COOP CT 2004 508737

WOODSTONE
"Intelligent System for Optimising the on-line Finish Process
for stone slabs and wood panels"

CO-OPERATIVE RESEARCH PROJECT

PUBLISHABLE FINAL ACTIVITY REPORT

Period covered: from 1st July 2004 to 30th June 2006
Date of preparation: July 2006

Start date of project: 1st July 2004 Duration: 24 months

Project coordinator name: Ing. Michele Coluccia
Project coordinator organisation name: C.G.S. di Coluccia Michele & C. sas

Revision: draft

B/ Table of contents

WOODSTONE PROJECT

1. Project execution 3

1.1 Project objectives 3

1.2 Project consortium 4

1.3 Work performed and end results 5

1.4 Methodological approach employed 7

1.5 Project achievements to the state-of-the-art 10

1.6 Project impact on the stone and wood sectors 12

1.7 Project photos 14

1.7 Project logo 16

1.7 Project Web-Site 16

2. Dissemination and use 17

1. Project execution

1.1 Project objectives

The general objectives of the WOODSTONE project were:

- Design, development and testing of a system for acquiring information on stone slabs and wood panels during final manufacturing phases and for assessing final product quality.
- The system will be made up of a digital camera, 3D laser scanner and hyperspectral device. The information acquired will be collected and elaborated by three specific SW systems.

More specifically, the technical project objectives consisted in:

- Supply reference parameters to final material manufacturing phases that influence finished product quality level: *semi-finished products are examined and the machines are informed on which operative parameters to respect on the basis of the desired qualitative standards.*
- Supply objective data to the finished product classification phase divided according to various quality levels: *finished product quality may depend on colour considerations and also on number and type of still existing defects on the finished product.*

At the moment, both the stone and wood industrial cycles are composed of various operative phases. In both cases, the industries produce semi-finished products that need to undergo final finishing phases: polishing and planing. These final operative phases, according to the working methods adopted, may influence the finished product quality level. In the greater part of cases, finishing is carried out in a standard way or is entrusted to experts' common sense. The project has been conceived by considering this situation. From a scientific point of view the core of the issue consisted in knowing how to adapt modern technologies (3D scanner, hyperspectral analysis and digital camera) to the project's specific needs. Two main problems needed to be tackled:

- Data acquisition phase: the equipment used must be interfaced and adapted to a particular type of data acquisition phase. The material defects are quite different, the material dimensions to be assessed (precisely) are large, colours could be extremely important, etc. In other words, assembling and adapting the individuated components to the project aims is in no way commonplace.
- Data collection and elaboration: the interpretation and the need to manage and link various types of data in such a particular field, is very demanding. The dedicated SW systems must characterise all the various types of existing defects: this may be carried out in strict connection with the end-users' experience; the "significant parameters" that must be

determined together with the end users must, in view of the subsequent finishing operations, be able to completely characterise the acquired defects.

1.2 Project consortium

List of Participants				
Participant Role	**Participant no.**	**Participant name**	**Participant short name**	**Country**
Contractor	1	COGEMAR Srl	COGEMAR	Italy
Contractor	2	CELVER Srl	CELVER	Italy
Contractor	3	AUTO Y C.N. SL	ACN	Spain
Contractor	4	PROYECCION EUROPLAN XXI, SL	PROYECCION	Spain
Contractor	5	GMG D Grammatopulous and Associates LTD	GMG	Greece
Contractor	6	IRIS MARBLE S.A.	IRIS	Greece
Contractor	7	SODEX ood Ltd.	SODEX	Bulgary
Cordinator	8	C.G.S. di Coluccia Michele & C. sas	CGS	Italy
Contractor	9	Dipartimento di Ingegneria Chimica di Materiali Materie Prime e Metallurgia – Università di Roma La Sapienza	DIC	Italy
Contractor	10	ERICA S.c.a r.l	ERICA	Italy
Contractor	11	Universidad Miguel Hernandez	UMH	Spain
Contractor	12	ELKEDE Design and Technology Center S.A.	ELKEDE	Greece

Co-ordinator contact details

Ing. Michele Coluccia

C.G.S. di Coluccia Michele & C. sas

Borgo Stretto, 10

56127 PISA – ITALY

Tel.: 0039-050-573205

Fax: 0039-050-573854

e-mail: cgs@cgsgroup.it

web-site: www.cgsgroup.it

1.3 Work performed and end results

The final outcome of the Woodstone project consisted in the implementation of a system to be positioned at the end of the wood and stone finishing cycle. The system, made up of three different types of equipment, was mounted upon a frame of cast iron pipes. A specific software system was set up for each equipment, while the developed lighting system was suitable for the overall system. The WOODSTONE prototypal system was implemented in the industrial premises of the Italian SME, project partner, COGEMAR and is made up of the following components:

- A metal structure with Innocenti tubes with maximum height from ground level equal to 4 metres;
- The WOODSTONE metal structure is positioned at the end of the traditional polishing work cycle, on the roller conveyor normally located at 80 centimetres from ground level where the stone slab or wood panel is placed for the polishing phases;
- Eight 135cm-long and 80 Watt neons (four on each side) located upon 2 Innocenti tubes positioned on the outer side of the roller conveyor directed towards the opposite-facing structure sheet; specific deflectors are used for diffusing light and avoiding reflections on the stone lab/wood panel;
- Laser scanner, digital camera and hyperspectral equipment, positioned at the structure top upon a connecting Innocenti tubes and specific supports;
- Devices for modifying the positions of scanner, camera and hyperspectral equipment according to the slab/panel to be acquired. The scanner, for example, must be positioned at 2.50 metres from the slab/panel. This distance must be modified for the other components.
- White sheets positioned on the four sides of the WoodStone structure to enable optimum image capturing of the slab/panel.
- SW interface equipment capable of setting up a quality control methodology for final quality assessment and automatic standards classification.
- The prototypal system assembled as described above and with the fully-tested system components will allow operators to carry out all acquisition and data elaboration operations in no more than 20 seconds, considering around 10 seconds for acquisition phases and 5 seconds for SW data elaboration operations.

The three equipments – laser scanner, hyperspectral system and camera – were all thoroughly tested in laboratory and on industrial scale. The test results showed that from an industrial viewpoint, the most effective and promising results were obtained with the digital camera and, consequently, with the specifically developed software. The camera, in fact, is able to give overall

qualitative and quantitative information on the interested wood panel or marble slab: this is important for firms and companies working in the wood and stone manufacturing sectors because interesting classification information and items may be acquired which is important from a commercial point of view. The laser scanner and hyperspectral system, instead, although able to analyse a single defect and give detailed qualitative information on such defect, are not able to give the same general commercial information as in the case of the digital camera.

While the laser scanner and hyperspectral system could be important interfaces for individuating and/or analysing details upon valuable materials and for setting up a more specifically detailed database, the digital camera is a highly practical tool which can be used for ordinary materials that are commonly treated and processed in wood and stone industries. In practical terms, therefore, the digital camera has certainly met the goals foreseen by the project and, in particular, by the project SMEs.

In detail, the 3D laser scanner enables to study and to measure area and distances in deep detail; the depth of a defect can also be thoroughly evaluated. This is interesting for analysing defects and for creating a database when handling and treating valuable materials. The scanner however also presents flaws: firstly the sample needs to be still when acquiring the slab/panel image. Although acquisition is very rapid, the working cycle is interrupted: this is not particularly convenient from an economic point of view for low-cost materials. Furthermore, the image acquisition does not cover the entire slab or panel and a series of acquisitions are needed to acquire the whole image. As mentioned above, this could be conducted for particular and specific cases (the need to study a particular defect, valuable materials, etc.) but not for everyday industrial work. Therefore, although the laser scanner laboratory tests achieved excellent results, it presented the two foregoing industrial problems.

The specifically developed software analyses all materials and distances that could be of interest when treating valuable materials.

Regarding system positioning, the laser scanner was positioned after the digital camera also for reasons of size.

The hyperspectral system gives excellent and thorough information on the materials composing the panel or slab. The system, therefore, is able to give details on the internal parts of the panel/slab and on the composition of a defect. From an industrial point of view, however, a main defect was individuated: the application field is quite small. Again, as in the case of the laser scanner, this system is interesting in order to acquire specific information on particular materials or defects.

The software set up for the hyperspectral system gives information on material/defect composition through a series of graphs.

Regarding system positioning, given its reduced size the hyperspectral system was positioned next to the digital camera.

The digital camera gave best results during the industrial tests. The entire slab and/or panel image was easily acquired by the camera and defects were immediately detected, even more superficial ones. For example, defects caused by the passage of rollers during the polishing phase were detected by the camera and well detailed in the camera software. Naturally, the camera is not able to acquire 3D images, therefore the depth of a defect may only be studied by using the 3D laser scanner.

The software set up for the digital camera may be easily used by all operators and is more user-friendly than the software set up for the laser scanner and hyperspectral system. In particular, the digital camera software gives a qualitative commercial evaluation on the material analysed by automatically providing the operator with real-time information on the quality of the examined slab and/or panel. Being able to have both defect and commercial classification details in real-time on the material treated by wood and/or stone manufacturers is an extremely interesting and important opportunity.

The SMEs involved in the Woodstone project are extremely satisfied with the project results. The overall system is able to respond to different requirements according to the type of materials that need to be manufactured. For ordinary materials, the digital camera gives excellent results on material defects and real-time, qualitative and commercial information that is easily managed by operators without specific computer skills. The system, however, also comprises other two systems that can be used upon more valuable materials and that give specific and more detailed information/measurements on defects and material composition.

1.4 Methodological approach employed

The overall project was divided into the following Work-Packages**:**

WP1 – Characterisation of the state of the art (future end-users belonging to the stone and wood sectors; advanced technologies available on the market that could be of interest to the project prototype and its components).

WP2 – Characterisation of technical specifications.

WP3 – Prototypal system design.

WP4 - Prototypal system implementation.

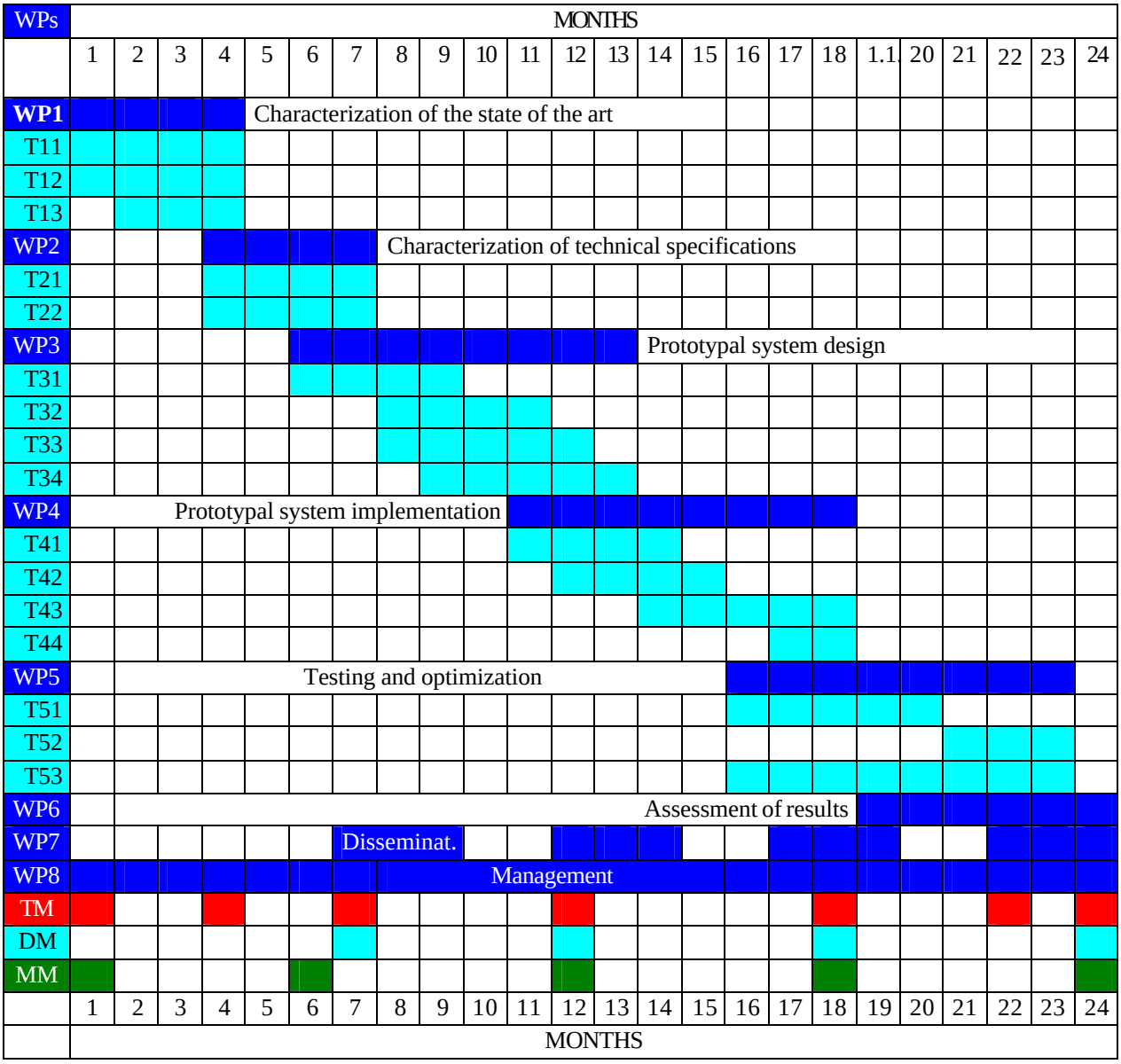
WP5 – Testing and optimisation.

WP6 – Assessment of results and exploitation plan.

WP7 – Dissemination

WP8 - Management

WOODSTONE GANTT Chart



Keys:

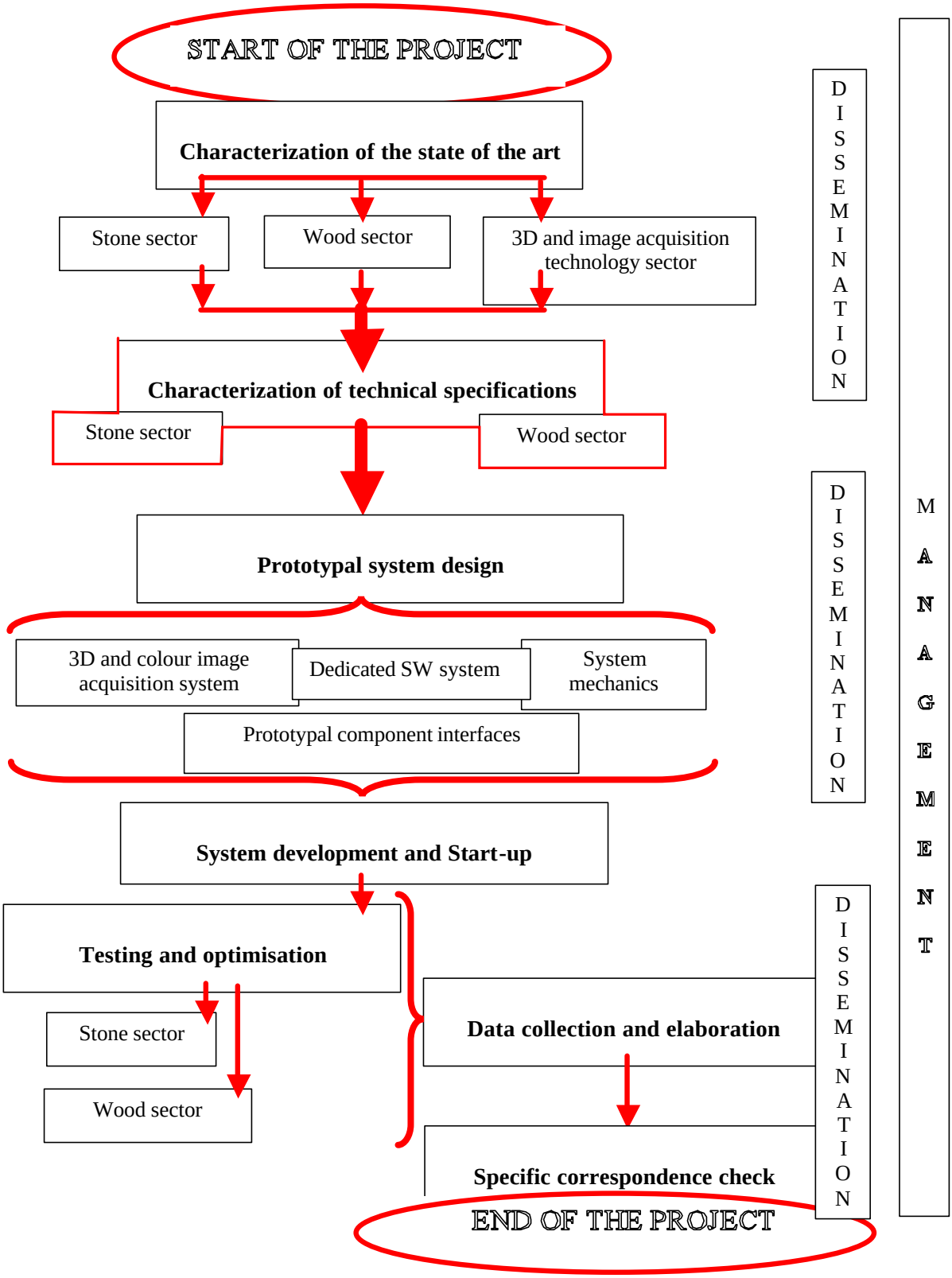
WP: Work-packages

TM: Technical Meetings

DM: Diffusion meetings

MM: Management Meetings

WOODSTONE PERT diagram



1.5 Project achievements to the state-of-the-art

Preliminary literature and patents research showed that no publication exists concerning eventual dedicated apparatus which can produce images for defects detection on the finished/polished surface of the stone and wood materials. Actually the methods employed in the manufacturing companies to assess the quality of marble or granite slabs and wood products are mostly based on human observation, thanks to the practical knowledge of the sector operators.

Application for Stone

The documentary study performed during a feasibility stage of the project has showed how in the stone industry the quality controls on the polishing lines for the ornamental stones, marble, granite and natural stones, are currently carried out by means of simple visual inspections seldom with the help of manual instruments such as *gloss-meters* based on the “light reflection” or *surface roughness* meters (as the Taylor Hobson type). These controls are aiming at measurement and evaluation of the following aspects:

- surface brightness
- polishing defects, i.e. wheel marks
- micro-cracks, voids etc.
- aesthetic defects, i.e. rust, spots, excessive veining, colour differences which affects the material uniformity.

In some leading companies, like the stone manufacturer COGEMAR, which are operating in accordance with the ISO 9000 Q.C. system the checking results from the manual inspection of finished slabs are regularly recorded in suitable documents for the product testing files. The commercial sizes of slabs are carried out by means of the usual measure instruments – scales – while the slabs thickness is seldom verified by the use of a calibre. Also the surface planarity controls are performed visually and, in case of doubt, by means of a simple metal strip. Anyhow the planarity of slabs is usually checked before the finishing process, very seldom after the slab cutting. No on-line control is provided and the aesthetic characteristics and the finishing results are evaluated by the machine operator on the basis of his own experience therefore he is also able to manage the polish process parameters.

Application for Wood

Wood represents one of the most used materials world-wide. According to its use or application (exterior and interior), its quality (selected essence) and characteristics(that is for a certain essence the degree of seasoning), its workability, its resistance to ageing, etc. wood presents different values. Surface finishing independently from its further use constitutes one fundamental and important processing stage, both if performed in a wood processing plant or after laying. As for

stone a lot of work was done to characterise wood in terms of its physical general properties, however so far there is no specific and systematic study or industrial system trying to correlate wood surface finishing status and properties, carried out adopting manual procedures, with the wood behaviour. As for stone wood surface finishing not only affects the structural and textural characteristics of the manufactured goods in esthetical terms but also influences their behaviour in terms of *durability* and *performance*.

During a preceding feasibility phase of the *Wood-Stone* project a documentary study has been carried out about the state-of-the-art and the existing technical scientific literature, publications, patents, standards and data-bases.
In spite of differences between stone and wood machining, the basic principle of controlling the polishing process is the same for the two types of materials. The achieved degree of surface finish or polishing is actually controlled on the base of human experience therefore is not reproducible. The worker decides on the base of his knowledge and his level of expertise which tools are to be used for each material, which kind of working procedure and when the polishing can be considered satisfactory.
The preliminary feasibility studies demonstrated as such an approach presents big limits. Stones, on one side, and wood, on the other, are respectively constituted by different lithotypes or essences presenting marked differences in terms of workability (due for stones to the different mineralogical composition and textural properties and for wood to essences' fibres and texture characteristics). For each family of these materials is thus necessary to utilize specific tools, abrasives and procedures, according to materials mechanical properties and induced actions on the products surfaces. Finally in the stone and wood manufacturing lines the interpretation of test results in order to classify the end products is only based upon experience and know-how of the inspection operators.

The development of the *Wood-Stone* system should have the following innovative goals:

- Objective classifier for quality degree of end-products;
- Results able to support CEN test Standards and compliance for certification to improve competitiveness of European ornamental products on the international market;
- Increasing of technical personnel qualification level to face the employment dropping trend;
- Process optimisation by the definition of standard working parameters valid for classes of analogues materials;
- Productivity increase, associated with an improved level of process quality.

- Definition of objective aesthetic parameters established on data bases valid for the most common stone and wooden panel categories. As a consequence an automatic classification of the properties of the two kinds of materials can be implemented.
- On-line mapping of the surface defects (micro-cracks, porosities, etc) and process imperfections (wheel marks, coarseness, etc).
- Continuous check of the polishing or finishing result in terms of brightness.
- Automatic measurement of the commercial slabs finished sizes.
- On-line control of thickness and planarity of slabs and panels.
- Q. C. records containing all the material and process data for commercial and contractual use.

This kind of new testing equipment will allow the stone/wood manufacturing enterprises in Europe to meet the actual concept of "total quality" for the finished products, also optimising the slab and panel finishing costs which are both highly required to face the competitiveness on the international stone and wood markets nowadays.

Finally the implementation and setting up of a non-destructive system able to fulfil a quality control methodology applicable to the stone sector, will permit the proper issue of a specific normative and test standards to be used for quality selection of the ornamental stones. This classification is essential to emphasise as the stone valuable characteristics are the fundamental way towards better economic targets of the European manufacturing SMEs in accordance with the Community strategic Policies. In particular the new European standards, now under preparation for dimension stones by CEN T246, could be a normative frame for adopting the new control procedures just based on the *Wood-Stone* prototype system

As conclusion it can be evidenced how the main *innovation* of this project is to investigate, understand and develop special control procedures in order to realise the optimal control of the materials surface finishing.

Today such an innovative system does not exist even if in presence of well identified industrial needs in the wood and stone sectors, therefore the development of the present project is of utmost importance.

1.6 Project impact on the stone and wood sectors

The stone and the wood industries are present in various European countries like in Italy, Spain, Portugal (for the stone sector) and in Finland, Germany, Sweden, Austria, France, United Kingdom, Denmark and Italy (for the wood sector) where both represent a very important economic sector in each country.

Both the European stone and wood sectors have faced a strong crisis during the past years caused by competitiveness from other producing Countries. In order to give a clear importance of the project results impact, it is useful to synthetically go through the strategies undertaken by European enterprises during the last decades. Competitiveness of non European enterprises has exceedingly grown during the last decade due to the following main reasons**:**

- Competitive labour costs;
- Much lower, if not completely non existing, waste disposal costs owing to the lack of environmental and working safety regulations;
- Raw material proximity;
- Progressive learning of working methods;
- Progressive acquisition of industrial technologies.

Against this, European enterprises are forced to face a market where their products may no longer boast those requirements that, for decades, used to make them competitive on all world markets. In other words, both in the wood and stone sectors (other industrial sectors could also be mentioned: footwear, tanning, textile, paper, etc.), non European finished products may be found on the market that are made with high quality raw material, that are well-manufactured and that cost less.

For this reason it is easy to understand how Europe must quickly and properly cover the road of technological innovation. The WOODSTONE project, in fact, intends to make new equipment and innovative and efficient working techniques become available to stone and wood enterprises. Thanks to these they will be able to reach two crucial, competitive requirements:

- Greater industrial process automation;
- Greater and standardised production quality.

The main objectives of the *Wood-Stone* project was to develop a *prototype control system* and to set up the relevant working procedures able to measure the fundamental parameters which can be correlated with the surface characteristics of the stone and wood materials produced in accordance to a Q. C. system organisation. The new system after a period of industrial testing in both stone and wood sectors will be processed for respective patents.

The development of this innovative system will allow the end user (stone and wood manufacturing industries) to acquire a competitive advantage as to maintain or consolidate the leadership that EC countries currently own respect to the non-European competitors. The system manufacturer SMEs will obviously open their market position as suppliers of inspection equipment in the stone and/or wood machining sectors. This will be obtained thanks to the envisaged engineering and industrialisation of the innovative WOODSTONE system characterised by performances that cannot be actually found in the stone and wood industries. The possibility, in fact, to develop a

system, and the related analytical processing strategies, able to detect, directly during the finishing processes, the characteristics of the surfaces both in terms of their aesthetic attributes (i.e. surface patterns, roughness) and/or their reflectance properties will permit to control the process on the basis of pre-assigned rules, optimising in this way the entire process without any human intervention. Such an approach will allow the manufacturing SMEs to produce more standardised and homogeneous products, envisaging the possibility to recognise as *"objective (quantifiable) quality certification"* a material attribute, i.e. the *surface finishing status*, strongly influencing the quality of the final product, so far completely ignored by producers and by the market.

1.7 Project photos

The following photos show the implementation of the WOODSTONE prototypal system in the industrial premises of the Italian SME, project partner, COGEMAR and some details of the prototypal system components:

Figure 1 and 2: WOODSTONE metal structure positioned at the end of the traditional polishing work cycle

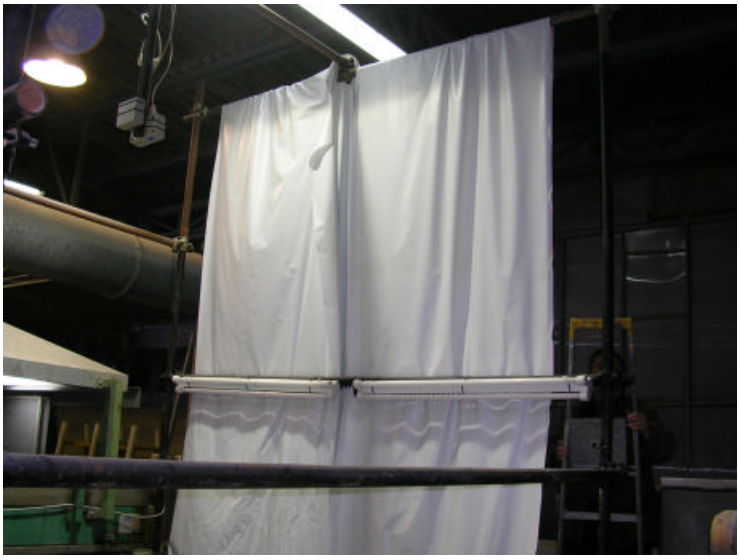


Figure 3 and 4: Details of the white sheets and of the neons positioned on the WOODSTONE metal structure

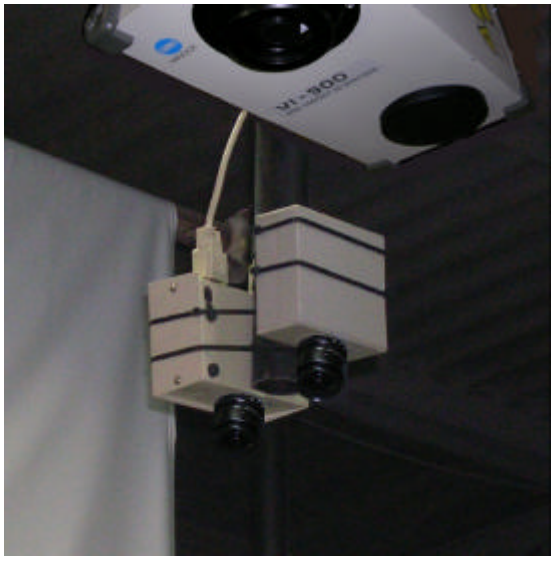


Figure 5 and 6: Details of the project equipment (camera, 3D scanner and hyperspectral system) positioned at the top of the WOODSTONE metal structure

1.7 Project logo

The WOODSTONE partnership defined the following project Logo:

1.7 Project Web-Site

During the first year of Wood-Stone activities the project website was defined: www.wood-stone.net.

The web site has a restricted area specifically dedicated to the project partners and an area open to the general public containing information on the project objectives and activities.

The aim of the web site was the development and diffusion of a tool that is able to diffuse the innovative project technology, to facilitate the exchange of experiences between possible users and of work developed by the different partners.

The web site was continuously updated throughout the course of the whole project.

2. Dissemination and use

Result 1. Innovative stone and wood inspection system

The innovative stone and wood inspection system will be used for acquiring information on stone slabs and wood panels during final manufacturing phases. Final finishing phases are today entrusted to the common sense of specialized workers. The project system intends examining in an objective way the semi-finished products and suggesting operative parameters to the equipment in strict relationship with desired qualitative standards.

The final outcome of the WOODSTONE project consists in the implementation of a system to be positioned at the end of the wood and stone finishing cycle. The system, made up of three different types of equipment, was mounted upon a frame of cast iron pipes. A specific software system was set up for each equipment, while the developed lighting system was suitable for the overall system.

The WOODSTONE prototypal system was implemented in the industrial premises of the Italian SME, project partner, COGEMAR and is made up of the following components:

- A metal structure with Innocenti tubes with maximum height from ground level equal to 4 metres;
- The WOODSTONE metal structure is positioned at the end of the traditional polishing work cycle, on the roller conveyor normally located at 80 centimetres from ground level where the stone slab or wood panel is placed for the polishing phases;
- Eight 135cm-long and 80 Watt neons (four on each side) located upon 2 Innocenti tubes positioned on the outer side of the roller conveyor directed towards the opposite-facing structure sheet; specific deflectors are used for diffusing light and avoiding reflections on the stone lab/wood panel;
- Laser scanner, digital camera and hyperspectral equipment, positioned at the structure top upon a connecting Innocenti tubes and specific supports;
- Devices for modifying the positions of scanner, camera and hyperspectral equipment according to the slab/panel to be acquired. The scanner, for example, must be positioned at 2.50 metres from the slab/panel. This distance must be modified for the other components.
- White sheets positioned on the four sides of the WoodStone structure to enable optimum image capturing of the slab/panel.
- SW interface equipment capable of setting up a quality control methodology for final quality assessment and automatic standards classification.
- The prototypal system assembled as described above and with the fully-tested system components will allow operators to carry out all acquisition and data elaboration operations in no more than 20 seconds, considering around 10 seconds for acquisition phases and 5 seconds for SW data elaboration operations.

Result 2. Quality Control Methodology

WOODSTONE has set up a quality control methodology through specific SW systems in order to assess final product quality. A software system was set up for each part of the overall stone and wood inspection system (3D laser equipment SW, spectral analysis equipment SW, digital camera SW) specifically adapted to stone slab and wood panel processing quality. The quality control methodology allow the issue of specific normative and test standards to be used for stone and wood quality selection of the ornamental stones.

The three equipments – laser scanner, hyperspectral system and camera – were all thoroughly tested in laboratory and on industrial scale. The test results showed that from an industrial viewpoint, the most effective and promising results were obtained with the digital camera and, consequently, with the specifically developed software. The camera software, in fact, is able to give overall qualitative and quantitative information on the interested wood panel or marble slab: this is important for firms and companies working in the wood and stone manufacturing sectors because interesting classification information and items may be acquired which is important from a commercial point of view. The laser scanner and hyperspectral software systems, instead, although able to analyse a single defect and give detailed qualitative information on such defect, are not able to give the same general commercial information as in the case of the digital camera.

While the laser scanner and hyperspectral software systems could be important interfaces for individuating and/or analysing details upon valuable materials and for setting up a more specifically detailed database, the digital camera is a highly practical tool which can be used for ordinary materials that are commonly treated and processed in wood and stone industries. In practical terms, therefore, the digital camera has certainly met the goals foreseen by the project and, in particular, by the project SMEs.

In detail, the 3D laser scanner software system enables to study and to measure area and distances in deep detail; the depth of a defect can also be thoroughly evaluated. This is interesting for analysing defects and for creating a database when handling and treating valuable materials. The scanner however also presents flaws: firstly the sample needs to be still when acquiring the slab/panel image. Although acquisition is very rapid, the working cycle is interrupted: this is not particularly convenient from an economic point of view for low-cost materials. Furthermore, the image acquisition does not cover the entire slab or panel and a series of acquisitions are needed to acquire the whole image. As mentioned above, this could be conducted for particular and specific cases (the need to study a particular defect, valuable materials, etc.) but not for everyday industrial work. Therefore, although the laser scanner laboratory tests achieved excellent results, it presented the two foregoing industrial problems.

The specifically developed software analyses all materials and distances that could be of interest when treating valuable materials.

Regarding system positioning, the laser scanner was positioned after the digital camera also for reasons of size.

The hyperspectral software system gives excellent and thorough information on the materials composing the panel or slab. The system, therefore, is able to give details on the internal parts of the panel/slab and on the composition of a defect. From an industrial point of view, however, a main defect was individuated: the application field is quite small. Again, as in the case of the laser scanner, this software system is interesting in order to acquire specific information on particular materials or defects.

The specific software set up for the hyperspectral system gives information on material/defect composition through a series of graphs.

Regarding system positioning, given its reduced size the hyperspectral system was positioned next to the digital camera.

The digital camera gave best results during the industrial tests. The entire slab and/or panel image was easily acquired by the camera and defects were immediately detected, even more superficial ones. For example, defects caused by the passage of rollers during the polishing phase were detected by the camera and well detailed in the camera software. Naturally, the camera is not able to acquire 3D images, therefore the depth of a defect may only be studied by using the 3D laser scanner.

The specific software set up for the digital camera may be easily used by all operators and is more user-friendly than the software set up for the laser scanner and hyperspectral system. In particular, the digital camera software gives a qualitative commercial evaluation on the material analysed by automatically providing the operator with real-time information on the quality of the examined slab and/or panel. Being able to have both defect and commercial classification details in real-time on the material treated by wood and/or stone manufacturers is an extremely interesting and important opportunity.

The SMEs involved in the WOODSTONE project are extremely satisfied with the project results. The overall system is able to respond to different requirements according to the type of materials that need to be manufactured. For ordinary materials, the digital camera gives excellent results on material defects and real-time, qualitative and commercial information that is easily managed by operators without specific computer skills. The system, however, also comprises other two systems that can be used upon more valuable materials and that give specific and more detailed information/measurements on defects and material composition.

Exploitation plan of Result 1 and Result 2

The results of a *market analysis* performed before the project start show that the economic growth and competitiveness for stone and wood industries can be significant of the potential world-wide

market. In fact for the European industries involved as technology suppliers, there is possibility to involve not only the Community market but also large categories of extra-community end-user companies downstream in the processing line. The stone and the wood industries are present in various European countries like in Italy, Spain, Portugal (for the stone sector) and in Finland, Germany, Sweden, Austria, France, United Kingdom, Denmark and Italy (for the wood sector) where both represent a very important economic sector in each country.

The growing competition from extra EC developing countries (mainly due to low manpower costs) actually forces European enterprises to follow the way of technological innovation and improvement of quality level as necessary requirements for remaining competitive in the stone and in the wood sector as well.

Italy is the biggest producer of stones in the world holding an excellent knowledge of marble and granite manufacturing. At the same time Spain is one of the leading wood producers in the world representing a fundamental country for the industrial manufacture of wood panels. The industrial partners of WOODSTONE will assure fast exploitation of the results in each project country.

The current data of the stone sector consider more than 1.300 existing quarries for countries of the Middle East, around 3.300 extraction sites for the Far East and well over 500 active quarries for the Americas.

The wood sector production value resulting for the European Forest Cluster is EUR 450 billion. Moreover the direct value of wood processing (woodworking, furniture, paper and pulp industries) is about EUR 185 billion while the production of sawn wood has been of 71,3 mill m3 in year 2000.

In particular the data emerging from the answer to the last question proposed in the market analysis carried out before the project, about the *price,* is very meaningful as the quantification in terms of “cost” of the inconveniences, tied to the traditional way of operating, provides a significant indication on the cost that enterprises would eagerly sustain to acquire the innovative system.

As synthetic result of the cost investigation done, supposing to depreciate the WOODSTONE prototype system in 5 years, the following figure has been obtained for the eventual buyers (stone machining companies):

- *quantification of inconveniences (for buyers)*: 50.000 Euro/year x 5 years = 250 KEuro

As it may be easily noted, this is an extremely significant value which emphasises how from an industrial point of view the adoption of the WOODSTONE system is certainly encouraging for the end user enterprises since the cost saving relevant to the occurring inconveniences for the polished slabs claims would cover completely the provisioning costs for introducing the new system into the stone polishing line.

The project exploitation phase will last around 12 months. The following action plan has been prepared for this purpose which refers to the 12 months after the project end date.

1 A commercial agreement will be prepared and subscribed before the end of the project that will protect the rights of all technology providers and end-users that have taken part in the implementation and experimentation of the prototype during the project.

2 Market analysis: an attentive inquiry aiming at the assessment of the European and world wide potential market will be activated at the project end. This inquiry intends tracing two distinct data categories:

- Quantitative characterization: potential turnover achievable on the European and world wide market; in other words, determination of number of WOODSTONE systems that could be sold; (this estimation has already been partially achieved through inquiries carried out in Italy and Spain during the project; the results of this preliminary inquiry stimulated the technology suppliers in developing the WOODSTONE project; this "quantitative" inquiry will be improved at the end of the project and extended to the whole Community and extra-Community panorama);
- Qualitative characterization: qualitative characterization of marketable systems: size, systems operating on one unit or two units, etc. (this type of inquiry began during the project thanks to the collaboration of the end-users);

More specifically, this market analysis will aim to achieve the following main objectives:

- Identify and describe the profile of potential clients.
- Estimate the size of the market and its segmentation by clients and geographical areas
- Identify the competition of the system in this market
- Prepare a sales forecast for the systems

3 WOODSTONE system patent: patent costs will be totally undertaken by the SME Technology Providers.

4 A cost characterization will be performed, connected with the market inquiries.

The analyses regarding the quantitative and qualitative evaluation of potential markets are necessary for determining the system/s cost in view of a large-scale production. Regarding the costs, once the results of the market analysis will be known, the advantages that various categories of end-users may receive from the WOODSTONE innovative system, will be examined. The inquiry starting point will be the results achieved by the research; the inquiry will be carried out thanks to the collaboration of the end-users directly involved in the project. The crucial aim consists in the characterization of the commercial cost that the WOODSTONE system may have, once it has been industrialized and produced on a large scale. In order to favour a quick penetration on the market, economic evaluations will be carried out with an amortization period of two years for the purchasing enterprises. These inquiries must be carried out on a Community and extra-Community level so that the WOODSTONE system may become available to the whole world market. With reference to

this aspect, a series of significant parameters must be examined that may vary considerable according to the country examined. The most important parameter will be the labour cost.

5 A direct consequence of the previous activity is the industrialization phase of the WOODSTONE prototypal system. In other words, the SME technical partners will see to the characterization of the WOODSTONE system/s ready to be commercialised. The results reached in the above points, with particular reference to the more requested systems on the market (qualitative marketing inquiry) and the cost analysis, will be the starting point for this action. The results of the project experimental phase will be closely examined and a detailed design of the various components will then be carried out; the viewpoint will not be to develop a prototypal system anymore but to place effective and efficient finished products having competitive costs on the market.

6 Production of n°3-5 WOODSTONE systems. This action foresees the first participation in fairs of the stone/wood sectors. The project consortium firmly believes that it is useless to take part in fairs unless at least a few examples of the system are available for being sold. By presenting just one available system in a fair, competitors could examine the system, copy it and quickly place a product with similar features on the market.

7 First participation in a fair of the stone/wood sectors within the Community (Italy or Spain); the participation will consist in displaying the WOODSTONE system and giving demos to potential end-users. The aim is to sell 3-5 available systems and receive orders for 5 further systems.

8 Production of other 7-10 WOODSTONE systems; the number of systems to be produced could increase according to the number of orders received during the first fair.

9 Participation in two European fairs of the sector.

With reference to the timetable, the following table emphasizes what will be foreseen for the 12 months after the end of the project (from month 24: end of the WOODSTONE project, to month 36: end of exploitation).

ACTION	*EXPLOITATION TIME* (months) – from the end of the WOODSTONE project											
	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3												
4												
5												
6												
7												
8												
9												

Project Dissemination activities

During the whole project year various dissemination activities were carried out. The table and the paragraphs below give details on these activities.

Overview table of the dissemination activities carried out during the first year of the project

Actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
Oct-2004	Project Logo	General public and project partners	All	Innumerable	Sviluppo Italia Toscana
March-2005	Web-site	General public and project partners (reserved area)	All	Innumerable	Sviluppo Italia Toscana
Oct-2004	Poster	General public, research, industry (stone, wood, SW sectors)	European	Innumerable	Sviluppo Italia Toscana
Oct-2004	Flyers / Brochures	General public, research, industry (stone, wood, SW sectors)	European	Innumerable	Sviluppo Italia Toscana
25/09/04	Workshop "FORMAT Workshop"	Stone industry and associations	Italy	50	Sviluppo Italia Toscana, CGS, Erica
Oct-2004	Conference for the Marble District	Stone Indsutries, associations and bodies	Italy	50	Sviluppo Italia Toscana, Erica
12-13/12/04	Conference "Region and Innovation Conference"	SMEs, industries, industrial associations, research organizations, etc.	Italy	100	Sviluppo Italia Toscana, Erica
Nov-Dec 2004	Specialization Course (EcoManagement and Audit Scheme)	Higher Education Students and Teachers	Spain	30	UMH
Apr-May 2005	Specialization Course (Industrial Waste Management)	Higher Education Students and Teachers	Spain	30	UMH
07-10/10/04	Fair MARMOMACC	Stone industries and organizations	All	10.000	Sviluppo Italia Toscana, Erica, CGS
26-29/05/05	Fair CARRARA MARMOTEC	Stone industries and organizations	All	10.000	Sviluppo Italia Toscana, Erica, CGS

Overview table of the dissemination activities carried out during the second year of the project

Actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
July 2005-June 2006	Project Logo	General public and project partners	All	Innumerable	Sviluppo Italia Toscana
	Web-site	General public and project partners (reserved area)	All	Innumerable	Sviluppo Italia Toscana
	Poster	General public, research, industry (stone, wood, SW sectors)	Europe	Innumerable	CGS, Sviluppo Italia Toscana
	Flyers / Brochures	General public, research, industry (stone, wood, SW sectors)	Europe	Innumerable	CGS, Sviluppo Italia Toscana
	Project CD-Rom	Research and industry (stone, wood, SW sectors)	Europe	Innumerable	Sviluppo Italia Toscana
26/05/06	Workshop "WOODSTONE project"	University students and professors, wood/stone industries	Spain	50	UMH, CGS, ERICA, DIC, ACN, PROYECION
27/01/06	Web Article on the website "ISIC ENTRY"	Stone industries and associations	Italy	Innumerable	CGS, Sviluppo Italia Toscana
May 2006	Interview for an article in the German journal "Naturstein"	Stone industries and associations	Germany	Innumerable	CGS
12-17/03/06	PITTCON'06 - 57th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy	International researchers	USA	500	DIC
Oct 2005	Scientific Publication for "OpticEast'05"	International researchers	Europe/USA	Innumerable	DIC
Jan 2006	Scientific Publication for "Optics and Photonics 2006"	International researchers	Europe/USA	Innumerable	DIC
March 2006	Scientific Publication for "IAMG'06"	International researchers	Europe	Innumerable	DIC
March 2006	Scientific Publication for "IAMG'06"	International researchers	Europe	Innumerable	DIC
29/09/05 - 02/10/05	Fair MARMOMACC	Stone industries and organizations	All	10.000	Sviluppo Italia Toscana, Erica, CGS
31/05/06 -	Fair CARRARA MARMOTEC	Stone industries and organizations	All	10.000	Erica Sviluppo Italia

03/06/06					Toscana, CGS

Project Logo

Use of the following project Logo in all the project documents and dissemination material:

Project Web-Site

During the first year of Wood-Stone activities the project website was defined and set up by Sviluppo Italia Toscana: www.wood-stone.net. The project website was continuously updated by Sviluppo Italia Toscana throughout the course of the project. The web site has a restricted area specifically dedicated to the project partners and an area open to the general public containing information on the project objectives and activities.

The aim of the web site is the development and diffusion of a tool that is able to diffuse the innovative project technology, to facilitate the exchange of experiences between possible users and of work developed by the different partners.

Project Poster, Brochures and Flyers

These dissemination tools have been prepared by Sviluppo Italia Toscana and CGS in English and Italian. The partners belonging to other participating countries have translated the poster, brochure and flyer in their own language (more specifically: Spanish, Greek and Bulgarian). The purpose was to inform by means of poster, brochures and leaflets on the project objectives and results, and on the technical characteristics of the project system.

The poster was displayed and the brochures/flyers were handed out during the attended fairs and conferences and in all the dissemination activities. Around 1000 brochures/flyers were prepared for each participating company.

The WOODSTONE poster is shown in the Annex A of this report.

Project CD-Rom

A project CD-Rom was prepared at the end of the project showing the results achieved and aiming at diffusing the project system and technology by means of multimedia material. The CD-Rom was produced in all languages of the participating countries. It is a dissemination tools to be used during fairs, conferences and seminars but also as a direct communication tool during visits to and meetings with stone/wood representatives.

Articles and Publications

During the second year of the project, the following articles was related to the project results:

- Web Article on the website "ISIC ENTRY" ("Lo specialista della pietra sul web" –"The stone expert on the web"). The "ISIC ENTRY" web article is shown in the Annex B of this report.
- Interview for an article in the German journal "Naturstein"

During the second year of the project, the project partners produced the following scientific publications related to the project results:

- Bonifazi G., Serranti S., Menesatti P., 2005, *"Hyperspectral imaging based techniques in ornamental stone characterization"*, OpticEast'05, 23-26 October 2005, Boston Marriott Copley Place, Boston, Massachusetts USA
- Bonifazi G., Gargiulo A., Serranti S., 2006, *"Hyperspectral imaging spectrometry applied to ornamental stone aesthetic quality assessment: procedures and analytical strategies",* Optics and Photonics 2006, San Diego, California USA.
- Bonifazi G., D'Aniello L., Serranti S., 2006, *"Ornamental stone quality control by imaging based spectroscopy",* XI International Congress on Quantitative Geology from Multiple Sources, IAMG'06, Liège, Belgium.
- Bonifazi G., Gargiulo A., Serranti S., 2006, *"Travertine marble quality labelling by imaging based procedures",* XI International Congress on Quantitative Geology from Multiple Sources, IAMG'06, Liège, Belgium.

Exhibitions and Fairs

The participation in seminars and fairs aimed at disseminating the project objectives and results, and promoting the technology set up and tested during the course of the project.

During the first project year the project partners attended the following fairs:

- Verona (Italy): MARMOMACC, 7th – 10th October 2004. Fair attendants showed interest towards the project and to EU funding possibilities.
- Carrara (Italy): CARRARAMARMOTEC, 26th – 19th May 2005. Interest on the part of fair attendants was shown towards the project objectives and results.

During the second project year the project partners attended the following fairs:

- Verona (Italy): MARMOMACC, 29th September – 02nd October 2005. Fair attendants showed interest towards the project results and to EU funding possibilities.
- Carrara (Italy): CARRARAMARMOTEC, 31st May – 03rd June 2006. Interest on the part of fair attendants was shown towards the project objectives and results.

Workshops and Conferences

The aim of organizing and/or participating in workshop and conferences was to present the WOODSTONE project to University students and professors, international researchers, SMEs, organizations and associations related to the stone and wood sectors and also to establish interesting contacts for future collaborations.

- As foreseen in the Technical Annex, a workshop was held during the first project year addressing Italian stone enterprises. The workshop was held in Carrara (Italy) on 25th September 2004 addressing all stone-related manufacturers, industries and organizations. The workshop was organized by the joint collaboration of Sviluppo Italia Toscana, Erica and CGS. The aim was to present the project objectives and inform the participants on the course of the project, but also to discuss the main problems currently encountered by stone manufacturers and to introduce and promote information on EU funding opportunities.
- Again in Carrara, a conference specifically directed to the Marble District was organized by Sviluppo Italia Toscana and Erica on 22nd October 2004. During the conference specific references were made to the Wood-Stone project and its objectives. References to the Wood-Stone project were also made during the "Region and Innovation Conference" held in Florence on 12th and 13th December 2004 that saw the participation of Sviluppo Italia Toscana and Erica. The innovative aspects of the project and the importance of promoting technology and innovation among SMEs was particularly highlighted.
- Two specialization courses were organized by UMH (Universitas Miguel Hernandez) – Department of Materials Science and Technology. The first was related to the EC regulation n° 761/2001 regarding EcoManagement and Audit Scheme, while the second was related to industrial waste management. During both courses references were made to the Wood-Stone project and to its objectives and goals. Material regarding the courses is attached to this Appendix (Information/subscription brochures and poster).
- A project workshop was held during the second project year addressing Spanish stone/wood enterprises and University students and professors. The workshop was held in Elche (Spain) on 26th May 2006 in the premises of the Spanish project partner UMH (Universitas Miguel Hernandez). The workshop was organized by the joint collaboration of UMH, ACN, PROYECCION, CGS, Erica and DIC. The aim was to present the project objectives and inform the participants on the course of the project, but also to discuss the main problems currently encountered by stone and wood manufacturers and to introduce and promote the innovative technologies and equipments (3D laser scanner, hyperspectral system and digital camera) used in the implementation of the WOODSTONE system. The brochure of WOODSTONE workshop held in Spain is shown in the Annex C of this report.
- During the second project year the DIC partner participated at the PITTCON'06 - 57th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, March 12-17, 2006, Exposition March 13-16, 2006, Orange County Convention Center, Orlando, Florida USA, a

conference specifically directed to the applications of the hyperspectral systems. During the conference specific references were made to the specific results obtained by using the hyperspectral equipment and software in the stone/wood industries inside the WOODSTONE project. In particular a WOODSTONE poster was showed in a special exposition area during the PITTCON'06.

Photos of the poster exposition area at PITTCON'06