protocols for conservation, becoming the updated tools that more advanced conservation institutes and more experienced professional restorers will use tomorrow.

The aims of further action are:

- to foster the creation of a network composed by experts in the fields of photonics, experts in the field of nanotechnologies, experts in the field of material science, experts in the field of conservation, experts in the field of archaeometry;
- to monitor and test the potential of newly discovered optical & laser components and systems, nanomaterials & nanoinvestigation techniques for the main tasks of improving the knowledge of the materials, of devising better preservation and conservation strategies, to improve the ability to restore deteriorated materials;
- to integrate the photonic techniques and nanotechnologies between themselves and with other ones in suitable validated protocols of application, in the search of optimised costs, of portable on-site instruments, of simplified, flexible and versatile use;
- to exchange experience between partners and devise cooperative research activity;
- to disseminate and transfer the best practice to public institutions and private end-users.

2.2. Maintenance

The study and transmission of knowledge of the materials used in historic buildings and their processing is as indispensable for the authentic conservation of monuments as the long-term testing of new restoration technologies and materials.

2.2.1. Lime Technology:

The industrialisation of the building trade in Austria since the 1960s has led to a loss of traditional craftsmanship which in turn has had severe effects for the conservation of monuments and historic façades. Instead of continuing maintenance and repair work with materials that had been used for many centuries, original plasters were knocked off and replaced with modern plaster systems. This not only meant a severe loss in authenticity, but more importantly, these new products neither met the aesthetical ends nor did they fulfil the structural demands. In order to be able to restore historic structures under the aspect of authenticity, it is therefore essential to study the historic building materials with a particular focus on lime technology and its practical application.

If these systems are to be applied successfully, a comprehensive knowledge of the specific characteristics of aggregates, binding agents and their processing is needed.

When restoring historic buildings, the adaptation work entails increased demands with regard to the use of an object or of specific building components. This could mean having to apply lime plaster systems for the first time and/or to partially adapt to the old plaster. Considering that damages to the plaster often occur relatively soon in masonry zones exposed to damp or in zones contaminated by salt, it is essential that different lime plaster systems (e.g. dead lime, hydraulic lime plasters) are tried out both with and without generators of micro-pores but also with different aggregates in order to detect the salt's mobility, origin and distribution in the plaster. Here, the research should concentrate on developing object specific plaster systems in combination with sustainable masonry desalination methods.

The supplementation and consolidation of traditional lime plasters by way of backfills and reinforcing measures should also take place in lime technology. Of particular interest would be the influence of different coats of paint on the functionality of lime plaster systems as well as the correlation between radiant heating systems and lime plasters.

Lime Floors:
Here it will be necessary to look into the interaction of lime floor fills with lime plaster and to develop lime attic floor fills and lime terrazzo floors for floor heating systems. Not yet available are planning and processing guidelines nor a specific training curriculum.

Special Plasters:
Sonic and heat insulation and micro-pore plaster utilising the building material air:

- Research into improved sonic performances of lime plasters when micro-pores and mineral light building materials are added;
- Heat insulation plaster for damp and salt contaminated masonry on the basis of lime technology.

Also not yet available is a long term study which would compare non-hydrophobic, concrete free restoration plasters made of lime with common restoration plasters. Equally lacking is a comparative study of lime and clay plasters including coating for radiant heating systems.

2.2.2. Façades:

One of the core issues in historic monument conservation is the conservation of historic façades. The following guidelines should apply as a matter of principle:

- Detailed description of findings and documentation of traditional inventory;
- Conservation on the façades of all defining building and design phases;
- Conservation, supplementation and reconstruction of imperfections using the original materials;
- Execution of surface coatings (whitewash) according to inventory;
- Implementation of restoration measures by specialised building contractors with adequately qualified staff and under the supervision of a conservator of façades;
- Continuous control, conservation and maintenance following restoration.

This guideline will only work provided the co-operation between scholars and scientists qualified in the conservation of monuments and craftsmen and restorers is ensured and that the craftsmen are adequately trained to meet the increased demands on qualification.

Most cities in Central Europe are characterised by their extensive inventory of historic buildings from the turn of 19^{th} to the 20^{th} century. Monument conservation of the past decades has only reluctantly dealt with this heritage. A recent research project carried out with the support of the European Commission focussed on the specific building materials used in this particular period (*Gründerzeit*) and the findings of this project raised considerable interest. But if they are to be implemented, a specific implementation focus covering the following steps will be needed:

- Development of non-destructive procedures to test and diagnose the plaster;
- Monitoring of statically endangered building parts and/or the degradation state of surfaces (not only plaster);
- Conservation strategies for damaged building structures;
- Management of ongoing conservation of facades (‘service programme’).

2.2.3. Lacquers and Coatings:

The inventory of historic window and door structures in the EU and beyond is considerable. In the past the primary building material was wood but metallic materials were also sometimes used.

In most cases the problem with partial repairs or overall restorations is not having any detailed knowledge of the existing old coating. If the restoration work is to succeed, it is indispensable to carry out a comprehensive analysis of the status quo. In other words, only a thorough and detailed study of the old inventory will allow taking the adequate restoration steps.

Another issue is that due to legal regulations in the EU, the composition of paints and lacquers has been changed considerably in recent years and will continue to do so in future. On the one hand there are hardly any companies left producing oil paints while on the other it has become very difficult to find craftsmen capable of adequately and professionally applying these “old” coating agents and carrying out the necessary preparatory work for the subsurface (e.g. heat impregnation with linseed oil). Moreover, there is a growing demand for accelerated drying periods, for the lacquer’s application scope to be as ample as possible and for coated structures to be “transportable” within a relatively short period of time. All of this is in direct contradiction with the slow drying process of oil paints.

If the authenticity of our cultural heritage is to be conserved, there is a need to study in more detail historical coatings and impregnations (composition of material and execution), to re-introduce production processes long abolished and to train those applying them.

When developing modern coating agents it is clearly necessary that their optical appearance must be largely adaptable to the historic inventory. With regard to their durability – provided cleaning and conservation measures are adequate – the building owners are likely to expect life cycles similar to those of the “old” coatings. This means that environmental changes must be taken into account as well. Experience has shown that top quality coatings can only be achieved by an equally highly qualified staff and by using syntonic coating agents. An essential starting point for further development potential will lie precisely in training and further training of professional painters.

2.2.4. Metals and Corrosion:

Corrosion protection of historic steel bridge structures:
Western Europe has a substantial inventory of historic steel bridge constructions primarily found in the national railway networks. Thanks to good corrosion control measures carried out by the railroad companies over the last decades, most of the constructions remain in a state which seems to allow economical restorations of defective corrosion protections without having to discontinue the bridges' operation – irrespective of the issues of authenticity.

So far the repairs and/or overall restorations undertaken allowed for „remaining within the system“. But because of changed European regulations, this will eventually no longer be possible. Tried and tested products containing lead or chromate have reached the end of their life cycle. Further reductions in solvent content are already fully under way.

For the time being products for so-called heavy corrosion protections are largely exempt from the regulation as the lacquer industry and commercial users were able to argue that there were no equivalent products available on the basis of water solubility and reduced solvent content. Thanks to these efforts the current version of said regulation – EU-Lacquer-Directive 2004/42/EC and the relevant Austrian provision (LMVO 2005) – provides a final period of grace for classical solvent based products.

With the EU Corropaint Directive already in preparation and its subsequent absorption into Austrian law, it is however only a matter of time until the use of water-soluble and solvent reduced coating agents will become obligatory for restoration purposes as well. As a consequence, all aspects in connection with the conservation of our site heritage need to be looked at and clarified.

So far the acceptance for and the experience with such systems – especially among contractors and craftsmen – have been low. Equally lacking is the provision of these products' specific properties in relevant test standards[6].

If the quality of corrosion protection is to be warranted once the new Directive comes into effect, the formulation, the testing of ageing processes/corrosion and the processing of water-soluble and solvent reduced coating agents must be developed further with a view to their market acceptance in this particular field. If, on the other hand, the traditional qualities are to be maintained, the question of alternative approaches to standardisation must also be addressed (see 2.4.3 for modern standardisation and its impacts).

Copper – Corrosion:
Because of changed environmental conditions, it is more than likely that the natural green patina on copper sheets on historic buildings which had always served as an optimum corrosion protection will no longer be achieved. In future this will mean a radical and

[6] E.g. ÖNORM EN ISO 12944

unacceptable change in the appearance of our heritage sites. At the same time all investments going into copper sheeting are basically in vain because the accustomed long-term durability is no longer given without the corrosion protection.

It is therefore of great importance to develop technologies enabling us to regain the accustomed copper coating – also on copper sheets mounted in the last decades. A relevant Austrian patent already exists, but it needs further development with regard to its practical application.

Construction Sheets – Corrosion:
The above also applies to construction sheets made of galvanised steel although to a different extent and scope. Since the production of galvanised sheet and technologies for subsequent after-treatment are mostly tuned to the mass market of the car industry, the qualities for construction purposes still available only a few years ago are no longer at hand.

What needs to be improved in particular is the handling of the sheets as they react to improper storing and/or contact with construction chemicals (from their surroundings) with excessive white rust or even premature red rust production.

All of the above calls for measures to qualify and determine the effectiveness of the sheet qualities currently available and for proper training of the craftsmen in order to continue restorations and repairs of façade and roof sheeting while conserving their properties both in terms of their optical appearance as well as with regard to their corrosion resistance (both determined by the patina).

2.2.5. Stone and Stone Surfaces:

The ongoing disintegration of structural elements and artworks made of stone (or other mineral materials) for the last 100 years raises tremendous conservation problems, in particular as a result of the 19th century removal of historic surface coatings and plasters when the visibility of the "natural" appearance of stone surfaces on historic buildings became modern and when they were executed in historicising styles (e.g. Notre Dame in Paris, Cologne Cathedral, Vienna city hall, Votivkirche, State Opera, Burgtheater, Museums, etc.).

The increasingly systematic research approach to stone conservation in recent years has led to several fundamental changes in the relevant technologies. However, the products and technologies applied continue to leave a number of issues unanswered: What still needs to be studied are the issues of efficiency and retreatability as well as long term effects and prognosis models for damaging processes.

Here, a new conceptual approach would be provided by the changed perspective of monument conservation concerning the visibility of stone and by applying re-discovered historic coatings as well as modern coatings for an improved stone fortification.

Structural consolidations of stone objects using organic and inorganic stone fortifying agents offer a chance to delay the damage caused by chemical and physical weathering processes. But experience with practical restoration work showed time and again that consolidations do not always succeed and that in cases where they fail the natural damaging process is even accelerated.

Requirements for stone fortifiers:

- A considerable penetration depth without excessive surface consolidation of the external areas;
- Caulking of calcareous spars – increase of micro-structural bonding strength – increase of tensile strength;
- No extension of the natural drying process of stone;
- No additional tension upon thermal and hygric strain;
- Resistance to low acids and alkaline solutions and UV radiation;
- No adhesive surfaces after conclusion of reaction – resistant to contamination;
- No significant changes of colour and gloss on surfaces;
- Reversibility (or retreatability) to avoid detrimental influence on subsequent restoration measures;
- Simple manipulations on building sites (paint brush, spray cans, etc.);
- Non-toxic after drying.

Laboratory studies involving both destruction free and destructive methods to determine the physical properties of stone both prior to and after consolidating measures already exist. Yet, the extensive data available shows that an improvement of physical parameters achieved and confirmed in the laboratory, does not necessarily mean a significant prolongation of an object's life cycle once it is set up outdoors. Because of very complex chemical and physical correlations between a consolidated object made of natural stone and the climatic situation at the exposition site, it is currently impossible to provide a reliable prognosis as to further weathering.

Scientific conservation research has shown that weathering tests carried out in the laboratory are not suited to adequately simulate the complex processes. The monument with its specific realities must return to the core of the interest not least because it can by itself provide all the information about its original state, the changes that have taken place and the responsible damaging factors.

Improved procedures are therefore required in the following areas:

- Monitoring of the monument to the effect of an objectified observation and measurement of the current state, the damage patterns and their changes over time;
- Development of control instruments for the inspection or long-term monitoring of the effectiveness of the conservation means and methods undertaken;
- Parallel scientific basic research of issues related to the original surface design (sockets, etc.), of responsible damaging mechanisms and of the mode of action of the conservation measures undertaken;
- Development of models to describe the processes.

2.2.6. Concrete Technology in Monument Conservation

With the worldwide patenting of the Henebique system of ferro-concrete skeleton construction in 1898, reinforced concrete steel constructions were built all over Europe. The new technology resulted in excellent industrial and technical buildings such as factories, plants and bridges but also in residential and office buildings and structural monuments all of which characterise our surroundings until this day.

Conservation of the early concrete structures gained in importance not least by the founding in 1988 of DOCOMOMO (Documentation and Conservation of Building, Sites and Neighbourhoods of the Modern Movement). Today it is seen as a matter of course to include these structures as an integral part of contemporary architecture on the agenda of contemporary monument conservation. In the near future a growing number of these objects will have to be listed.

After 100 years of exposure, the early ferro-concrete structures show more or less severe damages all over the world. The problem is aggravated in sites near the sea where the salt concentration in the air together with specific wind conditions have led to particularly heavy material corrosions.

From a scientific point of view what’s at stake is not only the conservation of original surface structures but also – from the construction point of view – of the ferro-concrete structures as a whole. The following research objectives need to be addressed:

- a still lacking overall inventory survey of the occurring damages as a typological collection of data;
- the basic ascertainment of the problem at hand in terms of static and physical building properties (heat insulation, thermal bridges), etc.;
- the first time ever formulation of the demands placed on monument conservation on the basis of monument values (authenticity, overall aesthetic appearance, etc.);
- the practical implementation (system solutions) and their economic dimension in the context of suitable standardisations.

2.2.7. Rising Damp Drainage

In Austria alone, the avoidable costs each year for the repair of damages due to ineffective or insufficient drainage measures amount to approximately 50 million Euro. The reasons for the frequent failures are found in planning, execution and application of materials and/or in the materials' quality. Another factor which seems to aggravate the situation are largely ineffective methods and procedures applied all over Europe. They include the so-called "contact-free procedures" which are set to be tested in a large-scale research project both on buildings and in the laboratory in order to clarify their effectiveness once and for all.

What needs to be tested within the framework of an additional research project is the effectiveness of radiant heating systems against capillary humidity. Although the practical applicability has already been confirmed in many comparative object studies, the scientific substantiation continues to be inadequate. Thermal and/or biological desalination methods on the masonry need to be developed further and subjected to comparative studies.

2.2.8. Ceramics, Glass, Mirror, Mosaic:

Ceramics:
Terracotta and glazed ceramic plates were re-introduced in European architecture in the 1850s. Their use reached its heyday in Jugendstil (Art Nouveau) around 1900 alongside with a great number of production plants and décor types. Again, since there is no detailed knowledge of the historical production technologies, the remaining objects raise a number of conservation issues that won't be solved without systematic surveys. It will be necessary to:

- carry out an inventory of still existing traditions (e.g. inventory of long existing companies, research in the archives);
- establish the reasons for deterioration and damages;
- establish standards for materials and methods of repair, etc.

Glass:
Glass was widely used at the time of Historism in the second half of the 19th century as well as later on in Jugendstil around 1900 and in Art Deco around 1930.
Another trend was to install interior and exterior glass roofs in galleries, banks and trading houses all of which raise delicate problems with regard to their technology, quality and conservation.
Later on, materials made of glass were widely used for huge figural window and door designs (in Vienna the only example studied is Otto Wagner's Kirche am Steinhof) and even more often for figural and decorative mosaics on facades when European companies expanded to the United States (e.g. Innsbruck Glass Painting). In the 1960s and 1970s industrially manufactured and more or less monochromic glass mosaics were often used.
All mosaics raise major conservation problems as soon as their cement or plaster adhesive is removed from the load-bearing walls (crack initiation, etc.). On the whole, the amount of relevant experiences or comprehensive studies and problem solving approaches available is very limited.

2.3. Management:

Following the European SRA structure (ECTP/FACH) innovations with regard to management are dealt with under ‘Horizontal Issues’, Chapter 2.4.

2.3.1. Inventory / Archiving:

For the built cultural heritage, it will be necessary to develop GIS-based data bases for the objects’ spatial definition. For the inventory of the mobile cultural heritage, data base systems in line with market requirements already exist, but their inter-operability continues to be unsatisfactory.

For the purpose of economically faster and more precise object definitions, the passive identification technology by means of RFID needs further elaboration. The development of appropriate interfaces connecting the existing data bases is likely to also solve the problem of the different systems’ inter-operability.

2.3.2. Knowledge Databases

Here, a data base with historic building knowledge (comparable to the one used in medicine) should be installed. Such data acquisition would only be conceivable on the basis of an international co-operation (initial steps in this direction have already been taken) and of open access for all interested parties.
Topics: building diagnostics, building research, material test reports, damage reports, application concepts, producers, literature, trade journals, craftsmanship with specific know how.

Another aspect which needs to be recognised as well is the innovation potential resulting from the correlation between contemporary architecture and cultural heritage structures. In Austria there is a number of very interesting examples which even in their radicalism have model character. Here, for instance, it would be worthwhile considering the installation of a data base, a competence centre Old/New with a collection of *best practice* models for undecided building owners/mayors/owners of monuments and/or historic buildings and to organise travelling exhibitions put together from data bases on topics such as city walls, small parks, etc.

The enormous amount of valuable inventory in Austria and its new EU neighbouring states with their similar construction modes – lime plaster, mixed masonry, counter sash windows – represents another area with tremendous economic, urban development and aesthetic potentials. In most cases, however, they are endangered by the fact that no-one really dares to restore the historic building inventory (key words: uncertainty of costs, lack of experts, etc.). A Renovation Academy should primarily aim at training craftsmen but also at addressing and training building owners.

2.3.3. Improving in-house Processes, Controlling, Calculation, Customer Services:

2.4. Horizontal Issues:

2.4.1. Risk Management:

Risk assessment and risk management have become a priority research issue all over Europe because of the already enormous extent of damage on our cultural heritage caused by natural and arbitrary risks but also because of the still unforeseeable threats from coming climatic changes. What's at stake for our cultural heritage is not just the predicted scope of damage but also the fact that in the event of damage it will be impossible to reconstruct the objects' authenticity.

What are the risks?
Examples of natural risks: floods, storms, avalanches and landslides, Tsunamis, volcanic activity, fire, the climatic change in general (drought, sand storms, excessive snow fall, glaciations, etc.)
Examples of arbitrary risks: fire, robbery, theft, terror, armed conflicts, etc.

The existing approach of Preventive Conservation must be developed further to become Integrated Risk Management which in addition to conservation related risks must also cover all other possible risks such as safety and security, ignorance, forces of nature, etc.

Tasks of Risk Management:

- Elaboration of exact documentations and data bases;
- Risk assessment;
- Monitoring systems;
- Management for damage limitations (Damage Limitation Planning);
- Planning of continued operation in case of emergency (Business Continuity Planning);
- Coordination with all emergency forces;
- Training of management and members of staff.

Protection of the Cultural Heritage against Earthquake Effects

The assessment of the scale of earthquake effects has considerably changed in many regions due to the works on Eurocode 8. This resulted in the fact that above all in countries north of the Alps where earthquakes had been no subject for discussion so far, the latter became the dominant loading condition. With regard to the cultural heritage this means that strategies, methods and measures have to be developed in order to be able to cope with this hazard. This is subdivided into 3 clear activities:

2.4.1.1. Site Effects
The effect of the incoming seismic waves is changed according to the soil nature. For the determination of site specific effects methods are required which can give very local statements based on measurement techniques. This so-called micro-zonation is to be further developed so that hazard maps can be established based on simple measurements.

2.4.1.2. Building Resistance
The experience from past earthquakes has shown that the building resistance does not comply with the current standard calculation models. Predominantly buildings with a good structural quality have considerably higher resistance factors than assumed. It is imperative to know this so-called over stress factor (OSF) in order to be able to decide whether reinforcements are necessary. The aim of the development must be to determine this factor for buildings of the cultural heritage by measurements.

2.4.1.3. Effect on the Mobile Elements of the Cultural Heritage

The effect of an earthquake on details of a system has been hardly studied. The so-called floor spectra can state which impact a known earthquake with a known epicentre will have on individual elements (e.g. on exhibits resting on foundations). These spectra are dependent on the site and the structure and cannot be determined by simple rules. An assessment by means of measurements for the establishment of the transfer function would be very helpful in order to be able to estimate the hazard potential.

The combination of all these activities to a big research project in the field of the cultural heritage seems to be an urgent necessity.

2.4.2 Energy Efficiency of Buildings, Building Pass, Quality Certificate:

In Europe there is a broad consensus concerning the need for energy saving. The issue of energy efficiency is addressed in the EU “Green Book”: “The primary aim is to strongly promote the use of alternative and renewable forms of energy and thereby reduce the demand for fossil fuels such as oil and gas.” (EMP Swoboda, in Die Presse, 17.3.2006, page 34). Considering that the most recent predictions concerning climatic changes and their impacts no longer allow for pure lip service, the “Directive on the Energy Performance of Buildings”[7] passed by the European Parliament already in 2002 must not only be consistently implemented but also needs substantial further development.

Energy will get increasingly expensive. In the coming years we will therefore see some dramatic changes with regard to the cost effectiveness of substitution investments and the generation of saving potentials. However, achieving the saving objectives set forth by the governments will only be possible by intervening on the existing historic building inventory – it is out of the question to wait for natural replacement investments (new constructions). An important next step will be to ensure that the “Building Directive” takes monuments into account as well.

The conservation of our historic building inventory calls for clever technical solutions (inner insulation, condensate prevention, increased control of natural ventilation processes, etc.) but also for a new standardisation concept (see Chapter 2.4.3.) and a comprehensive qualification strategy in the building trade and primarily on part of small and medium sized businesses. All traditional single small scale furnaces must be seen as an authentic part of this structural heritage. Apart from an objective assessment of **all** emission effects throughout the life cycle (see Chapter 2.1.2.), including currently discussed fine particulates emissions which are not considered in the “Building Directive”, the **existing** small furnaces in particular must undergo strict controls with a view to reducing the overall emission of pollutants. This requires a unified **European Quality Certificate** for small scale furnaces.

Consequently there is also a need for innovation in the fields of monitoring and maintenance of indoor air supply units and for a controlled provision of combustion air for small scale furnaces in household applications. The “Building Directive” needs to be extended to furnaces with a heat output of less than 20kW. The inspectors to be provided in this area must meet clear qualification profiles while the inspection of fine particulates emissions must be based on clear and internationally co-ordinated testing criterions and carried out with manageable equipment. At the same time increased attention will have to be paid to the health aspect of the indoor air quality (Zero Emission Products, see also Chapter 2.1.3., Indoor Climate Monitoring).

2.4.3 New Approach to Standardising:

[7] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings.

Standardisation needs to generally be looked at from a new perspective. Existing standards refer mostly to an obsolete state of technical knowledge, they are partly wrong (e.g. the caloric requirement calculation which has been removed) or they set forth problematic threshold specifications (e.g. condensate calculation in the outer shell with additional inner insulation). With regard to cultural heritage conservation, normative standards generally prove to be useless as soon as the authenticity of the monuments is to be conserved.

An appropriate response called the "performance based approach" already exists.
This approach no longer aims at a normative establishment of detailed specifications but at defining the objectives to be standardised to the most exact extent possible. It also aims at presenting flexible ways for reaching these objectives so that the up-to-date state of technical knowledge can be applied on a case by case basis. In contrast to normative standardisation which "freezes" the given state of technical knowledge, the "performance based approach" actually provokes and initiates innovation.

Yet, the understanding of the concept of standardisation must go even further than that: Standardisation needs to be taken into account for instance when legal regulations are being passed. An example is the problem with the current Equality Law for the Disabled 2006 and its impact on monuments. A new approach to standardisation should be tested along the example of barrier-free buildings and barrier-free monuments[8].
(see also Chapter 2.4.4.).

2.4.4. Culture Counts

What used to be a hypothesis – that investments in monuments have a particularly high economic profit earning capacity and that clever management methods in monument conservation succeed in generating excellent business results – is by now an internationally proven fact. In terms of research this points in three directions:

Macro-economic Perspectives:
The importance of cultural heritage for the leisure industry, tourism, etc. as well as for sustainable labour market policies (creation of highly qualified jobs) needs to be studied in the overall economic calculation.

Micro-economic Perspectives:
Best Practices Models in management need to be analysed with a view to develop benchmarks and to generally overcome the conflict between economic development/use on the one hand and conservation of the cultural heritage on the other.

Manpower Approach – Skill Building Approach:
This approach aims not only at conserving the cultural heritage but also at defining the necessary qualifications needed for the preservation of traditional skills. The qualitative aspect rests on the definition of skill profiles taking into account modern management methods, and it serves as a basis for the development of curricula[9].

2.4.5. Disability Friendly Adaptation of Historic Structures

[8] For a general introduction on the European level see: Alfredo Ronchi/Terje Nypan (Eds.): European Legislation and Cultural Heritage. A growing challenge for sustainable Cultural Heritage management and use; Milan 2006
[9] See also National Heritage Training Group (Ed.): Traditional Building Craft Skills – Skills Needs Analysis of the Built Heritage Sector in England 2005, London 2005.

The Austrian Equality Law for the Disabled (BGStG) has been in force since January 1, 2006. According to §1 the federal law aims at eliminating or preventing the discrimination of people with disabilities and thus guarantee their equal participation in society and their right to a self-determined life.
According to §2 of the BGStG, the law's applicability is defined as follows (free translation):

(1) The provisions of the federal law apply to the federal administration including its activity as holder of private rights.
(2) The provisions of the federal law furthermore apply to legal relationships including their initiation and foundation as well as to the availment or assertion of performances not covered by a legal relationship provided that in each case the access to and the provision of the goods and services available to the public are at stake and that the regulatory competence of the state is given.

In §8, Paragraph 2, the Federal government undertakes to take the appropriate and necessary steps to enable people with disabilities to have access to its performances and offers. In particular and following a hearing of the Austrian Working Group Rehabilitation it shall establish a plan for the removal of constructional barriers in buildings used by it by December 31, 2006 and to provide a step by step implementation (Step-by-step Plan for Federal Buildings).

The aim of the project is to plan, document and evaluate the possibilities for the removal of constructional barriers for the disabled on the basis of a number of selected objects.
The findings and resulting developments will provide important information as to how the law should be implemented.

2.4.6. Quality Assurance in Monument Conservation

If the conservation of our cultural heritage is to succeed, quality assurance regarding the anamnesis, diagnosis and therapy applied to a historic structure is of fundamental significance. Considering that the conservation of structural monuments calls for object specific solutions, standardisations, overall recipes and prefabricated measure packages must not be applied. Nevertheless, the quality assurance for any activity carried out on the object must be clearly defined and based on detailed humanistic and natural scientific research of the monument in question as well as on the international state of research and knowledge.

To fulfil this desideratum of monument conservation, national and international efforts to establish a definition of quality assurance will have to be stepped up.

2.4.7. Training and Qualification:

Proper training of technical and implementing staff as well as of planners and building owners will be decisive for the success of any of the craftsmanship needed in the field of restoration. The following skills are of particular importance:

- Drainage of rising damp
- Repair of concrete structures
- Restoration of natural stone
- Restoration of supporting wood structures
- Restoration of facades
- Facade surfaces
- Repair and maintenance of windows and doors
- Roofing
- Paintwork
- Plumbing

The specific demands of monument conservation call not only for research of the historic building materials and/or of new conservation and restoration technologies but also for proper implementation of the measures to be undertaken. Traditional craft skills are becoming extinct while today's training of craftsmen doesn't provide sufficient training in traditional techniques or in the proper handling of historic building materials. It is therefore absolutely necessary to provide specific further training. Training programmes to pass on the traditional knowledge or programmes linking the basics of monument conservation with the necessary practical on-site experience need to be expanded and increasingly offered. An essential aspect of such training programmes would be to ensure the co-operation of relevant independent institutions with self-employed specialists and the interdisciplinary exchange involving craftsmen, restorers, monument conservators, natural scientists, art historians and architects.

The ICOMOS ‚Guidelines for Training and Education' will have to serve as the frame of reference in order to enhance training and qualification in the field of cultural heritage conservation. Future developments will have to be based on the comprehensive list of principles established by these Guidelines. Since this list of principles covers a much wider field, an appropriate selection will have to be made for the individual curricula.

A European co-operation in training development includes the following aspects:

- e-Learning: Making use of modern communication technologies to support the learning process. Existing European experiences must be built in.

- m-Support: Making use of mobile telephones or palms could prove to be the only way to reach the many micro-firms on the market; they are indispensable for the conservation of our cultural heritage and must be involved in the innovation process.

- Training Centres: The existing national training centres on all levels of qualification must be organised to form a network and be involved in a European innovation perspective.

- Local Networks: Considering that the majority of companies in this area are small plants (less than 5 members of staff) and that a high percentage must be seen as micro-firms, it will be necessary to establish local support networks if they are to participate in the innovation process. What needs to be taken into account is that most of these firms do not have an administrative organisation capable of ensuring continuous communication and that representatives of these firms are only rarely in a position to leave their workplace if they want to meet their contractual obligations.

- Meta Networks: The local networks of micro-firms must be co-ordinated within meta-networks in order to provide them with the necessary information and thus to ensure the European innovation perspective.

- Integration of cultural heritage teaching in the curricula of the education system.