European Cooperation in the field of Scientific and Technical Research
- COST -

Secretariat

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COST 317/06

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding (MoU) for the implementation of a European Concerted Research Action designated as COST Action IE0601: Wood Science for Conservation of Cultural Heritage (WoodCultHer)'

Delegations will find attached the Memorandum of Understanding for COST Action IE0601 as approved by the COST Committee of Senior Officials (CSO) at its 166th meeting on 20/21 November 2006.

MEMORANDUM OF UNDERSTANDING
FOR THE IMPLEMENTATION OF A EUROPEAN CONCERTED RESEARCH ACTION DESIGNATED AS

COST ACTION IE0601

Wood Science for Conservation of Cultural Heritage (WoodCultHer)

The Signatories to this 'Memorandum of Understanding', declaring their common intention to participate in the concerted Action referred to above and described in the 'Technical Annex to the Memorandum', have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 299/06 'Rules and Procedures for Implementing COST Actions', or in any new document amending or replacing it, the contents of which the Signatories are fully aware of.

2. The main objective of the Action is to improve the conservation of our wooden cultural heritage by increasing the interaction and synergy between wood scientists and other professionals applying wood science and technology towards the study, conservation and restoration of wooden artefacts of artistic or historic interest (WCHOs, i.e. Wooden Cultural Heritage Objects)**.**

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at approximately 120 million EUR in 2006 prices.

4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of the document referred to in Point 1 above.

COST ACTION IE0601

Wood Science for Conservation of Cultural Heritage (WoodCultHer)

A. ABSTRACT AND KEYWORDS

European Cultural Heritage includes large numbers of objects made partially or completely of wood, e.g. panel paintings, wooden sculptures, music instruments, furniture and fittings, tools, vehicles, timber structures, wooden foundation piles.
Wood is a peculiar material, of biological origin, highly variable, susceptible to physical chemical and biological deterioration, hygroscopic, swelling and shrinking due to temperature and humidity variations, anisotropic, viscoelastic, mechano-sorptive; its ageing behaviour is not yet well known.
Wood science has greatly developed in the last few decades, and only recently started to be applied to the conservation of wooden artworks.
This COST Action aims to improve the conservation (including study, preventive conservation and restoration) of European Wooden Cultural Heritage Objects (WCHOs), by fostering targeted research and multidisciplinary interaction between researchers in various fields of wood science, conservators of wooden artworks, other scientists from related fields.
Special emphasis will be given to the ageing of wood material (e.g. its factors – physical, mechanical, biological, chemical, environmental – and their interactions), methods for studying long-term deterioration, interactions between WCHOs and the environment (in the atmosphere and in the soil, thus including archaeological wood), evaluation of long-term compatibility of methods and products for restoration, evaluation of equipment for the diagnosis, restoration, monitoring and conservation of WCHOs, implementation of results into preventive conservation practice and standardization.

Keywords: Wood, Cultural Heritage, Conservation, Deterioration, Ageing

B. BACKGROUND

B.1 Introduction

European Cultural Heritage is extremely rich and diverse, and present European policies stress the need of its valorisation and conservation.
Many objects belonging to European Cultural Heritage are totally or partially made of wood, including panel paintings, wooden sculptures, music instruments, furniture, building fittings, timber structures, wooden foundation piles. In the following, for the sake of brevity, the acronym "WCHOs" will be often used, meaning "Wooden Cultural Heritage Objects", i.e. objects designated as historically, aesthetically or culturally important, totally or partially made of wood, including archaeological and archaeo-botanic wood.
In the field of wooden artworks, experience confirms the need for thorough interaction between wood technologists/scientists and other professionals: engineers, architects, art historians, chemists, biologists, conservators, woodworkers etc., since no one competence/skill alone can respond to all the artwork's needs. Besides, there is a need that wood Scientists and technologists working in the field of conservation of wooden artworks meet each other and interact in the specific field of their own research, in order to attain deeper insights that will be useful in their multidisciplinary cooperation.

B.2 Current state of knowledge

In recent decades scientific knowledge of wood has substantially developed, including sectors such as knowledge of its ultra structure, rheological behaviour, deterioration mechanisms. However, only in a limited number of cases or locations the most advanced scientific knowledge is presently being applied to conservation and restoration of WCHOs.
It should be emphasized that conservation of wooden artefacts depends not only on the conservation of wood as a material, but also on maintaining the entireness and the functionality of the artefact as a whole. Just to make a very trivial example, in the case of a precious panel painting:
There is no point in maintaining just the integrity of the wooden support, if the paint layers crack and peel away, because of excessive shrinkage/swelling and/or distortion of the support, possibly caused by the environmental humidity variations (even if such movements are only temporary, the damage to the artwork is permanent; and in many cases deformations and distortions of the support can also increase progressively and become permanent);
However, no conservation of the artwork is possible, if the needs of the support are not given the appropriate attention, in order to prevent decay, mechanical damage, permanent deformations possibly caused by inappropriate environmental conditions or wrong restoration interventions.
Hence, the need for applying the best knowledge available must be stressed, in order to prevent and overcome the threats to our Wooden Cultural Heritage, produced not only by its “natural ageing”, but also by the changing requirements of society, the modifications in the macro- and micro-environment, the increasing amount of visitors, the limited amount of available funding and further exteenal factors.

a) Wood material

Wood structure and hygro-mechanical behaviour

Wood is a material of biological origin and is mainly formed by lignified cells, featuring various shapes and functions. It may be observed at macro- scale (by the naked eye), meso- and micro-scale (by a microscope), at which individual cells and wood anatomy may be examined. At an even greater scale, the ultra structure of the cell wall (made of cellulose, emicellulose and lignins) has been explored in recent years and further details are still under investigation.
Several peculiar properties of wood (such as hygroscopicity, anisotropy and rheology) are tightly connected to its ultra structure:

- hygroscopicity concerns the relationship between wood and water, which deeply influences its properties and behaviour (e.g. swelling/shrinkage, mechanically induced deformations);
- anisotropy means that several wood properties (including transport of moisture, swelling/shrinkage, strength, elasticity, and many others) depend strongly on the anatomical directions of wood (i.e. direction of the grain, of the growth rings, of the rays);
- rheology concerns the deformation of wood under applied stresses, including short-term elastic or plastic deformations, creep caused by duration of loads, mechano-sorptive behaviour which shows up under the combined action of loads and of moisture changes.

Very significant research in the field of wood’s hygro-mechanical behaviour can be found in the papers of the ESWM (European Society for Wood Mechanics: http://www.eswm.net/eswm.html). Several members of ESWM are members of this COST Action, since the hygro-mechanical behaviour is one of the main factors affecting the properties and conservation of wooden objects and structures, including the WCHOs. Such influence is briefly mentioned in the following section, as well as in the related literature.
Wood deterioration (biological and non-biological), preservation; prevention and control of decay

Wood can be deteriorated by biological as well as by abiotic (i.e. non biological) agents. The main abiotic factors are high temperature, fire, radiations (UV, gamma, ...) mechanical and wind erosion, climatic variations (dry/wet, hot/cold, etc.). The main biological agents are wood-decaying fungi (which require sufficient moisture and oxygen), wood-boring insects (which can attack also dry wood) and bacteria.

Natural durability is conferred to wood by extractives, produced and deposited by the tree's metabolism into the heartwood of some species, and acting as biocides or repellents against the agents of decay.

Deterioration in service depends not only on the natural durability of wood, but on the environmental conditions as well, which may favour or impede the deterioration processes.

The use of toxic biocides to prevent and/or fight biological deterioration is effective and widely diffused. However, such use tends to be increasingly limited, because of health and environmental issues; most of the biocides that were used for this purposes in the past (pentachlorophenol, lindane, arsenic, mercury) are nowadays banned.

Great care must be taken to prevent damage to WCHOs caused by treatments and by possible chemical interactions; also, since the effectiveness of biocides often diminishes with time, treatments may need to be repeated periodically. Research is therefore actively oriented towards new methods and/or products for prevention and control of biotic deterioration (mainly produced by fungi, insects and bacteria) of wood products, and especially WCHOs.

Anoxic eradication of infested (insects and fungi) wooden objects offers a biocide free and environmentally friendly solution for conservation of wooden objects of art; however, great care is needed in order to prevent damage (e.g. caused by humidity variations) during the treatment.

At the moment micro wave techniques are under development in order to treat wood in service against insect degradation. In several countries research is rapidly advancing in this field (e.g. The Netherlands, Italy and Belgium).

WCHOs were in the past often treated with various toxic biocides. Employees and visitors are daily in contact with the object, what sometimes represents a serious threat for their health. Research is ongoing for minimizing effects of past biocide treatment using bioremediation, chemical extraction and supercritical extraction.

Knowledge is still missing on several aspects of wood degradation, such as: bacterial degradation (a process most commonly occurring under water, e.g. at ship wrecks, foundation piles, water building constructions), fungal degradation (occurring when wood reaches – temporarily or permanently – high levels of moisture content), insect degradation (which may occur in dry wood as well), abiotic degradation (caused e.g. by exposure to chemicals, radiations, high temperature, stresses).

Diagnostic methods and equipment for analyses on wood

In many fields of Science and Technology, diagnostic methods and equipments have been developed, both non-destructive and destructive, in order to assess the macro-, micro- and ultra-structure of wood (both normal and anomalous), the type and amount of mechanical, chemical or biological deterioration and the internal structure of wood pieces.

Several techniques (e.g. X-Rays, Computed Tomography, Optical Contactless Measurements, FTIR, Scanning Electronic Microscopy, Molecular Biology) have been successfully used to improve diagnostic and conservation practices of WCHOs.

However, an operational knowledge of many techniques and the availability of related equipment has not yet sufficiently reached people in charge of conservation and restoration.

Interactions between wooden artworks and environment

Wood is a highly hygroscopic material (it tends to balance its own moisture content with the thermo hygrometric conditions of the surrounding environment), and many of its characteristics are significantly influenced by the moisture content level which it reaches. During moisture exchanges, gradients may cause deformations, stresses, and even cracking and collapse, due to shrinkage/swelling and anisotropy. Such conditions may be particularly serious in the case of works of art or high-level handicrafts (panel paintings, sculptures, musical instruments, furniture, etc.) because changes of its form may compromise the functionality of the object and/or the integrity of the decorative layers on wood supports.
This concept is often under estimated; for example, all too often serious damage to paintings is incorrectly attributed to wood ageing instead of relating it to actual unhealthy environmental conditions which may be too humid, too dry, too different from the natural original environment, too variable… and all of these conditions may cause problems in a single object at different times (UZIELLI, 1994; RIMABOSCHI et Al., 2000; UZIELLI and FIORAVANTI, 2000; DIONISI VICI et Al., 2005).
The problem is complex, and it is very difficult to define realistically acceptable “security limits”, specific for each individual WCHO, compatible with the correct conservation of the work, involving aesthetic, expositional, economic, architectonic constraints, and the great flow of visitors that many museums encourage but that are at the same time the source of worry.
Adequate control of the climatic conditions (if possible it should be a “passive” control, provided by the characteristics of the building) is indispensable for the conservation of panel paintings. This is more important and better than manipulating the artwork, as such manipulations, albeit often done with the best of intentions, may cause irreparable damage (UZIELLI, 1994).

Dendrochronology

Dendrochronology can be of great use for interdisciplinary research on WCHOs (sculptures, panel paintings, ...) including archaeological wood (water wells, findings, etc.). By studying the growth-ring patterns on wooden objects it is possible to determine the year in which a tree was cut down for timber production, needed for the creation of the artefact. Hence, this provides detailed information on the exact age of the object. Furthermore, tree-ring analyses can also provide more information about the provenance of the wood. The original timber source is not necessarily close to the place of construction. Considerable amounts of timber were shipped and traded in Europe during the middle Ages, often over long distances. The original timber sources can be retrieved by dendrochronology. This branch of tree-ring research is called "dendro-provenancing" (e.g. HANECA et Al. 2005a).
Intensive collaboration between wood biologists, dendrochronologists and art historians proved to be essential in order to reconstruct the creation process of, for instance, carved wooden altarpieces (HANECA et Al. 2005b). A thorough insight into the creative processes involved is essential for restorers and curators of valuable wooden objects.

Non-destructive inspection of wooden objects

Many studies and research on wooden objects require that the internal structure of the wood is visible. Even when just knowledge of surface characteristics would be sufficient, often dust has accumulated on the surface and blurs a detailed observation of the wood. Traditionally this was overcome by cleaning a strip on the object with a scalpel or, more recently, by removing the dust with an abrasive (micro-abrasion). Nevertheless, these are both invasive techniques that leave a permanent trace on the object.

Both, traditional Computed Tomography and recent advances in 3D-CT (3D Computed Tomography), now allow to scan wooden objects, and to reconstruct a virtual image of a cross-section of the object. Especially high-resolution 3D-images enable studies of the wood anatomical structure. Hence, internal study and dendrochronological dating of these objects could be performed in a totally non-destructive way. Nonetheless, in order to enhance the resolution of the 3D-images, some basic adaptation in the scanning geometry of state-of-the-art scanners are still required.
Since the response of wooden objects may be complex depending, among other factors, on thickness, densities, and water vapour permeability of wooden structures and design layers, attempts have been made to monitor historic wooden objects in situ in the real display conditions. Robust, fast and precise laser sensors, which provide non-contact measurements, have been successfully used for the long-term in situ monitoring of the dimensional response of wooden cultural objects to variations of temperature and relative humidity in their environment (BRATASZ and KOZLOWSKI, 2005). Direct, continuous non-destructive tracing of damage in wood at the micro-level is a further, particularly important field of study, since the continuous accumulation of small changes, rather than infrequent serious damaging events, accounts for much of the deterioration processes observed.
One of the very promising tools is the acoustic emission (AE) monitoring, popular in wood science and technology, and recently successfully applied to record directly the fracturing in wooden cultural objects exposed to environmental hazards (JAKIELA, BRATASZ and KOZLOWSKI, 2006). Another non-destructive method transferred from industry and engineering to the cultural heritage field is laser vibrometry. It consists in recording and analysing the excited vibration of the surface decorative layer to detect and map the delamination of paint layers.
Wider implementation of the direct non-destructive tracing of physical changes in wooden objects will verify the outcome of the numerical modelling and laboratory experiments in the conditions of real-world exposure. Practical sensors to indicate risk to wooden objects in museums and at historic sites, or during their transportation, should be developed and implemented in practice.

Numerical modelling of risk of damage

Uncontrolled variations in the environment of wood are principal hazards to its preservation. Moisture movement into and out of the wood in response to these variations can be modelled based on the laboratory measurements of the moisture contents in wood and water vapour diffusivity through the wood structure. Also, related stress levels can be modelled when mechanical properties of wood and its swelling/shrinkage in response to external changes are known. The numerical simulation allows predicting the thresholds in the magnitude and rate of the external variations which the wooden objects may ultimately tolerate without irreversible deformation or mechanical damage (Bratasz, Jakiela and Kozlowski, 2005). The allowable variations are expressed as maps of values, as not only the magnitude and rate of the variation are significant but also the range within which the variation occurs. Such maps of tolerable variations in the environment, verified by direct monitoring of wooden objects and accepted on the international level, would be a solid basis for standards for the environment of historic objects and recommendations for the heating, ventilation and air-conditioning in historic buildings.

Long-term behaviour and "accelerated ageing"

Deterioration of WCHOs may take place during very long time periods (decades, centuries); therefore, such processes are often difficult to be perceived in the usual observation times. However, there is an absolute need to study and understand scientifically such long-term phenomena, which by definition can not be reproduced in shorter time.

The so-called “accelerated ageing” processes are often deceptively based just on assumptions (e.g. time-temperature equivalence, or extrapolation of available data). Standard tests on adhesive joints require to “survive” short-term large stresses produced by moisture cycles, in order to approve them for moderate but long-term in-service stresses; for the very long expected life of WCHOs such an assumption is not reliable.
Therefore, new principles, criteria, observation and evaluation methods need to be developed in order to evaluate expected deterioration of WCHOs in the very long term.
Moreover, the properties and behaviour of “old” wood are not sufficiently known, as for what concerns the influence of ageing on the properties of ancient wooden artworks (ESTEBAN et Al., 2005, 2006). The knowledge of deterioration mechanisms of wood materials is also insufficiently developed.
One specific aspect is that the effect of time on degradation, even without biological phenomena, differs tremendously between different objects and different wood species, and is also related to the way the wood was handled before it was put in a construction. About this subject, there is a lot of practical knowledge in Europe, especially for oak wood, but a limited amount of scientific results.

Archaeological and archaeo-botanic wood

Archaeological wood refers to wooden artefacts, or parts of them, found in archaeological or paleontological stratigraphic land context, often in a wet or soaked condition.
The decay which affects wood from wet sites is mainly of biological and/or chemical origin, but a clear distinction between such two origins is often uncertain, since the biotic decay is a consequence of the enzymatic activity of some categories of organisms, particularly fungi and bacteria (BJORDAL, 1998; BLANCHETTE et Al., 1990; BLANCHETTE et Al., 1991; SINGH & KIM, 1997; POWELL et Al. 2001).
As a consequence of biological/chemical decay, archaeological woods often undergo significant physical-mechanical modifications such as decreased density, modification of EMC (Equilibrium Moisture Content) with given environmental RH% values, decreased anisotropy of dimensional variations and/or mechanical properties.
Soaked archaeological wood may reach MWC (Maximum Water Content) values up to 800-1.000%, increasing with the decay intensity. The volume shrinkage increases with MWC, and can reach even 80%; longitudinal shrinkage shows significant increase (SCHNIEWIND, 1990).
Characterization of archaeological wood is necessary before establishing any conservation program.

Timber structures

Timber structures belonging to Cultural Heritage obviously need to fulfil, as any other structure, all technical and legal safety requirements. However, the mere application of modern building design codes would often lead to consider such structures unsafe, which would imply their modification with interventions that could alter their technical and historical authenticity.
In fact, such structures have survived many years and centuries, and if duly maintained they can last many more.
There is therefore a need to improve present rules, to develop appropriate guidelines about criteria for conservation, and specific safety factors for verification of WCHO timber structures. Also specific appropriate load tests need to be improved and applied, as well as criteria for evaluating effectiveness and durability (during very long time, i.e. centuries) of interventions.
Historical timber structural systems can be saved through intervention (conservation or/and reinforcement, as needed) instead of replacement.
In particular, timber in seismic zones is extremely important for the integrity of monuments and historical structures.

Inspection of wooden structural elements in old buildings and assessment of their state of conservation and load-carrying capacity, are a necessary component of conservation strategies.
Visual inspection is always necessary, and might often provide more significant results if supplemented by equipment for (almost) non-destructive testing elements and joints, since some of them are often difficult to examine in depth because of their size, masonry walls, or decorated floors or ceilings.
Several methods are available (e.g. X-Ray densitometry and scanning, ultrasonic velocity, vibration analysis, drilling resistance) but their use and equipment still need to be improved (UZIELLI, 2001-2004).
Guidelines for inspection, assessment of load-bearing capacity, use of visual versus instrumental methods, practices and responsibilities, need to be developed for various situations, and included in standardization.
"Strength-grading" is a procedure for assigning with given reliability mechanical properties to timber structurs. Although the principles are basically the same for any timber, specific rules and parameters apply for specific wood species and provenances; a wide experience exists in many countries, and several CEN standards concerning "new" timber have already been published.
However, especially for existing WCHO timber structures, further knowledge is often needed, in order to take into account wood species and sizes used in the past times, and the effect of possible deterioration (e.g. fungal and/or insect decay) on the residual strength and stiffness of existing timber elements (UZIELLI, 2001-2004).

Wooden foundations

Already before the Roman area, wood was used all over Europe in foundations of buildings. From the 13th century onwards it was common to build on wooden foundation piles in areas with weak soils. At this moment many (historical) buildings are standing on a wooden foundation (e.g. thousands of houses and historical buildings in the Netherlands (Royal Amsterdam palace), down town Venice, Scandinavian cities (e.g. Stockholm, Helsinki, Gotenborg), St. Petersburg, Russia (e.g. the Hermitage), many buildings in Poland, etc. One of the threats is that if the wood is not water saturated for a long time soft rot fungi can be active. However, an even greater threat is bacterial degradation, which appears under water in anoxic conditions. Pine is especially sensitive for this type of degradation and it is estimated that almost half of all wooden beams used in European foundations are pine. For the Netherlands it is estimated that approximately 13 million pine piles are in service. Europe wide at least 130 million pine piles are used.
Controlling the process of bacterial degradation will provide tools to develop conservation methods for the piles in situ.
There is still insufficient knowledge on the process of bacterial wood degradation, a process most common under water (e.g. ship wrecks, foundations piles, water building constructions). There are strong indications that the rate of water movement in the wood is strongly related to the bacterial activity. If the influence of water movement in the wood is better understood, it will probably be possible to define strategies to control the soil hydrology or water streaming in open water which could give a reduction or even totally stop the wood degrading bacterial activity.

b) Wooden Cultural Heritage Objects objects (WCHOs)

In this section only a few examples can be given to underline the European dimension of the topic and to illustrate that this network is addressing a real current problem.

Music instruments

The Couchet, a harpsichord made by Ionnes Couchet in 1652, is a masterpiece and hence, considered and protected as a "National Treasure" in France; a challenge has risen when its restoration has been decided since the aim was to play this instrument again in concert. To anticipate the mechanical effects of various restoration strategies, the instrument and all the possible restorations were modelled with FEM; as a second step, the model has been fitted with non-destructive relaxation measurements; finally, the results coupled with the know-how of skilled harpsichords restorers have allowed to decide for one restoration protocol, satisfying both, the playability and conservation aspects.

Panel paintings and sculptures

A most significant and paradigmatic example of multidisciplinary approach in a research including the wooden support of a panel painting, can be found in the recently published book “Au coeur de la Joconde” (English version: “Mona Lisa: inside the painting”, published by Louvre Museum / Gallimard, 2006) concerning the world famous “Mona Lisa” panel painting by Leonardo da Vinci, on a 13 millimetres thick panel made of Poplar wood. This high quality book reports in detail the scientific research and analyses carried out at Louvre Museum by several specialists, coordinated by the C2RMF, on the occasion of the transfer of the artwork in the new show-case.
Together with historical aspects, analyses of the paint material and of the image, a whole chapter of the book concerns specifically the wooden support, its structure, the measurement of its geometry (both with and without contact), its influence on the craquelure of the paint layers, its physical and mechanical properties, its reaction to environmental variations. Based on long-term monitoring of its mechanical behaviour, a mathematical model has been established and verified, regarding the forces and stresses acting on the panel. The findings indicate that the degree of stresses do not entail risks of extending of the existing cracks (UZIELLI, DIONISI VICI & GRIL, 2006).

The Vasa ship

The 17th century Swedish warship “Vasa” was recovered in good condition after 333 years in the cold brackish water of Stockholm harbour. After extensive treatment to stabilize (by impregnation with PEG – Poly Ethylene Glycole) and dry its timbers, the ship has been on display in the Vasa Museum since 1990. Recently, salt depositions have indicated the possibility for ongoing degradation of the Vasa oak. Several scientific studies are performed, in order to clarify the reasons and mechanisms of such deterioration (SANDSTROM et Al., 2002). One group of scientists focuses on the mechanical properties of Vasa oak: a particular question concerns the mechanical properties and their dependence on the polyethylene glycole consolidant, moisture content and tissue degradation. Recent studies showed reduced compression properties in Vasa oak (50% in strength and modulus) and a difference in failure mechanisms as compared with recent oak, with specific emphasis on deformation mechanisms as studied by DSP (digital speckle photography) (LJUNGDAHL, BERGLUND and BURMAN, 2006; LJUNGDAHL and BERGLUND, 2006).

c) Standardization

Within CEN (European Committee for Standardization) the Technical Committee CEN/TC 346 “Conservation of Cultural Property” has recently been established. Some members of this Action participate, directly or indirectly, to the activities of CEN/TC 346. However, in order to encourage further work in the field of wooden artworks and to improve conservation strategies throughout Europe, there is a need to foster networking within the European scientific communities dealing with conservation of wooden Cultural Heritage.

B.3 European and global research, complementarity

Several national and European-funded research projects have been or are being carried out on subjects which fit well into the context of this COST Action. Just to mention a few:
- The EC-funded BACPOLES program (EVK4-CT-2001-00043), aiming to prevent bacterial decay of wood in foundation piles and archaeological sites, was recently successfully concluded, and some of its results will be instrumental for this Action.
- COST Action D42 “Chemical Interactions between Cultural Artefacts and Indoor Environment (EnviArt)” is running since 2006 in DC “CMST”; the topic is rather related to chemistry, and wood will play only a minor part in this Action, but the general concern about environmental attack on artworks and control through artificial aging techniques will make a collaboration evident.
- The COST Action E37 "Sustainability Through New Technologies For Enhanced Wood Durability", concentrated on the contribution of wood durability to sustainability through the development of systems for quality assurance and performance classification of modified wood and wood products as alternatives to wood treated with traditional wood preservatives.
- The EC-funded FRIENDLY HEATING project (2002-2005) developed a novel heating system for historic churches able to contain heat in the area where people seat and to minimize leakage of heat, dust and moisture to works of art. Numerical modelling and in situ monitoring of dimensional changes and acoustic emission of a wooden medieval altarpiece in the reference object of the project - the church in Rocca Pietore, Italy – was used to assess risk caused by various heating regimes.
- The EC-funded NOAH’S ARK project (2004-2007) is establishing meteorological parameters and variations which will affect in a critical way the material heritage environment in the coming 100 years. Besides, its aim is to develope strategies mitigating the resulting threats. A new improved climate risk index for wood exposed to the outdoor weather was proposed by using NMR imaging and numerical modelling to determine real moisture penetration depth and resulting real volumes of fungal infestation.
- The EC-funded SENSORGAN project (2006-2008) is developing sensors monitoring the principal hazards to the historic organs, including mechanical damage to wooden parts. Simple and economic acoustic emission sensors are being designed and tested to monitor directly and continuously the fracturing intensity in wooden elements of historic organs, induced by variations in their environment. The sensors developed can be further implemented to indicate risk of mechanical damage in a range of objects in museums or during transportation.

Apart from the time limited activities mentioned above, there are permanent institutional programmes that need to be mentioned:
ICOM-CC (the International Committee for Conservation of the International Council of Museums) has a “Wood and Furniture” Working Group, which covers all areas of wood such as wooden objects, wooden furniture, ethnographic wood (totem, poles etc), colored and painted wood, turned wood, gilded wood, structural wood, archaeological wood, wood technology and wood sciences. An intensive and fruitful cooperation with this working group is anticipated.
Cooperation with further international organizations will also be sought (including ICCROM, International Centre for the Study of the Preservation and Restoration of Cultural Property – ICOMOS-IWC, International Council for Monuments and Sites, International Wood Committee).

It must be stressed that, although cooperation and complementary with the abovementioned activities is anticipated and sought, there is NO OVERLAP with this Action. No other Action covers the same topic. This Action can be rated with a high degree of originality.

B.4 The framework of COST and WoodCultHer

COST is supporting networking of national funded research. Cultural Heritage is relevant to COST, as demonstrated by funding strategic workshops and specific Actions in different domains.
For the proposers COST was appealing for several reasons: first of all, cultural heritage is underrepresented in European funding programmes and every single opportunity is welcome to improve the situation. Research for cultural heritage in Europe is a national concern and many large museums but also private and public research organizations are partly dedicated to this item. However, the exchange of experience and the creation of synergy within those single initiatives are crucial to multiply the outcome. COST is providing this added value.
This COST Action provides a unique networking opportunity, i.e. a forum where professionals and scientists dealing with wood, and specifically with WCHOs, can meet to compare their experiences (same problems, in different countries, climates, type of objects...) and to improve conservation strategies.
Networking aside, the potential benefits of this Action are of great significance, and may be summarized as follows:

- fostering new ideas (new research projects)
- training researchers (both young and experienced professionals) in new specific techniques
- disseminating scientific information amongst the end users
- influencing standardization processes both at national and at European level (standardization of equirements, testing and evaluation methods, criteria).

C. OBJECTIVES AND BENEFITS

C.1 Objectives

Main objective

The main objective of the Action is to improve the conservation of our wooden cultural heritage by increasing the interaction and synergy between wood scientists and other professionals applying wood science and technology towards the study, conservation and restoration of wooden artefacts of artistic or historic interest (WCHOs, i.e. Wooden Cultural Heritage Objects).

Specific objectives may be identified as follows:

General

- To put into evidence how the modern scientific knowledge about wood may contribute to Diagnosis and Conservation of wooden Cultural Heritage.
- To favour meeting and interaction, at both scientific and practical level, of researchers in the field of wood, specialists in conservation of wooden artworks, manufacturers of equipment and products which might be successfully used for the diagnosis, restoration and conservation of wooden artworks.
- To acquire a deeper insight into several fields and processes concerning wood material (e.g. the ageing processes, their factors – physical, mechanical, biological, chemical, environmental – and their interactions), in order to improve the conservation of wooden artworks.
- To develop criteria for evaluating durability of interventions during very long time (centuries).
- To develop criteria for ensuring “re-treatability” (i.e. that present interventions will not impede future interventions, if and when needed).

Wood deterioration

- To develop new methods for the evaluation of new techniques and products for the conservation of wooden artworks.
- To acquire further understanding of the process of bacterial wood degradation in order to develop practical conservation methods to preserve historical wooden structures and remains in the soil.
- To further develop micro waves as a conservation method against insect degradation.

Diagnostic methods and equipments

- To develop and foster the implementation of the use of practical sensors to indicate risk to wooden objects in museums and at historic sites, or during the transportation of artworks.

Interactions between wooden artworks and environment

- To be able to better evaluate the interactions between individual wooden artworks and environment, also by direct monitoring physical changes and damage processes in objects.

Dendrochronology

- To stimulate the development of non-destructive high resolution scanners for in situ inspection of wooden objects to identify aging and degradation processes, that also allows tree-ring analyses (dendrochronology) for exact age determination.
- To disseminate results which obtained by applying "dendro-provenancing" techniques, in order to support further historical and technological studies.

Non-destructive inspection of wooden objects

- To further develop non-destructive methods and equipments, for inspection and evaluation of both movable and non-movable WCHOs.

Numerically modelling of risk of damage

- To develop and validate mathematical models and computer simulations of short- or long-term phenomena, from the observation of past events and processes, aiming towards prediction of future behaviour.
- To develop methods for predicting by simulation the long-term result of present interventions (e.g. present tendency to provide panel paintings with flexible cross-ties or frames).

Long-term behaviour and "accelerated ageing"

- To further explore specific subjects such as the properties and behaviour of "old" wood, the influence of ageing on the properties of WCHOs.
- New principles, criteria, observation and evaluation methods need therefore to be developed in order to evaluate expected deterioration of WCHOs in the very long term.
- To acquire knowledge and establish methods for studying deteriorations that take place during very long time periods (decades and centuries), and for evaluating the long-term compatibility of interventions, treatments, products, aiming to improve the conservation of wooden artworks.
- To develop adequate models of the ageing and deterioration processes, deriving from the observation of past events and processes, aiming towards prediction of future behaviour.

Archaeological and archaeo-botanic wood

- To improve prevention of bacterial decay of wood in foundation piles and archaeological sites.
- To develop methods and standards for evaluating procedures and products for conservation of archaeological and archaeo-botanic wood.

Timber structures

- To develop specific safety factors for verification of WCHO timber structures.
- To develop appropriate load tests for WCHO timber structures.
- To produce guidelines about criteria for conservation (and reinforcement, if necessary) of WCHO timber structures.
- To produce guidelines and standard documents concerning (for various situations and types of structures) inspection, assessment of load-bearing capacity, use of visual versus instrumental methods, practices and responsibilities.
- To develop criteria for evaluating effectiveness and durability (during very long time, i.e. centuries) of interventions performed on WCHO timber structures.
- To foster development of national or local grading rules for existing “old” timber structural elements; to encourage, make available and compare results of test campaigns aimed to determine reliable strength and stiffness values for such timbers.

Wooden foundations

- To improve knowledge and techniques appropriate for conserving wooden foundations piles under historical buildings.
- To increase knowledge on the process of bacterial wood degradation under water (e.g. ship wrecks, foundations piles), and to define strategies to control the soil hydrology or water streaming in open water leading to a reduction or even to stop the wood degrading bacterial activity.

Standardization

- To put in active contact the European scientific communities dealing with conservation of wooden Cultural Heritage, in order to provide a very strong and wide scientific background, and an informed consensus throughout European countries, for standardization (particularly of CEN/TC 346) in the field of wooden artworks.
- To contribute to European Standardization in the field (inputs to CEN/TC 346 "Conservation of Cultural Property")
- It should be emphasized here that since in the field of Cultural Heritage each artwork – especially if made of wood – is different (materials, wood species, manufacture, history, environment(s), decay/deterioration, interventions, …), each artwork needs/deserves a “personal” care, i.e. individual assessment, evaluation, solutions; therefore the technical standards should specify methods and criteria, not “standard solutions” to problems.

C.2 Benefits

The dissemination of scientific knowledge, recommended practices, diagnostic tools and methods, concerning the Conservation of wooden Cultural Heritage throughout European countries will produce numerous benefits, both conceptual and practical, for museums, collections, churches, historical buildings, for the persons in charge of their conservation, as well as for the general public.

European technical standards from CEN/TC 346, as well as other technical documents and recommendations, will be based on wider and deeper scientific knowledge.

General topics are:

- to facilitate inter-change of experience, techniques and personnel between European research institutes and organisations to avoid duplication and create added value;
- to hold conferences and workshops to provide up-to-date information on potential improvements in conservation of WCHOs, including evaluation methods for products and techniques.

The expected benefits for the scientific community, from this COST Action are:
- sharing of information across Europe from specific national research programmes and EU projects to support the development of a European Research Area;
- encouraging interdisciplinary research between the scientific community and industry;
- facilitating the creation of efficient research consortia addressing the needs outlined above and likewise adding value to ongoing co-operative research programmes (at the national as well as European level) and initiation of further projects;
- exchange of skills and experience across Europe in specific laboratory research techniques through short-term scientific missions;
- increasing competence of professionals and of young researchers, by means of Training Schools addressing specific subjects.

D. SCIENTIFIC PROGRAMME

This COST Action aims to produce interaction between researchers in various fields of wood, who specifically deal with conservation of Cultural Heritage. Such interaction will encourage and promote the above mentioned objectives.
In order to ensure the achievement of such objectives, the work programme of this COST Action may be subdivided into the following themes:
1. Mechanisms and characterization of wood ageing, changes of properties and behaviour of wood and of wooden artworks: properties would include ultra-structural, physical and mechanical, chemical, rheological, biological etc., as well as some very peculiar ageing processes concerning archaeological and water-logged wood
2. Non-destructive (micro samples allowed) and non-invasive methods and equipments for in situ and ex situ diagnosis and study of WCHOs
3. Criteria for evaluating procedures, techniques and products for interventions on wooden artworks (“acceptable, respectful and compatible”).

Three Working Groups will be formed on the basis of the above mentioned themes. Room for some flexibility should be left, and thus a forth Working Group could be established if needed.

E. ORGANISATION

The scientific programme will be based on three thematic Working Groups. Room for some flexibility should however be left, if the need for a further WG emerge at the start or during the course of the Action.
These groups and their sub-goals will be discussed below as scientific areas. The Working Groups will be coordinated by the Management Committee (MC).

The Action will be in compliance with the general rules of COST and will include:
- Technical and management meetings
- Workshops, conferences and seminars
- Exchange of experts, scientists and graduate students for training
- Joint projects in specific areas by two or more participants
- Pre-normative actions, joint publications and support for policy
- Education and training

With the exception of the Management Committee meetings, all meetings will be open to interested parties.

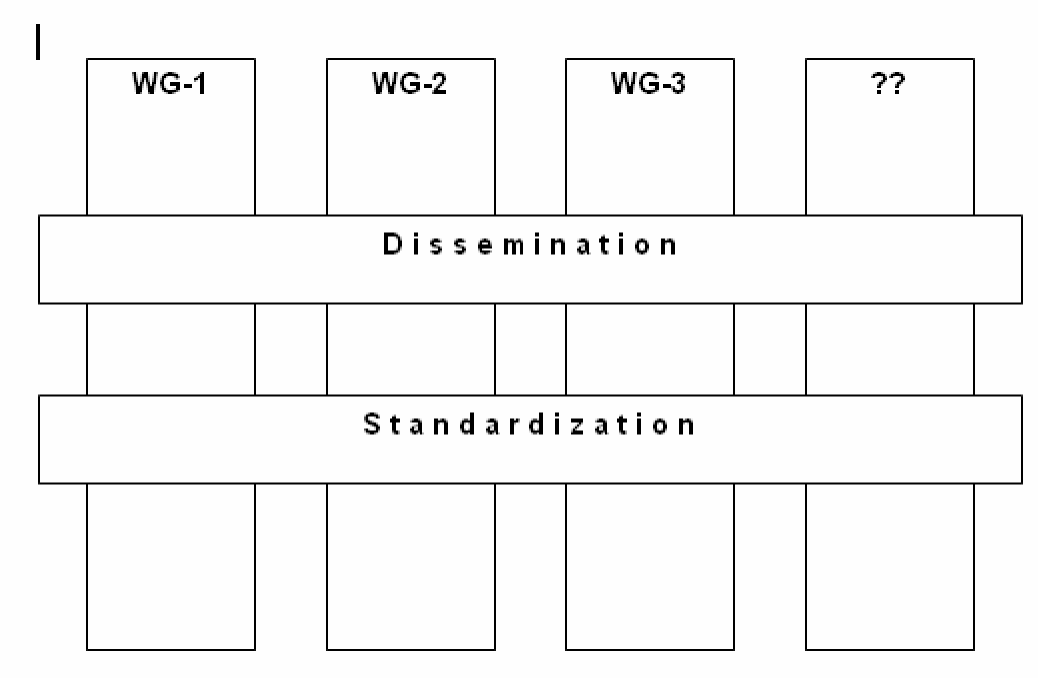


Figure 1. Organisation of the Action

While the working groups carry on their activities, they jointly participate to the "transverse" activities, such as dissemination and standardization (see figure 1).
Dedicated reports will be published by the WGs and composed to the annual report of the Action.
A Short-Term Scientific Mission (STSM) Manager will be responsible for the STSMs.
The coordination of the time schedule as well as contact with other COST Actions or potential partners will be organized by a Steering Committee consisting of the Chairperson of the Management Committee as well as the Coordinators of the Working Groups. Conferences, workshops, scientific meetings, exchange of researchers, Training Schools will be organized.
A web site will be developed for the on-line dissemination of the activities and results achieved by this Action.
Research projects fitting into the sub-topics described above will be submitted by scientists to the Management Committee members.
The organizational structure of the Action is depicted in Figure 2.
Training schools for young researchers and professionals will be organized by the Action.
Involvement of young researchers will be encouraged by targeting at least 10% of the Action's budget towards the participation of young researchers to Training Schools and Short Term Scientific Missions.
Gender balance will be assured all along the Action's development.
Means for attracting Students towards the Action's subjects and activities will also be considered, possibly but not exclusively through the Action's website.

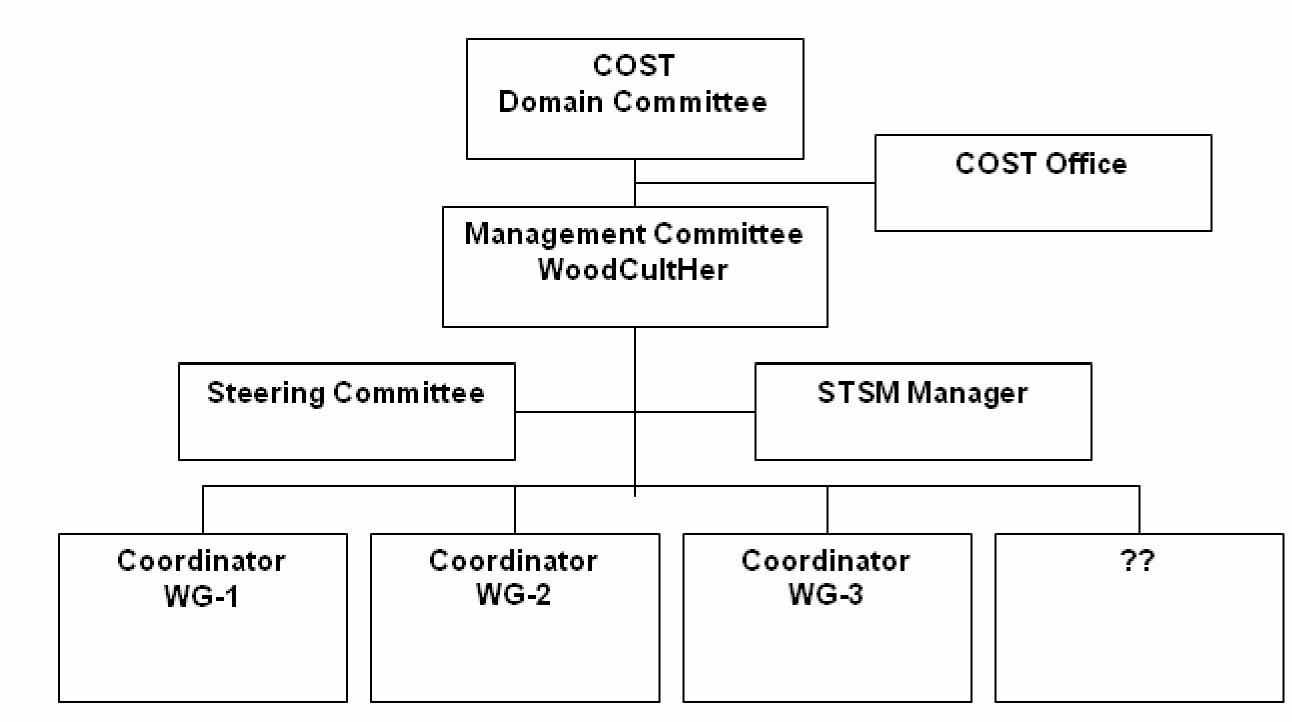


Figure 2: Organization structure of the COST Action

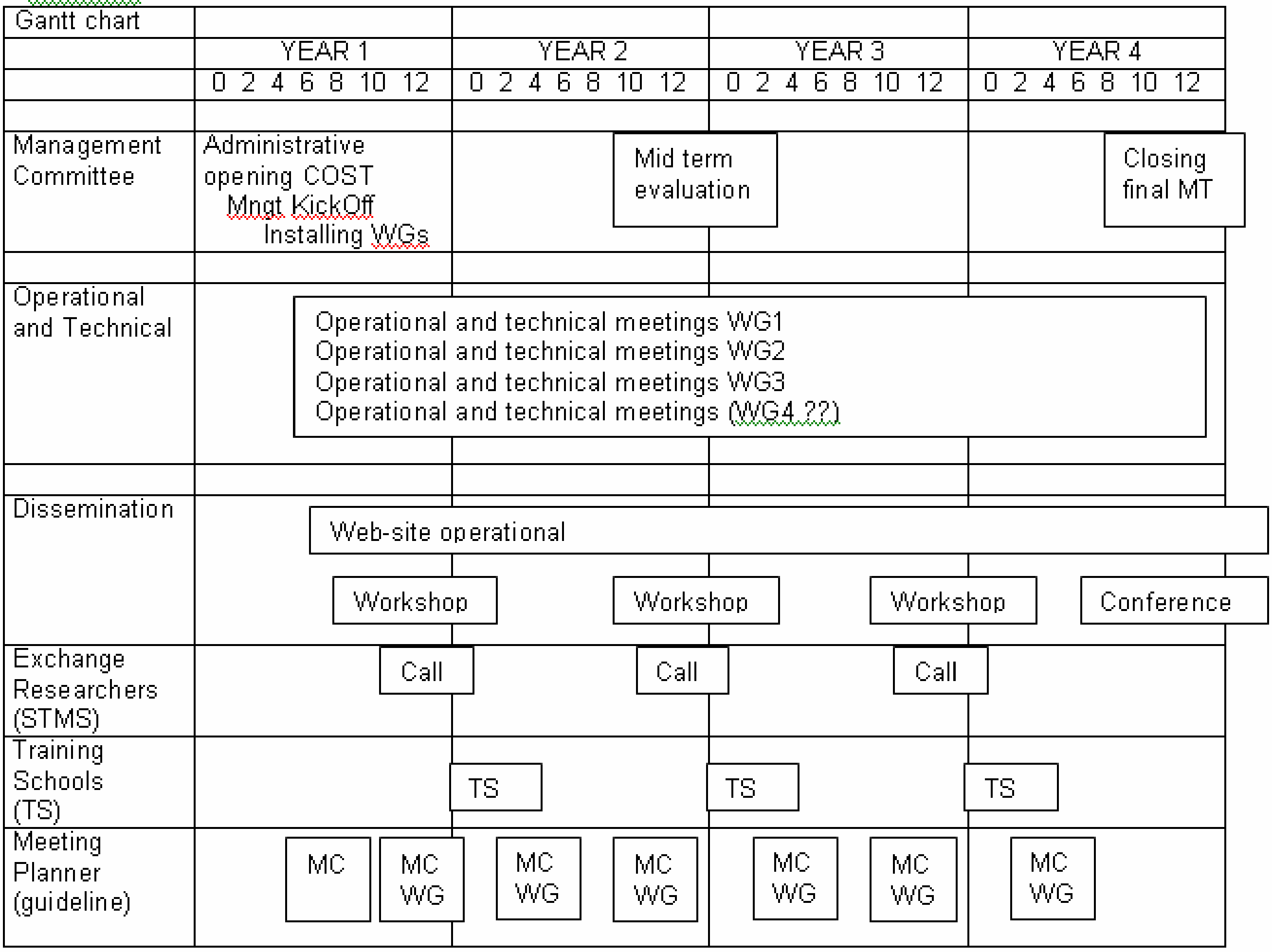
Monitoring and evaluating the achievements and objectives:
A mid term evaluation is foreseen, which will be organized as public workshop with the invitation of two external experts, one more technically based and one representing the end users. Any kind of change in research strategy will be considered, if the objectives are not in target. Annual reports will be provided. The final evaluation workshop will be assisted again by two external experts.

In order to assess potential application and for fostering exploitation of the results, the following provisions have been made:
- the web site of the Action will remain open after the end of the Action and updated with the list of publications and further developments
- potential end users will receive the contact details of the Action partners to maintain the network and encourage further collaboration.

F. TIMETABLE

The duration of the Action is four years.
During the first year of the Action, the kick-off meeting will take place where the Working Groups will be established.
Each WG as well as the MC will meet once or twice each year.
A mid-term evaluation is planned after 24 months.
Each Action-year ends with an event (workshop or symposium, final Conference).
Training schools for young researchers and professionals will be organized by the Action.
Table 1 shows a Gantt diagram with the general schedule of the proposed Action.

Table 1. The schedule of the COST Action



G. ECONOMIC DIMENSION

The following fifteen COST countries have actively participated in the preparation of the Action or otherwise indicated their interest:

Austria,	Belgium,	Croatia,
Czech Republic,	France,	Germany,
Greece,	Ireland,	Italy,
Poland,	Portugal,	Slovenia,
Spain,	Sweden,	The Netherlands,
United Kingdom.		

On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated in 2006 prices at 120 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

A public accessible web site will be established showing the results of the COST Action and the planning of the events. This site will be directly linked with the COST web site. The site will include also a password-protected area for quick exchange of working documents and draft reports/publications.
Dissemination of the work will also be done by official conference proceedings from each open event.
The reports of short-term scientific missions and Working Groups will be published on a regular basis on the website, in appropriate journals and proceedings of international conferences.
All publications arising from research carried out under this COST Action will acknowledge COST support and the MC will encourage and promote co-authored papers. Work carried out will also be submitted for publication to international journals and reviews.
The connection to CEN concerning standards will be realized by participating or providing documents for its activities.
The MC will keep contact with international and intergovernmental organizations active in this field and also use their means of dissemination. During its activity, and at its conclusion, the COST Action will be presented to policy makers and the general public in order to raise awareness of the obtained results and applications, and of the need for continuing research for conserving, protecting and maintaining our wooden cultural heritage.
Dissemination of results will be addressed to various types of end-users by different methods, outlined as follows:

Types of end-users	**Main methods for addressing the results of the proposed Action**
- General public - Scientists non directly involved in the Action - Manufacturers and service providers	- Posting of general information on the public part of the Action's website - Publications (on paper, on CD, downloadable): state of the art reports, interim reports, case study reports, proceedings, guidelines, manuals, final reports - Articles in scientific and technical Journals - Non-technical publications
- Scientists directly involved in the Action	- Posting of working documents on the password-protected part of the Action's website
- Scientists and professionals directly or indirectly interested in the Action - Manufacturers and service providers	- Workshops, seminars conferences and other events organized by the MC - Contributions to other national and international conferences and symposia - Articles in scientific and technical Journals
- Other research frameworks	- Establishing links, creating links with their websites
- Standards Bodies	- Participating and/or providing information to Standardization Groups (national, and European)
- European level policy makers, policy makers	- Contacts, as appropriate