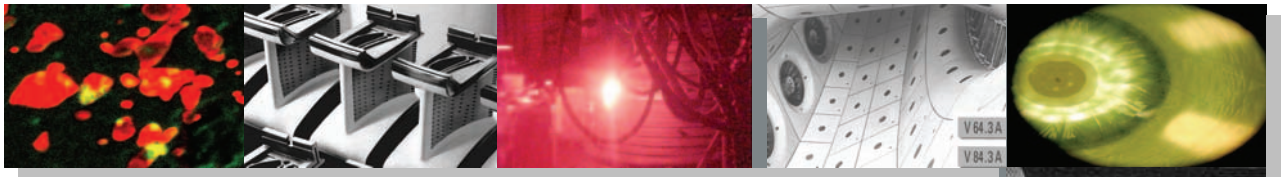
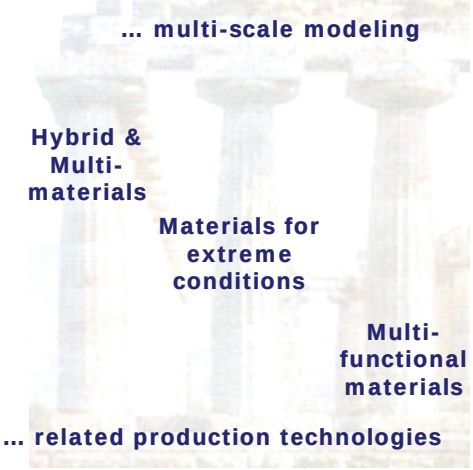


EuMaT

Materials for Life Cycle



Roadmap of the European Technology Platform for Advanced Engineering Materials and Technologies

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Version 27
June 27, 2006

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Executive Summary EU ("2-page Form")

EuMaT – European Technology Platform for Advanced Engineering Materials and Technologies

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Vision Document: The Vision document is included as Part II of the main document **"Roadmap of the European Technology Platform for Advanced Engineering Materials and Technologies (EuMaT)"**, entitled "Grand Challenges and the Vision ("The Vision Paper")"

Status of the document: Draft completed and agreed, published on web (www.eumat.org). The above document consists of the following main subdocuments:

Executive Summary; The EU ("2-page Form")
Introduction; Organization and alignment with other Technology Platforms and Projects
1. Grand Challenges and the Vision ("Vision Paper")
2. Realizing the Vision ("Strategic Research Agenda")
3. Technology Foresight Resources Financing of the Roadmap activities ("Implementation Agenda")

Annex I: Preliminary contact points
Annex II: EuMaT Terms of Reference
Annex III: Summaries of Interests Expressions of Interest

Platform launch date:

Kick-off Event Nov. 28. 2004 (Brussels), Launch Event June 27, 2006 (Brussels)

Overall Policy Objective:

The overall policy objective of the TP is the promotion of the leading global position and global competitiveness of the EU technology and companies in the area of Advanced Engineering Materials, as well as promotion of the consolidated and unified R&D and innovation European policy in this area, e.g. in the fields like materials resistant to extreme conditions, intermetallics or other multicomponent materials. The concerted EU R&D in this area is essential for the issues like material production technologies, monitoring and predicting material performance and degradation, environmental and/or health impacts.

The Strategic Research Agenda: Part of the "EuMaT Roadmap"
Status of the document: Draft completed, under revision, available upon on the web-site (**www.eumat.org**)

Executive Summary:

The main practical policy objective of EuMaT is to assure optimum involvement of industry and other important stakeholders in the process of establishing European R&D priorities in the area of advanced engineering materials and technologies. EuMaT should improve coherence in existing and forthcoming EU projects, and introduce "Radical Changes" and assure "Sustainable Development" in the sector of advanced engineering materials and related technologies. EuMaT covers all elements of the life cycle of "Advanced Engineering Materials & Technologies" (AEMT). The term AEMT refers in EuMaT to the three pillars

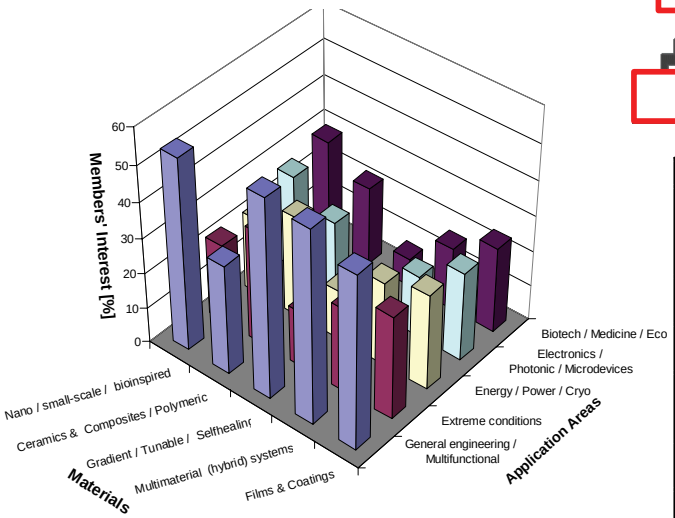
1. multifunctional materials,
2. Materials for extreme conditions
3. Hybrid & Multimaterials

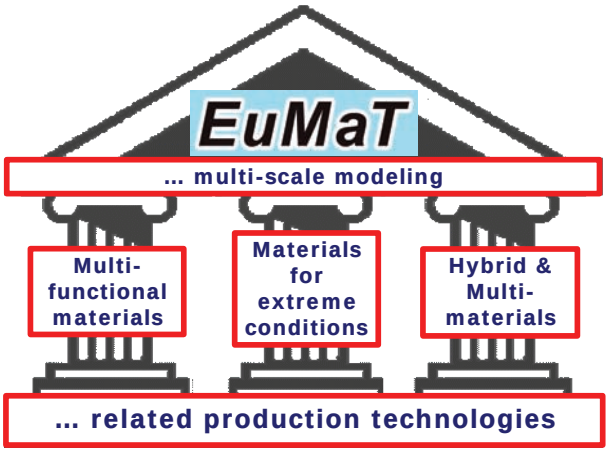
as used in engineering (and, e.g., coupled with "conventional" structural materials like steel, aluminum, titanium, metallic alloys, composites, polymers, advanced ceramics, coatings, adhesives, concrete, …) and/or used to enhance the engineering products, systems and processes in areas like energy, gas & oil, chemical, space, transportation, electronics, environment, health, etc. EuMaT covers the lifecycle of lightweight materials and nanomaterials in engineering components/ applications/systems. In particular it clearly points out the link toward large European projects like KMM-NoE (www.kmm-noe.org) and Extremat (http://www.extremat.org), in which advanced engineering materials like intermetallics, metal ceramic composites, functionally graded materials, self-passivating protection materials, radiation resistant materials and heat sink materials and high-temperature materials are investigated. The examples of **advanced new products** directly enabled by the progress in the area of advanced engineering materials are, e.g., gas and steam turbines (for 1600 ºC and 800 ºC respectively, ITER reactor or the "Third Millennium Car"). The advanced engineering materials will have a similar impact in the area of **manufacturing** (cf. the MANUFUTURE Technology platform).

Latest EuMaT Statistics

Status of: 08-06-06

Members total: **497**
out of which **83** 'core' partners





Material Modeling	61.23 %
Manufacturing / fabrication related material technologies (e.g. bonding, brazing, welding...)	63.66 %
Material testing, characterization & qualification	75.55 %
Impacts, risks, reliability & lifecycle	47.8 %
Material data management, selection & optimization systems	34.36 %
Pre-normative work, standardization	27.75 %
Int. collaboration, education, technology transfer	65.86 %

The overall performance targets which EuMaT envisaged for 2030 are to:

- help to reduce life-cycle costs of process equipment and infrastructure by 30% and energy consumption by 50% (more efficient materials)
- increase productivity of assets by reducing downtime by 25% (more reliable materials)
- protect the environment by containing processes (e.g. by recycling 95% of metallic and 70% on average of other advanced engineering materials at the end of their useful life)
- capture existing knowledge and effectively train a future workforce and develop capability and capacity to develop new generation of materials

In order to assure the breakthrough in the area, EuMaT will also tackle the horizontal and life-cycle issues like multi-scale modeling and simulation, testing, inspection, monitoring, characterization, including standardization and qualification of materials and manufacturing processes, prediction of in-service behavior/characteristics and failure criteria, risk and impacts of new materials and training and education issues. EuMaT has currently a very broad membership, as shown in previous figure.

The Strategic Research Agenda (SRA) is created with appropriate involvement of industry and other main stakeholders. It will provide a basis for identification of needs and will establish priorities on the short-term (3-5 years), the medium term (4-10 years) and the long-term (> 10 years) time scale.

The SRA covers the following items: (a) Aspects to be considered, (b) Methods for selecting, at EU level, future basic research directions, (c) Coordinating the Roadmap with other FP6 activities, (d) Strategies and policy for research excellence beyond national boundaries, (e) Academia / Industry collaboration, and (f) Expected impacts. The EuMaT SRA is a part of the EuMaT Roadmap document.

Major challenges have been identified in the areas of (a) development of new cost-effective and environment-friendly materials and related processes for challenging application conditions, (b) condition assessment and performance/degradation modeling/prediction, (c) knowledge management and materials information delivery. EuMaT organized its structure in terms of strategy and policy (High Level Advisory Board, General Assembly,), in terms of management (Steering Committee and Operating Agent), and in terms of technical work (Focus Groups, Coordination Groups working on SRA and horizontal issues, like e.g. international collaboration, standardization) and technical issues (modeling, multi-materials, production technologies, product life cycle management). EuMaT is open to all the interested new members and new members can join as regular partners, ad-hoc partners, investing partners and core partners. National Mirror Groups have been created in the following countries: Germany, Hungary, Italy, Romania, Slovenia (under construction), Spain, Switzerland, and United Kingdom.

Budget / Financing:

In the 7th Framework Programme (FP7) the resources planned for this area should go well beyond 4 billion €, for topics like better theoretical fundamental understanding of materials and their behavior, interdisciplinary aspects in materials science, linking fundamental research with products and linking to horizontal issues related to hazards, risks, environment, sustainability, standardization, etc. Annual operating cost for the EuMaT is estimated at about 600,000 € for the costs related to management, supporting activities and the work of the Focus Groups and Coordination Groups. Preparatory cost of EuMaT is currently covered by the participants, for their own costs. Costs related to the further development and implementation of the SRA should correspond to a budget of about 0.5 to 2.5 billion €/year. This budget will be obtained through the contribution of industry (target 35%), national governments (target 35%), and the European Commission (target: 30%). In order to assure for the large-scale coordination capacity needed, it is proposed to initiate Eureka and ERA-NET projects. National Mirror Groups will be financed at the national level.

Deployment Strategy:

The EuMaT deployment strategy covers (a) the coordination of the overall research work in the EuMaT area, and (b) provides the basis for planning of the future R&D in EU in the area of EuMaT (e.g. by periodic updating of the EuMaT SRA). EuMaT has already established a close cooperation with EMF (European Materials Forum), E-MRS (European Material Research Society), and DGM (German Association for Materials). Further collaboration agreements (Memorandum of Understanding - MoU) are under preparation with several other national and international groups. Similar MoU's are under preparation with the Technology Platforms on Steel and Aluminium (if/when launched), Transportation TPs (ERRAC & ERTRAC), Manufuture, Hydrogen and Fuel Cells TP , Industrial Safety and Pressure Equipment (if launched), Sustainable Chemistry**,** Construction, Zero Emission and other TP's. The EuMaT web (operational since October 2004) provides already links to existing TP and project web sites, relevant working groups, academic institutions, other international initiatives and other networks. The sites also support the functionality of the EuMaT management (members, national mirror groups, documents, meetings, publications, etc.

Next Steps:

The activities will cover:

- Linking to EUREKA and to national organizations and activities supported by national programs/projects;
- Finalizing the linking of EuMaT to E-MRS, ESF and other European professional organizations like cooperation with the German Materials Society (DGM), the French Materials Society (SF2M), or the Swiss Materials Federation (SVMT), as well as linking of EuMaT to other ETP's, like, e.g., Sustainable Chemistry, Industrial Safety, and others;
- "Merging" of the activities of EuMaT and those of the ETP Sustainable Mineral Resources (SMR)
- Final publishing of the EuMaT documents (vision, SRA, Implementation Agenda, Terms of Reference, etc.) and the Launch event (June 27, 2006);
- Periodic updating of SRA.

Introduction; Organization and alignment with other Technology Platforms and Projects

EuMaT Materials for the life-cycle

This document provides the Roadmap of

EuMaT – European Technology Platform
for Advanced Engineering Materials and Technologies

which has been launched in order to assure optimal involvement of industry and other important stakeholders in the process of establishing of R&D priorities in the area of advanced engineering materials and technologies. EuMaT should improve coherence in existing and forthcoming EU projects, and lead to (according the EU list of keywords):

1. "Radical Change"
2. "Sustainable Development"

Both, obviously, in the sector of advanced engineering materials and related technologies.

EuMaT should cover all elements of the life cycle of advanced engineering materials / technologies:

- design, development & qualification of advanced materials
- advanced production, processing and manufacturing
- material and component testing
- material selection and optimization
- advanced modeling on all scales
- databases and supporting analytical tools
- life-cycle considerations, including impacts, decommissioning, reliability, hazards, risks and recyclability.

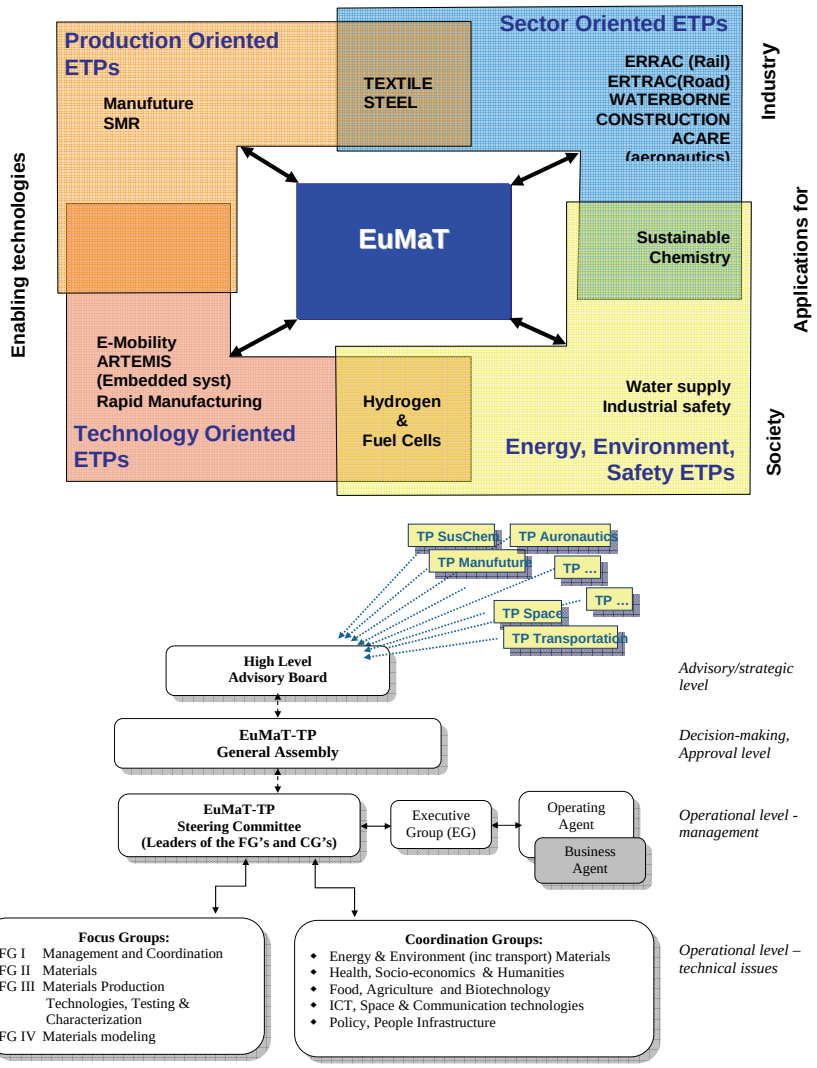
EuMaT – a horizontal TP

A strong interaction with other platform is envisaged. EuMaT with its strong material and technology base will take care of materials and related technology issues. EuMaT organization as horizontal platform is established in order to allow the cross link with vertical product platforms.

Similarly to Manufuture, EuMaT will connect

- Societal
- Technology
- Sectorial and
- Production oriented aspects.

The major link is established by the "High level Advisory Board". It will have senior representatives from major 'interested' parties at the Advisory board level. This includes chairs of other TPs or Projects. Details of responsibilities are shown in Annex II "Terms of References".



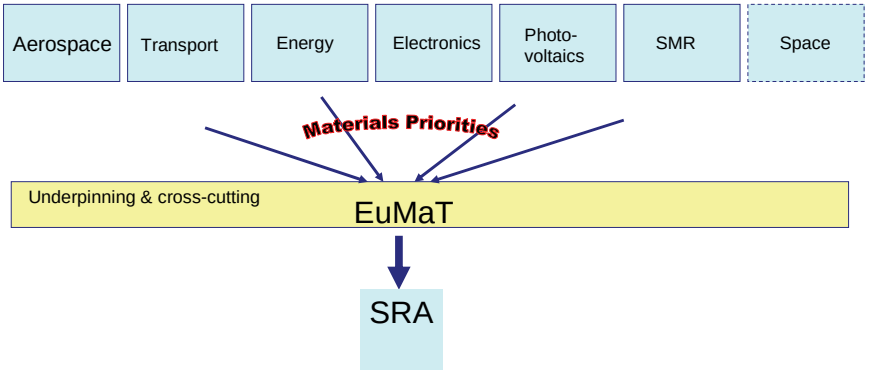
EuMaT Strategic Research Agenda (SRA)

With appropriate involvement of industry and other main stakeholders the SRA of EuMaT provides the basis for

- identification of needs and
- establishing priorities.

in the area of advanced materials and technologies. In addition, EuMaT will promote

- interdisciplinary education and training, and technology transfer and innovation
- societal considerations in the R&D (e.g. potential impacts on public health, safety, environmental risks)
- cooperation and initiatives at international level.



EuMaT goals and FP7 priorities

EuMaT started in fall 2004 with the goal

- to establish a cross-cutting and underpinning technology platform in the area of advanced engineering materials and related materials technologies,
- to establish a coordinated approach to materials R&D in Europe with particular emphasis on FP7

Further goals are:

- EuMaT structure aligns with EC priorities in order to allow clarity & transparency of how EuMaT aligns with FP7
- The structure has the buy-in of the EC, and their endorsement to recommend Materials priorities

EuMaT is aligned with FP7 framework priorities:

1. Health
2. Food, Agriculture and Biotechnology
3. Information and Communication Technologies
4. Nanosciences/ technologies, Materials and New Production
5. Energy
6. Environment and Climate Change
7. Transport
8. Socio-economic Sciences and the Humanities
9. Space and Security Technologies

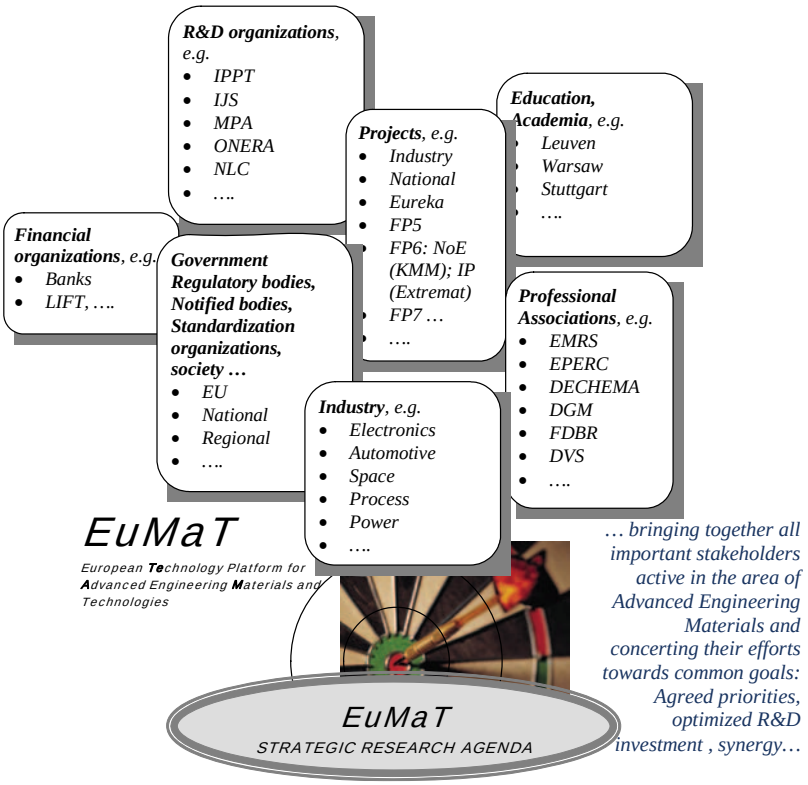
The vision is that EuMaT will determine the Materials priorities of these areas and then recommend R&D themes to the EC.

EuMaT will do this with co-operation of other Technology Platforms and Projects to ensure sharing of best practice and to eliminate duplication

EuMaT Stakeholders

Main stakeholders to be involved are:

- Industry (large, medium and small, embracing the whole production and supply chain, including component, equipment and sub-system suppliers, service providers and user industries; those involved in technology transfer; also, industry associations)
- Public authorities (regulators and policy makers, funding agencies; in the particular notified and licensing bodies)
- Academic community (apart for education and research also those involved in innovation and interested in the issue of. European Innovation Area);
- Consortia from other EU projects
- Financial community (private banks including the EIB, the European Investment Fund EIF, venture capital, etc.; in particular supporting SME's)
- Civil society, including users and consumers (involving the also the future customers, e.g. through associations).



Envisaged Financing of EuMaT

For the deployment of its Strategic Research Agenda EuMaT will explicitly look for other than only EU based financing. For this purpose EuMaT will concentrate its efforts on **strong concerting of the EU and non-EU financing**, helping to avoid duplication and/or any sub-optimal use of resources. For its financing EuMaT will very much look at the experiences from other success stories and relay on the principles of **PPP – Public-Private-Partnership**.

Scope of the EuMaT Roadmap document

The Roadmap document consists of the following main subdocuments:

- Executive Summary; The EU ("2-page Form")
- Introduction; Organization and alignment with other Technology Platforms and Projects

1. Grand Challenges and the Vision ("Vision Paper")
2. Realizing the Vision ("Strategic Research Agenda")
3. Technology Foresight Resources Financing of the Roadmap activities ("Implementation Agenda")

- Annex I: Preliminary contact points
- Annex II: EuMaT Terms of Reference
- Annex III: Summaries of Interests Expressions of Interest

Its time horizon is 2020, exceptionally 2030.

1. Grand Challenges and the Vision: Materials for the life-cycle and vision for 2020 ("EuMaT Vision Paper")

1.1. Introduction

Materials technology shall be a major success factor for European industry influencing the competitiveness of not just material technological industry but practically all industrial sectors. Investments in materials provide possibilities to succeed in global markets and to create new spear head technologies and products thus improving the employment in Europe. Investments for materials solutions that are designed based on life cycle impact basis support sustainable development and eco-efficient decisions of industry and society.

Today, materials technology including raw material extraction, processing, manufacture and supply is ***a major employee*** and may represent 1/5 of the GDP of EU. Advanced materials will require new employee profile due to its very research intensive nature and offer employment for highly educated professionals. Also, advanced materials technology can create a platform for growth of new enterprises in advanced materials business with high growth rates and good employment possibilities and promotes transition of European materials technology industry from ***resource-intensive to knowledge-intensive industry***.

New materials technological solutions serve also as a catalyst for other industries being an ***enabling technology for new innovations in process, machine building, energy, transportation and aeronautics industries***. Advanced ***life cycle cost based solutions*** strengthen the technology and competitiveness of European after market service providers.

EuMaT technology platform (European Technology Platform for Advanced Engineering Materials and Technologies) is a European forum that supports planning, decision making and investments in the area of advanced materials technology. Its proposals and actions are based on wide interface and feedback from industry, research community, public authorities and financial community.

The paramount theme for EuMaT activities is ***management of life cycle costs and environmental impacts*** through novel use of advanced materials technology. In principle advanced life cost management requires development of

- ***methodology and concepts*** for life cycle management of products and processes utilizing materials technology
- ***new materials and manufacturing methods*** that can be used to realize new products and life cycle material solutions
- ***improved understanding material degradation mechanisms (wear, corrosion, mechanical reliability)*** in order to be able to create functionally tailored materials solutions
- ***modeling and simulation*** of material degradation mechanisms of material properties and performance in operation as well as of the manufacturing processes utilizing computational methods

Advanced materials refers to new type of material groups and manufacturing methods, e.g.,

- ***new material groups***, e.g. nanostructured materials, metal matrix composites, multimaterials structures, functionally graded materials, smart/active materials
- ***new manufacturing methods***, e.g., multimaterials structures, spray deposition, new coating, joining and castings methods, powder metallurgical

methods, composite materials

- ***hybrid material systems***, novel use of advanced high performance materials together with commodity materials in multimaterial structures

In order to assure full impact of developed new material and component solutions, certain ***horizontal issues*** shall be covered as well, like

- prediction of in-service behavior / characteristics
- multiscale modeling and simulation
- testing, inspection, monitoring, characterization, standardization and qualification of materials
- training and education issues

The key overall performance targets for EuMaT are as follows:

- reduction of ***life cycle costs*** of process equipment and infrastructure by 30 % and energy consumption by 30%
- increase productivity of assets by ***reducing downtime*** by 25 % (more reliable materials)
- protect the environment by ***keeping the processes contained, by preventing unacceptable leakages and emissions*** and striving to use materials with decreased environmental impacts (e.g. by ***recycling*** 95 % of metallic and 70% on average of other advanced engineering materials at the end of their useful life)
- ***capture existing knowledge and effectively train a future workforce*** and acquire capability and capacity to develop new generation of materials
- create ***new materials***, that enable the design, production and use of innovative products with ***enhanced performance*** and ***new functions***

by ***development of innovative material, component and process solutions***.

EuMaT priorities are three pillars

- multifunctional engineering materials with gradient properties
- engineering materials for challenging applications and extreme conditions including light weight structures and high temperature
- multimaterial hybrid systems with advanced materials combined with conventional materials

Overall, according to EuMaT vision Europe will emerge by year 2020 as a ***leader in development and utilization*** of advanced materials technology solutions and related manufacturing methods. The prerequisite for this vision are

- a clear scientific, technological and industrial strategy (Strategic Research Agendas) aiming for development of materials solutions that are ***most competitive during the product life cycle***
- ***a long term***, ***balanced financing*** of the development work taking into account the needs of process, energy, transportation, aeronautics/aerospace etc. industries
- ***a well organized cooperation*** between all stakeholders and ***efficient implementation agenda***

EuMaT technology platform cooperates with other platforms as well as complements those application areas and industries which are not sufficiently supported by existing platforms, e.g. Sustainable Chemistry, Manufuture and Steel technology platforms.

1.2. Overview

1.2.1. Background

Materials technology is a complex and multi-disciplinary science, dealing with design and modeling, optimum use and manufacture of materials for functional applications. In recent years, "smart" or "active" materials have also received more attention. The bottom line in materials technology is to understand the relationships between material microstructure/composition and its technical properties, how microstructure influences behavior in different applications and how it is achieved and can be modified and controlled by manufacturing technology.

Materials technology has been considered for decades as one of the mega-technologies together with biotechnology and information technology, which shall have the greatest influence on the industrial development, society and well-being of the citizens. In applications like semiconductors, high temperature super alloys for aircraft engines, industrial gas turbines and aerospace materials technology have received recognition as mission critical key technology. Indeed, in these examples material technology has been in a vital role where less than satisfactory achievements would have had fatal influence on the development of the "hosting" technology. Nevertheless, in many other, less noticeable areas development of materials technology has been extremely fast resulting in radical changes in life cycle costs, e.g., new cutting materials used in machining, thin coatings for tooling, lighter structures for construction and transportation. In these examples, adoption of new materials technological achievements has led to radical reduction of production costs in scale which would not have been possible using normal production rationalization.

Emphasis and focus areas of material technology vary between different industrial sectors. In mining, aggregate, recycling and metallurgical industries wear control and mechanical reliability are by far the most important single materials technological issues and they have significant influence on the life cycle costs of the operation. In other process industries like chemical, offshore and pulp & paper industry, corrosion protection and surface properties are dominating material questions. Physical properties like thermal conductivity or high temperature mechanical properties may have significant influence in tooling applications, energy production or combustion engine components. In transportation and aeronautic industries strength to weight ratio, stiffness to weight ratio, formability and certain cases e.g. corrosion resistance are major material selection criteria.

It is becoming more important than ever before, that the technology and R&D investments in Europe are sufficient and balanced so that all essential industrial areas can be maintained competitive. Usually, technologies support each other by synergistic effect. Their combined use and concurrent engineering is today a self-evident approach in creating breakthrough innovations in all areas of technology and industry.

United States and Japan have been leading the technological development of new materials. If Europe cannot stay in the front line of this technology it may have influence not just in materials technological industries but also for European industries that are dependant on advanced material solutions, like process industry, machine building and maintenance providers.

1.2.2. Industry trends

Today, industrial companies are facing challenges of severe competition and rearrangement of global economy. Additionally, new challenges arising from environmental legislation, recycling requirements, increasing costs of energy and in recent years increasing cost of even commodity raw materials shall have significant influence on the costs of production. Simultaneously, production shifting to low labor cost countries in Eastern-Europe, India and China as well as rapidly developing technological competence in these same regions may all cause erosion of the competitive edge of Europe.

Life cycle costs evaluation

Evaluation of different material choices and their entire life cycle impact has been an increasing trend in recent decades especially in the process industry. For ***operators of plants, equipments and vehicles*** huge investment costs demand reliable operation with scheduled maintenance and minimization of shutdowns (asset management). In many process industry areas production up-time is one of the key issues influencing productivity and competitive edge on the plant. Best available material choices together with life time prediction and diagnostics capabilities would allow extension of the maintenance free operation time and planning of the shut downs in an optimum manner.

Life cycle management has the goal to establish the relationship between plant and equipment investment costs, maintenance/inspection work and availability requirements and control these in an optimum way to minimize life cycle costs and environmental impacts.

As an example, in USA it is estimated that direct costs of corrosion are US $ 18 billion annually, while the total national costs in all sectors of the economy are US $ 275 billion annually (Corrosion Cost and Preventive Strategies in the United States, NACE International, 2003). In certain industries, like chemical, pulp & paper or oil refining industry relative costs incurred due to corrosion damage can be much higher.

The cost of wear can be in certain industries tremendous. In Germany alone, the costs caused by wear were estimated to be EUR 16 – 20 billion, while in Finland the costs of wear were € 2,7 billion (Survey on Tribology in Finland, VTT Manufacturing Technology, 1999).

In industries like ***mining, aggregate and recycling*** the costs of component wear can be significant. In typical mining and aggregate industry applications wear parts and consumables may represent 40 % of life cycle costs other main cost items being energy 25 %, maintenance labor costs 5-10 % and initial plant investment only 15-20 %. In recycling industry, metallurgy and selected pup & paper applications the share of life cycle expenditure can be even higher.

In ***car industry*** target is to increase life time of key components controlling the maintenance free operation time by a factor of 2 while maintaining/improving the safety. Additionally, development of lighter weight structures shall have significant influence on the life cycle costs and environmental impacts due to reduced amount of material required and considerably lower fuel consumption. Furthermore, designing structures that are easy to recycle shall promote environmental sustainability. Replacement of conventional gasoline or diesel by alternative fuel will cause high wear, friction and increased thermal loading due to lack of lubricating properties of bio-fuels, reduced compatibility with engine oils and with seal material as well as increased risks of corrosion. Existing solutions cannot cope with these problems resulting reduced engine reliability and component life time, e.g., existing PVD coating were out during component run-in phase (too thin) or do not possess resistance against fatigue (existing thick layers produced by thermal spraying).

In ***energy industry*** reduced life cycle costs and costs of electricity for all fuel sources is the major challenge. Life cycle costs are related to great extent for plant reliability and availability, maintenance and operation costs. In parallel with these requirements, there is an increasing need to reduce CO_2 emissions power generation being the main contributor for CO_2 emissions. In order to reach the ambitious targets of reduced life costs and reduced environmental impacts of energy sector, significant materials technology challenges are met. In fossil fired plant, special problems are related to gas turbine combined cycle, advanced coal fired and CO_2 sequestration plants, e.g. development of advanced high temperature materials (steels, superalloys and composites). Power plants utilizing renewable fuel, e.g., waste/biomass plants, wind turbines, fuel cells and solar plants will require advanced materials with specific requirements for corrosion resistance (aqueous & high temperature), light weight technologies (composites, plastics) and environmental coatings. Nuclear power has its own unique technical challenges related to issues like material & fuel handling, fusion, fission & radiation damage as well as decommissioning & storage.

Among OEM´s (Original Equipment Manufacturers), the business and technology focus has been gradually transferring more and more to life cycle business development. One reason for this is the reduced amount of new installations in mature businesses like steel industry, pulp & paper industry, mining, chemical and oil refining leading to development of after sales market of the installed base. Investment in materials technology supporting development of after sales product and services is essential for European machine building and process equipment manufacturers.

Overall, life cycle management of operations, plants, equipments and vehicles requires thorough understanding of materials behavior, life time prediction technologies as well as advanced, innovative material and manufacturing solutions.

Environment / reliability

Environmental issues shall have a profound influence on the materials technological choices and development for many reasons. More stringent requirement for emissions and leakages require reliable high performance materials and understanding their behavior in processing handling hazardous chemicals and gases. This becomes even more

important as the process condition become more severe (chemical environment, pressures and temperatures) in order to improve productivity.

When evaluating the environmental impact of process plants, their renovation and maintenance should be carefully considered in addition to initial plant installation. In many cases and to an even larger extent, wear part and consumable consumption during the life time of the operation have much larger environmental impact than the plant installations themselves and environmental focus should be shifted instead for maintenance. From environmental point of view, minimizing wear, corrosion and mechanical damage of the plant components with the associated logistics (transportation of scrap parts from the site, transportation of new parts on site) would have clearly the largest influence on environmental impact.

During process machinery component degradation, the process quality drops leading to higher energy consumption, worse raw material yield and in some cases higher emissions. Typical example is the increased energy consumption of process pumps as the pump impellers wear. As the components involved in cutting, crushing and grinding degrade, there are similar effects but additionally, there may be significant reduction of the process yield resulting in increased raw material consumption.

In automotive industry and transportation industry light weight structures shall have a profound effect fuel economy as well as wear of machine parts which are both important for environmental issues. Development of lighter structures is depending of both the availability of new lower density materials as well as on the knowledge on how to utilize them in design.

New process requirements

New and / or modified processes are setting new requirements for the materials used in process industry equipments. Higher efficiency processes working at higher speeds, increased dynamic and/or static loads, higher temperatures and more severe chemical atmosphere may require material change, in some cases totally new materials not existing today. It is well known that materials technology has become critical for further development of the processes and machinery. In order to utilize material technology properly, it should be integrated to development and design process of the equipments and processes from the beginning.

In energy industry, new energy production processes utilizing either fossil fuel, renewable energy sources or nuclear fuel require new, advanced material technology solutions in order to be technically and economically feasible. Many of the new energy production methods are environmentally less harmful.

In chemical industry, higher process temperatures, new more severe chemical environments as well as recycling of the process media (concentration) shall lead to extremely severe corrosion problems and material challenges.

Continuously rising product demands

In most engineering branches, especially high-tech branches, there is a continuous trend for the existing products to achieve higher performance, better quality and functionality. This can be solved by smaller tolerances, higher running temperatures or higher running speeds for example. But in many cases the power and the performance of the product cannot be increased anymore, because the useful maximum of the running conditions of the used material is already reached. This barrier can only be broken by the development of new engineering materials with better properties that can withstand higher temperatures, pressure forces and wear load. Additionally, due to the worldwide competition, there is a high pressure on the European industries to develop new products. The competition of the global market cannot be won by the European industry just by further developing existing products. Europe should rather invest on development of new products with new features and innovative functions that are not available from regions outside Europe. An important precondition for this is to make new advanced engineering materials available that have new properties or new combinations of properties.

1.2.3. The role of materials technology

Materials technology is usually a supporting technology for the creation of process solutions, machines and engineering structures, transportation and aeronautics equipments. In process solutions materials technology is applied together with process technology, automation and machine technology to create competitive reliable solutions, see Figure 1. Presently, the relative role of materials technology has increased because of the focus on the life cycle management of the processes and limitations set by existing engineering materials. It should be born in mind that many engineering materials

solutions of the process installations and machines are pretty old, or based on the materials solutions developed originally for other industries, e.g. aerospace applications. In car industry materials technology is in critical role influencing manufacturing costs, weight (fuel consumption), safety and life time maintenance costs.

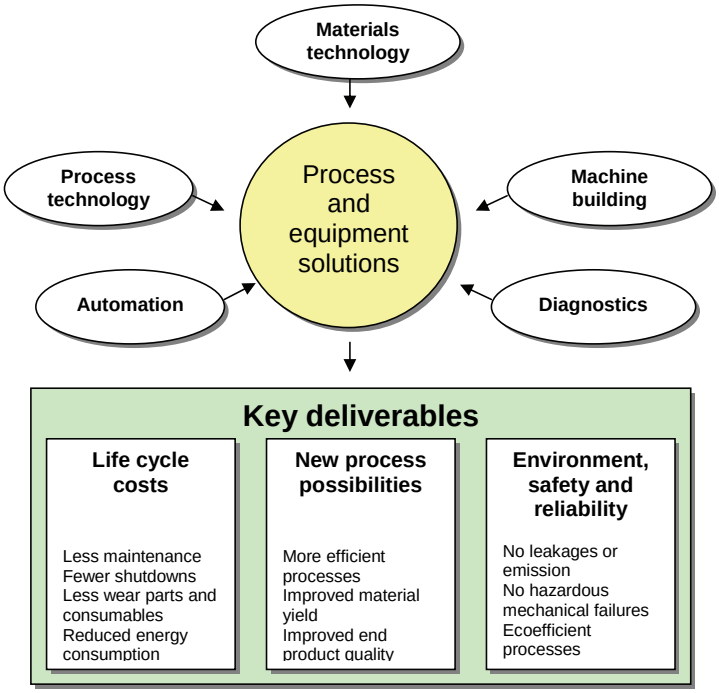


Figure 1. The utilization of materials technology, case process industry.

The role of advanced materials technology should be in many cases seen as an enabling technology for new innovative products and applications utilizing special features and functions of new material solutions, see Figure 2.

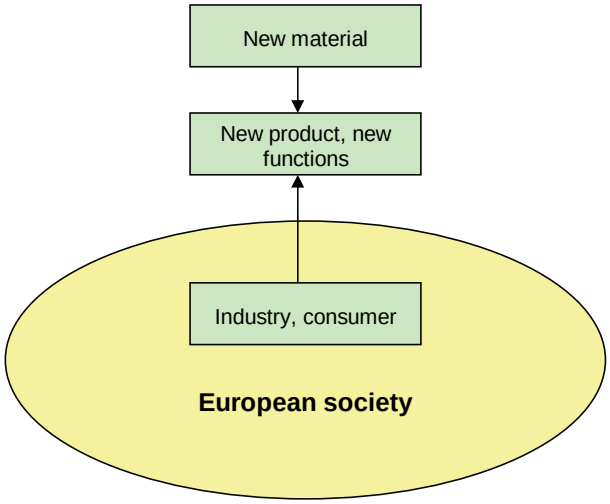


Figure 2. The role of new advanced engineering materials for innovative products for the European industry

1.3. Challenges

1.3.1. Materials technology eroding in Europe

USA and Japan have been leading the technological development of new materials in recent years. If Europe cannot keep up in the front line of this technology it shall have detrimental effect not just in materials technological industries but also for other European industries that are dependant of advanced material solutions, like process

industry, machine building, transportation, aerospace and maintenance providers.

Advanced materials technology is a vital technology for European industry. For the end users of process plants use of latest materials technology is prerequisite for life cycle cost control and reliable production. OEMs are serving not just the customers in Europe but also acting internationally. Materials technology as part of the technology portfolio is required for managing the life cycle business and provides possibility to offer unique wear part and consumables systems that differentiate them from suppliers of low cost countries, e.g. South-America, China, India and Eastern-Europe. Overall, materials technology provides possibility to improve the competitive edge of the entire business chain from material and components suppliers, to OEMs and process industry itself.

1.3.2. Human resources

Like in many other industries, suffering either from bad image, poor employment or being just not well known among young people, also materials technology has been facing problems of young talent not entering materials technology. This is a dangerous long term trend which may have detrimental effect not just on materials technology but also for the other industries sectors depending materials technology innovations. A bad image of steel and mining industry has obviously been partly responsible of the attitude of young people towards materials technology.

A special attention should be paid to knowledge management, especially capturing the knowledge and experience of existing generation of material scientists to new generation.

Advanced materials technology industry and related manufacturing industry requires well educated professionals. Due to its ***research intensive nature***, university level education is needed in key functions of R&D, product development and manufacture. Consequently, attractiveness of materials science and technology should be improved among young students making selection for their academic directions and careers. ***Cooperation between industry and academia*** is of utmost importance in order to create a path for a long development efforts required in advanced materials.

1.3.3. Cooperation and concurrent engineering

Materials technology is typically a technology that allows breakthroughs in other technological areas, in a way it serves as an ***enabling technology and technology catalyst for innovation in other areas***. Consequently, close cooperation with machine building, process technology and chemical technology is required in order to create viable innovations. The development should be based on concurrent engineering principles and interactive work with other technologies is a precondition for success. Process engineers and equipment designers should learn how to utilize materials technology toolkit in their technology portfolio. This is partly an educational issue partly also a question of knowledge management and design practices and traditions.

A basic problem in the interface between materials engineers and process/machine technology experts is ***lacking design tools of materials scientists***. Most design tools of materials scientists are very qualitative in nature due to insufficient understanding of basic phenomenon, lack of reliable material testing characterization data and small use of computational technologies. ***Computational materials science*** shall be an extremely powerful tool when improving the utilization of materials technology as well as when developing new materials and their manufacturing technologies. However, computational material science itself is not feasible if basic phenomenon is thoroughly understood and modeled or there exist not sufficient material testing and characterization data.

1.3.4. Long term nature of materials technology development

Materials technological development is by its nature long term and very research intensive, similar as pharmaceuticals or chemical industry.

Consequently, investments for materials technology shall not have immediate impact and they should be targeted for long term in strategic focus areas. Clear technological focus and well determined strategy is needed. A typical life cycle of new material system development is 10-20 years, and for applying new materials at least 3-6 years.

There is certain scientific dimension in materials science that will always keep the development time of new solutions longer than in other technologies. Typically, the material phenomena that are tested in laboratory or field testing phase are very difficult to accelerate without changing materials degradation mechanisms. Computational material science may shorten the development cycles in a future when sufficient material data is available.

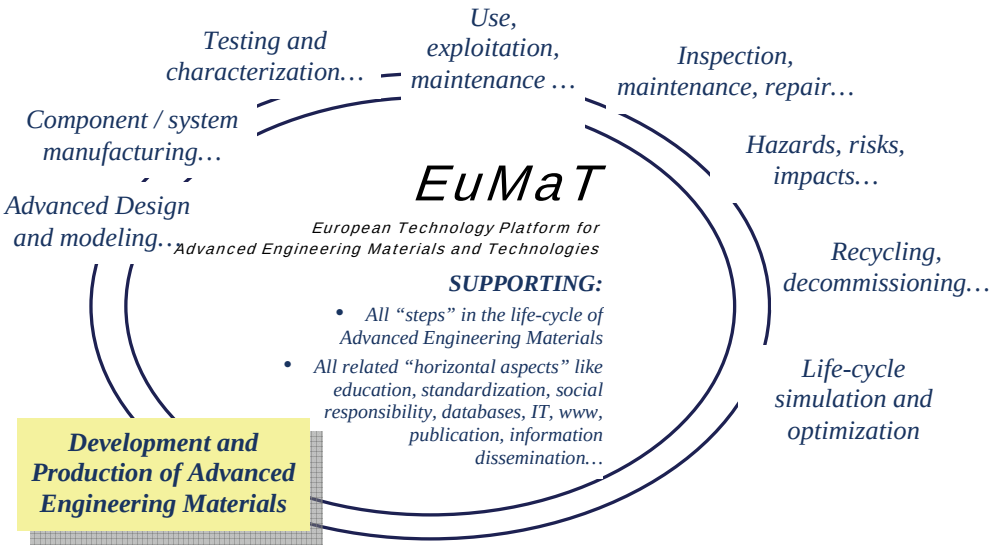
1.4. Vision

Our main vision items are:

- *Europe is global leader in developing, supplying and utilization materials technology*
- *Materials technology innovations create new opportunities for process, mechanical engineering, transportation and aerospace/aeronautics industries and related life cycle business management*
- *European research in academic institutes and industry, across the continent, is able for world class research in areas identified by Strategic Research Agenda (SRA)*
- *Materials technology is an integrated part of the design of industrial systems utilizing modeling and simulation as design tools*
- *Our materials technology solutions support sustainable development*

The key theme in our vision is

Materials for The Life Cycle.



1.4.1. Materials

Material development can be in principle divided into

(i) ***innovative use of existing material solutions*** based on good understanding of applications, material requirements and materials degradations mechanisms

(ii) ***modification of existing materials*** to fit better for applications (new grades for existing materials systems, possibly new manufacturing processes)

(iii) ***development of entirely new materials or materials groups*** (nanomaterials, active/intelligent materials, composites, hybrid and multimaterial structures etc.)

Accurate use of presently available materials requires both thorough understanding of the material degradation mechanisms acting in particular application and how this reflects materials requirements. Sufficient material property data and possible use of simulation and modeling is necessary to create best possible solutions.

Development of totally new materials requires long term R&D efforts, typically > 10 years. Due to the fast development of materials testing and characterization methods as well as use of computational material science, present possibilities for development of new type of materials e.g. nanostructured materials, composites, functionally tailored materials and multimaterial structures are more possible than ever before.

Our vision: European industry, research institutes and universities have created globally competitive level of materials technology which allows accurate materials engineering and sufficient scientific competence to develop new materials modifications and totally new material groups. Accurate and unique material selection allows significant life cycle cost reduction of the process equipments and machinery, transportation vehicles and aeronautics industries.

1.4.2. Materials and components manufacturing technology

Manufacturing technology of materials and components is typically an integral part of material development because the processing is the key to modify, optimize and control the microstructure, and consequently the technical properties of the materials.

Manufacturing technology of materials and components is presently focusing on

- Reliability and quality
- Lower production costs
- Shorter production chain and delivery times
- Flexibility and tailoring possibilities
- Reduced raw material consumption (yield) and energy requirements
- Hybrid manufacture

Vision: The technology available for European industry allows flexible and cost efficient manufacture of best available material and component alternatives using latest materials technology in novel combination with commodity process technology. Innovative use of hybrid manufacturing methods is an essential part of the manufacturing technology portfolio.

1.4.3. Life time performance prediction and condition assessment

Life time performance prediction is required in order to design structures and components with high reliability, to optimize the life time maintenance and renovation work and assess risk for premature failure. This is an extremely important area for plant operators and OEMs supplying maintenance work and gives tool for life cycle business management. Especially unplanned, sudden shutdowns are a major risk for processing plant with high investment costs.

The basic competencies required for accurate life time prediction are understanding of material degradation mechanisms, condition monitoring and diagnostics.

Vision: Our industry has capabilities to predict accurately the life cycle performance of the materials and components which allows new technological and business opportunities, e.g., performance based after market business, improvement of process machinery reliability, more accurate maintenance and shut-down planning and fewer risks for environment.

1.4.4. Simulation and modeling

Simulation and modeling of material behavior and degradation mechanisms, dependence of material structure on manufacturing methods and manufacturing processes, is prerequisite for materials and manufacturing method design as well as for the life cycle performance evaluation.

The ideal situation would be simulation of the total life cycle. This requires the combination of several research activities which are separated today. For many engineering materials the correlation of microstructure to technical properties e.g. creep is known. However the modeling of the manufacturing process to achieve the optimum microstructure is in infancy. Engineering uses materials data to predict the lifetime of components. However because of not existing correlation of microstructure and materials

data safety factors are included which will not exploit the engineering materials potential. Therefore the vision is to develop a virtual manufacturing chain with optimized materials technology and low scatter output.

Vision: Total life cycle design tools based on developed simulation and modeling capabilities are in both scientific and industrial used among European industry and research community.

1.4.5. Economic and social outcomes

The EuMaT technology platform and its strategic research agenda target measurable, economically and socially valuable goals. The key theme of EuMaT materials technology is ***"Materials For The Life Cycle"***. More precisely, targets can be defined as follows (see also Figure 3):

Process and equipment life cycle costs

- reduction of ***life cycle costs*** of process equipment and infrastructure by 30 % and energy consumption by 30 %
- increase productivity of assets by ***reducing downtime*** by 25 % (more reliable materials)

European industry world's leading supplier of innovative material technology solutions providing best life cycle economy

- Sufficient European ***R&D investments into key areas*** (EuMaT Strategic Research Agenda)
- ***Capture existing knowledge and effectively train a future workforce*** and develop capability and capacity to develop new generation of materials
- ***New employment possibilities*** for new and expanding materials technology industry

Materials providing safe working environment

- Reliable process and structures, min. 50 % reduction of accidents due to premature failures of key components
- Reduction of maintenance work which is usually more risky

Environmental sustainability

- Protect the environment by ***containing the processes, preventing unacceptable leakage and emissions*** and striving to use materials with decreased environmental impacts (e.g. by ***recycling*** 95 % of metallic and 70% on average on other advanced engineering materials at the end of their useful life)
- ***Selection of materials*** with minimum environmental impacts
- ***Lighter structures*** with associated smaller energy and fuel consumption

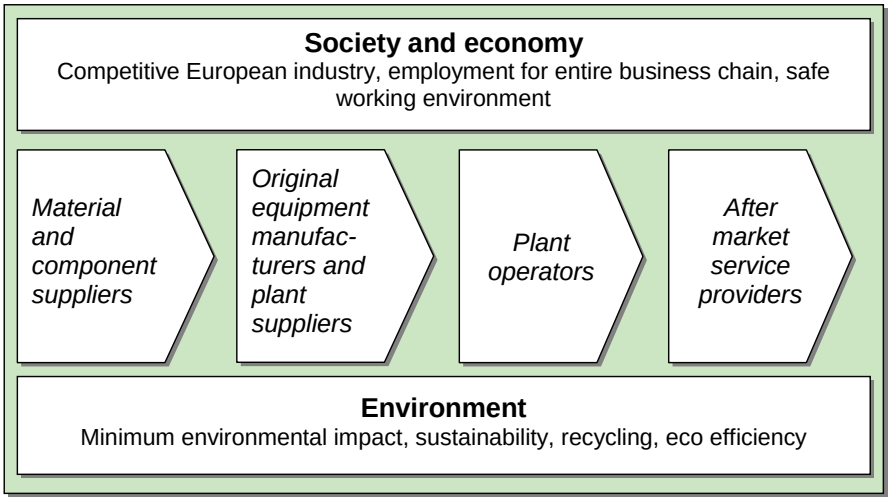


Figure 3. Social, economic and environmental impact of R&D investments for advanced materials technology.

1.5. How to Achieve the Vision

1.5.1. Research and technology priorities, general road map

The research and technology priorities and related road maps are presented in Figure 4.

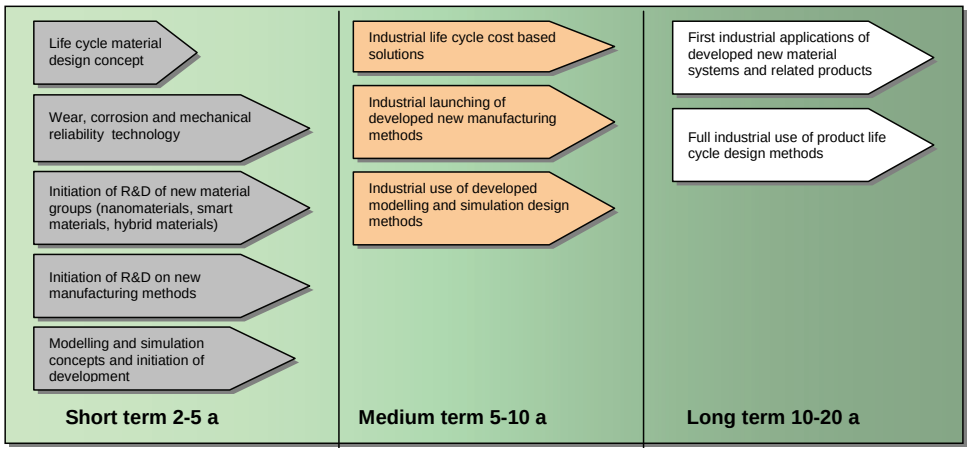


Figure 4. Research and technology priorities and related road maps.

Short term (2-5 years):

a) Develop total life cycle material design concept using selected case studies from industry (e.g. coated gas turbine blades, selected wear parts or consumables etc)

b) Develop further the next generation of tailored materials and tailored material solutions (e.g. for FGMs, new grades of steel, etc.) based on industry needs

c) Develop sufficient mechanical reliability technology based on industrial needs

d) Initiate research and technology development (formation of capable research teams and net works including sufficient R&D infrastructure) for industrially most attractive new spear head material groups, e.g. multimaterial structures, nanostructured materials, composite materials, new coatings etc

e) Initiate development of selected new key manufacturing technologies that would create long competitive edge for European manufacturing industry (hybrid structures, direct component manufacture, new joining methods, new cladding and coating methods)

f) Initiate work for development of reliable, scientifically and industrially viable modeling and simulation technology for materials and manufacturing engineering

Medium term (5-10 years):

a) Create first industrial life cycle cost based solutions utilizing development of material understanding and manufacturing methods

b) Take into industrial use the developed new manufacturing technologies

c) Take into industrial use developed new modeling and simulation methods and related design methods

Long term (10-20 years):

a) Create first industrial applications and products of developed new materials systems and related manufacturing technologies

b) Take into full industrial use developed product life cycle design methods

The research and technology priorities require a combination of modeling, experimental confirmation of the model and proof in real equipment operation. i.e. integration of laboratory experimental work, simulation and modeling, manufacturing development and demonstration in real equipment operation should be approach for the development work.

1.5.2. Key resources

Key resources for implementing the EuMaT Strategic Research Agenda (SRA) are ***universities, research institutes and industrial R&D and manufacturing facilities***. From industry, it is essential to have commitment and participation from the entire business chain including material and component suppliers, equipment and machinery suppliers as well as companies applying the equipments and machinery (process industry, transportation industry etc).

Due to the ***cross functional nature of the materials technology development*** work it should be integrated from the beginning to equipment and machine design, life cycle product and cost management and manufacturing technology development.

Because of the long term nature of the required development work, it is obvious that sufficiently strong research groups and net works should be formed with necessary research infrastructure and human resources. Selection of research laboratories to be developed into strong excellence centers should be based on their current human resources, R&D infrastructure and facilities as well as research strategy. Simultaneously, net working of key research units together with industry should be born mind when organizing development projects.

1.5.3. Technology platform

EuMaT is a horizontal platform that has to work with several platforms and projects, i.e., Steel, Sustainable Chemistry, Manufuture, KMM, and Extremat etc. It shall focus on

a) **Generic themes** that are common for several different technology platforms

b) Development of **entirely new material systems** (nanostructured materials, composite materials, multimaterials etc)

c) Development of **new manufacturing methods** (e.g. new material and component manufacturing methods, new joining, coating and inspection methods)

d) Development of **materials degradation mechanism understanding** (wear control and corrosion control technology, material behavior under extreme dynamic, static or high temperature loading etc)

e) Development of **life cycle material and component management concepts** and related modeling and simulation tooling

f) **Material technology applications** and issues that are not covered with other platforms (e.g. process machinery and equipments)

EuMaT technology platform has over 400 participants from different disciplines. Consequently the industrial and scientific views and needs from wide range of applications are well covered. Additionally, the entire business chain from material suppliers, machinery and equipment manufactures to end users is represented in the platform.

The EuMaT technology platform activities and targets are presented in different documents following the hierarchy of the figure below

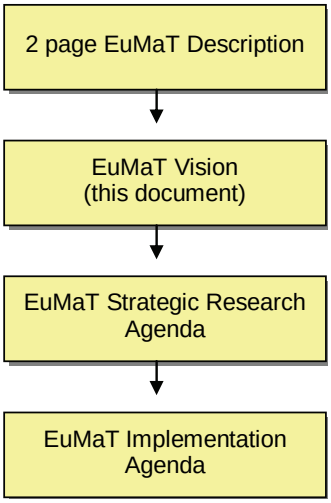


Figure 5. Hierarchy of the documents produced by EuMaT technology platform.

1.6. Vision summary

EuMaT technology platform shall promote the ***competitiveness of European industry, science and society*** by developing one of the key generic technologies, materials technology. With sufficient resources and efficient implementation, the ***industrial, environmental, social and scientific deliverables shall be significant***. Due to the enabling, catalytic role of materials technology for other technologies and industries, investments shall promote their competitiveness and development.

Europe has an excellent possibility to ***spearhead the materials technology*** *and* ***develop new innovative solutions and products*** because of the European scientific infrastructure and traditions, wide range of materials technological industry and science as well as natural European business chain from material suppliers to end users.

2. Realizing the Vision ("Strategic Research Agenda")

2.1. Aspects to be considered

EuMaT technology platform (European Technology Platform for Advanced Engineering Materials and Technologies) is a European forum that supports planning, decision making and investments in the area of advanced engineering materials and technology.

By definition: "Engineering Materials and Technologies" means:

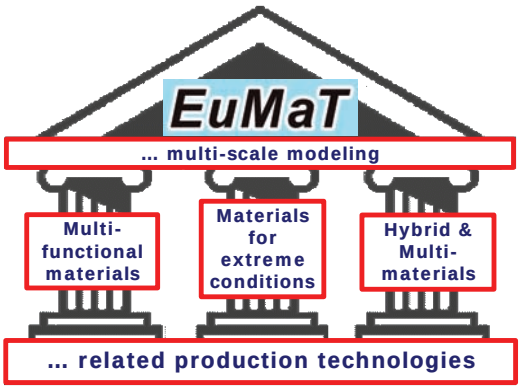
Materials and technologies used in todays and future engineering and used in todays and future products.

2.1.1. Purpose of the Strategic Research Agenda

The purpose of the Strategic Research Agenda is to provide a basis for identification of the needs for research and development on advanced engineering materials and technologies. It establishes the main lines of research in order to meet the grand challenges and will set priorities for short, medium and long term realization.

2.1.2. Scope of the document

The materials and products are shown based on the input of the involved industry. The EuMaT priorities are derived for the 3 pillars and the 2 horizontal activities.



Correlation with other technology platforms and projects are highlighted.

A priority ranking for the grand challenges is given and a time planning for achieving the performance targets is shown based on the input of the stake holders.

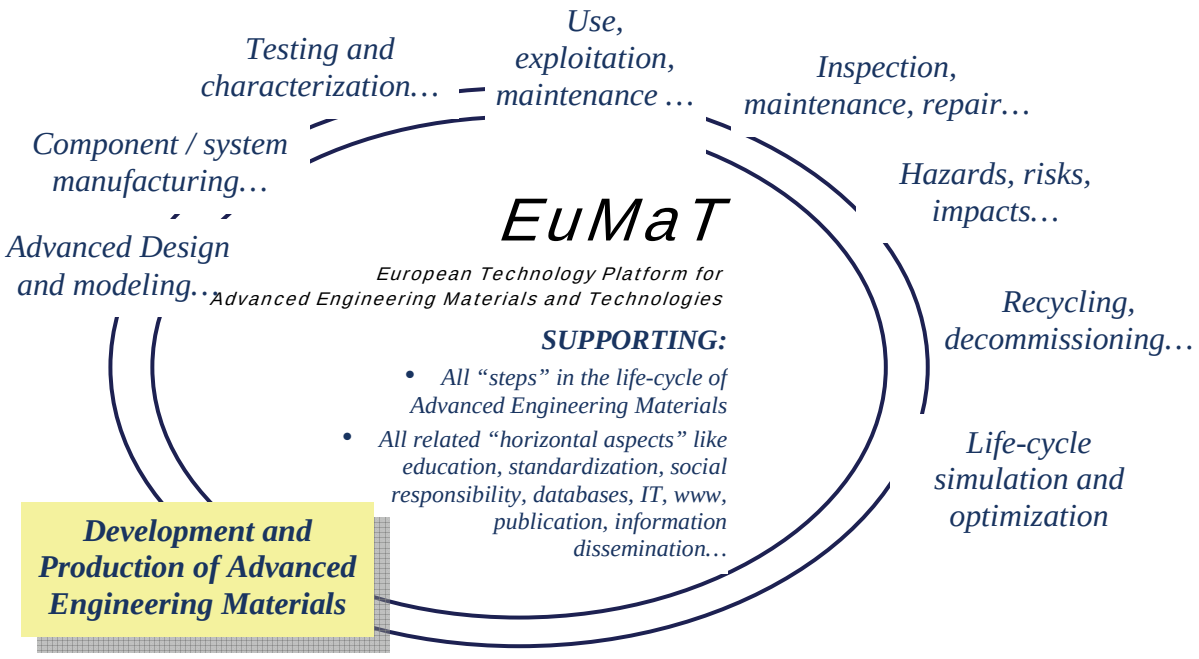
2.1.3. Overall EuMaT Policy Objective

Our general vision main items are:

- Europe is global leader in developing, supplying and utilization materials technology
- Materials technology innovations create new process and opportunities for process industry, engineering and life cycle business management

- European research in academic institutes and industry, across the continent, is able for world class research in areas identified by Strategic Research Agenda (SRA)
- Materials technology is an integrated part of the design of industrial systems utilizing modeling and simulation as design tools
- Our materials technology solution support sustainable development and application

The key theme in our vision is Materials for The Life Cycle.



The SRA shows why the EuMaT vision and main theme "Materials for the Life Cycle" is essential for European industry because of

(i) the economic and social outcomes

(ii) clear directions for strategic research agenda preparation

(iii) how the vision can be realized

EuMaT proposals and actions are based on wide interface and feedback from industry, research community, public authorities and financial community.

The Strategic Research Agenda (SRA) provides the main lines of research to be done and the primarily medium- and long-term priority research areas in order to meet/match the "Grand Challenges".

The Strategic Research Agenda is created with appropriate involvement of industry and other main stakeholders. It will provide a basis for identification of needs and will establish priorities on the short-term (3-5 years), the medium term (4-10 years) and the long-term (> 10 years) time scale.

2.2. Methods for selecting, at EU level, future basic research directions

The EU Commission R&D strategies clearly aim to the generation of knowledge for achieving three main targets: the improvement of product, process and services for a better life of citizens, the long term competitiveness of the European industrial and economical system, and the contribution to the worldwide sustainable growth.

The selection of present and future research directions should strictly stick to these principles, and among others fields, the material R&D activities will be inspired to these principles.

History tells us that civilization is anchored on materials. Now, at the end of decades of research on the materials it is time to reflect, to start a dialogue in the materials community about future directions research might take, illustrating how far materials research has come in the past century, and showing that a brief glance in the rear-view mirror can help determine vectors for the future.

The today common reflection will speculate on the materials our society would need in the coming decades and beyond for medicine, habitat, transportation, information technology, and energy generation and use.

We will look to the future of research itself, addressing yet unanswered scientific questions to which technology for ages to come should be propelled. The predictions which we will make, if nothing else, will help frame the research issues that may become important in the coming years.

The materials field has developed from one of finding and using materials to one where the materials essentially can be designed and tailored. Atom by atom. At the beginning of the 3rd millennium, one is tempted to speculate on materials that will persevere into the coming two decades and beyond. It can be comforting to imagine that research and development will determine the materials, the products, and even the market.

It is therefore prudent to speculate on what our society's longings are, and whether they are realizable at all with the current repertoire of knowledge and the materials required for the short term and for the decades beyond the current horizon. The immediate future reveals itself in developments already visible

Conscious of this complex scenario, EuMaT may play an outstanding role in the definition of the future materials R&D scenario, due to its characteristics of merging together the market, and hence societal, view inspired by the industry, and visionary and challenging view brought forward by the academy. Consequently, EuMaT community is able to assure a proper critic mass, to identify and define the state of art, the trends, and the strategic challenges which will appear on the stage of material science and technology, by a proper blending of industrial and academic inspiration.

This should result, and the SRA it is a first concrete example, in a pragmatic but also long term view contribution to the definition of future research directions in this field. In that sense, EuMaT may be a key element to support the EU Commission, in particular the concerned units of the Directorate General for Research, in selecting future research directions.

The EuMaT platform will cooperate with the European Commission, because, it will become a tool to create new ideas. In the EuMaT website, one call for expressions of interest will be created, and after a first analysis of the different proposals, a tool for ranking the interest of the proposals will be created, in order to give the European Commission an overview of the interest of the research in Europe.

Following the first SRA exercise, EuMaT will update and revise the SRA on periodic base (a first attempt is on three years base), to take into consideration the scientific and technological evolutions and for better refocusing the emerging industrial needs which should appear in a short-medium time horizon.

This exercise will be initiated and implemented by EuMaT, which will use all its internal structures (in particular the scientific and industrial advisory boards) for launching again and managing a broad discussion at European level among the involved actors, i.e. industry, academic, institution, national and international associations. The results will be used to redefine and adjust, when necessary, the R&D lines and to update the SRA.

With its wide geographical representation, EuMaT is also able to contribute to the harmonization and rationalization of national efforts on material science, at least by sharing the information from the different national programs, and acting as possible proposer of clustering initiatives. This is an important element when there is the need to identify clear R&D strategy directions, in a European global context characterized by still limited financial resources for R&D.

In its capabilities of putting together the whole set of stakeholders involved, and getting the right picture of R&D expectations, trends and visions, EuMaT should manifest its important role in supporting the Commission during the definition of the material R&D

work programs.

EuMaT entrust the organization of periodic meetings with the Commission, in order to allow the best transfer and share of information which could help the Commission in defining its R&D strategy for the sector.

It is also willing, on Commission request, the involvement of EuMaT (through its EuMaT-Commission contact group), to the concerned meetings of the Programme Committee, to contribute to the discussion and definition of future work programs (FP7). This will realize a direct link between EuMaT itself and the representatives of Members States, which are asked to co-share the decision-making procedure together with the Commission, and reinforcing the virtuoso triangle Institution, ETP, Members States.

2.3. Coordinating the Roadmap with other initiatives, technology platforms and FP6 activities

2.3.1. Cooperation with EUREKA, COST

EUREKA and COST are initiatives that allow the coordination at European Level of activities funded at national level. The different between them is that EUREKA is industrially driven and COST is a scientifically driven activity. The EUMAT Platform should be aware of the running EUREKA and COST activities, in order to canalize to the research ideas from the industries, research institutes, or universities in the right direction, it can be the 7th Framework program, EUREKA activity or COST. The National Mirrors and NCP of the European Commission will be a good help to make the approach possible and effective.

2.3.2. Cooperation to other Platforms; Networks, IPs

The cooperation with other Platforms and big structures as Networks and existing IPs of 6th FP will be also a need for EUMAT, since it is sure that there will opportunities for cooperation. These opportunities will be used to strength the cooperation with other Platforms and to establish common ideas. Sometimes the really new idea comes from the integration of ideas coming from different knowledge and background. From these links really innovative outcomes can appear in new products and processes, and then it is really important to establish links and new collaborative opportunities.

The following table show the result of a survey performed within the EuMaT editing group. The partners expressed their interest in cooperation with other technology platforms and ongoing FP6 projects. The table identifies the responses of several partners.

Technology Platform or large FP6 Project	"Zero Emission"	Steel	Manufuture	Transport	Aerospace / IMPRESS	H2/FC	SusChem	KMM	Extremat	SMR
Multifunctional Materials for Macro-Applications	high	low	medium	high	high	high	high	high	high	high
Engineering materials for challenging application conditions	high	medium	high	medium	high	high	high	high	high	medium
Multi-scale Modeling	high	low	low	medium	high	medium	medium	high	high	high
Related production technologies	high	high	high	medium	high	medium	medium	n/a	high	high
KEY PRODUCT(s) dependent on advanced engineering materials	1600 C Gas / 700 C steam power plant	650 C steels		"Third-Millennium Car"		new membrane materials		ITER	ITER	C-Fibre

It is evident that EuMaT as a horizontal platform sees correlations with many others technology platforms and projects where advanced materials and technologies are

required.

2.4. Academia / Industry collaboration

EuMaT has evolved from an established relationship between the academic and industrial partners from throughout Europe. Recognizing the current status of collaboration at different levels, as well as all the shortcomings, EuMaT sees this relationship as a two way process which can be substantially developed and enhanced by a global, Pan-European approach. This is particularly specific to the materials science and engineering applications, very large area with substantial diversities in academic and industrial research as well as in industrial applications. In the first instance, current status of the academia, the industry and their collaboration should be appreciated.

Many of the oldest and best established universities are in Europe. However, tremendous research potential has not been used efficiently. Currently, the research is often fragmented at local, regional and national levels. As a result, research achievements are often not efficiently used. This is resulting in slow application of the results, and depending on the type of research, followed by delay in commercialization. There is still a lot of repetitive work, not always resulting from the Intellectual Property Rights protection, which has been now much improved in Europe.

The industries in Europe are also the oldest (industrial revolution started in Europe), with unique knowledge base and skilled workforce. In some areas, European industries are still the most advanced in the world, despite the strong competition. However, there is an awareness of the intensive competition from both, the developed and developing countries, at every level, from low-tech to the very top-end, high-tech materials, processes and products. It must be noted that in many areas of fundamental and applied research, the US and Japan are often finding better ways in supporting academic/industrial collaboration.

Despite substantial advantages and huge progress made in European integration, there is still a lot of duplication of research and lack of adequate dissemination of the results. Both the industry and academia are far too often reactive in establishing research programs, rather that pro-active in exploring exciting new avenues, with potentially much higher rewards. To enroll into these new possibilities, a 'critical research and industrial mass', with a right attitude and backing is necessary. The research should not be limited to a narrow, 'problem solving' approach, being either a new material development, modeling, manufacturing or design optimization related research, but having a global vision of efficient integration of all of these into an industry lead collaboration with academia. That is exactly the EuMaT approach.

European projects in previous calls have demonstrated that pan-European research which includes intensive academia/industry collaboration can be very successful and cost effective, for the benefit of all participants and the Community at large. Mobility of ideas, researchers and capital have much improved cooperation, further developed healthy competition with overall reduction in research 'repetition'.

However, this is only the very beginning. Considering the potentials; human resources, tradition and facilities, European research potential is tremendous and can be much better used for wealth creation. In many ways, EuMaT is specific in addressing a number of issues mentioned before. International from the very initiation, with exceptionally strong links between the industry and academia. Furthermore, material research, and the approach by EuMaT members (both industrial and academic) is more inclusive in several ways. There is a strong emphasis on material science (new material development) but this is complemented by multi-scale modeling of applications, leading to product development and life cycle optimization. The participant from different industries and academic background prove this. Within the EuMaT, there is a strong determination, both within the industrial and academic communities, that the effective way forward must provide that often missing link, from new material conception to a novel, most efficient application. Not just a replacement of an existing material, product or modeling procedure, but a fundamental re-think of the product concepts, manufacture, function and associated scientific and engineering tools is required. Fruitful collaboration between the academia and the industry will lead to very exciting, novel, 'world-first' products, processes and procedures. No doubt, only such success will lead towards re-gaining European leadership in industry, research and wealth creation. By doing this, EuMaT takes the care about the environment as an integral part of all the processes. To achieve such goals, a creative academic and industrial collaboration is vital.

2.5. FG 1 Management and Coordination Issues

2.5.1. Communication and liaison with the EU

A strong, structured and collaborative relationship with the concerned services of EU Commission it is a must for assuring the best implementation of the EuMaT Strategy. The European Commission, with its concerned services, it is a key subject of the EuMaT platform and special attention it is devoted to keep the bidirectional flow of information about the two systems as much as possible effective, constant and profitable.

If the link it is certainly established with the intention of maximizing the implementation of R&D activities of the SRA, through the main EU Commission support schemes (FP7 on top), the relationship with the Commission services is also essential for promoting other important collateral actions and initiatives, aiming to improve the collaboration, coordination and synergy at European level in the field of material technology.

In this view, EuMaT will establish a dedicated task group, the ECCG (European Commission Contact Group), which will be charged of maintaining and assuring the right links with the European Commission, to achieve a full integration of EuMaT strategies and initiatives with the Commission action in the field of material technologies.

2.5.2. Communication and coordination with other ETP's

Materials are a pervasive key factor for the achievement of whatever any industrial success, both in terms of products and processes. Transport, energy, infrastructures, health, communication are, among the most important sectors, those which have clear, complex and challenging needs and expectations from material science. They demand, nowadays and in the future, improved and new materials for tackling their challenges.

Having topics relevant to all these sectors been addressed by specific ETP's, EuMaT is convinced that strong, structured and durable links have to be established with these ETP's in order to coordinate efforts at academic, industrial and institutional level for steering the material R&D activities. This would avoid redundancies and duplications, improve coordination and synergy between activities common to different sectors.

To that purpose a dedicated task group, ETPLG (European Technology Platform Liaison Group) has been established. The ETPLG shall report to the EuMaT Steering Committee with ideas, proposals and initiatives aiming at coordinating material R&D activities with the other ETP. ETP's targets already identified are: ACARE (aeronautic), ESTEP (Steel), HFP (hydrogen and fuel cells), ESTP (space), ERRAC (rail), and SUSCHEM (chemistry).

The ETP's represent such high level systems wherein all stakeholders involved in a certain sector are put together, that by themselves they can achieve an important first coordination level. However, different technological sectors show technological overlapping. In particular for their horizontal aspect; material technologies do represent one of the most relevant examples. This is the reason why a high level of coordination between ETP's, needs to be accomplished.

EuMaT envisages, and recommends, two levels of actions for pushing such coordination. The first one is on ETP's self initiatives, based on spontaneous definition of links between different ETP's, which have common technological interests and potential area of overlapping. The establishment of the above mentioned ETPLG is an example. The second one is at Commission level, where a centralized and coordinated initiative could be inspired to move toward the constitution of a stable coordination structure, composed by representatives of different ETP's. This structure should face and solve problems related to the overlapping activities by a proper allocation of mission tasks and technological objectives between the different ETP's.

2.5.3. General contact point

All the information about EuMaT strategies, activities, and events may be found in the EuMaT web site, at **http://www.eumat.org**. In the site it is also present a list of contact points and the list of national mirror contact points (where already established), to be used as entry points for EuMaT. Direct query to EuMaT may be also addressed by e-mail, using the dedicated web area "contact".

2.6. FG 2 Materials and Technologies

2.6.1. Classification and Definition of "advanced engineering materials"

EuMaT covers all elements of the life cycle of "Advanced Engineering Materials &

Technologies" (AEMT). The term AEMT refers in EuMaT to the three pillars

1. **multi-functional engineering materials with gradient properties**
2. **engineering materials for challenging application conditions, including high-temperature and light-weight**
3. **multi-material (hybrid) systems where advanced materials are combined with more conventional / structural materials**

… plus

4. **relevant materials (e.g. production or joining) technologies and**
5. **multi-scale modeling**

as used in engineering (and, e.g., coupled with "conventional" structural materials like steel, aluminium, titanium, metallic alloys, composites, polymers, advanced ceramics, coatings, adhesives, ordinary and advanced concretes, such as sulfur-polymer matrix composites, concretes and mortars, …) and/or used to enhance the engineering products, systems and processes in areas like energy, gas & oil, chemical, space, transportation, electronics, environment, health…EuMaT covers the lifecycle of lightweight materials and nanomaterials in engineering components/ applications/systems. The definition of the advanced materials includes light materials, nanomaterials, nanostructured materials, biomaterials, renewable materials, ceramics, polymers, coatings, hybrid materials, functional graded materials, multimaterials.

2.6.2. Research activity

The introduction of **lightweight materials** for vehicle structures is in particular driven by the need to reduce emission levels, however a growing influence on the choice of materials for vehicle construction is the requirement to recycle as much of the vehicle as possible at the end of its life. With regard to this focus, polymers from renewable resources (bio-based polymers) reinforced with natural (vegetable) fibers deserve special attention. Owing to biodegradability of both polymer matrix and reinforcement, such composites can be recycled through composting (bio-recycling). Vegetable fibers are low cost and low density. The latter feature leads to lightweight materials for automotive and construction. The challenge for the vehicle designers will be to offer in such lightweight vehicles at least the same or preferable even a better performance in the perspective of comfort (vibration, noise and harshness) and safety (protection to the occupants in the event of a crash).

Research onto the mechanical characteristics of lightweight and other new materials (composites with polymeric matrix, metal matrix composites, metallic foams, polymeric foams, multi-materials, sandwiches) should therefore be given high priority.

For what concerns **composite** material, with particular reference to polymeric matrix composite, much research is still needed for a clear definition of the different concurrent failure modes in the different loading conditions and for the elaboration of mathematical models capable of describing the interaction between failure mechanisms. An interesting round robin between European laboratories has already been developed with respect to the prediction of the composite strength in case of quasi-static loads. A similar exercise could be proposed to find mathematical models for fatigue loading resistance, dynamic behavior, and impact resistance. The effects of environmental conditions cannot be neglected in many applications that require not only peak performances but also durability therefore the effect of humidity, thermal shocks and thermal fatigue should be investigated as well as their interaction with mechanical load induced failure mechanisms.

For what concerns the **cellular materials** (also called structural foam), both metallic and polymeric, some research have to be still developed to inspect the relationship between the base material mechanical characteristics and the foamed material mechanical characteristics (in particular shear and multiaxial stress conditions) to predict its behavior once relative density, cellular microstructure and cell size are known. The variability of both base materials and derived foams is extremely large and affordable prediction techniques for the design are necessary. The dependence of the characteristic material parameter from the foam density is another point of particular interest for the design of the foam itself in the perspective of mission of the structural component.

Besides, unlike metals and like most other materials as plastics, their failure behavior is not independent from the hydrostatic component of stress. Therefore, it is not possible to characterize the material behavior solely by testing in uniaxial tension or compression. Different combinations of the hydrostatic and deviatory stress components must be applied to obtain the yield locus. This is obtained by testing in uniaxial tension/compression

together with at least hydrostatic tests, shear tests, or mixed hydro-tensile or hydro compression (Deschpande-Fleck or other techniques under development).

Standard procedures for characterization (with particular reference to impact loading conditions) and for classification have not yet been defined. But these are essential for qualification and robustness of the productive solution.

For what concerns the **sandwich** solutions, some research have to be still developed for their failure modes under quasi-static and impact loading, with particular reference to the anchorage between the core and the external sheets and the load transfer between the different constitutive parts.

The adoption of these new materials requires an in-depth research analysis on the more appropriate **joint technologies,** with particular attention toward both the specific properties and constraint of the joint technology itself and toward the **more appropriate choice in case of multi-material joints.**

In recent years fundamental studies on the mechanical behavior of **adhesives** (both of the aerobic and anaerobic types) have been developed both in the perspective of the quasi-static strength (the definition of the most appropriate limit curve and resistance model), of fatigue strength and impact behavior. Combined loading conditions (shear, tensile-peel, and their variable combinations) must also be considered, and many attempts to do this are under development.

A very peculiar application is **the joining of ceramics and ceramic matrix composites together or to metals,** for high-temperature and extreme environmental conditions. Due to their particular chemical and mechanical characteristics (brittleness), and very high production and manufacturing costs, they require both special joining materials and methods, and specific testing procedures.

Joining materials for ceramics and composites are far to be well establish and need in-depth research. Testing procedures are still missing: sometimes they are adapted from testing on other types of materials or testing of the bulk ceramic with unsatisfactory results.

Joining of different materials and their characterization is a topic of intensive discussion within the scientific community since ever.

Joining is often seen as something to be avoided and it is one of the reasons why advanced materials (i.e. ceramics and ceramic matrix composites, CMCs) are not properly used.

Joining is also a horizontal subject, able to interest fields ranging from thermonuclear fusion, to biomaterials, fuel cells and photonics.

It is also a subject of strong interdisciplinary among platforms, where materials scientists cooperate with mechanical engineers, electronics engineers, medical doctors, etc.

Even if a promising joining technique is available, the proper characterization of it is a weak point.

Most of the mechanical tests require a time consuming preparation. Large scatter in the results occurs. Interpretation of the results, to be usable for practical applications, is also very difficult.

Several alternative tests have been developed in many laboratories and this is highly detrimental for the comparison of the results. There are uncertainties on the comparison parameter to be used, which is difficult to be defined due to the very different internal stress distribution.

The **manufacturing process** and technology leave into the formed pieces residual stresses and modified mechanical characteristics with respect to the "virgin" material. Furthermore, the same piece obtained through different manufacturing process has different mechanical behavior (see for example gravity versus pressure die casting or hydro forming versus deep drawing). Research are to be developed in order to point out, from a general point of view, the influence of the manufacturing process on the structural behavior of the formed pieces.

Another point of great relevance is **materials ageing**. We are mainly working to enhance the vehicle strength, comfort performance and crashworthiness at the beginning of its life. Instead we have to wide our interest to the whole vehicle life. This means that the vehicle must remain to an acceptable level of safety while becoming old. A fundamental point in

this perspective is the material ageing (fatigue ageing, corrosion ageing, wear….). Research are to be developed in order to point out, from a general point of view, the influence of the ageing process on the structural behavior of the vehicular structures and parts.

Micro- and nano-structured materials are under development. Due to their peculiar characteristics that could be specifically enhanced for intended application they could provide new possibilities for design toward vehicular applications.

It is expected that as one of the results of the research effort, in the medium period, micro- and nano-structured materials could be designed with mechanical characteristics specifically enhanced for strength, dynamic comfort and crashworthiness. However, this possibility asks for systematic research about evolution of these types of materials in order to monitor and, eventually, to orient their development toward the application of interest.

Ultra fine microstructures having an average phase or grain size on the order of a nanometer are classified as nanostructured materials (NSMs). Currently, in a wider meaning of the term, any material that contains grains or cluster smaller than 100 nm, or layers or filaments of that dimension, can be considered to be nanostructured. The interest in these materials has been stimulated by the fact that, owing to the small size of the building blocks (particles, grain, or phase) and the high surface-to-volume ratio, these materials are expected to exhibits unique, mechanical, optical, electronic and magnetic properties. The properties of NSMs depend on following four common microstructural features: (1) fine grain size distribution (<100 nm); (2) the chemical composition of the constituent phases; (3) the presence of interfaces, more specifically, grain boundaries, heterophases interfaces, or the free surface, and (4) interactions between the constituents domains. The presence and interplay of these four features largely determine the unique properties of NSMs.

In nanophase materials, a variety of size-related effects can be incorporated by controlling the sizes of the constituent components. For example, nanostructured metals and ceramics can have improved mechanical properties compared to conventional materials as a result of the ultra fine microstructure. In addition, NSMs have the capability to be sintered at much lower temperatures than conventional powders, enabling the full densification of these materials at relatively lower temperatures.

Semiconductor NSMs are currently also considered to have technological applications in optoelectronics devices such as semiconductor quantum dots and photodiodes, owning to the phenomenon of "quantum size effect" caused by the spatial confinement of delocalized electrons in confined grain sizes.

Magnetic applications of NSMs include fabrication of devices with Giant Magneto-Resistive (GMR) effects, the property used by magnetic heads to read data on computer hard drivers, as well as the development of magnetic refrigerators that use solid magnets as refrigerants rather than compressed ozone-destroying chlorofluorocarbons.

In additions, nanostructured metals and ceramics seem to be candidates for new catalytic applications.

The development of semiconductor nanoclusters is an area of intense research efforts. These nanoclusters are often referred to as quantum dots, nanocrystals, and Q-particles. In the nanometer size regime, electron-hole confinement in nanosized spherical semiconductor particles results in three dimensional size quantization. Band gap engineering by size and dimension quantization is important because it leads to electrical, optical, magnetic, optoelectronic, and magneto-optical properties substantially different from those observed in the bulk materials. As an example, quantum dots can be developed to emit and absorb a desired wavelength of light by changing the particles diameters. This feature allows the construction of a finely tunable and efficient semiconductor laser.

In particular, in the car industry, most of components and microsystems which will equip the car of the future will need new artificial materials whose properties do not exist in Nature. Such a material can be designed according to a specific application and fabricated by the future upcoming advances in nanoscience and nanotechnologies.
The synthesis of Nano-Structured Materials NSMs from atomic or molecular sources depends on the control of a variety of "nanoscale" attributes desired in the final product. In general, the following four methods are used to make nanophase materials:

1. The first technique involves the production of isolated, ultra fine crystallites having uncontaminated free surfaces followed by a consolidation process either at room or at elevated temperatures. The specific processes used to isolate the NSM are, for example, inert gas condensation, decomposition of the starting chemicals or the precursors, and precipitation from solutions.

2. Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), and some electrochemical methods have been used to deposit atoms or molecules of materials on suitable substrates. Nanocomposites can be produced by depositing chemically different molecules simultaneously or consecutively.

3. By introducing defects in a formerly perfect crystal such as dislocations or grain boundaries, new classes of NSMs can be synthesized. Such deformations may be brought about by subjecting the materials to high energy by ball milling, extrusion, shear, or high energy irradiation.

4. The final approach used to make NSMs is based on crystallization or precipitation from unstable states of condensed matter such as crystallization from glasses or precipitation from supersaturated solid or liquid solutions.

Micro- and nano-structured materials research must be promoted by use of industrial by-products, otherwise disposed to landfill with environment damage.

Related to this are developments in the field of **intelligent (or smart) materials** & structures. Current research related to smart materials & structures in an automotive environment is mainly directed towards new solutions for noise reductions and vibration and shape control, visual and thermal comfort (smart windows). Applications for vehicle crash safety are substantially different due to the significantly higher energy levels involved. Because of this, completely new strategies for smart materials/structure applications in crash need to be developed. Applications of smart windows are possible also in display devices of different kinds.

Polymeric adhesives for surgical and medical applications: need of improvement of base research

Polymeric adhesives are widely used in surgical practice where conventional methods failed or are difficult to be used. In this field poly-cyanoacrylates are obtained in situ by polymerization of cyanoacrylic monomers. Due to their use for biomedical application the above polymers and monomers must possess some peculiar characteristics related to their toxicity and to the technical difficulty associated to their use. During the use of cyanoacrylic monomers the polymerization time has a relevant influence as well as viscosity and strength between artery and micro-catheters; by changing the group connected to the ester some properties can be altered but until now the commercial products are not fully satisfactory. Indeed, mixtures of different cyanoacrylates are used in order to modulate the characteristics of the final product.

2.6.3. Engineering materials for extreme (challenging application) conditions

This material class has very close relationship to EXTREMAT.

The engineering materials for challenging application conditions, including high-temperature and light-weight.

High temperature aggressive environments have become a particularly critical issue in a number of more advanced industrial applications. In many cases lifetimes of the plants or components are actually limited by the corrosion resistance of the materials. In several cases where higher operation temperatures would be desirable as they imply higher efficiency, the process is impeded by the exponentially increasing corrosion attack.

Extreme types of high temperature corrosion are always encountered when the formation of a protective, slow growing oxide scale on the material surface is prevented. As a consequence fast growing corrosion products like sulphides or porous oxides can be formed, or in extreme cases even volatile corrosion products like metal halides will be present. Another type of severe corrosion at high temperatures is the so called metal dusting attack. In this case the original metal disintegrates into powder consisting of small micro- or nano-sized metal particles and so called coke (carbon dust). Particularly endangered are process environments of very low oxygen partial pressure together with high activities of the aggressive compounds. E.g. particular processes in oil refining industries significantly challenge materials resistance at high temperatures since the process environments contain oxygen partial pressures as low as 10-27 bar, and sometimes even lower, together with high sulfur activities. The situation may become even worse in this type of industry due to present economic and ecologic requirements where, as for example in gasification of oil residues, additional compounds like vanadates or high carbon activities further increase the corrosive potential to an extent that presently no reliable materials solutions exist. The situation is similar for high carbon / low oxygen

activity environments as in encountered in steam reforming, steam cracking, and coal gasification.

The most critical type of high temperature corrosion is observed in the case of formation of volatile corrosion products. Industrial environments where such problems can be encountered are e.g. chemical process environments, coal or biomass gasification, etc., all with high chlorine concentrations. There have been several recent examples where biomass gasification plants showed material failure after relatively short periods of operation. The formation of volatile metal halides (usually chlorides) results in so called active oxidation or simply in vanishing of metal by conversion of solid material into gaseous phases due to the transition into metal halides.

It shall not be concealed that there are cases where all the aggressive elements mentioned so far, act together leading to synergistic effects and a particular challenge for the material resistance under operation conditions. Solutions can be developed by thermodynamic modeling of the stabilities of the different phases formed and in particular under which conditions protective oxide scales can be expected, and based on systematic approaches by the development and use of innovative coating systems.

Coating systems have some tradition in the gas turbine and jet engine industry. However, new routes of development for more advanced coatings are now at the threshold of becoming a dynamic field of activity aiming at new sophisticated multifunctional, multi-element coatings, e.g. by thermodynamic design of the diffusion process of multi-element CVD coatings. It is expected that the challenges of increasing process temperatures and at the same time encountering increased aggressive behavior of the process environment can only be mastered by target-oriented scientific approaches including the development of new generations of coatings.

2.6.4. Knowledge-based multi-component, multi-functional materials for macro-applications

The focus of KMM Network of Excellence is on materials tailored by the scientists to provide superior mechanical properties (high strength, superior hardness) while at the same time fulfilling some specific demands like low density, high resistance to wear, excellent performance in high-temperature regimes, enhanced fracture toughness, superior resistance to physical-chemical attacks including corrosion, oxidation, hydrogen attack. Some other functionalities comprise bio-compatibility in medical applications, enhanced resistance to mechanical and electrical fatigue in actuator materials, thermal barrier in gas-turbines.

These multiple functionalities are sought within the class of knowledge-based multicomponent materials (to be named KMMs in the sequel) comprising (1) intermetallics - a new generation of low-density, high melting-point materials for multisectoral applications, (2) innovative metal-ceramic composites designed to sustain complex thermo-mechanical loading or adverse physic-chemical environment, (3) novel functionally graded materials (FGM) involving knowledge-based grading of metal and ceramic constituents.

A class of KMMs are artificial materials constituted of:

- Nanoparticles, nanocrystals, colloids, sols, and quantum dots
- Self-assemblies and directed assemblies (of molecules and nanoparticles)
- Films, membranes, and coatings
- Nanotubes, nanowires, nanofibers, nanorods, and nanobelts
- Nanoporous, mesoporous, and microporous materials
- Hierarchical structures and molecular-particle networks
- Surface and interface sciences and engineering
- Inorganic-organic hybrids or nanocomposites
- Nanoceramics, metals, and alloys

When surveying the industry needs and applications of the KMMs, the following conclusions were drawn:

1. Cost seems to be the key point when talking about concerns in the field of KMMs. In other words, a sharp cut in prices/cost is required for industrial implementation.

2. Standardization is another key issue. From the industrial standpoint it is indispensable that all components, pieces, etc. fulfill general standards. Otherwise it is not feasible their use at an industrial scale.

3. As far as technical properties are concerned the answers are quite general and unspecific: wear resistance at room and at high temperatures, corrosion resistance, thermal shock resistance, control of the Young modulus, vibration effects damping, etc.

4. The other issue that is systematically raised is the mass production of KMMs. The lab products are OK but a further step is needed for industrialization. Scaling up is necessary for industrial success. Consequently, industry seems to claim for other needs related to production efficiency and cost. If this can be generalized then these "non technical" topics should be addressed when planning the new lines of research for the near and mid-term future.

2.6.5. Multi-material (hybrid) systems

The focus in hybrid material systems is on combining largely different materials, such as metals and ceramics in order to provide strength and ductility at the same time, e.g. for new structural applications in automotive and aeronautic applications. The advantage of superior fatigue properties at light weight is still to be implemented into components as a number of material properties are not yet fully explored.

Applications range from metal matrix composites (MMCs) such as ceramic particle reinforced metals or ceramic based hard metals where the ceramic part is the dominating one. On the other hand macroscopic phase divisions as in bi-materials are relevant in a large variety of industrial components. Moreover, functionally graded materials (FGMs) play an increasing role for structural components in automotive industry.

The practical needs can be summarized as follows:

1. Systematic overview on technical relevant systems for industrial purposes with respect to material properties, availability and costs.

2. Aspects of interface mechanics will play keys issue under service conditions including thermal and mechanical aspects. There is a large need to provide a theoretical framework including all presently know mechanical aspects for predicting interface properties, such as, e.g. interface fracture.

3. Another main concern before large scale production can be expected is the experimental support of theoretically predicted properties of materials and components.

Organic-inorganic hybrids are advanced materials that blend at the nanoscale level ceramics with organic polymers. In this class of materials, the peculiar properties of ceramics (thermal stability, high modulus, low thermal expansion coefficient etc.) and of polymers (high ductility, low temperature processability etc) can be broadly combined and tuned to the specific application. In bioengineering, for example, it is known that ceramics and metals used in bone replacement have higher elastic modules than that of the human cortical bone. Lower elastic modulus bioactive materials can be obtained by the combination at the molecular level of ceramics, such as titanium or silica, with a suitable flexible organic component. Organic inorganic hybrids are also promising as coatings for surface properties modification (barrier properties, scratch resistance, etc). The nanometric dimension of the inorganic domains guarantees optical transparency of the coating layer, which represents an additional attracting feature of these materials. Moreover the enhancement of mechanical and thermal properties of polymers by the inclusion of inorganic moieties, especially in the form of nanocomposites, offers the possibility to substitute metals or traditional composites in the automotive industry with innovative hybrid materials.

As the properties of polymers depends strongly on the chemical structure (kind of repeating units and, in the case of copolymers, their relative amounts and disposition in the chain), it is relatively easy to design polymeric materials with the most different characteristics, which could be employed successfully in a large number of important applications. A relevant example concerns solid state polymer based electrolytes for Lithium rechargeable batteries or hydrogen fuel cells, to be employed by automotive industry. In the former case crucial factors are the choice of the polymer, linear, branched

or cross linked, which has to be solid at room temperature and in which the dissolution of appropriate Lithium salts gives rise to a solid solution, characterized by high conductivity, wide electrochemical window and long term stability. In the latter case other kinds the polymer electrolytes has to be used, since they has to be characterized by a high proton conductivity, in order to permit an easy migration of Hydrogen ions. Another example concerns mono- or multilayer polymeric films, with appropriate barrier properties to specific gases, to be employed as packaging materials for meat or vegetable conservation, with good mechanical characteristics and easy to be sealed. Polymeric materials with specific barrier properties can also be used for the production of membranes employed in devices devoted to gas separation.

Two examples are given in the following in the field of multiscale modeling of interfaces in metal/ceramic hybrid systems, such as MMCs, FGMs and CMCs:

Multiscale modeling of interfaces in metal/ceramic hybrid systems

The atomic bonding at the interface is captured by ab initio methods in order to provide correct bond strengths for upscale modeling. In a next step many atom observations are performed based on molecular dynamics simulations in order to analyze fracture on the atomic level. Results from such simulations are then applied in discrete dislocation simulations in order to model dislocation activities providing the link to crystal plasticity simulations where different glide systems are activated during plastic deformation of the metal part. Moreover, continuum theoretical based cohesive zone models and damage models can be applied in order to analyze macroscopic fracture behavior.

Based on comparisons with metal/ceramic interface fracture experiments the theory and simulation procedure is to be improved. In a next step, predictions can be made for other metal/ceramic systems, for interface segregants and interface defects and their impact on the mechanical performance of the systems to be investigated.

Computer Based Design of Ductile Materials and Components with Improved Properties

New ductile materials with superior mechanical properties and well-suited mechanical behavior are in most cases based on modifications of already long-time established conventional materials. Thus, they provide the basis for sophisticated applications in existing working fields and in future developing areas. Due to their wide distributions theses achievements do have strong impact on the society as well as on the life of individuals. They require multidisciplinary approaches of long term and high risk and the reconsideration of presently available design-concepts.

Such developments effect typically materials in energy, sport, transport and health Industries and are related to safety, environmental and constructional aspects. Typical examples where these materials are used are high performance applications such as high strength ductile metals for pipelines, as well as metal sheets and metal matrix composites for application in car bodies. Expected are materials which are improved by at least 20% due to the increase of materials properties, such as strength or ductility) on the basis of microstructural tailoring as well as by the derivation of new materials and components for future applications. An approach to design new components is to start from a brand new artificial material. Nanotechnologies offer new perspectives to designing and material nano-assembling. Material elements can be put together at nanoscale in order to make up a new hand made row material whose properties are a result of its components' ones. Properties of the artificial material can be modeled by EMTs (Effective Media Theories) from the physical properties of its constituting nano-sized elements. This aim can be attained by interdisciplinary actions and well-founded research in comprising input from industrial requirements and in applying fundamentally new modeling aspects.

The largest markets for applications of improved materials can be found for crack-resistant deformable, ductile metals and alloys. Presently available computational tools to simulate the materials behavior is used to understand how the microstructure of ductile materials is formed, and by which factors the properties of such materials are determined. The achievement of this goal will be only possible if the complementary potential is brought together in an action with several interacting research clusters.

This program concentrates on modeling of material properties in order to improve materials with respect to ductility, strength and fracture strain as well as to substitute components made of these materials. The main benefit from this program is expected from large scale substitutions of wide-spread components. Modeling shall focus on multi-scale simulation approaches covering at least three principles different length scales in the range from electron theory to atomistic, dislocation theory as well as micro mechanics up to macro mechanics.

The modeling results have to be verified by experiments in order to show their validity for materials and components. This project shall be supported by materials companies which produce this type of materials.

2.7. FG 3 Materials Production Technologies, Testing and Characterization

2.7.1. Production Technologies

The development of advanced materials like those approached in EuMaT requires the corresponding effort to develop suitable production technologies. Both primary and secondary processes must be adapted or created to comply with the needs and challenges that the new materials demand. Even though it is known that the final properties of the component produced depend on the features of the raw materials and the applied production process and therefore each case must be studied independently, there are common aspects that are to be always taken into account.

The production processes of the future must comply with some general requirements:

Cost competitiveness. This aspect will continue being the main requirement in the development of new production processes even for high added value products and sectors that are used to paying high cost materials and components.

Sustainability policies. The need of complying with sustainable related policies will consolidate in the near future.

Flexibility. The trend for tailorable products will increase in the near future. Processes should adapt to changes in both process parameters and material composition.

Near net shape production. The development of near net shape production routes that eliminate production steps and increase both yield and competitiveness will continue.

Intelligent processes. The use of sensors and actuators that can automatically answer to the production needs in all the entire production cycles should increase to cope with the industrial needs of the material sector.

Adaptation to new materials. Development of new processes. New heterogeneous materials such as functionally graded materials, nanoporous ceramics and metals, polymer-metal hybrids etc. will require the development of suitable processes that can be controlled so that the final component is reliable and the properties are tailored to the specific requirements.

Today, a plurality of general methodologies are employed to synthesize this NSMs, several variants of these processes have been developed to generate compounds or alloys with specific composition and properties and also for optimized production.

There are basically two broad areas of synthetic techniques for NSMs, namely, physical methods and chemical methods.

1. Physical Methods

   Several different physical methods are currently in use for the synthesis and commercial production of NSMs. The first and the most widely used technique involves the synthesis of single-phase metals and ceramic oxides by the inert-gas evaporation technique. The generation of atom clusters by gas phase condensation proceeds by evaporating a precursor material, either a single metal or a compound, in a gas maintained at a low pressure, usually below 1 atm, in a gas condensation chamber. The evaporated atoms or molecules undergo a homogeneous condensation to form atom clusters via collision with gas atoms or molecules in the vicinity of a cold-powder collection surface. The clusters once formed must be removed from the deposition region to prevent clustered aggregation and coalescence. These clusters are readily removed from the gas condensation chamber either by natural convection of the gas or by forced gas flow. Sputtering is another technique used to produce NSMs clusters as well as a variety of thin film multilayered materials. The third physical method involves generation of NSMs via severe mechanical deformation.

2. Chemical Methods

Chemistry has played a major role in developing new materials with novel and technologically important properties. The advantage of chemical synthesis is its versatility in designing and synthesizing new materials that can be refined into a final product. The primary advantage that chemical processes offer over other methods is good chemical homogeneity, as chemical synthesis offers mixing at the molecular level. Molecular chemistry can be designed to prepare new materials by understanding how matter is assembled on an atomic and molecular level and the consequent effects on the desired material macroscopic properties. A basic understanding of the principles of crystal chemistry, thermodynamics, phase equilibrium, and reaction kinetics is important to take advantage of the many benefits that chemical processing has to offer.

However, there are certain difficulties in chemical processing. In some preparations, the chemistry is complex and hazardous. Contamination can also result from the byproducts being generated or side reactions in the chemical process. This should be minimized or avoided to obtain desirable properties in the final product. Finally, although many chemical processes are scalable for economical production, it is not always straightforward for all systems."

Priorities

1. Tools (computational related and knowledge based) for accelerating development of new, low cost production processes and materials.

2. Larger reliability. Fundamental and applied research on the relationship between process parameters and microstructure of advanced materials.

3. New processes that can reduce the cost of the final components. Near net shape approaches.

4. Recycling methods suitable for the recovery of the reinforcing phases in composite materials and construction and demolition waste in new safe structural concretes.

5. Reduce the cost of machining and finishing operations.

6. Development of processes that comply with sustainability policies

2.7.1.1. Vision and General Targets

Reduction of processing costs by the target oriented usage of modern materials and emerging processes. Reduction of overall life-cycle costs of structures and components including their environmental impact using the advanced materials and processes.

Achieving sustainability by qualifying new processing technology and securing future product and waste recyclability.

Controlled operation of manufacturing technologies for future needs in different fields like archetypes, forming, joining, surface treatments under adding the aspects of product recycling and the certification of the fabrication processes.

Advanced modeling and simulation of manufacturing processes (e. g. molding, injection, stamping …) and of new materials incl. hybrid structures for construction engineers. Implementation of supplementary new material software modules to be imposed on standard construction software (universal material selector and supplementary data base). Cooperation with FG 2 "Materials" and FG 4 "Material Modeling". Development of corresponding Data Base Systems.

Exploitation of the full material power for the application over the complete life cycle by improved health monitoring.

Exploitation of the full power of new advanced materials and multi-materials by gaining knowledge of damage mechanisms at future possible operation conditions and knowledge of effects of microstructure and treatment technologies on properties, material resistance, damage mechanisms with the aim to reduce scatter of properties and consequently to improve material power exploitation together with reducing risks and increasing safety and reliability on the properties of the components.

Effects of defects always expected in series production can be minimized when using on line non destructive measurements.

2.7.1.2. Materials Production Technologies

Intelligent, fast, environmentally compatible, joining homogeneous and composite materials. Cost efficient fabrication, service and recycling concepts (full life time based).Generation and dissemination of production technology know how.

- Archetypes (near net shape, tailored products) e. g.
- Investment casting (die making), melting processes, new foundry cost effective near net shape processes
- Squeeze casting (new alloys, high speed infiltration, temperature and reaction control,)
- Rapid Prototyping (hybrid materials in one a shot process)
- Powder metallurgy
- Spray deposition and vacuum deposition: 2 technologies for future on line process.
- Forming (e. g. stamping, hydroforming, forging using grain sized alloys...) increasing the strength/weight relationship.
- Drawing (draw peeling)
- Mechanical treatments (including roller burnishing, shot peening etc…)
- Joining (hybrid structures e. g. aluminum/steel car body structures: bonding appears to be the unique solution and very efficient)
- Machining (e. g. ultrasonic machining, laser machining, save machining of magnesium…)
- Hybrid manufacture and multimaterials structures (plastic-metal, metal-metal, problems when manufacturing, mechanizing, and joining technologies)
- Hybrid manufacture and multimaterials structures
- Brazing
- Welding (e. g. laser welding of new materials, for enhanced surface properties…)
- Bonding (technology for improving the adhesion of coatings with the surface, problematic of hybrid materials, using reinforcements only when requested). The tendency seems to be used more complex geometries and less number of components.
- Matter self-assembly methods: for self-assembly is intended here a method of constructing structures at nanoscale by simulating the way biological systems build molecules, viruses, cells, plants, and animals. Self-assembly involves a process known as convergent synthesis which takes place for eons in life forms of all kinds. Self-assembly should not be confused with positional assembly. In the latter process, the engineer has a relatively high degree of control over where each individual atom or molecule is placed. In self-assembly, although the positioning and arrangements of atoms or molecules might be just as critical as in positional assembly, the process is carried out largely by nature once the engineer has initiated it. In that sense, self-assembly is a sophisticated chemical reaction. Some nanotechnology researchers are, however, exploring ways to add positional control to chemical synthesis.
- Surface treatments (e.g. Continuous PVD, nanostructured coatings, multi-nanolayers as functionally graded coatings, plasma electrolytic oxidation enhanced with nanoparticles…)
- Surface modifications (e.g. heterogeneous catalysts, biofunctionalisation…)
- Finishing technologies (Plasma polishing, boring, femtosecondlaser, nanostructured surfaces for increasing the oil retention characteristics…)

- ECM/EDM
- Recycling (e. g. enhance the use and properties of secondary materials, more cost effective recycling technologies)
- Identification and separation technologies (based on physical and chemical properties of the materials and components)
- Design for mechanical disassembling (this is a direct consequence of considering the lifecycle cost)
- Design for compatibility with environment (e.g. Biodegradability, ecotoxicity, renewability, biocompatibility)
- Certification of the fabrication processes (homologation of new process, is a tendency not only in automotive sector, but in all the sectors, since there is a tendency to subcontract process to specialized companies that can produce at high speed in cost effective conditions (most of the times SMEs)

2.7.2. Testing and Characterization

It is possible to characterize directly the process or via the product characterization. Possible research ideas:

- On line Non Destructive analysis and inspection methods, seems to be in the near future the most effective way to control on line process. Sensors and systems should be integrated to achieve more cost effective automatic process control.
- It is still unknown the influence of the materials characterization (friction, fatigue,...) depending on process conditions (temperature, strain velocity, lubricant)
- When speaking about durability, reliability, damage tolerance, traceability and accelerated tests, there is a need to establish guidelines and standard procedures to evaluate materials properties at the laboratory.
- Databases of coatings and materials depending on their functionality and their application cost over ferric and non ferric substrates
- Routine and advanced characterization methods for time efficient analyses (e. g. mechanical [DMTA], microscopically [optical, acoustic, SEM-EDS, FIB-TEM, and scanning electrochemical microscopy, SECM], spectroscopic [GDOS, XPS, AES]
- Roughness is a surface properties that has a lot of influence in the material behavior but still is far to know in depth. Traditional parameters Ra, Rz, Rvk, Rpk… with traditional profilometers, should be correlated to new advanced 2D-3D measurements, confocal microscopy and AFM, in order to get an in depth understanding on the effects of the surface in relation to their tribological behavior.
- In order to predict the behavior of the materials it should be necessary to reproduce the wear mechanism (impact, abrasion, adhesion, pitting...) trying to reproduce the real working conditions (oscillatory or rotatory movement, pressures, speeds, temperatures. A lack of standardization of appropriate tests to simulate different components (gears, rolling bearings, engine components,…) make necessary to make and effort in writing guidelines, that can be standardize in a further steps, using when round robin tests.
- In relation to corrosion testing it is possible to use several techniques: impedance studies, SECM, electrochemical noise, potentiostatic studies to reproduce different corrosion mechanism (localized corrosion, uniform corrosion, and corrosion bellow tension) and to evaluate the corrosion rate with the final objective of predicting the behavior and understanding the passivating phenomena.
- The use of new active and passive sensor technologies for a life time health control for components will be the way for exploitation of the full material performance over the complete life cycle by improved health monitoring.
- Bioactivity (e. g. osteoinductive materials), biocompatibility (medical applications), biodegradability (for disposal efficiency or risk of accidents), renewability (to assure supply in the future) are new concepts to take into

account when speaking about the lifecycle of materials.

- Thermal degradation (loss of performance when increasing temperature), fire resistance (to avoid risk of accidents), smoke development (to reduce the effect of accident) and flame retardance (with similar effects) are also new concepts to tests and to take care when designing specially organic materials, polymers, wood composites, but also some type of metals.

- The problem of Fatigue, thermo mechanical fatigue, pitting phenomena or thermal chock tests, is that it is necessary to perform a lot of tests to get results, making very long the experimental tests. In these cases, modeling should be closely considered in parallel with experimental tests, in order to avoid extensive testing when trying to understand the properties and applicability of a new material.

2.7.2.1. Quality assurance, reliability and non destructive testing

Implementation of mechanical dynamical tests for the quality control of the products (adaptation of the DMTA method from contemporary standard applications to the severe conditions of characterizing metals, ceramics, composites)

Implementation of new and efficient analysis technologies for microstructure analysis (e. g. Lift-Out sampling via FIB-technology (negligible sample damaging by lift-out sampling of micrometric samples))

Implementation of further acoustic, spectroscopic etc. NDT methods, e. g. for large-scale components made from light-weight high-performance long-fiber reinforced composites and their joints and other applications of advanced materials with the aim to reduce risks and probability of failure in operation and consequently to enable new materials to expand into applications with high claims on safety.

Dissemination of know how to potential users (Manifold strategic efforts are needed to generate the adequate technology and prepare the human resources simultaneously for constructive interactions)

- NDT used for through life issues:

    1. Design (Rapid Prototyping, Reverse Engineering, Design for Inspection, Laser Strain Mapping to validate FEA models).

    2. Manufacture (NDT metrics to the process control)

    3. Introduction to service (QA of the final product)

    4. In service support. (Support for damage tolerant structures, advanced inspection techniques for new materials, feedback to dynamic maintenance planning)

    5. Life Extension (Intelligence to support the continued use of materials passed their original design life).

- Additionally a mapping exercise to identify common procedures across these life phases.

- The characterization of damage and QA/QC of repair processes and an electronic material repair manual (repair process linked to NDT data).

Finally, the introduction of new electronic NDT design manuals (to provide intelligence on inspection methods for design engineers).

2.7.2.2. Development of processing data systems

- Generation of process data bases (full set of observable properties)

- Process simulation

- Networking within EuMaT

2.8. FG 4 Material and Process Modeling

2.8.1. Introduction

Materials modeling include familiar tools which are already part of engineering practice. These include finite element (FE) and finite difference (FD), computational fluid dynamics (CFD), and free-energy minimization programs. Its theoretical base has been a successful and valuable part of the science and engineering of materials. The applicability of materials theory to almost any established and newly emerging topic of materials science promises that it will play an increasingly guiding, stimulating and visionary role in the search for novel materials.

The synthesis of NSMs from atomic or molecular sources depends on the control of a variety of 'nanoscale' attributes desired in the final product. In general, the following four methods are used to make nanophase materials, and a satisfactory model of the fabrication processes is fundamental to help the material designing, in particular:

- The first technique involves the production of isolated, ultra fine crystallites having uncontaminated free surfaces followed by a consolidation process either at room or at elevated temperatures. The specific processes used to isolate the NSM are, for example, inert gas condensation, decomposition of the starting chemicals or the precursors, and precipitation from solutions.

- Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), and some electrochemical methods have been used to deposit atoms or molecules of materials on suitable substrates. Nanocomposites can be produced by depositing chemically different molecules simultaneously or consecutively.

- By introducing defects in a formerly perfect crystal such as dislocations or grain boundaries, new classes of NSMs can be synthesized. Such deformations may be brought about by subjecting the materials to high energy by ball milling, extrusion, shear, or high energy irradiation.

- The final approach used to make NSMs is based on crystallization or precipitation from unstable states of condensed matter such as crystallization from glasses or precipitation from supersaturated solid or liquid solutions.

Modeling role depends greatly on the industry involved. Technological needs vary enormously, depending on:

- Types of material: Metals and metal alloys, Ceramics and glasses, Semiconductors, Polymers and polymer-based composites…

- Property to model: Magnetic, Electrical, Optical, Thermal, Mechanical…

- Length scale: From nanometers to the meters (usually mixed)

- Timescale: From nanoseconds to geological timescales.

With such a wide range to cover, it seems clear there is no a universal best method: in effective modeling, the degree of sophistication is right for its task.

'The general thrust (of material modeling) is clearly somehow to aid the improvement of materials for identifiable needs. Whether this means new materials, new processes, new inspection methods, or some other development, depends on the context, the constraints and the drivers. The style and level of modeling depends strongly on the problem. The science varies from simple scoping calculations, through systematic use of interatomic potentials and thermodynamic databases to the state-of-the-art electronic structure calculations. … Looking at previous reviews of materials modeling, there is an implicit assumption that computer hardware or software is the most serious limitation. This view is changing. The hardest parts now seem to concern brainware and experience. Can you frame the problem in a way which can be modeled at an appropriate level of detail? Can you understand the modeling output well enough to give adequate answers? Have you enough confidence in those answers to take an unpopular decision: could you tell an enthusiastic senior manager "You can't do things this way," for example? Robust reliability is the key to acceptance of modeling.' From: Marshall Stoneham, University College London, UK

2.8.1.1. NEEDS / CHALLENGES

Classical materials science activities in the past largely focused on bulk properties of different materials by characterizing them experimentally and analyzing them theoretically in terms of continuum mechanics models. This view has changed dramatically over the last few years. Both experimental and theoretical tools have improved considerably so that much stronger **links between basic physical and chemical properties at the atomic / molecular structural level and the overall properties of the material** have been established. In this context materials modeling will play an increasingly important role as it moves more and more from a description of idealized limiting cases towards an almost complete characterization of the system being investigated. To make progress in this area, coordinated efforts between researchers in many theoretical disciplines as well as equal interplay between theoretical and experimental investigations are needed.

2.8.1.2. What are the "advanced engineering materials" to be modeled?

- Hybrid multi-material systems: metals-plastic, ceramic-metals, composites, intermetallics
- Ceramics & Composites / Polymeric, foams (also metallic)
- KMM: Gradient / Tunable / Self-healing
- Films & Coatings / Adhesives
- Nano / small-scale / bio-inspired

2.8.1.3. Types of applications for the "advanced materials"

- Aerospace
- Automotive, Rail & Marine industries (replacing conventional metals)
- Gas turbines, Pressure vessels, Wind energy (turbine blades)
- Micro-chips & micro-machines
- Biotech & Medicine
- Extreme conditions: high-temperature, high pressure, creep, corrosion and radiation resistance
- Adaptive to environment (tunable), to stress and monitoring
- Timescales can range from seconds to hundred years

2.8.1.4. What material properties need modeling?

- Stiffness / Strength
- Failure modes, post-yield behavior, crack propagation, damage tolerance
- Durability (long-term behavior): fatigue, creep, wear, corrosion, degradation
- Interface behavior (reinforcement-matrix, inter-layer, multi-material joining – debonding, delamination, contact)
- Thermal expansion, electrical conductivity
- Coupled behavior: thermo-mechanical …
- Damping, metal-metal impact
- Fluid-surface interface, using for example molecular dynamics

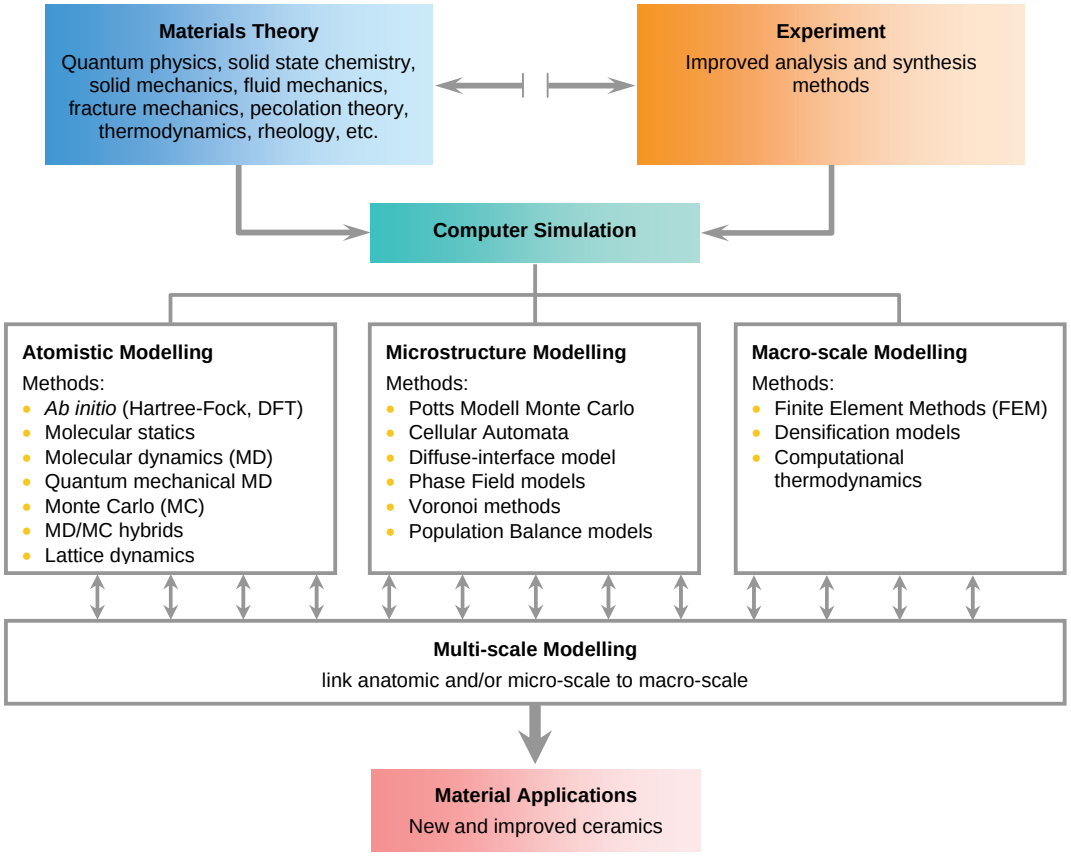
2.8.2. MANUFACTURING PROCESS MODELING

- Modeling the means to obtain a material is as important as modeling the final material.
- From composites hand lay-up towards RTM and Resin Infusion
- Pultrusion / Filament winding / Stitching / Injection molding
- Thermoforming
- Joining / bonding / welding technologies
- Near to shape production / Power metallurgic

2.8.3. TARGETS - What should be done?

The style and level of modeling should depend on the problem, and have the **right degree of sophistication for the task in hand**. Advance materials systems cover (as listed before) a wide scope of materials and exhibit a range of behavior on different length and different time scales. The **multi-scale problems** should be addressed by application of materials science and mechanics at the various levels of size to identifiable small-scale structures and the use of analytical and numerical methods to compute the macroscopic response of the component/structure.

To understand properties of complex ordered and disordered, inorganic and organic, and hybrid materials **links between** the **microscopic atomic structure** and the **macroscopic 'observables'** has to be established. The virtue of this 'bottom-up' approach is its **predictive power**.



Multi-scale modeling is the combination of various techniques that treat disparate length and time scales into a consistent simulation. The simplest approach is to use output from small-scale simulations as the input to larger scale calculations (bottom up approach). Other strategies incorporate feedback loops, or perform detailed, computationally expensive calculations only at critical points in the simulation. One difficulty that needs to be cleared includes deciding where the transition from "discrete" to "continuum" behavior

occurs, and how representative small-scale simulations are of large-scale phenomena. From: C.A.J.Fisher (Japan Fine Ceramics, Nagoya, Japan), see below an illustration of multi-scale modeling applied to design and simulation of advanced ceramics.

Models which relate materials composition, structure, process parameters, ending up product performance and design, should be developed.

- From nano/micro-scale towards macro-scale. **Multi-scale modeling**: surface molecule interaction, molecular dynamics, interface, FEM, component. **Predictive modeling**.
- Non-linear behavior, damage evolution
- Stochastic models
- Material data for tuning the models: Experimental testing
- Validation: Correlation numerical models - experimental testing

2.8.4. WAY TO ACHIEVE THE TARGETS

Technological needs vary enormously and unpredictably, anyhow all identified issues (…) will need to be addressed in years to come.

- RTD initiatives including material modeling and validation of the models by experimental characterization. Development of new constitutive laws for deformation and failure of the new materials starting from its basic components (multi-scale modeling).
- RTD initiatives for manufacturing process. Interdisciplinary group on specific problems (fluids, mould filling, solidification, residual stress …). Integration of production parameters (time, temperature, pressure, etc.) into the material model.
- Incorporation of constitutive laws into software packages including end-user friendly interfaces to make them useful for industrial applications
- Follow-up from academic code to a commercially useful tool
- Modeling teams must be stable enough to build experience and confidence in modeling techniques. Both, academic and industry should be involved in supporting them.
- Develop Material database (with guidelines for acceptable data)
- Training of material engineers in order they demand better material models in their daily industrial activities and training scientists in order they can develop those models.
- Learning from the past.

Computers hardware capacity does not seem to be a serious limitation. On the other hand, the ability to frame the problem and understand the limitations of a model is crucial.

Models need good data which will be generated from improved testing and evaluation methods.

2.8.5. EXPECTED BENEFITS

Material modeling offers a better understanding on how the material will behave in different conditions and supports the development of new materials with enhanced performance for particular industrial applications. Predictive modeling cuts down on experimentation and cost and speeds up time to market.

Optimum material microstructures can be forecast and designed rather than found by trial and error whilst maximizing structural high performance and sustainable safe life.

The expected benefits can be listed as:

- Help in designing the desired/required material (optimization, fitness for purpose)

based upon an understanding of microstructure and properties.

- Facilitate material selection and processing based on property requirements - mechanical, electrical, magnetic, optical, thermal, etc.
- Contribution to more competitive manufacturing processes: time, temperature, pressure to use.
- Increase confidence in the material final performance
- Reduction of final product cost and time to market (cuts down on prototypes and experimentation)
- Inspire a future generation of scientists and engineers.
- Contribution to standards
- Virtual testing, that is replacement of actual tests, for example full scale crash tests, by simulation, can dramatically reduce design costs and time-to-market, especially in highly demanding technological products: this requires in-deep modeling of all materials

2.8.5.1. Material Modeling

Material properties modeling (microstructure, texture, internal stresses, physical and mechanical properties, acoustical damping, wear and corrosion resistance, lifecycle...). Correlation with experimental behavior.

2.8.5.2. Modeling of Manufacturing Processes

Simulation of manufacturing processes (solidification, 3D injection with or without reinforcement, fibers, anisotropy...) and systems (virtual and accurate products, conduction positions).

2.8.5.3. Product Lifecycle Modeling

Integration of the environmental impact and the cost impact, reflecting the overall lifecycle consequences for the product or process development.

2.8.5.4. Advanced design and modeling

Simulation of real components (mechanics, fluids, noise, vibrations, function, NVH, life prediction including fatigue 3D, physic and chemistry, tribology at 3 levels, nano, micro and macro) linking to their design.

2.9. Horizontal Issues – Coordination groups

2.9.1. Optimization of natural resources, sustainability

In order to assure the future of the children of our children is necessary to optimize the use of natural resources. Renewable materials (developing high performance vegetable oils, wood derivative materials and additives, biofuels, bifuels trifuels efficiency...), Recycled products (enhance properties of secondary alloys...). Sometimes to introduce such type of products, it will be necessary to establish fiscal incentives, up to increase their cost effectiveness of their manufacturing processes, since up to now, production process are optimized for mineral oils, fossil fuels, or primary alloys.

Environment is another source of concern, since the increase of the CO_2 concentration in the ozone layer, made more than evident, the tendency to the heating of the earth. Increase of efficiency of the moving elements, reducing the friction by means of the development of a new generation of coatings, can save huge amounts of energy and thus CO_2 emissions. Use of biodegradable materials, seems to be the way to address when developing organic materials (plastics, lubricants) in order to avoid environment deterioration when lubricant or plastics are released in the earth due to accident or bad uses.

The use of coatings without chromium or heavy metals has also been already considered in

the end of life of vehicles directive. Now alternatives should be found not only for automotive, but also for aeronautic applications. Lack of data for qualification of the materials is an important issue

Lightweight materials are a must for all transportation systems. Reduction of weight has to be accomplished to reduce fuel consumption and emissions. Especially in a situation, worldwide, for which masses of the accessory systems (safety devices, comfort equipments…) continuously increases. The recent awesome cost increase even of the poorest materials (such as common steel) is also a strong reason to decrease materials weight.

Sometimes there are negative consequences when using natural resources (biodegradable lubricants, biodegradable plastics), since performance is not still enough developed, and further improvements are necessary to be incorporated in order to justify a sustainable change for the user. Integrated Lifecycle environmental and cost are very necessary to be implemented in order to take proper decisions. In case of biofuels, negative consequences can be linked to compatibility with engines materials, since normally biofuels dissolve more water and corrosion may appear easily. New higher performance materials should be developed, selected and implemented in critical components. Development of life cycle management systems.

2.9.1.1. Development of life cycle management systems

Lifecycle management systems will be very important to minimize maintenance costs of equipment and devices. The prediction of the components lifecycle, analyzing tendencies, checking the difference in behavior of components between an established normal state and anomalous level using the appropriate sensors, seems to be the most appropriate tool. Telemaintenance should be considered as the next step to make cost effective maintenance, making necessary to integrate complex multidisciplinary technologies of communications, maintenance experts, sensors and hardware, surface treatments and materials selection. It seems difficult, but it is the challenge to achieve the objective of EUMAT that is develop materials with a more cost effective lifecycle (including production, use-maintenance and recycling).

2.9.1.2. Material Data bases

Databases are required as a tool to manage the available knowledge and to find needs for further research. Well structured data systems can act as expert systems to take decisions.

Materials qualification is the capability of a material with a given process and properties to be used for one application. Data bases for selection of the materials and coatings should be available for materials qualification.

Development of new innovative products requires a broad and reliable base of technical and scientific data. A large number of these data exist but is, however, scattered over many different industrial fields and contained in numerous publications and small data bases.

Comprehensive database design and development to organize the overwhelming amount of broadly scattered data is a key issue in order to make use of this potential. Strong efforts are needed to collate, integrate and interlink these scattered data in efficient and intelligent databases.

Many of today's key industrial technologies depend upon successful containment of high temperature processes (examples are energy conversion, environmental technologies, chemical process technologies, power generation, waste incineration, hydrogen production, petroleum refining, fuel cell design, production of forestry products, and other processes).

For this particular field an increased need for enhanced efficiency, improved reliability and safety, greater flexibility and better economic performance exists, which can only be accessed by a better exploitation of the knowledge of industrial materials properties.

Developments in this technology have traditionally employed trial and error approaches and have required extensive, costly and time consuming testing programs to accomplish only incremental improvements for each application. This produces data which are not readily transferred to other applications. But more importantly, the traditional approach imposes time delays so great that industrial investments may be postponed, causing new investments to shift to lower cost countries. Important obstacles resolving these issues in industry are the wide variety of alloys available, the diverse corrosive environments, and the lack of recognition of comprehensive approaches to use high-temperature corrosion data to select appropriate alloys and to assess engineering lifetimes. Similar examples

could be give for other materials parameters and industrial applications, e.g. gas turbines, power stations, etc.

Future research efforts should therefore take maximum advantage of the best available scientific understanding, advanced models, comprehensive algorithms, prior data, and new data, to directly support advancement of the European industry. Innovative approaches and models should be adapted and verified to create innovative, intelligent and functional data bases which can be directly applied to industrial needs.

A European distributed dynamic material database/ data warehouse of advanced engineering materials and technologies is to be established. The database is virtual database in the web. Institutes or information providers fill in information acc. to be established release rules. Registered users can extract the information. The database follows the example of the Japanese database (NIMS…).

The objective of this task is to develop data bases for material selections in function of the properties. New materials and new properties, needs to be addressed in databases, as a tool for selection. Environmental data have not been included in most of the database selections. In the case of lubricants, biodegradability, toxicity and tribological test data should be available. Example of need: materials for substitution of heavy metals.

2.9.1.3. Simulation Systems

Simulation tools are required to develop materials process and products. Both numerical and experimental tools are complementary and need to be developed and integrated to make possible to prove at laboratory, prototype and in field level what has been predicted previously numerically. In the next future, it should be possible to predict the behavior of the materials (wear, fatigue, corrosion, tribocorrosion, vibration, noise generation, thermo mechanical properties…). In order to achieve this objective, it is necessary to simulate different mechanisms involved in the failure criteria, establish testing procedures to evaluate each mechanism that can be standardized for different applications. This is the most promising way to have in the future knowledge based materials.

2.9.1.4. Testing equipments available in Europe

The research infrastructure can be enhanced if the testing equipments available in research institutions and Universities are known. This will enhance the use of the infrastructure by companies, making easier strength the collaboration at European Level, and that companies, will know "who can do what". This can be possible to do in the future between EuMaT partners, making stronger the links between EuMaT Participants.

Very flexible and versatile dynamic web tools will have a key role in achieving this goal.

2.9.1.5. Process data bases

Materials processes are dominated by industries, but normally are firstly introduced in the market by universities and research centers. The availability at an European Level of Process data bases, "who made what process", will be a really good tool for companies, for end users, that could be able to use externally the infrastructure of other companies and research centers, in a European Virtual Area. This can be done between EuMaT Members, as a starting point.

2.9.2. Prenormative work and standardization

A lot of effort has been done in the FP6 in developing testing procedures for example for engine testing trying to reproduce the wear mechanism. It is necessary now to use this available knowledge to really establish a prenormative work that will involve testing at different levels laboratory from laboratory to real field tests, in order to support the generation of new standards, improve the reliability based on strong correlations and applicability. Despite, there is some standard tests for corrosion (climate chamber tests), tribology (ASTM GG99,…), the procedures are far from reproduce the wear mechanism since the nature of the material, should be taken into account and most of the standard test are defined for a limited scope of materials. Also this type of work is necessary to be performed for mechanical, thermal and dynamical tests, electrical, biological, material properties, noise, and vibration evaluation.

Also there is a need for prenormative work in the field of determination of biodegradability and toxicity for non aqueous substances (lubricants, polymers...), establishing levels of repeatability that will assure the future work. Also it is necessary standardization smart

and multifunctional materials, hip and knee prosthesis simulation...

The methodology of the lifecycle assessment (environmental and cost analysis) should be integrated with ecodesign and risk assessment technologies and standardized as a tool for industrial decisions.

Close cooperation with CEN group, for example in the characterization of coatings, or ASTM standards and DIN is necessary to try to approach already acquired knowledge into new standards.

2.9.3. Dissemination and exploitation

EuMaT Platform with a large number of participants represents a very good tool for dissemination of project results, as a forum of new ideas, as a tool to create consortia, as a way to find the needs of the industries. The website, collects information of the needs of the industries, gives the opportunity to share documents actually between more than 350 participants, and is an excellent tool to find the European Dimension when trying to approach to the interested research Community. The knowledge of "who made what" in Europe, can enhance the exploitation of the results at European Level.

Workshops will be organized, when possible in parallel to important Congresses in order to make easier to present project results and at the same time prepare new ideas for projects. Seminars as TOFD organized by MPA, or about Biolubricants organized by TEKNIKER will be prepared around different topics, and in special at the end of research projects, in order to open public research results to the researchers, as a tool to create new ideas and views. The website created and maintained by MPA, will be the main tool for communication. National mirror websites will be linked to European one and will have the function of acting as interface to National activities, increasing exponentially and in a national language the effect of the European Research.

European Projects will be assisted by the dissemination possibilities within the umbrella to go for further research and development in the future. Assistance to relevant Trade fairs and Congresses will help to increase the number of members trying to involve specially SMEs in the EUMAT Platform, increasing the research European group of Materials.

Intellectual property determination is always a subject of analysis when European Projects and new research ideas are created between industries and research centers with previous background. EUMAT could act as a support for companies, when trying to deal with these aspects, addressing "European Help Desks for Intellectual Properties Issues" when convenient.

2.9.4. Studies and reports

Studies and reports could cover the future materials susceptible to study, tendencies, evaluation and results analysis, and dissemination of studies. For example, in the frame of Virtual Tribological Institute has been created a book trying to compile the research carried out at European Level about biolubricants. The knowledge can serve for policy support in the introduction of European Ecolabel launched in May 2005

2.9.5. Policy support

EuMaT can act as policy support when trying to eliminate the chromium, when trying to implement the use of biodegradable lubricants, when trying to trace every component for residues management… The knowledge acquired by the EUMAT Participants, that collect the experience of a huge number of research projects carried out at European Projects can help to support this policy (bottom up approach) and also to give solutions when the need of implementing a Policy, requires the support of new background research.

2.9.6. People

Mobility of people will be in the FP7, one of the tools to make possible the transfer and creation of new knowledge. One of the strongest points in Europe is that the people is really well prepared, with a high level of studies for both women and man (in the past this was possible only for men before the technology was introduced at home level). We have to exploit these sources at the level of Europe, making data bases of expertise available, making easier the mobility, making stronger the cooperation, in order to be able to learn how to move, and how to take advantages to compete in the Global world. Multimedia tools can be further exploited to enhance education and teaching in our research collective. Target groups and subjects will be ranked.

2.9.7. Infrastructures

Some Virtual Institutes started in FP5 (Tribology, Laser...), as a way to make stronger the collaboration between research institutes, and industries. The knowledge acquired for these Virtual Institutes in the way how to integrate, how to create new initiatives, how to define the new areas of research, how to define the needs of industries, can be used in the frame of EUMAT Platform to strength the links and to use the knowledge already acquired.

2.9.8. Education and dissemination activity

Within the frame of the EuMaT platform a number of different instruments for education and dissemination of knowledge about material science and engineering application could be used, namely courses, workshops, seminars, conferences and training.

In many cases opportunities are already activated and the best solution could be a synergetic co-operation with the colleagues that are organizing the meeting of interest for our group, in other cases specific initiatives could be organized by members of the EuMaT platform.

- **courses** are intended as courses within the frame of University lectures. Agreement between Universities could be encouraged, lecture notes and educational support material can be prepared in order to enhance the quality of the teaching and assure the continuous updating;

- **workshops** are intended as meeting for discussion of on-going research activities, no conference paper are requested, no proceedings should be printed. Simply presentation of recent results and, mainly, discussion of open question are addressed; therefore workshops are strictly thematic. A decision must be assumed inside the platform if the participation to the workshop is reserved to the platform partner only (and eventually to a limited number of invited guest) or are open to the contribution of the scientific world.

- **seminars** are intended as courses for higher education and /or continuing education. The basic idea is similar to the courses structures but the subject is delimited and the content is presented with a deep insight. CISM (International Centre for Mechanical Science - Udine, Italy - an organization sponsored by the European community) and other Universities and Research Centers could be considered as well; Euromech could also be a well established partner;

- **conferences** are intended as structured occasions with the formal presentation of papers and with the printing of proceedings, books as well as CDs. In Europe there is a number of conferences every year dealing with material science and engineering applications, for example Euromat, ECCM (European Conference on Composite Materials), DYNAMAT, ….. An agreement can be proposed for the scientific sponsorship of the conference and for the participation to the scientific board, in order to include the subject of particular relevance for the platform between the themes of the conference;

- the definition and use of **data-bases** of materials using up-to-date technical means, to make available to the partners and to the European researchers and industrial actors, the knowledge and know-how in advanced material classification, definition, processing, characterization, etc. and all related topics. Many different tools (such as, for example, material selection chart) will help researcher and designers select and design the most suitable and economical material for any different application.

- Finally, **training** is intended as a stage by a research laboratory of researchers of another organization in order to make experience of some scientific and/or technological matter where the hosting organization as a recognized excellence level. In particular this could be of interest for PhD students and young research fellows.

Particular attention must be paid to **PhD student**, post-doctoral, and any other research fellow stages not only for what concerns their scientific formation but much more for the growth that could result for the European scientific community coming out from the personal knowledge between people and from the use of cooperation between people of different countries.

2.10. Expected impacts

2.10.1. General

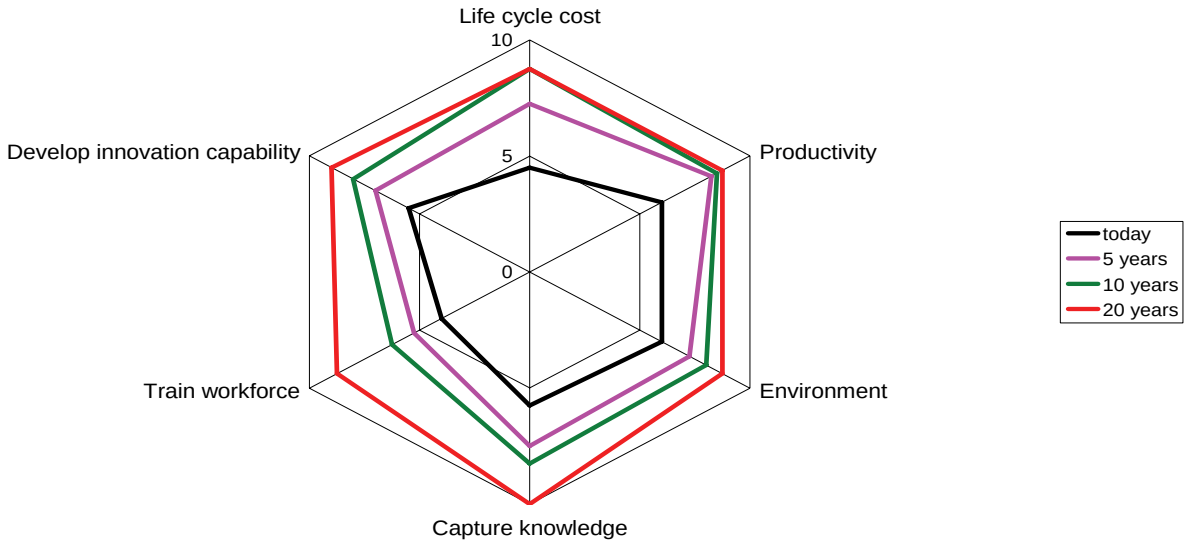
The priority selection of the advanced engineering materials and technologies is based on the requirement of the involved industry. A first survey of the EuMaT partners participating in the editing group according to the EuMaT priorities resulted in following table:

Across all involved industries the engineering materials for challenging applications are considered most important together with the related production technologies. Multifunctional materials apparently are specialties in Automotive (Transport in general) and industry applications. BIOmed is addressed by one partner only with high priority on BIOmed materials. Multiscale modeling is of high interest for energy, general industrial applications and rail.

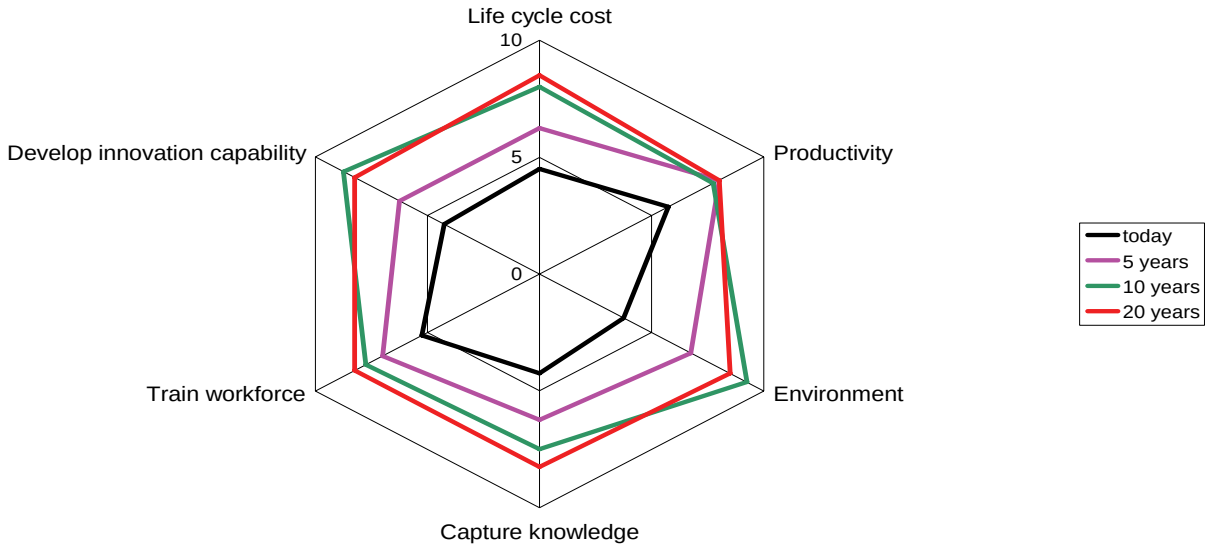
	New cost effective material, innovation	Condition assessment and lifecycle methodology	Knowledge management	Future European materials production	Improve Europe's role in engineering material and technology
Multifunctional materials for macro-applications	**low**	**medium**	**low**	**low**	**low**
Engineering materials for challenging application conditions	**high**	**high**	**medium**	**high**	**high**
Multimaterial (hybrid) systems	**low**	**medium**	**low**	**low**	**medium**
Multi-scale modeling	**low**	**medium**	**high**	**medium**	**medium**
Related production technologies	**medium**	**low**	**medium**	**medium**	**medium**

2.10.2. Users' expectations

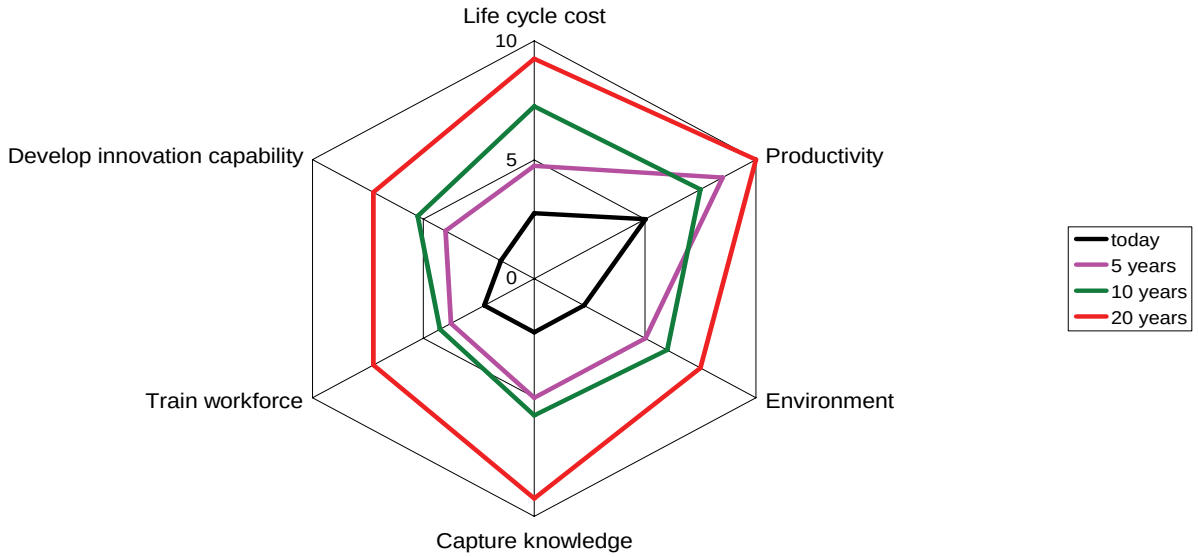
The figures below show the planning of different stakeholders:



Performance targets of "Industry" (mainly automotive and aero)



Performance targets of "R&D"



Performance targets of "Energy-Industry"

2.10.3. Impacts per typical application areas

Industry	Automotive / Transportation (incl. Rail)	Energy	Aero	Industrial Applications: e.g. solar industry; semi conductor industry; chemical industry (Pumps)	BIOmed
Multifunctional materials for macro-applications	high	low	low	high	
Engineering materials for challenging application conditions	high	high	high	high	medium
Multimaterial (hybrid) systems	medium		low		high
Multi-scale modeling	low	high	medium	high	low
Related production technologies	high	high	high	high	
Foresight 5 years	Reduction of energy needs by 30 to 50 %. The production in and on Multilayer Tools would increase productivity drastically on the same equipment reducing the energy needs (30%) and the need for costly investment for the mass production. This would also lead to reduction on environmental impact up to 50%. This technology would be the basis for multi material high pressure die casting.	Solar grade silicon. Making available cost-efficient photovoltaic systems is one of the key challenges in reducing the dominancy of fossil fuel over the coming decades. Crystalline Si PV is a well proven technology and could be implemented immediately with direct benefits to diversifying the energy generation away from fossil fuel burning.	New streamlined precious and specialty metals recycling processes, powder metallurgy incl. thermo-mechanical treatment and bonding techniques and their usage to a combined production of new materials for nano- and microelectronics like advanced packaging, front end/advanced gate technology, non volatile memories, PC-RAM (phase change technology), plasma display panels, radio frequency identification tags. These are multi-purpose developments enabling on the one hand the usage of completely. New technologies and/or result in higher efficiencies, lower cost manufacturing, saving of resources and improved recycling processes. 5 years target reduction of life cycle cost 30%. Materials for Optoelectronics; new low cost long wave infrared sensors and optics for road safety, process control, predictive maintenance, sensing in smart buildings (fire, system controls), people counting (sports, events, shopping venues), security and new materials for fast data transfer combining Electronics and Photonics.		

2.10.4. Impacts per typical material types

LIGHT MATERIALS IMPACT

The transport industry supports the need to meet new challenges: customer demands for improved safety and comfort, stricter environmental legislation and public concern for environmentally friendly transportation.

Manufacturers want to make cars and trucks that are lighter, use less fuel, more easily meet lower emission standards, offer higher standards of performance, yet allow flexibility in production (bigger ranges, produced faster). In part they want to do this because there are shifts in consumer preferences (increased environmental consciousness) in some markets, greater interest in higher performance in other markets, and the need to implement and anticipate tougher legislative standards in line with Kyoto/Montreal (or in California individual state) policy requirements.

An increased knowledge of new light materials and components and of the manufacturing processes is needed in order to fully adopt and further develop the cost-effective and environmentally safe production technology to meet future demands of the transport industry. Increased knowledge of manufacturing of fuel- and weight efficient cars with preserved safety and driving properties is important to further improve the competitiveness of both the European light material production and car industry.

Environmental benefit is clearly due to the substantial weight saving potential of high performance light alloys components. Fuel savings, reduced exhaust emissions and enhanced performance are key issues in the development of the EU transport system that can be achieved increasing the use of light materials and components, presenting multi-functional properties. Weight reduction is the key-factor for reducing CO2 emissions, which can be reduced by 30% thanks to an optimized use of light materials.

ECONOMIC IMPACT OF WEAR REDUCTION

The level of tribological knowledge and its application influence society in several ways. Optimized friction in industry and transportation results in energy savings, controlled wear and lubrication improves the efficiency and quality of production and results in increased reliability and safety, reduced costs due to down-time and reduced environmental risks and impact. It has been estimated that about half of all the energy produced is used in the industrialized countries are to replace worn out products. The calculated direct cost for friction and wear in an industrialized nation has been estimated at 7% of GNP and detailed studies carried out in several countries (e.g. USA, UK, Germany, and Finland) show that 1% of the GNP can be saved by the use of more optimized tribological solutions.

However, even if recent development has been rapid, our knowledge today about the mechanisms and interactions taking place between two moving surfaces is still poor in comparison with the detailed knowledge that exists about other science fields. A better understanding of the tribological phenomena will form the basis for finding better and optimized solutions to important industrial problems related to the functionality, reliability and lifetime of machinery, engines and control of manufacturing processes.

ECONOMIC IMPACT OF CORROSION

Corrosion affects our society on a daily basis causing degradation and damage to household appliances, automobiles, airplanes, highway bridges, buildings, power production and distribution systems, oil and gas installations, industrial plans and much more.

The annual costs of the impact of corrosion widely quoted for the U.S. and Europe amount to 3% of GDP, yet research has shown that 70% of this cost could be avoided. In the U.S. alone, Battelle Institute reports corrosion of metals costs almost $300 billion per year - more than the total cost of environmental catastrophes such as floods and fires. Battelle estimates that one-third of this cost could be saved by simply applying existing knowledge and technology. In addition to the economics, the significance of impact on public and environmental protection must be considered. Catastrophic corrosion failure has resulted in both human fatality and ecological disaster.

The corrosion costs can split into the following areas:

Transportation: This category includes vehicles and equipment used to transport people and products (i.e., automobiles, ships, aircraft, etc.) The study shows the annual cost of corrosion in the transportation category is $29.7 billion.

Infrastructure. The infrastructure category comprises the following industry sectors:

highway bridges, gas and liquid transmission pipelines, waterways and ports, hazardous materials storage, airports, and railroads. The annual direct cost of corrosion in the infrastructure category is estimated at $22.6 billion.

Manufacturing. The production and manufacturing category includes industries that produce and manufacture gasoline products, mining, petroleum refining various chemical and pharmaceutical products, paper, and agricultural and food products. The annual cost of corrosion in the production and manufacturing category is $17.6 billion.

Utilities. The utilities category is divided into the following industry sectors: gas distribution, drinking water and sewer systems, electrical utilities, and telecommunication. The total annual direct cost of corrosion in the utility category is estimated to be $47.9 billion.

The annual corrosion costs can be reduced by applying some control methods. These methods include protective coatings, corrosion resistant metals and alloys, corrosion inhibitors, polymers, anodic and catholic protection, corrosion control services, corrosion research and development, and education and training.

2.10.5. Preliminary evaluation of economic impact of the Advanced Materials

The "Advanced Materials" market includes the design, manufacturing development and production technologies useful to obtain the product's final shape as well as the definition of the characteristics of the materials to be used and the parts. Therefore, the Advanced Materials development requires high investment rates in Research & Development activities as well as in technological transfer, nevertheless this is a necessary step towards the improvement of European industrial competitiveness assuring environment preservation during the entire process.

A preliminary evaluation, based on the Mc Kinsey's studies during the nineties, states that the economic market of the Advanced Materials should be estimated in about 40 billions euro per year with a 18% rate of annual growth, while the correspondent rate of growth for the conventional materials is 3% only.

- Advanced Ceramic Materials -

The primary geographic markets for advanced ceramics will remain Western Europe, North America (primarily the United States) and Japan. This is due to the size and technological advancement of these areas with respect to the primary product markets (aerospace systems, motor vehicles, and electronics). As this small group of nations continues to dominate these industries, they will also continue to dominate both the production and consumption of Advanced Ceramics.

Worldwide demand for Advanced Ceramics is projected to rise 6.6 % to nearly US $ 32 billions in 2004. Demand will continue to be primarily driven by the rapidly growing electronics industry, which is the largest and best-established market for these materials. The continuing growth in the popularity of consumer electronic goods (including portable computers, cellular phones, and electronic games) and the increasing amounts of electronics utilized in motor vehicles, industrial machinery and other durable goods will spur on demand for electronic components and on the demand for ceramics materials used as dielectric [2].

In structural ceramics (cutting tools, automotive and aerospace components), demand will be below average due to the inherent brittleness of ceramics, caused by their tendency to form micro-cracks during manufacture. The result is high rates of product rejection, which increases production costs and makes significant penetration of these markets difficult. This is especially true of larger parts (such as automobile engine blocks or aircraft turbine blades) and the majority of uses are in smaller components, such as valve parts and bearings.

Particularly, regarding the US market demand for Advanced Ceramics is forecast to return to a pattern of strong growth through 2008 and exceed US $ 11 billion in 2008. As general economic and industrial activity continues to recover from the recessionary environment of the 2001-2002 periods, significant pent-up demand will be released. This will benefit ceramics used in the electronics and industrial machinery markets, both of

which had contracted sharply and will now rebound strongly.

Alumina Ceramics will continue to be the primary product form in use, due to the relatively low cost and generally favorable performance characteristics. Nevertheless, Alumina share of the market will slip slightly, as other ceramic materials (such as cordierite, ferrites and titanates) expand their presence. Such material shifts will be prompted by the development of new products and applications that will broaden the overall acceptance of ceramics.

Monolithic Advanced Ceramics (un-reinforced ceramics formed in a single piece) account for the majority of total demand, and include such products as semiconductor substrates, automotive and aircraft parts, filters, membranes, catalyst supports, cutting tools and wear parts. The use of ceramic coatings and ceramic matrix composites will continue to grow, particularly in applications where increased hardness or other enhanced properties are required.

The most significant market for Advanced Ceramics is still electronics, an outlet which accounts for 35 percent of demand. It also represents the fastest growing ceramics market through 2008, although gains will decelerate over the longer term. Other significant growth markets include industrial, medical, environmental and transportation products.

- Metal Matrix Composite Materials -

Concerning Metal Matrix Composites, MMC, the market is still relatively modest (100 million euro in the 1999), but it is previewed to grow nearly the double within 2005 [3]. The composite polymeric material market is nowadays estimated to be around 8.5 billions euro [3]. The market uncertainty for a short-medium time period is mainly due to the aeronautical and transports industry crisis as a consequence of September 11th. Fiber Reinforced Polymer/Plastic, FRP, composites for infrastructural applications show, in this area, a particular behavior: the present market value is approximately 270 million euro, but it is expected to reach 1.4 billions euro in the 2010, increasing more than 500% [4].

- Superconductor Materials -

Superconductors based products market, according to Conectus (Consortium of European Companies determined to use Superconductivity), is expected to increase from 1.1 million euro in the 2000 to approximately 20 million euro in the 2020. The market share increase of these materials will depend on the capability to develop low cost innovative production processes for superconductors high temperature reliable performance.

- Semiconducting Materials -

Electronics is today largely spread, with applications ranging from integrated circuits for computers and consumer devices (mobile phones, automotive, etc) to displays, from photovoltaic cells to sensors, with a continuously expanding range of applications. At the moment, all these applications are covered by essentially one class of materials, the "classical" semiconductors, i.e. inorganic materials produced with very high purity and sophisticated techniques. Among all these materials, silicon plays presently the very most important role.

However, in recent years a new class of semiconducting materials has emerged, the semiconducting plastics (or polymers). These materials have a semiconductor typical behavior sharing the basic electronic properties, nevertheless still present some drawback comparing to silicon, especially in terms of lower performances (lower mobility of the charge carriers) and limited durability (marked tendency to degradation). On the other hand, polymers are very cheap, both in the production stage as well in processing stage, so an impressive amount of studies are being carried out on this subject all over the world.

Because of their poorer performances, plastic materials for electronics are not expected to substitute, in the near future, silicon and other inorganic materials. For certain applications, however, such as large area consumer electronics, or devices where enhanced mobility is not requested, they may integrate the classical materials used for these applications.

In addition, a number of new applications, and therefore new markets, will be targeted by semiconductive plastics, in particular because of one of its main properties, mechanical flexibility.

The following applications are envisaged for semiconductive polymers and molecules:

- RFIDs (radio frequency ID tags),
- Flexible photovoltaic cells,
- Foldable displays and transistor arrays,
- Distributed sensors,
- Wearable electronics,
- Flexible lighting and signal

- Metallic Materials -

The traditional metallic products will be in the future the most used engineering materials but innovative steels, thanks to new production processes and new transformation technologies, will gradually increase their importance. The raw steel production in the European Union in 2002 has been equal to approximately 160 million tons with an increase of 0.1 % regarding 2001. Italy is the second steel producer for importance in the European Union, while Germany remains the first and France the third. Relatively to the industrial field of metals and special alloys - comprising the metals and refractory alloys (W, Mo, Nb, Ta), the metals of the Platinum group, the Superalloys (as Ni, Fe, Co) and the light alloys (Al, Mg, Zr) - the European Union represents the more important market in the world, estimated in 2001 in approximately 10 billions of euro; an increase was predicted for 2005 and it reached approximately 12 billions of euro. In particular, the Aluminium and Light Alloys consumption in the European Union is attested to be more than 20 million ton per year (approximately a third part regarding the world-wide consumption) with an average consumption of approximately 22 kg per capita and the market is still increasing. In the USA, between 1990 and 2000, it was recorded a growth of 40% (Europe + 30% in the same decade). The situation in Japan appears, to be stable, but in transport and construction industry, a very important increase of this class of material usage was registered: 32% and 26 %, respectively.

Driven by the stainless steel market, the demand for nickel is growing which accounts for 54% consumption in the USA. The next largest market is the super alloys consuming 10% of Nickel production. Nickel demand has grown at a rate of 4% per year in the last decade, with 7% growth seen during the past two years. Demand is up in the US, Europe and Japan, despite the absence of economic recovery. However the greatest growth in demand is in Asia and specifically China [8].

- Nanomaterials -

Nanomaterials market and applications will be of great economic importance. Nowadays, there are 35 countries involved in nanotechnologies and nanomaterials development [9] as listed in the following table:

In 2003, the total public funds dedicated by all the above mentioned countries to nanotechnologies Research and Development activities were about 3.1 Billions of US$.

US National Science Foundation predicts for 2015 a market development of about 1000 billions of US$ that will have different impact regarding the application area:

Materials beyond chemistry:	**$340B/y**
Electronics:	> $300B/y
Pharmaceuticals:	$180 B/y
Chemicals (catalysts):	$100B/y
Aerospace:	~$70B/y
Tools:	~$22 B/y

Source: National Science Foundation (2001)

Starting in 2000, the nanopowders market for energy production, the catalytic effects for structural applications has been estimated at about 62.5 million euro where:

- 96.1 % for catalytic applications
- 2.8 % for structural ceramic applications

- 0.3 % used for plasma coating.

In 2005 it was estimated for nanomaterials economic impact 87 millions of euro and an important market growth was provided to the following applications [10]:

- Fuel cells (+148.6 %)
- Photo catalysis (+52.8%)
- Coatings (+100%)

It is interesting to observe that USA nanopowder production companies in a very short time got a position in the NASDQ ranking list.

- Additional Consideration -

An important and transversal issue that is strictly related to the Advanced Materials is the materials tribological behavior and its economic impact.

A percentage of 10 to 30% of the whole industrially-produced energy is lost due to frictional dissipation.

Wear is the primary cause of damages and mechanical components rupture, together with accidental failures and corrosion.

It has been estimated [11, 12] that more than 1% of GNP (expectedly, 1.4%) of an industrialized country could save, by an adequate attention to tribology, particularly in education, research and application.

This conclusion has been supported by a number of official investigations carried out in several Countries (UK, Germany, Canada, China and others).

The main sources of economical losses due to inadequate R&D efforts in tribology where identified as:

- consumption of energy due to friction and reduced efficiency;
- maintenance costs;
- replacement of materials and components;
- machines and plants shutdowns;
- higher investment costs for shorter in-service life
- higher manpower costs;
- increased lubricant consumption

Not less important, it was verified all over the world, that the economical benefits of research activities in tribology are 1-2 orders of magnitude higher than the addressed investments.

It has been evaluated that about 50% of the economical losses in system requiring tribological efficiency and reliability may be ascribed to problems concerning '**materials**':

- selection of materials as part of a 'tribological system',
- choice of optimal in-service conditions,
- relationship between microstructure, properties and practical behavior
- production processing and microstructure
- thermal and mechanical stability,
- surface condition and modifications, etc.

Friction and wear have been generally approached in terms of 'Lubrication' and 'Choice of lubricants'. The frequent failures of 'lubricating systems' as well as the increasing demand for unlubricated systems has considerably promoted the importance of the materials

science for tribology.

Listed below, we can find the main sectors of 'Tribology' [12], regarding the highest 'density' of investigations addressed to the different causes and prevention of wear:

- Materials Science and Technology ~40%
- Mechanical systems 30%
- Lubrication, Lubricants 20%
- Others (Diagnostics, Instrumentation, Information, etc.) 10%

Demanding areas with requirements to be satisfied by research activities in tribology:

- Functional reliability in severe in-service conditions (materials production and selection as constitutive part of design)
- Economic and energy saving (as reported above)
- Environmental area (lightening, lowered friction, less oil and lubricant consumption, less pollution)

- Employment -

The employment strictly related to materials field is not well known. Nevertheless, it is possible to observe that people directly employed in the advanced materials sector is quite low but on the opposite, the indirect employment is very high.

For example in Italy the employment scenario was:

- in 2002 the metallurgical industry involved 128.000 employs (Federmeccanica)
- in 2002 the metal products industry involved 345.000 employs (Federmeccanica)
- in 2002 the ceramic industries involved about 90.000 employs (Assopiastrelle)

- Research and Development -

USA is known as the main character in the research and development and production scenario around the world. USA founding to the research and development in the field of new and advanced materials are of great importance (DOE, DOD, DARPA and NASA). DARPA for example fixed its R&D priorities to low cost and light weight Structural Materials, Functionalized Materials for electronic applications, "intelligent" Materials and Structures, Materials for the generation and the storage of energy. Form the productive area in the 1998 the USA assured the 35% of the world-wide production of High-Tech products, in which many types of Advanced and New Materials are taken into account (Japan approximately 20% and Germany approximately 6 %). In particular in the 1998 USA controlled 55% of world-wide the aerospace market (National Science Foundation - Science & Engineering Indicators 2002).

It is interesting to notice that for the USA the three greater export markets of Advanced Materials are the same countries that play an important role in the same area: Canada (24,6%), Japan (16,3 %) and Germany (8.7%).

As far as in 2003 the USA government support to the R&S in the field of the nanotechnologies, comprising also the nanomaterials [13], was approximately of 770 million of euro and investment prevision were of about 820 million of euro in 2004 with a budget increment of 9.5%. To that example it should also be considered that USA declared [14] the intention to become within the 2020 nation leader in the field of the Aluminum and relative alloys (at the last 5 years the USA government, through DOE and other Government agencies, has promoted and founded projects related to the Aluminium industry for a the total value of 100 million euro)

At the same time USA government supported also casting and microcasting industries for a total of 50 million of euro of investment. To complete this panorama it must be point out that the USA manufacturing industries have developed own strategic projects without government founding.

Finally it is important to remember that the budget dedicated from Japan in the biennium

1997 - 1998 for the development of innovative steel [16] has been of 50 million euro.

Another interesting example of R&D investment coming form the Far East is given by the South Korean Government. With the objective of becoming one of the most industrialized nation of the world, the South Korean Government, from 1992 up to 2001, launched several projects called G-7 HAN (Highly Advanced National Projects) from which, at least five, are related to Advanced Materials technologies, as superconductors, biomaterials, new and advanced manufacturing processes, Materials for energy, etc covering a total funding of approximately 1500 million of euro.

European activities regarding Advanced Materials research and development, has been always considered of high priority, as can be demonstrated by the progressive investment growth from the 3 Framework Program (730 million of euro equal to 11.5 % of total funding) to 5th Framework Program (2.620 million of euro to 18 %). The EU 6 Framework Program revealed a radical change of direction if compared to the others countries. In fact even if mitigated from the emphasis on thematic about nanomaterials and the nanotechnologies, the financial support for the Advanced Materials R&D in the 6th Framework Programme was about 1300 million of euro.

2.11. Specific material classes and proposed research and development topics

More specific project plans will be evaluated base on the expressions of interest of the EuMaT group. The following chapters already describe certain proposed activities in cooperation with other ETP's and projects.

ISSUES PERTINENT TO Engineering materials for challenging application conditions:

Applications under extreme loading	**Composite materials**
coated high temperature component: existing: Ni base + MCrAlY+ZrO2 TBC 5,10 years: new coatings up to 1500°C 10, 20 years: up to 2000°C new base material (CMC?,…) new coatings	
Materials systems to withstand higher temperature and more aggressive environments (e.g. waste, biomass, gasification) in power generation plant: Coatings (thermal barrier & corrosion resistant for 30kh life-in 10 years) New higher T alloys (steels systems)	
High temperature heat exchangers. Today: high temperature metal alloys with zirconium coatings. In 10 years SiC/SiC with EBC and TBC for temperatures up to 1600°C. n 20 years: CMC's for applications up to 2000°C	High temperature heat exchangers. Today: high temperature metal alloys with zirconium coatings. In 10 years SiC/SiC with EBC and TBC for temperatures up to 1600°C. In 20 years: CMC's for applications up to 2000°C

ISSUES PERTINENT TO Engineering materials for challenging application conditions:

Advanced light weight materials for transport application	**Advanced materials for tribological applications**
Aging of structural materials under long term service conditions, such as light weight materials, metal matrix composites (MMCs), functionally graded materials (FGMs) and coated materials. Applications under extreme loading: Aging of structural materials under long term service conditions, such as steels, light weight materials, MMCs, FGMs and coated materials. Composite materials: Aging of structural materials under long term service conditions, such as composite materials, MMCs, FGMs and coated materials.	Improved steels for turbine application by multiscale simulations in order to reduce cavitation erosion.

ISSUES PERTINENT TO Engineering materials for challenging application conditions:

Advanced light weight materials for transport application	**Severe wear application**	**Applications under extreme loading**	**Biomaterials and biometric materials**	**Nanostructured materials**	**Advanced materials for tribological applications**	**Composite materials**
High-strain steels and aluminium alloys for lightweight vehicle structures; foams for high energy dissipation components (existing, up to 5 years)	Ceramics based on natural grown materials: in 5 years different types of SiC. In 10/20 years different ceramic materials and components Improved and novel friction pair materials component: brakes and clutches existing:	Material and product existing, 5, 10, 20 years coated high temperature component: existing: Ni base + MCrAlY+ZrO2 TBC 5, 10 years: new coatings up to 1500°C 10, 20 years: up to 2000°C new base material (CMC?...) new coatings coated oxide/oxide Composites for	Ceramics based on natural grown materials: in 5 years different types of SiC. In 10/20 years different ceramic materials and components	Material and product existing, 5, 10, 20 years	Material and product existing, 5, 10, 20 years Ceramics based on natural grown materials: in 5 years different types of SiC. In 10/20 years different ceramic materials	coated oxide/oxide Composites for combustion chambers in new gas turbines existing: Ni base + MCrAlY+ZrO2 TBC 5, 10 years: replacement by CMC's up to 1500°C including TBC system 10, 20 years: up

Advanced light weight materials for transport application	Severe wear application	Applications under extreme loading	Biomaterials and biometric materials	Nanostructured materials	Advanced materials for tribological applications	Composite materials
	Iron/organic; steel sinter, carbon/carbon, carbon reinforced ceramics 5, 10 years: new materials- low wear, high temp. vastly improved existing materials 10, 20 years: life of the vehicle new base material (CMC?,…) new coatings	combustion chambers in new gas turbines existing: Ni base + MCrAlY+ZrO2 TBC 5, 10 years: replacement by CMC's up to 1500°C including TBC system 10, 20 years: up to 2000°C new fiber reinforcements for the CMC's As in Severe Wear Applications			and components As in Severe Wear Applications	to 2000°C new fiber reinforcements for the CMC's As in Severe Wear Applications

2.11.1. Advanced materials (including light alloys) for transport application

Lines of interests:

Light materials and tailored nanostructured coatings, with high mechanical strength, wear and corrosion resistance, flame retardant properties and high capacity of energy absorption properties (plastics, light alloys of Al, Mg, Ti, thin wall steels, composites HSS and their coatings) that allow emission reduction

Near net shape materials production and on line production and coating processes

Multimaterials (hybrid) Systems: Metals-plastic, ceramics-metals, composites, Al-Steel, metal-rubber, plastic-TPEs, plastic-metal-TPEs for automotive applications.

Functionally graded materials and self lubricant coatings for critical working environments (engines, sensors, mechanical components, bifuels and trifuels engines, energy or fuel storage...)

High temperature materials (thermal barrier coatings, nanocoatings, ceramic thin film coatings) for engine components, turbines resistant to corrosion, wear, creep, temperatures.

Catalytic and photocatalytic materials and nanostructured coatings for different applications (new combustion systems, alternative fuels, micro-combustion, environmental treatment, self cleaning...)

Materials for embedded sensors, to improve data acquisition, on line monitoring and new designs.

Anti-icing coatings for aeronautic applications, Nordic countries.

Environmentally friendly coatings for transport components (free of Cd, Cr, and Pb…)

Advanced materials that allow **noise** (absorption and isolation), **vibration** damping, impact, formable, corrosion and wear resistant.

Materials design taking into account lifecycle of material fabrication processes and assembly, their recyclability and cost.

Biodegradable and renewable materials (lubricants, fuels, plastics) to reduce the CO_2 emissions.

2.11.2. Materials for severe wear applications

This material class is to be treated in close cooperation with Extremat and KMM-NoE.

The concept of thin layers (TL) is closely related to functionally graded materials. In fact, all surface treatments and coatings aimed to increase wear and fracture resistance induce gradual or stepwise transition to bulk properties. Well established techniques such as shot-peening, laser treatment, ion implantation, have been developed and extended to generate nanocrystalline surface coatings with grain sizes of order of few tens of nanometers. New techniques include thermal spray, electrophoretic deposition, chemical (CVD) and physical vapor deposition (PVD), ion beam assisted deposition (IBAD), etc. The surface layer can be created with grain sizes varying smoothly from the surface to the bulk. Also the gradients in porosity and density can be controlled to increase the damage resistance and reduce stress intensity factors at crack tips. Recent experimental and theoretical works demonstrated that controlling gradients in thermal and mechanical properties provides a new potential for design of surfaces and interfaces with higher resistance to cracking and wear subjected to mechanical surface loading and thermal gradients. The diverse applications include load-bearing engineering structures, protective coatings, bioimplants, and magnetic storage media.

Normally materials are designed to reduce friction properties, but some applications (disc brakes for example) require high friction and stable properties. In this application light weight and high temperature resistance and high resistance to thermal fatigue are the main issue. For the counter material asbestos free material are being used now, but the problematic now is that there are so many number of different substitutes that no body know exactly what will happen with their substitutes in the long term. Performance vs. environmental compatibility studies should be qualified in order to standardize some materials to be used for this application. Since security is really important, to identify the relationship between the properties of the materials and the performance should be further studied.

2.11.3. Materials for severe chemical environments

Severe chemical environments lead to corrosion. Therefore the study of the passivating mechanism of the materials that allow avoiding the corrosion needs to be further studied in order to avoid corrosion phenomena. Thin film coatings have been developed up to now to avoid wear also when working at high temperatures (e.g. cutting tools), but the understanding of the corrosion phenomena when using these types of materials should be done, for example, developing tailored selfpassivating materials.

2.11.4. Materials for applications under extreme loading

Intermetallics constitute a new important class of engineering materials. These are mostly compounds of metals whose crystal structures are different from those of constituent metals. They are formed when the bonding strength between unlike atoms (e.g. Ti-Al) is larger than that between like atoms (Ti-Ti, Al-Al). They possess crystal structures with an ordered atom distribution, and due to their properties they occupy the intermediate position between metals and ceramics. The intensive research of these materials started in mid-1970s in view of expectation that they may become prime candidates for high temperature structural application, especially in jet engines in order to increase service temperature and reduce weight.

The best known representatives of intermetallics are shape memory alloys (SMA), e.g. Nitinol which have gained a growing importance due to the effect of shape memory having its origin in martensitic transformation. The other important intermetallic compound is γ–Ti-Al based alloy, in view of its low weight and high temperature resistance. The examples of applications are in the space shuttle of NASA, turbine blades, valves in combustion engines. The beneficial properties include low density (~3.8 g/cm^3), high specific yield strength (yield strength/density), high specific stiffness, good oxidation resistance and good creep resistance at high temperatures.

However, low ductility and fracture resistance have limited the wide application of intermetallics Ti-Al. The intermetallics γ-Ti-Al is called "microlaminates" in view of the lamellar structure of two phases γ and α_2-Ti_3Al so their mechanical response resembles that of a layered composite material. Therefore, the analysis of ceramic composite materials and intermetallics can be carried-out within the same formalism.

Intermetallics that are of interest for the contemporary industries include:

Iron aluminides (cost-attractive for automotive applications to replace stainless steel) titanium aluminides for aerospace applications nickel aluminides for gas turbine

applications Nb_3Al for its superconductivity and certainly a material for the future smart materials (NiTi, Cu-Al-Ni, Cu-Zn-Sn) for sensors, actuators, etc. magnetic and superconducting materials (Fe-Al, Nb-Al, Heusler alloys)

Intermetallics are known for high temperature properties including melting points, e.g. NiAl 1663 C, TiAl 1440 C, Nb_3Al 2060 C, and high elastic modulus. Typically, they manifest high strength at temperature, creep and environmental resistance (e.g. oxidation, sulfidation) and relatively low densities. They have strong potential for replacing superalloys and stainless steels in moderate and high temperature structural applications. Their exceptional properties lead to increased operating temperatures, efficiency, and reduced maintenance.

Iron aluminides may be used as low-cost coatings particularly for corrosion resistance in sulfur-containing applications. Shape memory alloys (Ni-Ti, Cu-Al-Ni, and Cu-Zn-Sn) are well suited for actuators, couplings, electrical connectors, sensors, cardiovascular stents, spectacle frames, and adaptive (smart) structures.

Nitinol (NiTi) has long fatigue life, relatively high ductility and corrosion resistance in addition to displaying two unusual phenomena: the pseudo-elastic effect and the shape memory effect due to reversible martensitic transformation. Biocompatibility of NiTi resulted in numerous medical applications.

Titanium aluminide (Ti-Al) is the proper material if light parts subjected to a high stress level shall work at high temperatures - that means hot rotating parts. The low weight allows an easier computer control of the motion process. Since Ti-Al is ductile at high temperatures, it sustains some 100 MPa of stress before it gets to be irreversibly deformed and this before it breaks. A very important cost-controlling feature is the possibility to produce Ti-Al in the classical way by casting it in an ingot and then forging it. Since a lamellar microstructure has proven to be favorable, an initially lamellar, nearly unidirectional oriented composite must be forged. This process of forging is not really understood. The lamellae tend to deform strongly showing partial rotations of the material of 90°. The microstructure gives the impression of the buckled substructure. The local concentration of strain energy drives a dynamical recrystallization process which is mesoscopically represented by a softening. The consequence is a very strong concentration of the strains showing a partially rotated material nearly undeformed in the neighborhood of heavily deformed shear concentration zones. Therefore, modeling is an important tool to understand the developing microstructure in a macroscopic heavy deformation process like forging. This is a new topic, and much research is necessary.

2.11.5. Functionally graded materials (FGMs).

The trends in advanced materials research and development for many years have considered an obtaining of homogeneous reliable materials such as metal alloys, ceramics, etc., providing that no significant differences in its properties will be revealed in final components. The rapid growth of aviation and spacecraft technologies has required more tough combinations of the characteristics and life time of components. However, new developments have created a lot of specific problems in materials design and applications. For the purpose of attaining a superior stress relaxation, materials possessing superior oxidation and thermal shock resistances, and other related characteristics are highly desirable. These goals became very common also for many other fields of modern engineering, such as electronics, communication systems, tools, biomaterials, and many other special applications.

Such artificial material will be inhomogeneous and will be characterized (in the most common case) by non-linear 3D-distribution of phases and regarded properties. Such functional materials are distinguished from isotropic materials by gradients of composition, phase distribution, porosity, texture, and related properties (hardness, density, resistance, thermal conductivity, Young's module etc.). The definition of these materials, known as FGM, may be summarized as "**A functionally graded material (FGM) is a material with engineered gradients of composition, structure and/or specific properties aiming to become superior over the homogenous materials composed of the same or similar constituents**".

An FGM was just recently generally described as "a new class of materials" or "a new material". However, an FGM is only a material which has gradients of composition, structure and related properties. It does not become "a new material", if metal or ceramic phase is distributed within the structure in an ordered, functional way. "A new material" would certainly need new certification procedure to be used, whereas "old" material need not. On the other hand, an FGM is characterized by the sophisticated behavior of FGM components in comparison with conventional (macroscopically uniform) materials. This ensures designers and engineers, who like to employ the full advantages of FGMs, should take several key issues into account. When an FGM is being designed, one has to know

about the optimal gradient of a certain property and/or composition. It is not possible to specify a gradient composition in the material without the knowledge of exact requirements for the application of this material and its working conditions.

The second problem arises when an FGM component has to be tested. Usual techniques such as standard thermal conductivity measurements application makes a little sense for FGMs because the results will depend on the way the specimen is located or cut from the whole component. For other properties a significant modification of testing is required due to gradients of structure and/or composition, there exists a difference in chemical potentials (partial free energy) of the phases, which is a driving force for dissipation processes like diffusion and migration.

However, despite the significant results achieved in the lab scale and reported in the literature, no wide practical implementation of these FGMs yet happened (except for some products and countries, like in Japan). Many excellent FGM specimens were simply too expensive, too difficult to make in bulk, too hard to control in real working conditions. The lack of theoretical basis, materials design routes, understanding how the FGM work, etc. has hindered the commercial implementation.

There are several approaches to attain a composition gradient in the FGM. Gases, liquids, and solids can be used as starting materials to be treated either physically or chemically to obtain the desired distribution. The gaseous method is one of the easiest ways to control the concentration of the phase being dispersed, but it allows obtaining the FGM component mainly in the form of a film or a thin plate in the direction of material thickness. There are several possible methods for FGM processing: chemical techniques, CVD, PVD, plasma-spraying, SHS, powder metallurgy, SPS, etc. – more than a hundred methods have been identified in Japan for FGM processing. It is not possible to foresee the "best-fit" method alone, which can satisfy to a lot of requirements and technical limitations of the whole FGM spectrum. It is not even known which materials will be optimal ones for a particular component, because the properties of this component might be varied strongly depending on the way it put to its application place. Therefore, one of the potential answers can be in the optimal combination of several such routes. This combination will be different for each system studied, depending of the properties of the materials used.

In general it is not possible to specify a gradient composition in the material without exact requirements from the application of this material and its working conditions. Therefore specific conditions require, in principle, a new material or its new gradient structure. The remarkable growth of the FGM-related studies, publications, national and international events, shows that this area has a substantial potential and may be one of the leading directions in materials science and engineering. Initially designed as thermal barrier coatings (TBC) for a superior thermal stress relaxation, they grew up into a new field of artificial structures, utilizing non-conventional properties, resulting from synergetic integration of different materials in one component. The FGM concept has demonstrated that compositional, micro- or macrostructure gradients can not only dismiss undesirable effects such as stress concentration but can also generate unique positive functions. The topic of gradients and multi-layers in solids, especially in particulate materials, presents itself as a promising perspective.

Some recent applications of FGMs

FGM systems	Applications
Hard metals	Tools, drilling tips, consumer wear resistant applications
Metallic	Diamond tools, power generation, medical devices, laser beam targets, etc.
Metal - ceramics	TBC, thermal shock resistant and anti-corrosion components, piezoelectric actuators, nuclear power generators, spacecraft systems, packages, solid oxide fuel cells (SOFC), consumer kitchenware, biomaterials
Ceramics based	Chemical sensors, SOFC, magnetic sensors, imaging and storage, sensors, actuators, capacitors, biomaterials
Steels, alloys	Coatings, joining, gas turbines, bond coats, hardfacing etc.
Semiconductors	Electronic devices, energy conversion, smart screens and displays, holography, optical memory
Composites and carbons	Structural components, energy conversion

Types of functionally graded materials

TYPE	PROPERTIES	PROCESSING	APPLICATIONS
Ceramic/metal bulk FGMs Thin film coatings	Thermal stress relaxation; high-heat resistance and wear resistance, high mechanical strength	Spark plasma sintering process PVD, CVD	High efficiency engine components Cutting tools
Titanium(alloys) with graded density or porosity	combination of good mechanical properties and light weight	Additive, layer-wise process: Direct Metal Laser Sintering (DMLS) of powders	Light weight structures for aircraft and space industry, implants
Tool steels with C, V, Cr gradients; steels or Ni superalloys with ceramic (oxide, carbide) particle gradient	combination of toughness and hardness or wear resistance	Additive, layer-wise process: 3D-Printing with local material composition control (generating a green part of powdered material and sintering or infiltration)	Tools, medical instruments, implants, aircraft and space industry
Functionally graded cemented carbide: titanium based surface ceramic layer, tough cemented carbide core and intermediate layer with graded composition	Wear resistance, breakage resistance, thermal crack resistance	Sintering	Cutting insert
Ferritic - austenitic combinations like 316L and 17-4PH; steel - ceramic combinations	magnetic and non-magnetic; ductile and stiff and other	Co-Injection Molding and co-sintering (building a graded interface)	Automotive industry, sensors; medical instruments

2.11.6. Biomaterials and biomimetic materials

Possible research areas:

- **Multimaterials (hybrid) Systems**: Metals-plastic, ceramics-metals, composites, Al-Steel, metal-rubber, plastic-TPEs, plastic-metal-TPEs,
- **Biomimetic materials** (biosensors, biocompatible properties, for implant applications, corrosion control…) and bionics (prosthesis...).
- **Nanomaterials** for use in photonics, electronics, optoelectronics, mechanical systems, medical applications and micro/nano-systems, and ceramic systems.
- **Biomaterials for prosthesis** (metal-metal, metal-PE, ceramic-ceramic, ceramic-PE with or without coatings).
- **Therapies synovial and bionic fluids** and their standardization.
- Fast, flexible, economic, and with made-to-measure production properties of applications with **biocompatible materials and coatings** including legalization procedures.

- **Bioactivity, biocompatibility**.

2.11.7. Nanostructured and advanced materials for tribological applications

Suggested research areas:

- **Microstructured**, multifunctional, autolubricant, triboreactive coatings and their environmentally acceptable processes
- **Environmentally friendly coatings** for multifunctional applications (free of Cd, Cr, and Pb...)
- Continuous vacuum processes (CVD/PVD...)
- Manufacturing processes for **multifunctional materials** for applications (electrical, optical, magnetic, mechanical, tribological, ceramic products).
- **Electrodeposition** of multifunctional thin films and coatings (metals, metal-composite, metal-polymer...)
- **Film obtaining processes** and nanostructured and multifunctional films via anodic oxidation (anodized), electrophoresis, vacuum, for non conductive) ceramic surfaces.
- **Smart materials** (which improve with use), processing, interface, embedding in structures and parts
- **Inspection / monitoring** methods On-line
- **Accelerated fatigue and corrosion**, extreme conditions tribology and tribocorrosion of advanced materials (-50ºC-900º)
- **Risk-informed ageing**: new industrial application of risk-based inspection and maintenance
- **Correlation between tribological behavior** (friction and wear) numeric and experimental
- Tribological and tribocorrosion tests **standardization**
- **Compatibility of ecological** lubricants, materials and coatings, biodegradability and toxicity

2.11.8. Composite materials

The metal ceramic composites have attracted the interest of the industry and research organizations due to the excellent combination of properties they exhibit: high specific mechanical properties, high and tailorable thermal and electrical conductivity, low to moderate thermal expansion, good wear resistance, good behavior at high temperatures.

Depending on the base material one distinguishes ceramic-matrix composites (CMC) and metal-matrix composites (MMC).The ceramic matrix composites can be reinforced with ceramic and/or metal inclusions in the form of particles or discontinuous fibers (e.g. whiskers), or layered ceramic coatings or multilayers. Also, there is a new class of CMC with interpenetrating network microstructure like Al_2O_3/Al (alloys), TiO_2/Al (alloys), and Al2O3/MexAly (intermetallic compounds).

The metal-matrix composites (MMC) reinforced with ceramic particles or discontinuous fibers include (i) Ti-based MMC (Ti+SiC or Si_3N_4) to replace Ti-based superalloys for jet engine fan blades, compressor components, and (ii) Al-based MCC (Al + SiC, TiB_2, Si_3N_4 or Al_2O_3) for automobile engine blocks. Ceramic coatings constitute a separate class of composite materials. By layering different structural ceramic materials, the fracture toughness can be increased through enhancement of toughening mechanisms, or residual stress effects. Various processing techniques may induce microstructural gradients within layers or coatings, usually associated with change of grain size. Metal-ceramics composites in the form of an interpenetrating microstructure can be processed by infiltrating metal into a porous ceramic perform. The advantage lies in the flexibility of the microstructure which can be produced, as it is possible to change the metal content and the ligament diameter of the metal. Also, different metals can be infiltrated into the same type of ceramic performs.

The origin of MMCs dates back to the 1950s and early 1960s. Boron fiber reinforced aluminium alloys and tungsten reinforced copper attracted the attention of researchers in those first years and the use of boron/aluminium composites in the Space shuttle struts was one of the first significant applications. Afterwards the application of a MMC diesel

piston insert by the Japanese firm Toyota in the 70s was a milestone for the industry.

After these initial results, the continuous research and funding of projects related to these materials took place after the early 1980´s. 25 years later the actual use of MMCs and CMCs in industrial applications is much lower than foreseen in the 70s. In 1990 the worldwide market of MMC was estimated to be between 3-37 million US $ and in 1999 it was estimated to be around 103 million US $. 62% of this volume is within the ground transportation applications and 26.5% in thermal management applications. Aerospace comprises around 5.4% of the total market.

2.11.9. Hybrid materials

Materials and components containing multiple constituents and materials (material-mix) are increasingly designed and fabricated to full-fill the service requirements in a cost-effective manner and with enhanced performance. Here is the focus is given to the materials containing "two or more materials" to form a single material or component to be used in advanced structures. The underlying difference of the hybrid materials for example from metal-matrix-composites (MMC), as described above, is the scale of the constituents used to fabricate these materials. The micro-level of microstructure is involved in MMC-type of materials are here not being dealt with, but more macro level of material-mix to develop material-mix components with enhanced properties.

The well-known example for this hybrid material category is "Glare" material which is used in aircraft fuselage to enhance damage tolerance behavior of existing metallic structures made of single aluminium alloy sheets. Furthermore, "tailor-blank" sheet technology of the car making industries can also be mentioned to give another example. These pioneering examples which have found wide spread industrial applications can and need to be increased using advanced joining technologies to full fill the ever increasing demands for better structural performance with lower cost and weight.

Therefore, there is a need to design and develop innovative material combinations using various advanced joining technologies (laser beam and friction stir welding, brazing, bonding etc.) to fabricate multi-material components.

By increasing the maturity of such a technology, new engineering structures can be more damage tolerant and corrosion resistant while reducing the weight and cost. The use of hybrid or multi-material components can be an effective approach for reducing the weight of the weight sensitive structures and applications. Furthermore, design engineers can make benefit of the different properties of the materials used to form the hybrid material/component. This can manifest itself as an increase of strength, toughness, corrosion resistance and improvement of resistance against damage growth under external load.

The European Technology Platform ETPIS (European Technology Platform Industrial Safety) has already identified the research need for the assessment of structural integrity of the hybrid & multi-materials and components. In this context it is an excellent combination of efforts of EuMaT and ETPIS TPs to support and organize the needed research efforts in this field.

❖ *Challenges in Research for Hybrid & Multi-materials and Components*

The main challenge of the hybrid materials is to control of the properties of the interface or joint area between different materials. Selection and development of joining technology with and without interlayer or filler material to fabricate durable interface with enhanced local properties are the current major challenges for the material scientists and engineers. Research is needed to develop technologies to be able to join dissimilar materials with better understanding of the evolving microstructures at the interface and joint area. The size, joint geometry and bulk properties of the materials under consideration to form a hybrid material should be taken into account during the design of the material or component. Formation of brittle phases or highly low strength microstructures or defects at the interfaces needs to be prevented to be able to generate innovative structural materials operating under external loads or under extreme conditions.

❖ *Research needs in the field of Hybrid & Multi-materials and components*

- Develop and establish the design and fabrication principles of the hybrid (material-mix) components.
- Development of advanced joining technologies for "metal-metal" and "metal-composite" hybrid systems. Advanced welding technologies should be improved to create hybrid joints with "low distortion", low residual stress and high fracture

toughness.

- Develop and establish principles of interface or local engineering for safe design and performance of the multi-material components with improved understanding of the bi-material interface behavior under various loading conditions.
- The use of existing knowledge on the role of strength mismatch between materials on the deformation and failure behavior should be enhanced to be able to design hybrid materials with higher damage tolerance.
- Research on the development of local engineering principles involving relationship between process, property and performance (3P) of the interfaces should be conducted for innovative hybrid materials and components.

2.11.10. Challenges and main lines of research in Intermetallics

The main drawback to the use of intermetallics is their lack of toughness at room temperature and the high cost of processing. In fairly brittle intermetallics, the activation of damage, by micro-cracking and crack propagation, is an essential aspect of the ductility and mechanical strength. Some possible lines of research are briefly summarized below, with the objective of better understanding, modeling, and monitoring the intermetallics ductility, toughness and resistance, at room or high temperature, by applying experimental and numerical methodologies at various scales.

❖ *Design of intermetallic compositions with improved ductility and fracture resistance.*

There are some possibilities to develop multiscale approaches and simulation studies at the atomistic level in order to better predict the intrinsic chemical bond breaking process occurring at the crack tip. Such analyses require the input of accurate interatomic potentials and further work is needed in this area. Activity in the domain of computation methods (ab-initio, molecular dynamics) for fracture modeling should be in the application of design tools to generate intermetallics with engineering properties that accommodate operational factors like temperature, load, environment, together with much improved ductility at room temperature and increased fracture resistance.

❖ *Monitoring microstructure of intermetallics for a better toughness and ductility*

Here, the recommended areas of research comprise developing more systematic knowledge and understanding of relationships between the metallurgical parameters at the micro-scale and the toughness and ductility of intermetallics, especially titanium aluminides. Such material parameters can be the composition (near gamma, duplex, partially lamellar or fully lamellar), the grain size, the lamellae spacing, preferred orientations, textures. Also, quantifying in a more precise way the processes of Ti3Al and lamellar structure formation as function of the heat treatment control parameters (temperature, duration, cooling rate, aging conditions) is an issue deserving more research effort in the near future.

❖ *Searching for new materials of desired properties with the help of micromechanics*

Micromechanics of materials provide a link between the material structure and mechanical properties at different scales of observation. It can predict and explain macroscopic effective properties in terms of the material microstructure and behavior at a micro-scale where physical mechanisms of deformation are better recognized. That approach is applicable to potentially useful microstructures and not restricted to those already characterized experimentally. Hence, micromechanics represent an important tool that supports the materials science in searching for new materials of desired properties. Clearly, the micromechanical approach has its limitations, for instance, it is difficult to treat complex thermo-mechanical phenomena dependent on many factors.

Combining the processing methods, experimental approaches, analytical models and computational tools the integrated research effort should also be directed towards a better understanding of the creep behavior of intermetallics for structural applications at high temperature. This includes clarification of the importance of lamellar structures (and lamellar spacing in addition to grain size), the influence of preferential orientations, the void nucleation processes, their growth and coalescence at grain boundaries, and their dependence on the grain boundary roughness. Modeling approaches should take into account micro-scale features like grain boundary tortuosity, heterogeneous local strain fields, and grain to grain interactions.

❖ *Multiscale analysis of advanced materials in inelastic range*

Micro-macro transitions made at different levels can be combined to perform a multiscale analysis. In view of the systematically increasing power of modern computers, the

importance of that approach will grow. At present, among polycrystalline intermetallics such investigations appear to be most advanced for titanium aluminides. Much has been done in the multiscale analysis of composites which can be applied to composites with intermetallics as constituents. The predictive power depends to much extent on how closely the real microstructures and basic mechanisms of deformation can be modeled. Therefore, numerical simulations must be accompanied by detailed characterization of the microstructure and effective properties of real materials. Although the transition from the atomistic structure to the behavior of a polycrystalline specimen is possible in principle, this is not straightforward and remains as a challenging task in a broader perspective.

❖ *Modeling and understanding of overall toughness and ductility at room temperature*

Analytical models cannot handle properly the details of the various mechanisms and defects that interact and contribute to the accommodation of the high anisotropy and heterogeneous strain fields. On the other hand, numerical modeling to date have not introduced together important features in the local plasticity mechanisms and their interaction with crack nucleation and microcrack propagation. Taking into account respective orientations of the microstructure (especially lamellar orientation vs. grain boundary orientation) and the various slip and twinning systems appears to be a key for predicting ductility at room temperature. Two kind of tools must be properly combined in order to fulfill such a requirement: (1) - identification and quantification of active plastic mechanisms by in situ observations, without cracks, during crack nucleation, and during crack propagation (measuring local strain fields by optical methods); (2) - numerical analysis of the corresponding experimental configurations (by finite element methods, with complex micro-slip based constitutive equations coupled with cohesive laws at various positions, in the neighboring of the notch or of the propagating crack), in order to obtain local stress fields and appropriate nucleation/propagation criteria.

2.11.11. Challenges and main lines of research in Metal-Ceramic Composites

Even though the too high final cost of the materials remain the most important reason that explains the current situation, there are other aspects that have also hindered the use of metal-ceramic composites such as difficulties in secondary processes, low ductility and toughness, anisotropy, lack of data regarding the behavior at long term, lack of data for modeling and simulation, lack of standardization etc. On the other hand, improvements have also been attained in concurrent engineering materials (aluminium and magnesium alloys, organic matrix composites, titanium alloys, steels, etc.) and it seems clear that even though the number of applications for metal-ceramic composites should continue rising, it will be difficult that the expectancies created at the beginning are reached.

Presently it is generally accepted that metal-ceramic composites will cover new applications in niche markets in the near future but it may be very difficult to see them in large series applications or large volumes.

2.11.12. Research needs in the field of Metal Matrix Composites (MMC)

- Cost. To lower the cost is an essential factor for the automotive market. Not so much for the aeronautical one.
- Development of new alloys and reinforcements for increased performance. Not just to adapt existing alloys and reinforce them.
- To improve ductility and low toughness of existing materials.
- To increase the reliability of MMCs. Fundamental research is needed to reach to know the relation between microstructure and properties.
- Cast MMCs that are cost competitive and can work at T between 300-500ºC are required from end users.
- Research in the technology of performs is needed. The cost of performs should decrease and furthermore process development is needed to obtain net-shape performs.
- Research in the area of secondary processing is also critical. Recycling aspects must be systematically studied as well as machining and welding operations.
- Development of databases and standards specific for these materials. The industry needs databases that comprise all properties, test and evaluation standards.

2.11.13. Research needs in the field of Ceramic Matrix Composites (CMC).

The "Advanced ceramics technology roadmap" identifies several aspects that industry will require from advanced ceramic materials in its Vision for 2020 document:

- Tools (computational related and knowledge based) for accelerating development of new, low cost materials.
- Larger reliability.
- Increased T-capability. Components that can work in T of up to 1500ºC.
- Lower costs. CMCs should be cost competitive with metals in high T niche applications.
- New processes that can reduce the cost of the final components. Near net shape approaches.
- Non-destructive testing methods that can be applied for CMC applications.
- Development of databases with material specifications and design guidelines.
- Standardization.
- Recycling methods suitable for the recovery of the reinforcing phases.

Priority research themes and topics

	MAIN LINES OF RESEARCH (5 YEARS)	MAIN LINES OF RESEARCH (20 YEARS)
MMC	Development of low cost materials and production routes, e.g. cheap particulate MMCs based on performs (Al and possibly Mg) for high temp and wear applications	Research on new, cost competitive reinforcements and performs.
	Development of non-Al based composites	Development of cost competitive near net shape production routes
	Research on recycling, machining, finishing, welding etc. alternatives	Development of sound databases for the materials and process parameters/obtained properties.
	Development of new Matrix/reinforcement systems. Innovative particulate MMCs with multifunctionality, self-sensing and self-healing potential (Al, Ti and steel).	Development of sensors and control methods for production quality.
	Need of fundamental research to predict the mechanical and physical properties. Nano-reinforced MMCs for varied structural applications where currently monolithic metals are used.	Development of simulation and modeling tools adapted to particle reinforced materials.
	Development of NDT concepts that take into account the specific features of MMCs.	Use of sensors and actuators in the processing routes for MMC production.
CMC	Further research on microstructure-properties relationship.	Fundamental research on CMCs.
	Research of new interphase materials, fibers and matrices.	Development of low cost ceramic fibers. Development of near net shape and lower cost production routes.
	Development of NDT (non-destructive testing) methods suited for CMC materials. Development of modeling tools.	Development of reliable databases.
	Research on microstructure-properties relationship.	Research on new production routes, gas phase routes, etc.

In addition to the above lines of research on MMC, it should be stressed that there is hardly any knowledge on long-term mechanical behavior and fatigue of the metal-ceramic

composites and relatively poor understanding and knowledge on interfaces in these materials. The production of nano-size MMCs using SHS, plasma and spray-drying is worth consideration having in mind their potential application as coating materials. Systems that can be looked at include Ti-TiC, Ti-TiB, Ni-TiC, Al-TiC, and Al-TiB2. According to KMM-NoE survey analysis, the main lines of research in metal-ceramic composites in the 5 year time horizon will be direct powder deposition (DPD) for components with tailored functionality by rapid manufacturing processes use of 3-dimensional and non-destructive methods for damage analysis (e.g. high-resolution tomography) improved models for lifetime assessment of CMC and MMC.

For a long term perspective (e.g. 2020), the main challenges in metal-ceramic composites may be MMC with superior creep resistance using nanosized reinforcements reliable intermetallic MMC with superior high temperature properties produced by reactive methods oxidation, damage and creep resistant CMCs for turbine applications >1400°C either by superior concepts of environmental barriers, self-healing coatings etc. (especially for non-oxide fiber composites) using creep resistant single crystalline oxide fibers and improved interface concepts.

2.11.14. Challenges and main lines of research in Functionally Graded Materials

During the last years, functionally gradated (graded) materials (FGM) in general have been developed from single specimens to industrially oriented applications. On the contrary to original (yet straightforward) FGM concept - a superior thermal resistant material for the space plane – recent FGM components are being developed for a variety of applications (tools, coatings, packages, semiconductors, optical and biomaterials, etc.). Several national R&D programs (Japan, China, and Germany) and many international cooperative projects have been carried out in the field. Despite the significant results achieved, practical implementation of these FGM was shown only a little. It was noticed that many excellent FGM specimens were simply too expensive, too difficult to make, and too hard to control in mass production. The lack of theoretical basis, materials design routes, understanding how the FGM work, etc. has hindered their commercial implementation.

❖ ***Application-driven FGM design, optimization and tailoring***

Because FGM are highly multifunctional in respect to properties, time and spatial coordinates, they must be developed for specific applications, where their huge benefits might be utilized in the best way. This requires a combined effort in materials solutions design, optimization and final tailoring to the customer's demands:

- Development of theoretical, holistic and hierarchical multi-physical models for "gradient media" (e.g. how to calculate free energy, electronic structure, entropy, phase equilibria in a non-homogeneous system? How to account gradient fields caused by a presence of non-uniform composition or structure variations, changing spatially or in time?). Due to the gradients in FGM, the "normal" approximations and models, used for traditional composites, are not directly applicable. The situation becomes even more complicated, when an FGM has multi-scale gradients (macro-, micro- and nano-scale), where defects such as vacancies and dislocations start to play an important role in the transfer processes and mechanical behavior of the specimen. The possibilities of microstructural changes have to be also considered when FGM is put into its application, and the reliable lifetime of the component has to be evaluated.

- Development and applications of numerical techniques, analytical approaches and combined methods to properly analyze, evaluate and predict certain properties of the FGM structures as functions of some input parameters (compositional, microstructure, etc. gradients). Most numerical schemes use discrete distribution models, and even if this non-isotropic phases distribution complies with a certain law, the resources necessary to define, conduct, and interpret such an analysis, are prohibitive for complex structures. This direction should focus on gaining more understanding about "optimal" FGM design and the most suitable properties they should have. The calculation of the gradients and the design of the FGM component must be based on its real working conditions and possible restrictions, with the maximum of available information, including the properties computation, stress evaluation and non-steady heat and mass flow analysis.

- The experimental investigations of physical, mechanical and other properties of FGM on different levels are absolutely necessary for validation of theoretical models, for testing of the adequacy of design approaches and for a reliable feedback from the experiments. Here one of the important issues is in a tight connection of the FGM testing with their applications and real working

conditions. For FGM, the same observation of measurement process of one specimen yields different results depending on the way the sample is placed. It is obvious that development of adjacent testing methods (such as in-situ measurements of anisotropic thermal or electrical conductivity, 3D-stress and strain distributions, etc.), including various advanced NDT and "deep" procedures (neutron thermo diffraction, Raman/IR, positron annihilation) is a major by-product of the FGM research in general.

❖ ***Making FGM components***

After FGM design issues are solved and an exact knowledge of the kind of FGM solution needed is obtained, the FGM component must be properly manufactured. For the most applications, complicated and expensive manufacturing techniques cannot be used. Thus "conventional" powder metallurgy (PM) remains the most useful method for mass production of FGM. Different coating methods like plasma spray (APS/VPS), high-velocity oxy-fuel (HVOF) may be also listed under PM benefits. For traditional PM, the consolidation process (free sintering, hot pressing, HIP, SPS/FAST) as crucial consolidation step needs to be better understood for the different material combinations. Theoretical tools to forecast the suitability of a proper gradient formation should be developed and tested concerning their transfer to experimental investigations. Prediction of interface effects such as phase formation and diffusion properties could also lead to easier and better understanding of finding the appropriate material for special applications.

- Development of simple, robust, cost-efficient methods for manufacturing of 3D FGM components with prescribed gradients in green and final states. One of the most crucial steps within the FGM formation process is to obtain final parts with un-deformed, complex geometries and defined gradients of either composition or porosity. In this respect a lot of work is still needed to adapt the existing processing techniques to industrial viable production routes. Therefore an up-scaling of laboratory processes to industry scale is very important. Processes have to be selected which are capable of manufacturing "real" parts and not only material samples. Industry in general is dependent on cost-effective production technologies addressing either a large scale production or a small scale production of prototypes for special applications. They are further dependent on producing parts with reproducible geometry, gradient structure as well as mechanical and physical properties of the final part. Therefore the quality assurance of the manufactured FGM part will be a key factor before technology transfer from basic and/or applied research to industry will be possible. The structural control of the FGM components should be performed during the whole fabrication process, since the structural changes in the final material may in general affect the desired properties level.

❖ ***Making materials business of FGMs***

It is a must for an FGM to be also a material, which should be competitive with other alternatives to become economically and technically feasible. For an FGM component to be successfully realized, the prerequisite is an absence of suitable homogenous materials or composites able to provide necessary level of properties for demanding applications (aviation, spacecraft, electronics, tools, etc.). Such an issue eventually has given before an impact to the FGM development, looking for a superior stress relaxation, oxidation, wear and thermal shock resistances, as well as fracture toughness for thermal barrier coatings (TBC) for spacecraft, gas turbines etc. applications.

The industrial practice shows that the production costs should be minimized to improve the competitive level of the FGM components with conventional ones. Every additional operation could make the component fabrication unprofitable even if the achieved properties level is higher (the acceptable "price/quality"-ratio). The exceptions to that are mostly space/aircraft and defense applications, where desired properties of the components cannot be obtained by any other means at reasonable costs.

❖ ***Major FGM priority themes***

Materials basics	Generic modeling, design and optimization procedures, integrated with experimental feedback Advanced testing methods
Consumer-oriented products with a high added value	Biomaterials, implants, medical sector in general (including bioactivity studies) Home electronics and household equipment, smart cards, smart windows/monitors Home energy systems (included distributed) Smart wear, materials for sport and leisure

Demanding industrial applications	High-temperature processes (power generation and conversion, metallurgy, nuclear, solar, thermal, fuel cells, etc.) Low-temperature processes (catalysis, fuel cells, biotechnology, thermal management applications, sensors and actuators, photonic components) Materials processing (advanced tools, surface treatment, friction and wear-resistant applications) Radiation-protection materials, materials solutions for security applications
Demanding applications "for tomorrow"	Fusion power components, superconducting components Space and deep space flights applications Advanced aircraft components

2.11.15. Nanostructured materials

Fast development of new materials in the second half of the XX century can be to a large degree linked with the concept of materials microstructure and with dissemination of various microscopes, needed for microstructural investigations at relevant length scales, reaching frequently down to atomic level. As a result materials emerged with chemical composition, phase content (size, shape arrangement) engineered, or at least controlled, with the resolution limit below a hundredth of a millimeter.

In the recent years the concept of materials microstructure has been pushed to the next mile-stone by wide interest in nano-structure materials which are fabricated or controlled with the spatial resolution limit below a tenth of micrometer, i.e. two orders of magnitude lower than standard materials.

Materials based on this new concept, almost by definition can be directly applied to low dimension structures, such as thin films, interfaces and micro-elements. Indirectly, the better understanding of the processes taking place in nano-structures will improve in a longer horizon standard engineering materials.

Nanocomposites based on polymeric materials and clays are particularly attracting since give rise to a consistent increase in thermo-mechanical properties (e.g. modulus, heat distortion temperature, etc) with low filler loading (5% w/w). Therefore the final nanocomposite material present a consistently lower density compared to traditional micro-composites that need higher filler (20-30% w/w) contents to reach similar properties.

The presence of low amounts of organically modified clays produces a consistent improvement in barrier properties of the material rendering it suitable for a wider range of applications. The improved barrier properties give rise to higher thermal and hydrolytic stability of the materials, thus increasing the life of the final product.

The thermal stability of the organically modified clay represent a fundamental issue in order to achieve good mechanical properties, good thermal stability and long term life of the final material. The research of stable organic surfactants for the clay modification is of high priority in order to obtain materials with good properties, long life and good final aspect.

Nanocomposites based on thermoplastic materials can be recycled and can also be produced using recycled materials.

The interaction between the clay and the polymer matrix is of fundamental importance in order to retain a sufficient impact resistance of the material while increasing its modulus. Indeed, traditional composites and nanocomposites with low adhesion at the interface between polymer and clay, are always more brittle compared to nanocomposites with good compatibility between the clay and the matrix.

The study of the interactions between the filler and the matrix should also have important effects on the properties of micro-composites made with traditional fillers.

The addition of clays is proved to increase the biodegradability of biodegradable thermoplastic polymers such as poly(lactic acid), polycaprolactone and aliphatic polyesters from long chain diacids and diols.

❖ *Priority lines of research – medium term perspective*

Nano-structure materials have attracted enormous research interest. For this interest not to fade away there is an urgent need to: (a) strengthen the theoretical background for nano-scale control of properties and (b) widen the range of applications in which the

nano-structuring is essential for providing the key properties.

In the context of the theoretical setting, the outstanding challenges are related to description of the size effect on the relevant properties. In particular more elaborate models are needed for size effect on combined mechanical, optical, electronic and magnetic properties. These models should provide tools for estimating the critical size and the effect of size distribution on the properties of nano-structured materials. Verification of such models certainly requires concerted efforts of a larger number of research groups and access to state-of-the-art facilities for investigations of the materials at nano-structure level.

For widening the use of nano-structured materials in industry in medium term perspective the focus should be on products in which small quantities of nano-structured materials change rapidly their performance. These products include miniaturized components (nano-wires, nano-membranes) for variety of mechanical-electronic systems. However, even larger opportunities are expected in the case of artifacts with active thin films of interfaces. Nano-structured thin films are already changing the market in products raging from paints, coatings to catalytic substrates and bio-active surfaces. In order to strengthen the development in this field, more research is needed on interactions of nano-structured surfaces with variety of environments understood in the most general way.

In the same context an important line of research should be directed towards nano-structured powders. These materials can be viewed as generic nano-component changing/modifying properties of almost any material, either solid or liquid. Techniques for rapid characterization of nano-powders are needed to develop technologies for their application to polymers and metals. Functionalizing and control of the surface of nano-powders is one of the outstanding research issues in this field.

❖ *Priority lines of research –long term perspective*

In the long term perspective the research should be aiming at nano-structured volumetric materials and large components. Applications in this case are much more challenging as they require not only bulk nano-materials but also technologies for fabrication methods of various elements which preserve their nano-character. Also novel techniques for assembling (joining) nano-structured components are of prime importance from that point of view.

❖ *Needs/Challenges*

The challenge in the medium term perspective is to prove usefulness of the concept of nano-structured materials to industry. For this it is certainly needed that dispersed human resources and research infrastructure are pooled into the projects which can provide industry with new products in acceptable time frame.

In a longer term perspective, one of the challenges is to train potential users of nano-structured materials in variety of fields of industrial activity. Wide range of applications of nano-structured are expected to emerge only under their active participation.

Another challenge over a long term horizon is to control the risk related to the use of nano-materials. To this way studies are needed in particular on the "natural nano-particles background" and their effect on human beings.

2.11.16. Materials for advanced steam power plants

The development of highly efficient steam power plants (> 50 %) is related to the technical control over steam temperatures of more than 700 °C. The jump over the "50 % margin" in the power plant development is not simply a further development up to now but is a revolution in new material requirements. Consequently, for economic considerations the cost increase in new high tech-materials has to be compensated by higher efficiency followed by cost-cutting measures for fuel and certification procurement. Therefore the design of a competitive total concept for advanced fossil fired power plants is of highest priority. Consequently appropriate materials must be developed for high-temperature-loaded areas in steam generators, piping, valves, and the turbine.

The steam power plant requires materials which can tolerate live steam conditions exceeding 700 °C and pressure up to 400 bars. Therefore, new joining and gasket technologies have to be explored for such conditions. The subject of steam corrosion at such temperature levels will be of a new dimension. New protective coatings have to be developed to protect both against oxidation and corrosion as well as temperature (cooling). Improving simulation tools contributes largely to cut development cycles and

costs and so reduce manufacturing costs. Accepting this new power plant technology depends mainly on the fact of how susceptible it is to failure. There are new, technical challenges in the area of the combustion chamber. The high temperature levels in the combustion chamber cause changes in the development of mechanisms for nitrogen oxide and slagging. Additionally, it is required that the combustion chamber must be adaptable to all the different qualities of coal and coal compositions. This makes fundamental investigations necessary to comprehend the development of minerals, combustion mechanisms, as well as the distribution of air and fuel.

The demands on material for steam turbine rotors are essentially higher than for gas turbines because of applying nickel basis super alloys required for thermally highest loaded components. This applies mainly to the long-term stability of properties (> $2x10^5$ h) and component dimensions. Therefore, it is difficult to use nickel based super alloys for these applications they must be further developed and qualified on the basis of available materials.

On the basis of the temperature of 700 °C – 720 °C and temperature window for precipitation heat treatment of nickel-based forged alloys it cannot be assumed that structural stability can be guaranteed for the complete employment of the component of > 200.000 h. Phases are expected to change and reshape causing modified mechanical properties during operations. Therefore relevant safeguarding of stress-rupture properties such as creep strength and creep strain limit have to take place. Furthermore, manufacturing large components needs good possibilities for pouring, recasting and formability. In comparison to gas turbines, the present design of steam turbines use mono rotors measuring up to 1.2 m in diameter, 6 m in length, and a total weight of up to 30 t. These are very large dimensions of the important component made of nickel-based material even when applying alternatively welded turbine waves. The limits of the component dimensions produced and investigated up to now exceed the application of existing precipitation-hardened alloys. Appropriate measures for detecting defects and flaws are important to definitively exclude catastrophic failure. The creep crack resistance of advanced materials is very interesting because of the limited ductility and the influence of the environmental agents. An important problem to be solved is the weldability of components consisting of different types of material (Nickel based alloy / 10 %Cr-steel). Appropriate welding methods are to be developed and welded joints of large components have to be qualified. In parallel adequate NDT-methods have to be developed.

Power plants are designed on the basis of valid codes respecting approaches mainly using analytical formulas (DBF **-** design by formula). DBF is linked to a data basis of material characteristics and experience in relevant damage mechanisms well proved in decades. Inelastic continuum-mechanical based approaches (DBA design by analysis) are increasingly used in the harmonized European design standards. Prior to commissioning and putting into service the components concerned a qualified design method has to prove that a safe operation is possible under the specified conditions. This has to be in accordance with the general relevant specification of national laws respecting European Directives (e.g. the Pressure Equipment Directives PED)**.** During the operation of the plant according to national regulations to industrial safety time limits for inspections of the total plant and parts of the plant have to be determined on the basis of a safety-engineering approach.

Future power plants will have to deal with the following problems related with materials: There are considerable gaps in the data basis of the actual design characteristics of the new materials.

- The deformation and damage behavior of new materials is not completely known especially in relation to realistic complex component loads. They have to be numerically recorded and delineated. It is important to examine whether existing design methods, proof of integrity, strength and damage hypotheses comply with these demands. Validating the numerical approaches requires basic accompanying experimental investigations. For example, thick-walled large nickel-based components, welded joints of dissimilar materials

- The existing DBF is no longer the dominating design method. Due to the high costs of the components the new materials have to be used very economically. New scientifically proved ambitious methods of design have to developed, which help to determine precisely safety margins to realize more favorable geometries.

- There are no adequate design methods for using composite materials and materials composite resp. multi-functional materials.

These problems can be solved so:

- Systematic qualification of materials to be used as basis for optimum design.

- Compiling materials and component adapted design and integrity concepts. Apart from the consequent advancement of methods of the inelastic continuum mechanics design by analysis the total simulation of the component behavior have to be put in the foreground covering component load – operation – fuels – materials exhaustion (surface reactions, local and global damage conditions) – including new non-destructive test methods to demonstrate critical flaw sizes – interaction of operation and running.

- Introduction and fitness of multi scale simulation techniques. Especially development of advanced protective layers (heat insulation, oxidation) resp. multi-functional material systems which include special conception (sensoric, damping, self-healing …). They all require a better comprehension about the way physical /chemical phenomena work in the material and component. This requires multi-disciplinary approaches to be developed so that complex behavior of these materials can be understood and described to improve their effective industrial implementation. The multi-scale modeling seems to be promising since scale integration from the nuclear level to the continuum mechanical approach can be considered. These modeling approaches require an experimental validation.

There are similar problems in monitoring the plants. However, contrary to existing plants there is relatively little resp. no operational experience made with components of new materials / material systems.

Concerted R&D work is required for condition-oriented monitoring of components made of new materials because lack of knowledge may clearly shorten the monitoring intervals and so be disadvantageous to the operating efficiency and the availability of the plants. Adapted on-line monitoring concepts have to be developed and verified. They must consist of the integrated simulation of operational loads, the modeling of damage processes, the determination of the failure probability (time, location), of probabilistic methods for non-destructive testing as well as damage mechanisms.

The specific themes for steam power plants have to be considered mainly in the component (manufacturing, design, monitoring) and in the necessary safeguarding of the materials in view of properties, processing, and operational behavior:

The main focus of research into steam turbines is on:

- Development and qualification of nickel based / steel joints, further development of steel for application up to 650°C temperature

- Material models and service life concepts of Ni-based-alloys

- Determination and modeling of the relaxation behavior of Ni-based alloys and welded joints under multiaxial load and non isothermal conditions

- Multifunctional layer systems against corrosion, oxidation, erosion and wear

- Further development of available nickel-based alloys and determining the operational relevant behavior.

Research into steam generators, piping and valves is mainly focused on:

- Important research activities to implement new materials

- Corrosion and oxidation behavior of new materials

- Formation of slags on new materials due to flue gas

The following R & D tasks are of special interdisciplinary importance in view of the complete power plant:

- Identification of defects/flaws in thick-walled components made of nickel-based alloys and welded joints with non-destructive test methods

- Defect acceptance concepts , fracture mechanics, Integrity concepts (brittle failure)

- Lifetime prediction and monitoring (high-temperature measuring technique, damage accumulated methods) including the damage development in nickel-based materials also based on micro-structural characterization and. thermo-

dynamic modeling.

- New manufacturing technology concepts for thick-walled components

The following long-term themes are the view of the material experts:

- Optimization with regard of economic use of material and manufacturing of components for 700 °C steam power plants (e.g. large components in steam generator/turbine, fittings/valves, piping)

- Material concepts for steam power plants with >700 °C (heat insulation, oxidation and erosion protection)

- High/strength, cost-efficient light constructional materials for turbines to be applied in both high/temperature and low temperature ranges

- Extensive coating for temperatures up to 750 °C (heat insulation, oxidation and erosion protection)

- Corrosion behavior under oxy coal atmosphere

- Investigation of slag formation and composition under oxy coal conditions

- Sulfate-induced high-temperature corrosion of austenitic materials and nickel-based alloys at T > 650 °C

2.11.17. Materials for advanced gas turbines

There is a demand of longer lifetime in combination with cost-efficient operation. The materials should show an improved capacity to withstand increased mechanical-thermal load. If materials have been identified with such properties their implementation in the design phase requires extensive knowledge about their specific behavior as the processing time of the relevant components is reduced.

The topics with most urgent need for realization and most promising benefit are listed in advance:

- High temperature coating systems: Developing and modeling of improved thermal insulation and protection systems against oxidation and corrosion. Improvement of lifetime at temperatures > 1200 °C up to more than 25000 h. Increase of cyclic endurance. Self-healing coating systems.

- Assembled blades in association with optimized materials: manufacturing technologies, properties of the joints also in association with coating. Development of Rapid Tooling and Rapid Manufacturing Technologies. Improvement of materials: increase of creep strength (service temperature) and corrosion resistance. New types of materials (ceramic composites).

- Improvement of rubbing and sealing systems e.g. in the gap between blade and casing: simulation of the tip rubbing process and influences on vibration and damping, procurement of characteristic data, modeling. New deposit material in the rubbing area (avoiding damage of blade tip, high wear and oxidation resistance to keep the gap tight)

- Ultra High-strength materials for rotors: production technology for large components, determining material properties of available materials. New materials for blades of low density and their manufacturing technique. Determination of design limits.

- Refurbishing methods: process development for straight solidified, and single crystalline materials, improved testing methods to define the degree of damage. Repair of coatings. New joining techniques for thin walled blades. Inspection and testing after repair.

- Lifetime modeling: Consideration of combined loads, influence of defects if new materials will be used. Multiscale modeling of deformation and damage development. Evaluation of safety margins in order to make full use of material capacity.

- Economic standard structural materials: increased thermal flexibility and extended lifetime at high temperatures require improvement of already existing standard materials (e.g. casing: nodular cast iron): application at higher

temperatures, improved resistance against LCF loading, new concepts to evaluate component integrity on the basis of critical flaw sizes.

- New types of structural materials: e. g. ceramics, ceramic composites, reinforced Ni-aluminides

2.11.18. Materials for Oxy fuel process

Realizing oxy fuel processes requires extensive research into both gas turbine application and coal-fired boilers. In view of materials technology the following questions have to be clarified on a short-term or medium-term basis since they are mandatory:

- Corrosion behavior of ferritic and austenitic steels, nickel-based alloys and their protective layers in flue gas atmosphere (CO_2-rich, low oxygen).

- Stability of slags under oxy fuel conditions with specific consideration of the formation of low melting alkaline and alkaline earth carbonates.

The greatest technical challenge is the development of economical membranes to separate pure oxygen from air. New materials have to be developed with clearly higher permeation rates than die currently known systems. In the same way the technology for metal-ceramic joints has to be developed for such components...

2.11.19. Materials for advanced Coal gasification

If conventional routes are not followed and, for example, a hot gas cleaning will be integrated specific materials problems due to corrosion and temperature arise.

Coatings of high chromium content and new high-strength materials allow higher process temperature in existing and future gasification processes. Apart from metallic corrosion protection layers mainly environmental barrier coatings (EBCs) on a ceramic basis provide a high potential, to protect components against corrosion caused by sulfurous gases such H_2S and COS.

For gasification providing CO_2 and hydrogen as end product membranes have to be developed (proton conductors and nano-scale porous membranes).

2.11.20. Materials for advanced energy applications - Cross-sectional themes

Cross-sectional themes are topics which consider more than one component within the plant technology. The following themes are mentioned as key words:

New Materials:	e. g. new methods for the architecture of materials with specific characteristics (molecular and atomistic models) New adequate testing methods to determine relevant material characteristics
Joining technologies:	e. g. joining of dissimilar materials
Monitoring:	e. g. sensors, NDT-methods
High temperature sealing technologies	e. g. Rubbing systems, gaskets
Design and modeling:	e. g. molecular and atomistic models, constitutive equations, multiscale modeling with implemented damage hypothesis
Refurbishment:	Repair technologies and adequate evaluation methods

Materials needs for energy technologies
- requirement for future applications of materials against the key energy areas

Energy	Plant / components	Structural Materials	Functional Materials	Multifunctional Materials	Biomaterials
Generation (Conventional and advanced fossil)	e.g. Steam turbines Boilers Gas turbines Gasifiers Fuel cells Hydrogen from coal Coal liquefaction	Steels Alloy steels Superalloys Ceramics Composites Coatings	Activated carbons Filters Interconnectors Membranes Sorbents Chemical looping materials	Structural Health Monitoring (SHM) systems, Diagnostic Smart materials, Catalytic filter materials	Anti-corrosion biofilms
Generation (Nuclear)	e.g. Boilers & turbines Decommissioning/ storage Reactor vessels Fission/fusion materials	Steels Alloy steels Superalloys Ceramics Composites Coatings	Filters, Active carbons	SHM Materials for remote robots Self-repair materials SMART materials	
Generation (Renewable)	e.g. Wind turbines Tidal power Hydro turbines Biomass plant Heat exchangers Fuel cells	Composites Polymers Steels Superalloys Ceramics Coatings	Photovoltaic Thermal materials (Geo and Solar) Fuel cells materials Anti-fouling coatings	Photovoltaic materials Piezoelectrics Fuel cell materials Catalytic Filters Conducting membranes Solid Electrolytes Thermoelectrics Power harvesting SHM SMART Actuation materials	Biofuels Biomimetic structures Biohybrid materials Anti-corrosion biofilms
Transmission	e.g. High conductivity applications Insulators	Ceramics Polymers composites	Piezoelectric materials Superconductors		
Storage (Electrical)	e.g. Batteries	Ceramics Non-ferrous alloys	Electrode materials	Electrolytes Materials for Integrated Power Systems	
Storage (Hydrogen)	e.g. Pipelines Compressors Pressure Vessels	Steels Alloy steels Composites	Carbon Nanostructures Activated carbon membranes	High capacity/integrity materials	

3. Technical Foresight and Resources needed for the realization of the EuMaT Roadmap activities ("Implementation Agenda")

For the forthcoming FP7 call(s) the Focus Groups will formulate approx. 5 topics per call combining the following aspects:

a. EuMaT Focus Group activities, namely those of

   FG I Management and Coordination
   FG II Materials
   FG III Materials Production Technologies, Testing & Characterization
   FG IV Materials modeling
   FG V Horizontal issues – coordination groups

b. FP7 priorities, namely:

   1. Health
   2. Food, Agriculture and Biotechnology
   3. Information and Communication Technologies
   4. Nanosciences/ technologies, Materials and New Production
   5. Energy
   6. Environment and Climate Change
   7. Transport
   8. Socio-economic Sciences and the Humanities
   9. Space and Security Technologies

c. and, EuMaT, 5 priorities, namely:

   1. multi-functional engineering materials with gradient properties
   2. engineering materials for challenging application conditions, including high-temperature and light-weight
   3. multi-material (hybrid) systems where advanced materials are combined with more conventional / structural materials
   4. relevant materials technologies and
   5. multi-scale modeling

The priorities are then defined as a combination of the most relevant of the above items.

The format for each proposed topic (not project!) is given below and should be the basis for the definition of the "bullet points" in the calls:

RTD TOPIC: **...**			
Brief description of the topic and rationale at a level which you would find in a work program			
Main development issues and targets at a level which you would find in a work program			
Expected impact in quantifiable terms at a level which you would find in a work program (please try to avoid quantifications like "improvement of machining speed by 20%", which as such do not give much useful information without additional data about the specific application, size of the market etc...)			
Sectors addressed:			
Required RTD investment: **xxxx €**			
Implementation priority/justification: Prioritisation within the topics put forward in the SRA of the ETP, taking into account critical dependencies etc.: "1st priority because.... (largest return on RTD investment/prerequisite for further research/etc.)"			
Notes/comments: ***e.g. possible coordination needs with other thematic programs***			
Elements to be included in the call	**State of the Art**	**Vision/targets**	**Forecast materialization**
Description of the elements to be included in the call (For example, a RTD topic "Flexible assembly systems could include the following elements: integration of automated and manual working places; development plug & produce function elements; development in-line control for assembly systems; simplified user-interfaces & programming tools.)	***In terms of process/technology, organization (if applicable), tools (if applicable)***	***In terms of process/technology, organization (if applicable), tools (if applicable)***	

EuMaT TOPIC:

Materials for Energy Supply and Environmental Protection

Brief description of the topic and rationale at a level which you would find in a work program

Across Europe and the rest of the world, there is a need to establish a sustainable approach to energy, in terms of its production, use, conservation and management whilst at the same time meeting strict economic and environmental targets.
The global focus on Energy & the Environment should be used as a driver to further develop world-class knowledge and capability in Europe in the field of materials for energy generation, transmission, storage, and conservation. The opportunities for, and contribution materials can make to, reliable and sustainable forms of energy generation (e.g. fossil & renewables), and conservation (e.g. construction, manufacturing, transport) are enormous and the EU, with its acknowledged expertise in Materials Science, must take these opportunities to further develop its world class expertise which must be retained within the EU materials community. The technologies must then be implemented to secure jobs in areas such as materials production, processing & manufacturing, particularly in the high added value technologies associated with these industries, for which Europe is renowned.

By necessity, this programme will be a multi-sectoral, cross-cutting activity involving amongst others; Energy, Construction, Transport & Manufacturing industries. In particular, transferable material solutions from other sectors and across the entire Energy portfolio should be examined to achieve maximum competitive advantage for the EU. Whilst the need for developments in materials for clean energy generation may be obvious, developments to underpin energy conservation and storage, as part of a balanced future Energy strategy, must also be put in place. The programme will also, by necessity, need to cover the whole spectrum of material classes from metals, composites, carbons, ceramics, to nano-, functional and multi-functional materials, as well as novel methods for on-line and off-line condition monitoring.

Main development issues and targets at a level which you would find in a work program

1. Materials for the generation of electricity, heat and clean fuels (e.g. hydrogen, bio-fuels, etc.). These will include high temperature materials, coatings and functional materials for zero-emission fossil fuel, nuclear, biomass and waste-fired power plant, including fuel cells, as well as materials for other renewable energy technologies including solar (PV & thermal), wave/tidal and wind.
2. Materials for energy transmission and storage. This should include materials for electricity, gas and hydrogen distribution, pipelines for captured CO_2, as well as H_2 storage, advanced battery technologies and other methods for energy storage.
3. Materials design and selection for rejuvenation and recyclability, thus maximizing sustainability and providing new approaches to design of engineering systems and 'eco' buildings.
4. Materials for energy conservation and efficiency in use. This will include materials for construction e.g. glass, insulating materials, ceramics, coatings, etc. It will also include development of lightweight materials for automotive and aerospace sectors in order to reduce fuel consumption and emissions.

Expected impact in quantifiable terms at a level which you would find in a work program

To stay below the proposed 2^0C temperature rise target, greenhouse gas emissions need to be reduced by at least 50% compared to 1990 levels by the mid-21st century; this requires the deployment of zero-emission technologies to start in the very near future. This target will only be achieved using all available approaches to reduce emissions in generation and reduce demand/optimize use by the consumer. This requires cross-sectoral materials development for clean energy generation (fossil & renewables) using CO_2 neutral energy sources/fuels or carbon capture and storage, energy storage (e.g. H_2), transmission, & conservation (in buildings, manufacturing and transport).

For example, by 2020 it is our objective to develop materials for use in clean fossil fuel power plants with multi-pollutant control which will deliver, in an economically viable manner, near zero emissions of CO_2, or be in a position to include CO_2 capture systems (i.e. capture-ready). With full deployment of these technologies worldwide, CO_2 emissions could potentially be reduced by ~100GtCO_2 over a 50 year period, thus firmly establishing zero emission fossil fuel as a major component in the portfolio of energy systems offering low CO_2 emissions around the world. Given that historically EU industry has supplied close to 50% of the global fossil fuel power plant market and has an excellent reputation for innovation in the development of advanced systems and components, this vision will place Europe at the forefront of industrial/economic competitiveness.

If we take into consideration the role materials can also play in other areas of energy generation and conservation, their potential impact on CO_2 emissions is enormous.

Further examples include:-

- new materials for more efficient renewable energy generation (e.g.. photovoltaics, fuel cells)
- energy conservation through materials development for the building/construction sector.
- lighter weight materials for the transport sector to improve their efficiency and reduce emissions

Sectors addressed:

These include:- Energy, Materials, Manufacturing, Transport, Aerospace, Construction

Required RTD investment: **500M€**

Implementation priority/justification: Prioritisation within the topics put forward in the SRA of the ETP, taking into account critical dependencies etc.: "1st priority because…. (largest return on RTD investment/prerequisite for further research/etc.)"

Protection of the environment & minimizing the impact of climate change are the most serious challenges faced by humankind today and must be the number one priority. Probably the greatest impact in alleviating the problem will be made by reducing CO_2 emissions. The global focus on Energy & Environment should be used as a driver to further develop world class knowledge and capability in Europe in the field of materials for energy generation, transmission, storage, and low energy processing and energy conservation. This in turn will re-vitalize many industrial sectors within Europe,

increasing employment and wealth creation.

Notes/comments: e.g. possible coordination needs with other thematic programs

Coordination with other ETP' e.g. ZEFFPP, ESTEP, ACARE, MANUFUTURE, SUSCHEM, ERTRAC, will be paramount. Also collaboration with networks such as KMM and Extremat will be needed

Elements to be included in the call	State of the Art	Vision/targets	Forecast materialization
Key action 1: Materials for power and heat generation (e.g. fossil fired power plant, renewables), heat recovery (e.g. in chemical plants) and low CO_2 fuels (e.g. H_2, biofuels,). These will include high temperature materials (metals, refractories & composites), coatings and functional materials for fossil-fired power plant (including fuel cells and /or CO_2 capture & storage) as well as biomass & waste fired plant. Also, materials for other renewable energy approaches including solar (thermal & photovoltaic), tidal/wave and onshore/offshore wind. Key action 2: Materials for energy transmission/ storage and the transport of CO_2 and H_2. This should include materials for H_2 storage, CO_2 pipelines, advanced battery technologies and other methods of energy storage. Key action 3: Materials for recyclability and sustainability. This will look at the sustainability issue to develop new materials and methods of recycling and re-use of existing materials in new high technology systems, with a systematic approach to environmental considerations into product and process design and manufacturing- 'Design for Environment'/'Design for manufacturing' DfE/DfM. Key action 4: Materials for energy conservation, This will include materials for green buildings and construction with low environmental impact, e.g. glass, insulating materials, ceramics, smart materials, etc. Key action 5: Materials for lightweighting. This will be of particular relevance to the automotive and aerospace sectors. Key action 6: Materials selection and modeling. This will include improved materials databases, property assessment methods and through life cycle modeling from alloy development, process and production modeling to the modeling of performance in service.	For all of the key actions the current state of Materials Development of a broad range of materials has to be enhanced to improve their resistance to more arduous operating conditions and monitor their performance in service (on-line and off-line) and increase service lives. This includes high temperature materials, corrosion resistant materials, smart materials and coatings for corrosion, oxidation, wear/erosion & thermal protection as well as membranes and other functional materials (e.g. for H_2, O_2 or CO_2 separation). For transport and 'lightweighting' the development of Composites and aluminium, magnesium, titanium alloys will be necessary. Generic areas such as Materials Modeling (including through life cycle) will have to be further enhanced along with lifetime prediction, testing & characterization methods.	'Development of the EU as the world's centre of excellence in Materials Engineering for 'Energy Materials.' This will provide multi-sectoral support across Europe (in particular the manufacturing sector, automotive, aerospace and energy), enhance the competitiveness of these sectors, increase their contributions to GDP and increase/maintain employment in Europe in specialist materials technologies.	2010-15

EuMaT TOPIC:

Development of new materials tailored to next generation transportation.

Brief description of the topic and rationale at a level which you would find in a work program

Materials will evolve in the next ten years in order to follow step-by-step the strict emission reduction requirement and the increasing demand for structural performance and multifunctionality. Lightweight overall requirements will be an important issue that could be achieved through focused material development and more efficient and rationalized deployment, with innovative design solutions which enable their full potential to be achieved. Moreover, the emerging needs due to the industrialization of new countries will modify the present availability of materials around the world. The drivers for the evolution of automotive materials application can be identified as: i) emerging strict requirement in terms of reduced weight and improved structural safety; ii) innovative and personalized product; iii) environmental and sustainability issues; iv) socio-economic environment; v) regulatory climate; vi) new map of end user.

New materials need adequate manufacturing system including new forming, joining, assembly, surface protecting and painting processes. A pre-competitive effort is needed to upscale the artificial materials fabricated in the laboratories to the industrial plants (emphasis should be placed on the integration of new materials into macro-scale assembly lines) and to set-up automotive manufacturing processes from the base material to recycle-reuse, mainly in term of cost, investments, environment. Furthermore, the advent of nanotechnologies offer today a unique opportunity to design artificial materials whose properties can be tailored to the next generation vehicles requirements. Thanks to the nanotechnologies advances, artificial Nano-Assembled Materials (NAMs) can be designed and fabricated to fit specific application requirements. Different nanosized materials can be properly assembled at the nanoscale to make up a new hand-made raw material whose properties are the result of its nano-components and their spatial distribution. The interest in these materials has been stimulated by the fact that, owing to the small size of the building blocks (particles, grain, or phase) and the high surface-to-volume ratio, these materials are expected to exhibits unique, mechanical, optical, electronic and magnetic properties. The properties of NAMs depend on the following four common structural features: (1) the fine grain size distribution (<100 nm); (2) the chemical composition of the constituent phases; (3) the presence of interfaces, more specifically, grain boundaries, heterophases interfaces, or the free surface, and (4) interactions between the constituents' domains. The presence and interplay of these four features largely determine the unique properties of NAMs.

Main development issues and targets at a level which you would find in a work program

In the car industry, main general research issues have been identified according to the vehicle foreseen future advances:

- Development of new light materials for vehicle structures (car-body & chassis)
- Development of new materials for interiors
- Development of new materials for light-weight wiring
- Development of new materials for power train
- Energy efficient manufacturing processes for efficient fuel vehicles
- New joining techniques and advanced assembling/dismantling processes
- New nanostructured materials for automotive sensing technologies
- New nano-assembled materials with integrated sensing and actuating capabilities
- New composites with enhanced damping properties and superior damage tolerance

Expected impact in quantifiable terms at a level which you would find in a work program

Artificial materials development/improvement to enable:

- the automotive industry to improve efficiency (reduced fuel consumption, pollution and costs) and safety;
- the use of innovative and effective integration of emerging and developed mixed material integration technologies;
- penetration of mixed material structure concepts;
- New manufacturing processes for automotive industry (OEM + tier1 + suppliers + SMEs)

Sectors addressed:

Automotive sector, aerospace and telecom, railway, ship building, domestic appliances.

Required RTD investment: **150 M€ (funding) Integrated project, NOE, Streps**

Implementation priority/justification: Prioritisation within the topics put forward in the SRA of the ETP, taking into account critical dependencies etc.: "1st priority because…. (largest return on RTD investment/prerequisite for further research/etc.)"

1st priority: development of new materials for car-body, chassis and wiring to improve efficiency, in particular through weight reduction;
2nd priority: development of artificial materials of new physical properties for new functions
3rd priority: take up of the artificial materials fabrication processes – from laboratory to plant.

Notes/comments: e.g. possible coordination needs with other thematic programs

This research need is integrated to the Design and Production research strategy described in ERTRAC and Technology Platform, particularly with "Vertical Activities" related to Materials and Production and Global Competitiveness and with "Horizontal Activities" on Standards and Design Data and Logistics. Mainly it refers to the TRANSPORT thematic area and acknowledges fruitful integration with MANUFUTURE Technology platform. A link should be established with NMP thematic area, and one could with IST, Aeronautic and Space.
These research subjects are coherent with the automotive OEM's standpoint clearly described in the EUCAR position paper of April 7th, 2006.

Elements to be included in the call	State of the Art	Vision / targets	Forecast
Key action 1: Recyclable artificial composites; for example, polymer based nano-composites, in particular for car-body and chassis. Multiscale modeling of structural and functional properties, joining all size scales should be included here. Key action 2: Innovative recyclable material natural based, recycled material employment within the standard production line (supply chain). Key action 3: Coating, multilayers and metal based structured materials (also nanostructuring) to confer new properties (e.g. hardness, tribological, chemical reactivity, etc.) on surface without affecting the bulk material structural properties. Innovative, eco efficient painting/coating which enables new material application. Paintless coloration could be included here. Key action 4: Functionalized textiles for interiors (nanofibers); biocomposite and naturally-based polymeric materials shall be proposed in this frame. Key action 5: Crack-resistant nano-ceramic composites for high toughness applications. Also Metal Matrix materials and advanced metal-polymer-ceramic composites can be investigated in this frame. Key action 6: Carbon fiber reinforced polymers for light-weight applications in the transport industry. Efforts shall be concentrated on increasing material durability and damage tolerance. Key action 7: Virtual-developed foundry technologies for an environment clean efficient machining. Key action 8: New joining techniques and advanced assembling/dismantling processes: new adhesives compatible with oncoming processes; development of technical approaches to integrate new and old materials in the conventional fabrication processes. Key action 9: Protection materials for extreme operation conditions; in particular, carbon based self-passivating materials for high surface temperature (1300°-2000°C) and stress gradients of limited erosion for enhanced thermo-mechanical properties. Key action 10: Multi-material multi-functional integrated solutions for innovative design through a full material exploitation. Key action 11: Improved employment of light weight materials, competitive and reliable manufacturing processes, and new concept application. Key action 12: CO2 emissions reduction, beside costs of exhaust after-treatment systems reduction and energy consumption lowering by: 1)improved surface treatment technologies 2)catalyst innovative materials, e.g. alternative materials to the platinum metals	In order to advance with respect to present materials State of the Art, research needs to focus on really innovative materials and on new concept/way of application to fully enable and stress desired functions, for example lightweight potential. Further, the research, development and manufacturability of this new materials should lead the EU infrastructures forward respect to the emerging not EU competitors. Conventional approaches in material and processes development are helped by new frontier studies represented by the nanosciences; nanotechnologies begin to offer the opportunity to engineer new materials tailored to next generation vehicles although real industrial exploitation remains difficult due to the absence of a validated manufacturing process. Nanotechnologies offer the possibility of make up new materials by assembling building blocks of elementary complex nano-objects (complex means here a material constituted of more than 2 elements), this approach enables the design of artificial superstructures with atomically sharp interfaces with enhanced functionalities. Interesting results will probably be obtained coupling more conventional innovative approaches with radically new processes, like the ones offered by nano-technologies	The vision is joining science and technologies to develop an EU global expertise on materials. In particular, to enhance expertise for product and process design integration to make time to market and process cost competitive with the established ones. Specific targets: • To improve prediction of the final material and of the components made with this material; • To design and build materials having tailored properties (stiffness, strength, hardness, ductility, corrosion resistance, thermal expansion, etc) to fit transport applications using inexpensive manufacturing processes to be scaled up to big volume; • To increase material performances, in particular: lifetime, production rate, reuse and recycling, functionality, to develop production processes of low environmental impact; • To Improve structural functionally graded material for body, chassis and power train applications that could enable different architectural and concept solutions (e.g.. hollow crankshaft, improved lightweight con-rod, structures/sub-assemblies with improved crash worthiness); • To improve dies: lifetime, performance, higher production rate, friction reduction, scrap reduction, used power reduction, functionally induced properties on application, material downsizing through specific coating application, life durable improved lubricant. Components: self scrap protection, self cleaning treatment, improved light emission/transmission; • To promote high conversion efficiency after-treatment systems in all working conditions for a significant scenario change in the actual trade-off between CO2 and pollutant emissions (i.e. lower tailpipe emissions mean today higher fuel consumption for both gasoline and Diesel engines); • To develop new adhesives development and fast curing system. Low or ambient temperature reticulation (compatibility with paintless materials, and with future lower temperature paint process), application system to enhance the global energy consumption; • To apply light weight materials that today are not processable through conventional painting/coating processes; • To develop efficient disassembly, fully recyclable materials, inexpensive recycling re-use processes.	2010-13

EuMaT TOPIC:

Nano-assembled-materials enabled components and micro-systems

Brief description of the topic and rationale at a level which you would find in a work program

Nanomaterials with novel electric, magnetic, optical, and mechanical functionalities have been widely demonstrated and are recognized to hold the promise of revolutionizing the way in many fields: health, energy, environment, transportation, space, telecom, etc. Nanotechnologies will push forward frontiers of science and enable the design and the fabrication of new nanostructured and-Nano-Assembled Materials (NAM), NAM-based-components and microsystems both to improve existing applications and to serve new ones today only theorized.
Nowadays, NAMs offer unique opportunities to the EU industries to be competitive by increasing the real and perceived value of their products (improved performances, lower weight and power consumption, added functionalities, etc.) while maintaining or reducing costs for a sustainable growth. Yet, a pre-competitive effort is needed to upscale NAMs fabrication from laboratories to industrial plants; emphasis should be placed on the integration of nanomaterials into macro-scale components and micro-systems by exploiting the broad industrial basis of microtechnologies.

Main development issues and targets at a level which you would find in a work program

The main target of the research proposed is promoting the fabrication of nano-objects such as: nanoparticles (simple and core/shell), nanowires (single element and multilayered), nanotubes, nanolayered stacks, etc., in a systematic way, in order to have nano-objects of monodispersed properties to be used as elementary bricks for NAMs. On these topics, lots of efforts have been spent in the work-frame VI, mainly to study, from a fundamental point of view, physical phenomena happening when matter is confined at nanoscale. The results achieved pave the way to optimism, new phenomena were discovered, systems up to now only theorized were fabricated, but yet lots of efforts have to be spent to reproduce identical systems, a key point to make the most of such a system. In particular, to get this general goal, the following points should be powered:

1. Modeling and design tools for:
   - Complex nano-objects, e.g. core-shell nanoparticles, multilayered nanowires, etc. Physical properties change when matter is nanosized. Particular efforts should be spent to study phenomena at the interfaces of the nano-objects' constituents, e.g. nanoparticle core-shell interface, nanowire layer-to-layer interfaces, etc). Interfacial phenomena play a fundamental role on the NAMs' physical properties both intended for components/micro-systems and for structural materials to serve diverse applications; a fundamental knowledge concerning this subject is limited and should be further explored.
   - Matrices with nano-objects arrays embedded. To envisage the 'effective' properties of NAMs from the properties of their elementary constituents. Modeling should take into account cooperative effects of the single constituents and the role of interfaces between the host matrix and the elementary nano-constituents.
2. Development of the enabling technologies:
   - Fabrication and characterization of nano-objects. The fabrication technologies should be optimized to guarantee a low size and morphology dispersions. The nano-objects shall be characterized in terms of elemental composition, morphology and physical properties. New phenomena are expected to be discovered.
   - Fabrication and characterization of NAMs. Development of techniques to co-deposit host matrices and nano-objects of controlled size and properties. Synthesis in situ of nano-objects in a host matrix and filling of nano-porous templates are also welcome. A goal of this research is to enable the fabrication of NAMs of 'effective' properties uniform over the whole volume.
3. Development of nano-objects and NAMs of improved functionalities to conceive new components and micro-systems for the automotive, biomedicine, energy and the telecom industries.
   - Priorities in automotive: The future advances of the car industry will rely on a further development of existing components and microsystems to serve mainly power train applications. It is acknowledged that either engine or drive train represents tough environment wherein components and micro-systems have to be operated. In this frame, the main target is to develop innovative materials (Nanostructured and Nanoassembled) to upgrade existing devices and improve the vehicle performances. Components have to be operated at high temperature, comply with highly variable operation conditions, vibration and maintain weight, power consumption and unit cost as small as possible. A second priority in the automotive is to develop new NAMs-based-microsystems enabling pluralities of different functions, e.g. sensing, actuation, energy scavenging and communication. Taking into account the components electromagnetic compatibility, the development of high temperature and vibration resistant materials is yet an important step for their final packaging. Important fallouts are expected in the space and industrial robot industries.
   - Priorities in biomedicine: To develop Micro-Fluidic-Systems (MFS) for diseases early diagnosis. The MFSs are thought here as a micro-laboratory wherein biocells tagged by core/shell magnetic nanoparticles or nanowires or light emitting clusters can be investigated by NAMs based sensing elements. In case of magnetic tagging also actuation is possible.
   - Priorities in Energy: To develop new catalysts to increase the conversion efficiencies of fuel cells and biodiesel and to synthesize biodegradable lubricants. New high temperature resistant materials for nuclear reactors, energy micro-generation units for MST energy scavenging and conversion materials for waste energy. To develop new materials from waste (ex. Glycerin)

Expected impact in quantifiable terms at a level which you would find in a work program

The strongest impact of the research proposed is on the automotive context which represents here the main driver. Although, in principle, all automotive components will benefit of the research advances, the most important impact is recognized on the sensor market. Important fallouts are yet expected in emerging fields such as biomedicine. It is generally acknowledged that the vehicles future evolution, to guarantee high efficiency and comply with the restrictive regulations on pollutants emission control, will pass by a close loop adjustment of combustion; to do this, more sophisticated components have to be developed.
Demand for automotive sensors in the North American light vehicle OEM market is increasing of 10.7 percent annually to get $4.5 billion in 2007, comparable figures are expected in Europe by 2010. While automotive sensor demand over the past five years experienced only moderate growth, demand is expected to accelerate rapidly over the next five years, as

multiple new mandated products that prominently feature new sensor applications are rolled out, and as market-driven technology introductions accelerate.
In particular, It is expected:

- Intermetallics for extreme conditions and biomedical applications
- Metal ceramic composites with innovative micro- and nanostructure for multisectoral applications
- Novel materials and technologies for FGM and functional multilayers Intermetallics for extreme conditions and biomedical applications
- Metal ceramic composites with innovative micro- and nanostructure for multisectoral applications
- Novel materials and technologies for FGM and functional multilayers Intermetallics for extreme conditions and biomedical applications
- Metal ceramic composites with innovative micro- and nanostructure for multisectoral applications
- Novel materials and technologies for FGM and functional multilayers Low unit cost of components (e.g... a few Euros).
- Take up of the nano-assembly technologies will be developed for high volume production (Forecast 2010).

Sectors addressed:

Automotive sector, bio-industry, telecommunications, space

Required RTD investment: **150 M€ (funding) Integrated project, NOE, Streps**

Implementation priority/justification: Prioritisation within the topics put forward in the SRA of the ETP, taking into account critical dependencies etc.: "1st priority because…. (largest return on RTD investment/prerequisite for further research/etc.)"

1st priority: development of techniques to have nano-objects of the same shape and size (monodispersed morphology);
2nd priority: modeling of NAMs of new physical properties for new generation components;
3rd nano-assembled materials resistant to high temperature, severe thermochemical attack, blasting, corrosion and wearing;
4th priority: nanoassembled materials fabrication – from laboratory to plant.

Notes/comments: e.g. possible coordination needs with other thematic programs

The present research refers to the NMP thematic area and acknowledges fruitful integration with EUCAR and the MANUFUTURE Technology platform, in particular "Transport". A link could be established with other thematic areas such as: Transport, Lifescience, IST, Aeronautic and Space. These research subjects are coherent with the automotive OEM's standpoint clearly described in the EUCAR position paper of April 7th, 2006.

Elements to be included in the call	State of the Art	Vision/targets	Forecast materialization
Key action 1: Interfacial phenomena in multilayered nano-assembled materials, in particular multilayered nanowires and thin film stack for sensing and artificial materials development. Key action 2: Development of nano-assembled materials of improved properties with respect to a bulk material commonly used in the context addressed. In particular the research shall be focused on one or more specific targeted properties such as, e.g., weight, elasticity, conductivity, permeability, permittivity, etc. Multiscale modeling and fabrication. Key action 3: Joining new and old materials; in particular, advanced materials for extreme conditions should be integrated into mainstream fabrication processes of components. Key action 4: Nano-assembled coating, multilayered materials and nanostructures to confer new properties on a material surface without affecting the bulk ones; in particular, under the mechanical, tribological and thermal point of view. Key action 5: Nano ceramic composites for advanced engineering applications, in particular components packaging. The design, synthesis and characterization of high-toughness (crack resistant) ceramic nano-composites that retain superior properties at high temperatures. Modeling for life time prediction - through life cycle. Key action 6: Multifunctional molecular and active polymeric materials for sensors, displays and organic semiconductors. Both organic and inorganic elements can be assembled by bottom-up approaches at molecular level to make	Most of components for the automotive industry are today commercially available; however, the restrictive unit-cost constraints of the automotive context reflect the performance limits of products on shelf. Components and micro-systems are mainly based on Si technology. The R&D is mainly focused on Si-compatible materials. Research on new materials mainly concerns a miniaturization of bulks. Top-down and Bottom-up approaches are under development either for nanostructuring or miniaturize. An important lack of fundamental science to envisage physical properties of nano-materials is still acknowledged. Nanostructured materials not only are essential in electronic devices and for densification in ceramics, but also	Modeling and simulation: Development of fundamental physical models to envisage properties of nanoobjects. Definition and calculation of Effective media parameters to describe the nanoassembled materials behavior from properties of constituting nano-elements. Fabrication: Pushing to frontiers of science the fabrication of nano-objects monodispersed in size to discover new phenomena in confined matter. Taking up self-assembly techniques to mass production. The vision is to develop the capability to design and build materials having tailored properties to be used in components and micro-systems using inexpensive manufacturing processes. More in details: • Artificial materials made by in-situ	2010-13

materials of new properties. Key action 7: Ferromagnetic /Ferroelectrics nanoassembled materials for multifunctional devices. Proposal to join the magnetism and ferroelectrics scientific communities. Key action 8: Nano-assembled-materials for MST energy scavenging units; in particular, nanosized magnetostrictive/piezoelectric coupled multilayers. Key action 9: Development of smart nano-assembled-materials of improved performance; in particular: shape memory nanowires embedded in light-weight matrices. Key action 10: Nano-composites light-weight structures with enhanced damping properties and superior damage tolerances; in particular, carbon nanotubes based ones. Key action 11: Magnetic nanowires, nanorods, fine particles and light emitting nanocrystals for biomedical, genomics and proteomics applications. Key action 12: Lightweight bio-composites, in particular, natural fibers in polymers composites. Key action 13: Functional nanomaterials for fuel cell to increase the conversion efficiencies of fuel cells, in particular, within the ranges of catalysts, membranes, which in many cases are critical for the employment of fuel cell technology.	represent a starting point in the formulation of a finished catalyst. Many of the recent advances in materials' synthesis yield materials that their primary grain sizes are a few nanometers. Properties of materials of nanometric dimensions are significantly different from those of atoms as well as those of bulk materials. Suitable control of the properties of nanometer-scale structures can lead to new sciences as well as new devices and technologies.	synthesis of micro- and nanoparticles in light weight matrices; • Core-shell particles (also nanoparticles) synthesis e desegregation; • Nanostructures passivating coatings and nanostructures self-assembly; • Nanostructures manipulation; • Complex electrodeposition of multilayered nanowires in light-weight matrices; • Low roughness interfaces by pulsed electrodeposition to fabricate multilayered stack in porous templates; • Wear resistance at nanoscale • Self organization of nano-particles during synthesis.	

EuMaT TOPIC:

Direct and Inverse Advanced Engineering Materials design through Integrated Multiscale Collaborative Frameworks

Brief description of the topic and rationale at a level which you would find in a work program

In the European Technology Platform for Advanced Engineering Materials and Technologies (EuMaT), multiscale modeling and simulation is considered as a "Horizontal Issue" which informs is functional to all the key Pillars (Knowledge-based Multifunctional Materials, Materials for Extreme Environments, Hybrid & MultiMaterials). The proposed "Integrated Multiscale Collaborative Frameworks" represent a new frontier for multiscale, for the improvement of existing Engineering Materials and Technologies and for the design, development and application of New Generations of Nanostructured Materials, and Nanotechnologies including the future nanobased Material. This new kind of Frameworks allows, for the first time, to take into account, inside a unified context, all the phenomena, from atomic and molecular scales to the engineering ones which rule materials design, processing and application including life-cycle and sustainability issues. Integration of atomic/molecular scales, typical of nanoscience, with the micro, meso and macro worlds is a fundamental challenge for a wide industrial application of the most innovative nanotechnologies in the materials, engineering and processing areas. Integrated Multiscale Collaborative Frameworks realize a real "two-way" science-engineering integration from an industrial point of view and put the bases to create a new ***"Multiscale Quantum (Nano) Engineering World".***

Key features of the new Frameworks

- **New Industrial Development Strategies :** New Frameworks allow to integrate the classic "Direct" or "Bottom-Up" R&D approach (from basics to engineering, processing and performance requirements) with a new "Inverse" or "Top-Down" strategy (from performance requirements to fundamentals) leading to a really **"Science-based Industry Driven"** technology and materials development strategy. Frameworks output is directly applicable to industrial design problems. The Multiscale strategy leads to engineering models with increased predictive capabilities and reliability and a significantly reduced number of adjustable parameters. Models are "science-based", but directly usable by designers not necessarily by scientists.
- **Integrated Engineering Strategies Modeling and Characterization:** a key industrial challenge for a cost effective development and production of both traditional and innovative Nanomaterials is the integration of computational modeling with experimental and testing techniques. Integrated Multiscale Collaborative Frameworks enable real unified modeling - experimental & testing strategies thanks to the "Multiscale Information Space" concept and method
- **"System Engineering" Strategies :** New Frameworks enable also an easier integration of advanced materials and devices into systems (Multiscale System Engineering approach) by taking into account the full spectrum of interactions among devices, components and systems.

The proposed Frameworks synthesize in an innovative way experiences and achievements the most advanced trends and challenges of US and Japanese programs on the field of advanced material technology and directly incorporate a wide spectrum of existing computational models and methods with limited modifications enabling so affordable development costs, times and risks.
Integrated Multiscale Collaborative Frameworks are a comprehensive and coherent expression of the key themes and issues addressed by EuMaT Strategic Research Agenda: New Frameworks position themselves as an essential horizontal resource for all the Clusters and Application Areas envisaged by EuMaT such as Knowledge-based Multifunctional Materials, Extramat and Hybrid Materials Biomaterials and , including all the emerging and future Nanomaterial, Nanoprocessing and Nanotechnology fields in key Areas for Europe and European Industry like Energy, Electronics, Aeronautics, Automotive, Space, Bio-Medicine and Civil Engineering.

Main development issues and targets at a level which you would find in a work program

The key target of the proposed research area is the ***Development of new "Integrated Multiscale Collaborative Frameworks"*** as an enabling "Horizontal" resource and integrated tool to be *directly* applied to the design and development of materials and devices and related processing techniques in all the application clusters and areas foreseen by EuMaT. Direct application is fundamental both for validation and as a key driver for a continuous tuning and improvement of the Frameworks. It is a "two-way" link.
Application experiences are a fundamental driver to improve both the overall Framework Architecture and the Framework Components (multiscale models and methods, multiscale data bases, multiscale visualization software). At the same time, "Integrated Multiscale Collaborative Frameworks" directly take advantage of and drive scientific advances in a wide range of research fields. They offer a context were research advances in different fields can be integrated and applied to industrial problems in a reduced time and cost framework (key issues for Nanotechnology). New Frameworks realize a synergistic integration between a "Science-driven Engineering" and an "Engineering-driven Science" approach whose most striking symbol is Nanotechnology.

Main elements of the Framework running on "Virtual Distributed Environments (Cyberinfrastructures)":

- Languages and Modules to describe physical and chemical structures and related Structure – Properties – Performance – Processes relationships and interdependencies over the full range of space and time scales.
- Steering (or Strategy) Module to define different strategies to integrate over a full spectrum of space and time scales different sets and sequences of analytical, computational and experimental & testing techniques and methods
- Library of Analytical, Computational and Experimental & Testing Models, Methods and Techniques and related Multiscale methods to correlate and integrate them over a wide range of different (space and time) scales. A key feature which distinguishes the proposed Framework from other existing advanced Frameworks, is its ability of integrating, inside a coherent and unified strategy, computational and experimental & testing techniques and methods thanks to the "Multiscale Information Space" concept
- Modules tailored to address specific design tasks and issues like dynamics, durability, manufacturability, environmental degradation
- Multiscale Data and Knowledge Analysis and Management Module
- Multiscale Visualization Modules

Expected impact in quantifiable terms at a level which you would find in a work program

The lack of well integrated European-wide initiatives in this new Area is a very high priority and it is the basic motivation

which underlies the proposed research. Europe has the occasion to take the lead in these strategic fields and EuMaT is a real opportunity to do that. Accordingly, *the fundamental goal of Integrated Multiscale Collaborative Frameworks is to produce real industrial and technological breakthroughs, not simple evolutionary improvements.*

Specific expected benefits:

- Intermetallics for extreme conditions and biomedical applications
- Metal ceramic composites with innovative micro- and nanostructure for multisectoral applications
- Novel materials and technologies for FGM and functional multilayers Reducing development, maturation and application times for innovative nanostructured material developments
- Reducing Development Risks (Failure Probability) for highly innovative projects by significantly get the dimension of the so called "Valley of Death" down and Increase confidence in the material final performance
- Improved Flexibility in nanostructured material design and tailoring possibilities
- Reduced raw material consumption and energy requirements
- Promoting a wide adoption by Industry of the "Green by Design" approach as opposed to the traditional "Waste Management" strategy. Taking the lead in the "Industrial Green by Design" sector would give EU industry a strategic competitive edge over US and Asian competitors (Japan, Korea, China and India).

Sectors addressed:

Integrated Multiscale Collaborative Frameworks are inherently cross disciplinary and cross sectoral. Accordingly, they can be of primary relevance for a wide range of sectors: Aeronautics, Automotive, Electronics & Photonics, Biomedicine, Chemistry and Biochemistry, Energy, Space, Security

Required RTD investment: **150 M€ (funding) small and large projects, NoE**

Implementation priority/justification: Prioritisation within the topics put forward in the SRA of the ETP, taking into account critical dependencies etc.: "1st priority because…. (largest return on RTD investment/prerequisite for further research/etc.)"

1st priority: design and development of the new Integrated Multiscale Collaborative Frameworks
2nd priority: setting up application programs which apply this new kind of Frameworks to a wide range of highly innovative industrial materials & processing programs.
3rd priority: establishing direct links between the Application and the Framework development worlds
4th priority: design and development of Educational Frameworks and related specific programs and initiatives

Notes/comments: e.g. possible coordination needs with other thematic programs

A distinguishing feature of the proposed research is that it concerns all the areas where traditional as well as new advanced Nano materials and processes play a key role: NMP, Aeronautics, Space, Energy, Transport, Electronics, and BioMedicine. Furthermore, "Integrated Multiscale Collaborative Frameworks are a strategic driver for a wide spectrum of the Computing, Information and Communication areas (IST) (new modeling and simulation software, multiscale data analysis and management systems, visualization systems and techniques).

Elements to be included in the call	State of the Art	Vision/targets	Fore-cast
Key action 1: Design and development of **Integrated Multiscale Collaborative Frameworks** for Materials, Devices and Processes Design, Development and Testing running on Cyberinfrastructural Environments. This action will include the definition of the general Architecture, Functional and Application Areas, Best Application Practices and Strategies, Validation Strategies for the Frameworks and related Cyberinfrastructural Environment and the definition of the architectural characteristics, performance, functional and application areas of the Framework components. These frameworks will be extended to be applied to specific "System Engineering" Issues. The validation of the Frameworks will be carried out through specific **Application-oriented** projects approaches. Key action 2: Design, development and validation of the Framework Components running on Cyberinfrastructures with a special emphasis on the design, development and validation of : • New Generation of Languages Models and Environments to	A very large number of European and International Research Centers are developing activities which are focused on the design, development and the application of computational multiscale methods both in the traditional Materials Engineering and Processing Area and in the Innovative one (Nanomaterials and Nano-processing). Computational Multiscale is applied inside European industry to address Material design and development issues with particular reference to sectors such as defense, energy and chemistry. As far as the International Scenario is concerned, three factors are characterizing US and Japanese Programs : 1. the average dimension of the initiatives and programs is normally higher than the correspondent European ones 2. the development of true Integrated Collaborative Multiscale Frameworks 3. the close integration, inside long term cooperation contexts, of University – Research – Industry and the application of the new "Industrial paradigm" application –driven (top – down) for technology development A single "Integrated Multiscale Collaborative Framework" can be conceived to be applied to a more or less wide spectrum of Material Areas and Issues. The US DoD AIM-C Program (led by Boeing) focuses on Composites. The "Structuring Knowledge" Project led by University of Tokyo and funded by METI (Ministry of Economy, Trade and	Targets: ***a New Generation of Systems, Methods and Techniques:*** • Integrated Collaborative Frameworks for Materials, Devices and Processes Design, Development and Testing [SW] • Multiscale Experimental & Testing Technologies, Systems and Environments [HW and SW] • Multiscale Data and Knowledge Analysis and Management Systems [SW] • Multiscale Visualization Systems [SW] • Multiscale Modeling and	3-10 years

describe physical and chemical structures and related Structure – Properties – Performance – Processes relationships and interdependencies over the full range of space and time scales. • Integrated Multiscale Steering (Strategy) Methods and Environments which allow to develop Integrated Multiscale and Multi Methodological (integration of analytical, computational and experimental & testing methods and techniques) Science-Engineering (Top-Down and Bottom-Up) Strategies for the design (including life-cycle and sustainability issues), development, testing of new materials, devices, components and related processing/production technologies and techniques. • Multiscale Data Analysis Integration and Management Methods and Environments which will apply the Property, Structure, Performance, Processing relationships over a full range of scales (Top-Down and Bottom-Up strategies) to correlate data coming from different multiscale design and testing strategies resorting to a full range of different methodologies (analytical, computational, experimental & testing). . Integrated correlations will lead to an "Integrated Knowledge-based Vision" of Materials Characteristics and Performance, Processing, Life-Cycle and Sustainability Issues and of all the aspects characterizing the whole design, development and testing cycle. • Multiscale Visualization Methods and Environments • A New Generation of Multiscale Computational and Experimental & Testing Methods and related Integration methods (multiscale multi-methodological approach) aiming to generate the needed amount of knowledge and information to be supplied to run the models and modules. <u>Key action 3</u>: Design, development and validation of a New Generation of Educational Courses which incorporates the basic principles and paradigms embedded in the Integrated Multiscale Collaborative Frameworks. The new courses will be based on specific "Multiscale Collaborative Educational Frameworks" which will take full advantage of new Multiscale Visualization, and Data Analysis and Knowledge Management Modules developed in the context of the Integrated Multiscale Collaborative Framework projects.	Industry) is an Integrated Multiscale Collaborative Framework conceived to be a "Horizontal" platform for the whole Nanomaterial Japanese Project constituted by eight specific projects (nanoceramics, nanometals, nanocomposites...). Different Integrated Frameworks, more or less focused, are, anyway, characterized by a large degree of commonalty. Some examples of US and Japanese Multiscale Collaborative Framework Programs in the traditional Materials Area and in the Innovative one (Nanotechnology) • **Computational Material Design Facility (CMDF) – Caltech** CMDF developed an "Integrated Multiscale Computational Framework" for the design of Complex Materials, Chemical and Biological Systems. It foresees both the classical (bottom-up: from science to engineering) paradigm and the novel one (Inverse or application – driven that implies identifying new structural combinations of materials capable of providing desired properties). The Framework is currently applied to the development of innovative (nanostructured) materials. Example: Hierarchical Design for Predicting Real Optimized Materials Program (PROM) – Thermoelectric materials – Thin film ferroelectrics – Non-linear optical materials – High Energy Density Materials • **NSF Center for Computational Materials Design (CCMD)** – Georgia Tech and Penn State University. Besides these universities CCMD has several members coming from research Centers and Industries: Air Force Research Lab, Army Research Lab, Auraryd, Corning, GE, General Motors, Knolls Atomic Power Lab, Lawrence Livermore National Lab, Los Alamos National Laboratory, nGimat, Pratt &Whitney, ThermoCalc, and Timken. Focus Areas : Multifunctional Structural Materials and Nanomaterials & Nano to Micro Devices Key Issues – integration of multiscale computational modeling with systems – based engineering. – physics - based simulation of : process – structure - property relations – digital interfaces to facilitate collaborative, distributed decision - based design. • **Structuring Knowledge Project in Nanotechnology Materials Program**: Construction of a Knowledge Infrastructure (Framework) for Nano-materials and Devices. The Program is managed by The University of Tokyo and funded by METI (Ministry of Economy, Trade, and Industry). Japanese Government launched a large long term Nanomaterials National Program constituted by eight (8) Specific Application Oriented Projects and by a special Project named "Structuring Knowledge (SK)". The objective of the SK Project is to develop an "Integrated Multiscale Science - Engineering Platform (Framework)" named "Nanomaterial Platform" to design innovative Nanomaterials and to systematize knowledge gained inside the several application-oriented projects. SK uses a "Knowledge System" which correlates data and information by applying the "Process – Property – Structure" relationships strategy. This System is an interesting application of the new (top-down or application-driven) Industrial Paradigm for materials technology development and a clear demonstration of the new "Strategic" Frontiers opened by "Integrated Multiscale Collaborative Frameworks".	Simulation Tools to address Design (Materials, Devices, Components and Processes), Testing, Life-Cycle and Environmental issues [SW] • Multiscale Educational Courses and Environments [SW]	

EuMaT TOPIC:

Novel multifunctional materials for multisectoral applications in highly demanding operational conditions

- **Intermetallics for extreme conditions and biomedical applications**
- **Metal ceramic composites with innovative micro- and nanostructure for multisectoral applications**
- **Novel materials and technologies for FGM and functional multilayers**

Brief description of the topic and rationale at a level which you would find in a work program

INTRODUCTION. The proposed topic addresses a class of knowledge-based multifunctional materials (shortly *KMM*) combining metallic and/or ceramic multi-components tailored for durable and safe performance in multisectoral applications. The topic is of strategic importance for Europe as it belongs to the forefront of the materials research worldwide with prospective impact on many sectors of European industry. Importantly, it emphasizes the issue of cost-effective production routes while not compromising on enhanced material properties as these are needed in highly demanding service conditions. The topic should be treated within EuMaT, a cross cutting European technology platform, due to versatility of the *KMM* in different industry sectors on one hand and the proposed methodology, advocating integrated problem-oriented approach, on the other. This *KMM* methodology is comprehensive in the sense that it spans processing, characterization, modeling, and assessment of the produced elements (in industrial environment of the end-users). As a consequence, multipartner task forces with different expertise will have to be formed to tackle research problems suggested by the EuMaT industry members. To this end, EuMaT offers a convenient platform for direct two-way interaction between research and industry partners. Somewhere along the line, as the research work progresses, the horizontal character of the proposed *KMM* topic may well get focused on some specific applications. Therefore, it is highly desirable to establish close ties with other technology platforms dealing with specific sectors/applications in order to combine the research effort, exchange of experience and disseminate the results obtained. The proposed topic is concerned with three main groups of advanced materials: Intermetallics, Metal Ceramic Composites, Functionally Graded Materials and Functional Layers.

Intermetallics offer a compromise between metallic and ceramic properties. As aluminides (TiAl, NiAl, FeAl, etc) retain a high specific stiffness and tensile strength at temperatures up to 700°C-900°C and have superior corrosion resistance relative to stainless steels, also in sulfur-containing environments, they are and can be further tailored to applications in aerospace, automotive, chemical and fossil fuel industries. Smart intermetallics (NiTi, Cu-based and Fe-based intermetallics) found large number of applications in biomedical devices, aircrafts, fasteners, sensors, etc. However, increase in commercial usage of intermetallics is inhibited by their poor ductility and toughness at room temperature what causes difficulties in manufacturing and generates high cost of processing. Though intensive studies over the last decades brought the solutions for the most drawbacks there is a need for further R&D devoted to wider and most effective usage of these advanced materials in EU industry.

Metal Ceramic Composites with novel mechanical, electric, thermal and magnetic functionalities are recognized to hold the promise of revolutionizing the several technological fields: including energy, environment, transportation, space, telecommunications and healthcare. A great variety of metal ceramic composites with designed micro- and nanostructure, including particle reinforced and fiber reinforced materials, as well as nanostructured and laminate composites, will enable the design and the fabrication of new multifunctional and structural components for durable and safer performance enabling both to expand their use in existing applications and to materialize new uses in yet unexplored fields. Novel metal ceramic composites are materials offering unique opportunities to EU industry to be competitive by increasing the added value of manufactured products (improved performance, higher durability, lower weight and energy consumption, multiple functionalities, etc.) while being an integrated part of a sustainable growth strategy. Several aspects of metal ceramic composites development require further R&D emphasis, which include micro- and nanostructure characterization, influence of processing on micro- and nanostructure, modeling of micro-cracking, fracture and fatigue, defect kinetics and creep mechanisms, modeling of micro-macro transitions as well as assessment of industrial needs and applications.

Functionally Graded Materials (FGM) and **Functional Multilayers.** Functionally graded materials (e.g. Bio-FGM, piezoelectric FGM) and functional multilayers are increasingly conquering large market shares. The Bio-FGM offer enormous possibilities for substitution or repair of lost tissue function. The performance of such materials is validated through a number of physical, chemical, and biological tests as well as in animal or clinical studies. However, finding of new or improvement of existing processing routes, as well as employment of tissue engineering scaffolds in various clinical and biological settings is largely done in a trial-and-error procedure. Alternatives such as theory-supported material design are hardly existent for biomaterials. The key issue in biomaterials design is the interface between man-made material and biological environment (i.e. tissue). Therefore, theory-based understanding of the functioning of biological materials beyond the well-established chemical characterization and visualization would offer enormous possibilities for technological progress in tissue engineering, a key topic in economically strong, but aging societies such as encountered in the EU.
Prominent examples of functional multilayers' application are multilayer actuators, multilayer sensors, and multilayer semiconducting devices. For example, Europe is leading in the technology of multilayer actuators, a field with triple-digit growth rates. However, the actuators are based on lead-containing compounds. Strong research investments, mainly in Japan threaten the current leadership position. Research in the development of novel lead-free piezoceramics is therefore very much in demand. This research should include ab-initio modeling of feasible substances, processing of multi-component materials and advanced structural research. Input from materials science, chemistry, physics and mechanics is required. Another example lies in the field of semiconducting ceramic multilayers. Ceramic multilayers can be printed and maintain a higher reliability as compared to semiconducting polymers. However, preparation of semiconducting ceramics, including their doping and their control of defect states at interfaces is barely available. Monolithic ceramics with continuously varying chemical composition show, after poling, an inhomogeneous distribution of dielectric and piezoelectric properties. A similar effect may be achieved with a constant chemical composition and an inhomogeneous poling field. Such functional gradient materials especially are suitable for bending actuators e.g. in bimorph layered systems. Advantages are low internal stresses, low production costs and the possibility to design systems from materials which are lead-free. Huge financial profits loom on the horizon in the field of printed electronics. In this field, Europe has the best starting point, as it controls more than 70 % of the world-wide market of printing machines. Thereby, collaboration between mechanical engineering and electrical engineering with materials science, physics and chemistry would make it possible to gain and strongly secure the leading market position.

Main development issues and targets at a level which you would find in a work program

Intermetallics. The main target of the research is establishment of the reliable knowledge and know-how databases on intermetallics that encourage the community of European designers to widespread the use of intermetallics as well as the assessment of the real alternative to conventionally used materials in view of the reduced total life-cycle costs. It will also lead to EU expertise on these materials. To achieve this general target the following issues should be tackled:

1. *Improvements of properties and controlling the microstructure in order to achieve multifunctional materials*
   The ductility and strength of aluminides is controlled by chemistry (the alloys used and their composition) and material microstructure. Alloying elements increase ductility at room temperature and improve resistance to oxidation and creep strength at high temperature that is especially important if long-term service is considered. They also cause the grain refinement. Material microstructure affects significantly material properties, for example, in case of titanium aluminides development of the lamellar microstructure changes their properties in view of fracture toughness, creep resistance, tensile ductility and strength. Microstructure is controlled by the proper processing. Further researches on the relations between properties and microstructure as well as microstructure – processing technology are clearly needed. The important issue is also the stability of the obtained microstructures as far as life-cycle reliability is concerned. In the area of shape memory alloys (SMA) research on properties and microstructure should lead to improvement of bio-performance and bio-compatibility as well as development of the alloy composition with reduced amount of possibly cytotoxic elements (e.g. Ni)

2. *Establishment of reliable property database as well as characterization and modeling standards with the aim to encourage the EU designers to replace the traditional materials by intermetallics*
   It is observed that unsatisfactory usage of intermetallics is caused by the lack of reliable databases concerning the properties of intermetallics. This creates the need to develop characterization techniques together with their standardization. There is also much research needed in the field of modeling, specifically prediction of material behavior and properties with account for micromechanics, multiscale analysis in inelastic range permanently enhanced by the increasing power of computers, analytical modeling of fracture and creep processes.

3. *Transfer of developed new processing technologies from laboratories to commercial production*
   Industry appears to be on the threshold of significant use of intermetallic materials for light-weight elements. There are many traditional and novel techniques belonging to ingot metallurgy and powder metallurgy developed to process intermetallics: routes based on massive transformation, SHS route, mechanical alloying and hot isostatic compaction, powder metallurgy based on reactive sintering etc. Some of them have been already applied on industry scale. However, for wide-spread applications it must be shown that semi-finished products and components with specified properties can be manufactured in large quantities at reasonable costs. For structural applications appropriate joining and repairing techniques must be available which guarantee processing of reliable joints exhibiting good mechanical properties especially at temperatures below brittle-to-ductile transition. For the application of SMA intermetallics, proper surface processing techniques should be developed to achieve better bio-performance, also processing methods should be improved towards cleaner, more efficient precise alloying with reduced waste as well as integration of multifunctional properties of SMA to form smart elements (e. g. self-repairing one)

4. *Identification and exploration of new potential areas of applications*
   Aluminides are expected in the future to be used as components in high-speed aircrafts, also in aerospace advanced engines (TiAl) and in chemical or fossil fuel industries, they probably will find (FeAl/Fe3Al, NiAl/Ni_3Al) application in air deflectors for burning high-sulfur coal, ethylene crackers, coatings for oil drilling components, coal burners, in high field and large-scale magnet applications e.g. coils in thermonuclear reactors (Nb_3Al, Nb_3Sn). There should be also a research effort undertaken in the area of smart intermetallics devoted to their further applications in medicine and industry taking the advantage of their interesting properties e.g. magnetic shape memory effect. Other possible applications of intermetallic materials may be as matrix material for metal matrix composites and as thin films and intermetallic layers serving as coatings on metal substrates containing intermetallic forming elements and enhancing performance of elements under harsh in-service conditions.

Metal Ceramic Composites. The main target of the research proposed is to promote the fabrication and characterization of metal ceramic composites with innovative micro- and nanostructures. Great effort on related topics was spent in FP6 to integrate research activities on materials science, solid mechanics and manufacturing technologies in the field of metal ceramic composites. A comprehensive literature survey was performed and the areas in need of further research related to metal ceramic composites were identified. In particular, to achieve the goals enumerated above, the following aspects should be targeted:

1. *Microstructure characterization*
   - Understanding of interfacial fracture and its relation to processing.
   - Knowledge of properties at elevated temperatures, relating to crack propagation, cyclic and slow crack growth, oxidation, and corrosion and wear.
   - Determination and evaluation of properties under operational conditions, e.g. regimes of temperature, static and dynamic loading, atmospheric and other operational media.
   - Increase understanding of the relationship of properties to microstructure, with special regard to statistics (scatter), microstructural morphology, processing and modeling.

2. *Influence of processing on microstructure*
   - Use of highly purified starting materials which have a strong effect on the structure and composition of the interfaces and on the evolution of the microstructure.
   - Densification kinetics of ceramic matrices containing particle inclusions. Prediction of final part shape and dimensions from data of the "green" bodies.
   - Influence of nanoparticles on the mechanical properties of the composites
   - Cost/performance ratio of new (nanostructured) products has to be optimized and the reliability of the products improved.
   - Improved cost-effective processing methods; influence of process parameters on properties is paramount.
   - Developments in coatings of fibers to improve wettability.
   - Development of new cost competitive matrix/reinforcements combinations.
   - Reliable methods for processing nanocomposites of relevant dimensions and shapes

3. *Modeling of micro-cracking, fracture, friction, corrosion and fatigue*
   - Modeling realistic (with random variations) distributions of particles in CMC.
   - Inclusion of surface/interface effects at nano-scale.
   - Modeling of debonding and cavitation effects.
   - Multiscale modeling including realistic microstructure.
   - Reliable test data on interfacial properties.
   - Modeling of stress transfer between phases in interpenetrating CMC.
   - Consideration of residual stress field in crack growth modeling.
   - Multiscale techniques for developing interfacial and damaged matrix constitutive relations in nano-particle/nano-tube CMC.
   - General improvement in simulation techniques at nano-scale.
   - Improved methods relating CMC and bimaterial microstructure to fatigue growth phenomena.

4. *Defect kinetics and creep*
   - Light weight metal matrix composites with stable and strong metal-ceramic interface leading to improved properties at elevated temperature.
   - Modern non-destructive testing methods to improve the understanding of creep or corrosion damage. Combination of such methods with suitable fatigue models for CMC for improved prediction of the fatigue remnant life of components.
   - Creep and fatigue data for complex loads (which prevail in real applications). Tests under multiaxial loading.
   - Investigations concerning plasticity-creep interactions in CMC even for uniaxial stress state.
   - Information on creep, corrosion, fatigue and reliability behavior of CMC with interpenetrating network microstructures.
   - Long-term durability of fiber reinforced CMC at elevated temperatures: (1) creep and rupture of the fibers, (2) environmental degradation of the constituents. Creep properties of oxide fibers (.e.g. by recrystallization) and stability of interfaces as breakthrough for CMC applications in demanding environmental conditions.
   - Creep, corrosion characteristics and damage mechanisms of laminates. New concepts to enhance creep and fatigue properties of metal ceramic composites. Performance of layered ceramic matrix composites in the transverse direction.

5. *Micro-macro transition, multiscale modeling effective properties*
   - Multiscale modeling techniques to cover ab-initio dynamics, atomistic simulation and macroscopic analysis.
   - Reliable techniques for modeling the complete production process.

6. *Industrial needs*
   - New cost competitive reinforcements to avoid the use of high-cost base materials.
   - Development of non-Al composites for higher performance.
   - Near-net-shape production routes to cut cost of secondary processes, e.g. machining, finishing, and welding.
   - Development of new MMC and CMC systems with high ductility, toughness and corrosion resistance.
   - Development of NDT concepts for the specific features of MMC and CMC.
   - Interphase materials, for stable CMC at temperatures in the range 1200-1500°C.
   - Improved reliability of CMC.
   - Development of low cost and flexible production routes, e.g. those based on the gas phase.
   - Improved understandings of the oxidation, creep, wear and fatigue resistance of CMC.

FGM and Functional Multilayers.
The key research challenge in Bio-FGM is the identification of 'universal' material properties of elementary building blocks inherent to whole classes of Bio-FGM, as well as universal pattern of interaction they obey over various observation scales. Such material properties are of mechanical, physical, or chemical nature, they are related to material volumes or interfaces at a suitable observation scale. They would allow for 'translation' of chemical into mechanical/physical information or vice versa, in a unified setting. The identified properties of the elementary bricks used in nature would define clear structure/function/property-requirements to be met by the biomaterial to repair the lost tissue function. Therefore, identification of micro and nanostructure mechanics and physics of biological materials is expected to lead new, more precise ways in biomaterials design for repair of lost tissue function, replacing a trial-and-error procedure by a truly engineering-science based approach. This would significantly enhance applicability, security, and economy of tissue engineering solutions.
In functional multilayers and piezoelectric FGM there are two main targets to be approached: Development of novel materials and development of novel technologies as suitable for mass production, which includes knowledge of high-reliability technologies.

1. *Development of new materials for actuators:*
   - New actuator materials need to work without additions of lead and other toxic elements. Several crystallographic systems are yet only marginally explored. Most promising appear combinations of perowskites based on Bismuth, Niobium, Titanium and Tantalum. As perowskites show high solid solubility, many opportunities arise.
   - New actuator materials can be developed using ab-initio computations to aid in the search for new materials. Current computational methods and computer power is just at the verge of being useful to develop new functional materials based on atomic building blocks. Density functional theory for virtual atoms or by using large super-cells has shown the first useful results. These techniques need to be developed further to help the development of cost-efficient material through simulation techniques.

2. *Development of new materials for semiconductor applications:*
   - Printed electronics requires p- and n-doped semiconductors, where printing ceramics can offer new markets in the form of radio frequency identification (RFID). The ceramics envisaged are based on several oxide systems with different options for doping. The materials require dispersion as a printable medium and curing at low temperature on a variety of substrates.
   - Fabrication of printable electronics requires development of new technologies for printing and concurrently adaptation of design of the electronics circuits. Therefore, modeling of current flow and defect states is very much in demand.

3. *Development of multilayers for a wide range of applications:*
   - Priorities in motion control: Motion control is a vast future field which describes the ability to move small components and medium-sized components at frequencies up to 100 kHz and with a precision of less than 1 micron, at the same time with a stress resilience of several MPa at least. Naturally, motion control is required in the car for small motors (e.g. piezomotors for air ventilation, but also piezoinjectors for superior fuel control). Motion control, however, is required in many more other technologies. Amongst these are: textile technology, printing technology and high precision movements in the microtechnology industry as well as space industry.
   - Priorities in Biomedicine: Sensors and actuators are required for efficient control and support of many bodily functions. Amongst these are sensing of pressure and temperature. Also, for stabilization of key functions, drug delivery using small actuators may be warranted, which may be activated on prior sensing facility.
   - Priorities in Communication: Communication with radio identification techniques is one of the biggest markets for the future. Identification tags based on printing technology are required to provide costs in the area of less than 5 cents per product.

Expected impact in quantifiable terms at a level which you would find in a work program

Intermetallics. Their properties and development/improvement of processing methods will enable:
- the automotive industry to improve efficiency (reduced fuel consumption, pollution, and costs) and safety (e.g. noise level) due to high specific stiffness of intermetallics
- the chemistry and fossil fuel industry to develop elements of mixed material structure with high corrosion and erosion resistance extending their life cycles and thus reducing the total life costs
- generation and exploration of new possible areas of application in medicine as far as shape memory effect is considered
- the transfer of novel manufacturing processes to automotive, aerospace and biomedical industries.

Metal Ceramic Composites. The strongest impact of the research proposed is on transportation, energy, environment and to a less extent healthcare and telecommunications

FGM and Functional Multilayers. As for expected impact of Bio-FGM, the costs resulting from lost, injured, or diseased tissue are hard to estimate, but already single diseases responsible for tissue injury, such as osteoporosis, result in enormous costs (31.7 billion € in 2000 in Europe). Thus, any improvement in the production process or in service life quality of tissue implants or scaffolds, such as reduction of prosthesis decay and rejection, and of costs of hospitals for replacement of prosthesis will have a strong impact on European societies. On the level of an individual, the cost for medical devices would fall, making them available for the majority of the population and alleviating the burden on European social security systems.

As for functional multilayers, the two main fields considered here are the actuator and the semiconductor technology. Piezo-injectors currently grow with a growth rate of more than 100% in Europe and add several thousand new jobs every year. It is expected that the area of printed electronics will develop to a similar new market field.

Sectors addressed:

Intermetallics: Automotive and aerospace sector, chemical, fossil fuel industries, biomedical sector
Metal Ceramic Composites: Transport, energy conversion systems, environment and sustainable development, telecommunication, healthcare
FGM and Functional Multilayers: Bio-industry, medical system; bio-medicine and drug delivery, automotive sector, textile industry, telecommunication

Required RTD investment: **450 M€ (funding) - Collaborative Projects**

Implementation priority/justification: Prioritisation within the topics put forward in the SRA of the ETP, taking into account critical dependencies etc.: "1st priority because…. (largest return on RTD investment/prerequisite for further research/etc.)"

Intermetallics
1st priority: Development of intermetallic materials for high speed vehicles engines through weight reduction
2nd priority: Development of intermetallic materials of new physical properties for new functions
3rd priority: Take up of the intermetallic materials fabrication processes – from laboratory to industry
4th priority: Intermetallic materials resistant to high temperature and serving as corrosion and erosion resistant coating

Metal ceramic composites
1st priority: Development of processing techniques to reliable production of metal ceramic composites with tailored micro- or nanostructure
2nd priority: Modeling of metal ceramic composites exhibiting multiple functional properties and structural integrity for new generation components
3rd priority: Measurement of relevant mechanical and functional properties
4th priority: Design and fabrication of components of real shape and dimensions exhibiting resistance to high temperature and stresses, severe environmental attack, abrasion and wear

FGM and Functional Multilayers
1st priority: Development of lead-free piezoelectric materials
2nd priority: Development of ceramic doped semiconductors
3rd priority: Development of multilayer technology (including electrodes, poling, etc.) for new piezoceramics; development of printing technology for cost-efficient RFID
4th priority: Tailoring of biomaterials based on mechanical/physical/chemical identification and characterization of universal elementary constituents through combined experimental-analytical-numerical approach – theory supported transdisciplinary tissue engineering

Notes/comments: e.g. possible coordination needs with other thematic programs			
Elements to be included in the call	**State of the Art**	**Vision/targets**	**Forecast materialization**
Intermetallics Key action 1: Titanium aluminides for room and high temperature application in the automotive and aerospace industry. Micromechanical and multiscale modeling should be here included allowing understanding of microstructure and its stability – properties relationship. Key action 2: FeAl for intermediate temperature application where its remarkable oxidation and sulfidation resistance is important. Key action 3: NiAl as structural material of high strength at elevated temperature Key action 4: Exploration of Nb_3Al and Nb_3Sn as candidates for electromagnet applications due to their super-conducting properties Key action 5: SMA intermetallics investigation in biomedical applications, enhancing their performance and reducing cytotoxicity. Analytical (phenomenological) and micromechanical modeling of shape memory materials should be here included Key action 6: Exploration of possible areas of application of magnetic shape memory alloys (NiMaGa, Fe-Pd, Fe-Pt) Key action 7: Intermetallics as matrix materials in metal matrix composites Key action 8: Intermetallics in mixed material structure: intermetallic thin films and layers	**Intermetallics** • The observed interest in intermetallics as light-weight materials has been driven during last decade by titanium aluminides and R&D progressed significantly. They have led to better understanding of fundamental influence of alloy composition and microstructure, relative to mechanical properties and processing behavior. It has been shown that they can be processed using conventional metallurgical methods. However, these materials still require characterization relative to their behavior in extreme conditions (high temperature, dynamic loading) and enhancing efficiency of processing technology • Major problems of SMA intermetallics concerning manufacturing techniques and thermo-mechanical treatment have been already tackled. A research effort is now directed to improving existing technologies, development of reliable standardized characterization techniques, exploration of new SM effects and new SMA among intermetallics • As for FeAl, NiAl with their high corrosion resistance and intermetallics presenting super-conducting properties, the database on properties and modeling of this materials is rather limited and extensive research are needed to accelerate increase the use in commercial application of these materials	**Intermetallics** The vision is joining science and technologies to develop an EU global expertise on advanced materials. In particular, to establish expertise for product and process design in terms of characterization and modeling standards to make time to market and process cost competitive with state of the art solutions. Specific targets are: • to develop intermetallics characterization techniques allowing procedures for standardization • to achieve reliable property database for intermetallics • to develop, on the basis of micromechanics and multiscale modeling, the methods of controlling the material microstructure and its stability • to develop modeling techniques applicable for prediction of material behavior during the manufacturing process and service life-time • to increase material performance in the forecast application areas: particularly the intermetallics' ductility, toughness and resistance at room or high temperature, creep resistance, as well as biocompatibility in the case of SMA • to improve the processing routes for intermetallics allowing the transfer of novel technologies from laboratories to industry and their increase applications in structural elements • to reduce costs of processing route to make use of intermetallics more competitive with respect to state-of-art materials • to develop reliable techniques for production of mixed material elements where intermetallic thin films and layers serve as oxidation and erosion protective coatings	2010-2013

Elements to be included in the call	State of the Art	Vision / targets	Forecast
Metal Ceramic Composites Key action 1: Low-cost production processes. Key action 2: Multiscale modeling. Key action 3: Low-cost production of large volumes of nanoparticles. Key action 4: Ceramic-metal interface characterization. Key action 5: Dispersion of nanoparticles in ceramics, metallic matrices and coatings. Key action 6: Derivation of microstructure-property correlations for specific targeted properties, mechanical strength, elasticity, thermal and electrical conductivity. Key action 7: Joining of metal ceramic composites and integration with current materials in functional systems and devices. Key action 8: Development of advanced metal ceramic composite coating systems (e.g. porcelain/vitreous enamel coatings), multilayered materials and nanostructures to confer new properties on a material surface without affecting bulk properties. Key action 9: Metal ceramic composites with ceramic matrices with improved fracture toughness. Key action 10: Modeling for life time prediction - through life cycle. Key action 11: Carbon nanotube based metal ceramic composites, processing methods for new structures based on CNT integrated in ceramic and light weight metallic matrices for functional and biomedical applications. Key action 12: Functional metal ceramic composites for fuel cell applications to increase the conversion efficiencies of fuel cells. Key action 13: Metal ceramic composites for fission and fusion reactor technologies. Key action 14: MMC from waste materials as recycling strategy for problematic wastes and sustainable development / rational use of resources. Key action 15: Metal ceramic composites s for advanced high pressure die casting and near net shape manufacturing.	**Metal Ceramic Composites** The continuous research and funding of projects related to these materials took place after the early 1980´s. 25 years later the actual use of MMC and CMC in industrial applications is much lower than foreseen in the 1970s. In 1990 the worldwide market of MMC was estimated to be between 3-37 million US $ and in 1999 it was estimated to be around 103 million US $. 62% of this volume is within the ground transportation applications and 26.5% in thermal management applications. Aerospace comprises around 5.4% of the total market. Even though the too high final cost of the materials remain the most important reason that explains the current situation, there are other aspects that have also hindered the use of metal-ceramic composites such as difficulties in secondary processes, low ductility and toughness, anisotropy, lack of data regarding the behavior at long term, lack of data for modeling and simulation, lack of standardization. There is hardly any knowledge on long-term mechanical behavior and fatigue of the metal ceramic composites and relatively poor understanding and knowledge on interfaces in these materials. The production of nano-size MMC using SHS, plasma and spray-drying is worth consideration having in mind their potential application as coating materials.	**Metal Ceramic Composites** Modeling and simulation: Development of fundamental microstructure-property correlations to predict mechanical and functional properties of novel metal ceramic composites. Influence of nanoparticles on mechanical and functional properties of ceramic and metallic matrices Fabrication: Development of highly purified starting materials which have a strong effect on the structure and composition of the interfaces and on the evolution of the microstructure. Cost/performance ratio of new (nanostructured) products to be optimized. Improved, cost-effective processing methods to be developed. Further understanding of the influence of process parameters on properties. Development of new coatings for fibers to improve wettability as well cost competitive matrix/reinforcements combinations The strategy is to develop the capability to design and produce metal ceramic composites having tailored functional and mechanical properties to be applied in components and systems using inexpensive manufacturing processes.	2010-2013

Elements to be included in the call	State of the Art	Vision / targets	Forecast
FGM and Functional Multilayers Key action 1: Development of lead-free piezoceramic materials for novel actuators. Key action 2: Development of next generation lead-free solders including SnZn, Bi-containing and composite solders; lead-free high-temperature solders. Key action 3: Development of suitable electrode materials and poling methods for the new materials. Key action 4: Development of high temperature piezoelectric materials to push the application limit to higher temperatures. Key action 5: Development of non-ceramic functional layers with acting and/or sensing capabilities (e.g. SMA or magnetostrictive materials). Key action 6: Development of poling methods and design for long-time reliability, both for use at high temperature as well as for use for many cycles is required. Key action 7: Modeling of novel actuator materials with respect to possible degradation mechanisms for long-term use. Key action 8: Modeling and testing of piezoelectric FGMs with respect to optimal material design before poling and/or the optimal poling conditions. Modeling and testing of electromechanical, damage and failure behavior of piezoelectric FGMs. Modeling of optimal structural design of piezoelectric FGMs with respect to their electromechanical properties. Key action 9: Development of new ceramic semiconductor materials and understanding of their band structure. Methods of cost-efficient production of novel semiconducting ceramics, particularly in the form of dispersed nanoparticulates. Key action 10: Suitable doping elements and doping techniques, leaving accessible defect states and mobile charge carriers are required. Key action 11: New electronic designs for printable electronics with robust and affordable technologies. New printing machinery for cost-efficient printing of RFID tags. Key action 12: Quantitative, theory-supported identification of nano/micro elementary components and their mechanical/chemical/physical interaction in biological tissues. Key action 13: Development of nano/micro-structured biomaterials through integrated closed-loop 'processing-characterization-modeling'.	**FGM and Functional Multilayers** Lead-containing multilayer actuators are available, but have to be outphased due to environmental regulations. Tens of thousand of jobs are endangered if new materials cannot be developed. Japan is currently leading in the development of lead-free piezoceramics. Currently, very few materials with insufficient properties are available for high temperature motion control. The current materials cannot be used with high efficiency above 200°C. Once motion control is available above this limit temperature, more technologies can be available as well. The field of printed electronics is about to develop with many competing technologies. Printed semiconducting polymers for many technologies, e.g. for large displays have conquered large market shares, providing large employment opportunities. It is expected, that the same will happen with printed electronics based on ceramics. Qualitative, statistics-based description of structure-function-property relationships Trial-and-error procedures for testing novel biomaterials	**FGM and Functional Multilayers** Modeling and simulation: Ab-initio modeling of polarization as a function of electric field for new piezoceramic materials. Finite element simulation for electromechanical performance of new actuator materials. Simulation of charge flow in new printed ceramic and hybrid technologies Fabrication: Pushing to frontiers of science the fabrication low-temperature multilayer, non-toxic piezoceramic for superior motion control for billions of cycles and large frequencies appears feasibly. The vision is to develop the capability to design also new semiconducting ceramics for the booming communications industry. Experimental tools: Micro/nano/picoindentation, ultrasonic/acoustic testing, X-ray based techniques, multiaxial mechanical testing, etc. Theoretical tools: Mathematics of homogenization, Poro-micromechanics, Molecular dynamics etc. Technologies: Solid-liquid phase separation, starch consolidation, electrophoretic deposition, slurry coating etc.	2010-2013

Annex I: Coordination and contact points

The coordination and contact points have been defined as follows:

EuMaT Industrial Board
Dr. Eisele, BOSCH, Germany
Dr. Renner, BAYER Technologies, Germany

EuMaT Scientific Board:
Dr. Maile, MPA, Germany
Prof. Basista, IPPT, Poland
Dr. Linsmeier, MPI Plasmaphysik, Germany

EuMaT Operating agent:
Prof. Bogaerts, Technologica, Belgium

EU (Commission)
Dr. S. Becker, RTD-G, Materials

Main contact/coordination:
Dr. A. Jovanovic / secretary: Ms. R. Kokejl
MPA Stuttgart, Pfaffenwaldring 32,
70569 Stuttgart, Germany
Tel: +49 711 685 63007; Fax: +49 711 685 63947;
E-Mail: Roswitha. Kokejl@mpa.uni-stuttgart.de

Annex II: EuMaT Terms of Reference

The undersigned parties:

Having recognized European coordinated supporting studies as important contributions to the understanding, improvement and codification of advanced engineering materials and technology features;

Having recognized the importance of existing research results, material know-how;

Considering that the European Commission (EC) is promoting, between its member and associated countries, European co-operative studies in the field of industrial technologies, materials development and industrial safety.

AGREE

to participate in a European Technology Platform for Advanced Engineering Materials and Technologies, referred to as EuMaT, on the terms and conditions set out below.

Article 1. Scope And Objectives

a) Objectives
The overall policy objective of the TP is the promotion of the leading global position and global competitiveness of the EU technology and companies in the area of Advanced Engineering Materials, as well as promotion of the consolidated and unified R&D and innovation European policy in this area, e.g. in the fields like materials resistant to extreme conditions, intermetallics or other multicomponent materials. The concerted EU R&D in this area is essential for the issues like material production technologies, monitoring and predicting material performance and degradation, environmental and/or health impacts.

b) More detailed objectives are:

The main practical policy objective of EuMaT is to assure optimum involvement of industry and other important stakeholders in the process of establishing European R&D priorities in the area of advanced engineering materials and technologies. EuMaT should improve coherence in existing and forthcoming EU projects, and introduce "Radical Changes" and assure "Sustainable Development" in the sector of advanced engineering materials and related technologies. EuMaT covers all elements of the life cycle of "Advanced Engineering Materials & Technologies" (AEMT). The term AEMT refers in EuMaT to the three pillars

4. multifunctional materials for macro-applications, primarily
5. engineering materials for challenging (extreme) application conditions, including
6. multimaterial (hybrid) systems

as used in engineering (and, e.g., coupled with "conventional" structural materials like steel, aluminium, titanium, metallic alloys, composites, polymers, advanced ceramics, coatings, adhesives, concrete, …) and/or used to enhance the engineering products, systems and processes in areas like energy, gas & oil, chemical, space, transportation, electronics, environment, health, etc. EuMaT covers the lifecycle of lightweight materials and nanomaterials in engineering components/ applications/systems. In particular it clearly points out the link toward large European projects like KMM-NoE (www.kmm-noe.org) and

Extremat (http://www.extremat.org), in which advanced engineering materials like intermetallics, metal ceramic composites, functional engineering materials with gradient properties, self-passivating protection materials, radiation resistant materials and heat sink materials and high-temperature materials are investigated. The examples of **advanced new products** directly enabled by the progress in the area of advanced engineering materials are, e.g., gas and steam turbines (for 1600 ºC and 800 ºC respectively, ITER reactor or the "Third Millennium Car"). The similar impact would the advanced engineering materials have in the area of **manufacturing** (cf. the MANUFUTURE Technology platform).

c) Official Language

Official language is English. Based on needs and availability of resources, informative versions of selected relevant documents may be provided also in other two CEN languages (German and French). Possibly, for all the main documents written in English, summaries will be provided in German and French.

d) Limitations

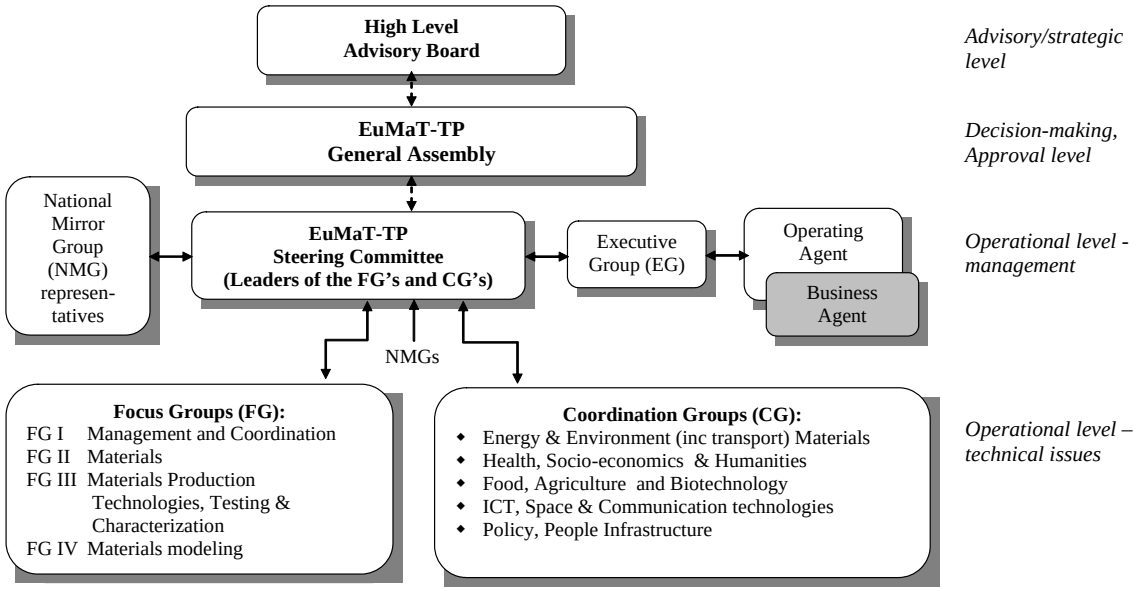
The collaboration will not propose services such as inspections or expertise and will not consider itself as a technical group for codes and standards elaboration and writing.

e) Self-sustainability

It is the objective of EuMaT to pursue the goal of self-sustainability and the members may undertake necessary steps to assure that the internal organization of the TP serves achieving of this goal better.

f) Organization

A description of organization of the EuMaT Technology Platform is shown in the figure below.



Article 2. General Assembly and the High Level Advisory Board

The General Assembly shall consist of all the members of EuMaT.

The General Assembly shall meet as a matter of principle once a year following the meeting of the High Level Advisory Board upon and the call of the Operating Agent (Article 4), in order to examine the initial annual report of the Steering Committee (Article 3) and to express views on questions related to EuMaT.

The High Level Advisory Board and the General Assembly shall be responsible for the approval of the Steering Committee performance.

The High Level Advisory Board consists out of senior representatives of major interested

parties, e.g. chairs of other platforms and projects, material associations, politics and member state representatives. The task of the board is to provide strategic guidelines for EuMaT and assess if EuMaT policy is consistent with the strategy established in the vertical technology platforms. The board convenes once a year.

Article 3. Steering Committee And Executive Group

a) The control of the EuMaT shall be vested in a Steering Committee (SC) defined under this Article. The Steering Committee shall vest financial control in the Executive Group when necessary.

b) The Steering Committee shall consist of the members of the Executive Group and the chairmen of the Focus Groups and the Coordination Groups. The High Level Advisory Board shall confirm the nominations for the Steering Committee.

c) Each voting member of the Steering Committee may be accompanied by non-voting members (e.g. National Representatives (Article 5), experts from research institutions, manufacturers or universities). Non-voting experts can be appointed permanently or they may be invited to a limited number of meetings or for a limited number of points on the agenda of a meeting.

d) The Steering Committee shall:

1. Be responsible for any substantial amendment made to the EuMaT multi-partner collaboration agreement. Semantic and editorial issues will be handled at Executive Group level.

2. Approve the creation and constitution of groups necessary for the implementation of the Agreement, generally called Task Groups (Article 6).

3. Review the execution of tasks ensuring that they are carried out in line with the objectives laid down in this Agreement and giving general direction to the EuMaT Secretariat. (Article 4)

4. Help with the technical arrangements for the execution of the tasks.

5. Convene the High Level Advisory Board and the General Assembly each year.

6. Elaborate and present to the High Level Advisory Board and the General Assembly a report on the activities of EuMaT.

7. Keep all the parties informed of the progress of the work by means of an annual progress report and a general assembly.

8. Inform the interested industrial parties, the regulatory bodies and the codes and standards bodies of results and conclusions of the task programs as released under Article 10.

9. Provide information to the General Assembly on activities outside EuMaT dealing with advanced materials and technologies.

10. Favor and manage International contacts, relations and exchanges of information.

11. Manage possible collaboration with International organizations dealing with advanced materials and technologies.

12. Delegate the chairman of EuMaT the authority to sign all collaboration framework documents with other organizations agreed upon by the SC.

e) The Steering Committee shall meet as a matter of principle twice yearly. The meetings will be convened by the Chairman or in his absence by a Vice-Chairman. A special meeting will be held within a reasonable time after receiving a written request from a minimum of three parties or from the EuMaT Secretariat.

f) The Steering Committee shall operate and reach its decisions to the greatest extent possible by unanimous agreement. However, when a formal vote is

requested by a voting member or is required by the rules, each voting member shall have one vote. The Operating Agent shall be non-voting. Voting will be organized by the Operating Agent, along the CEC rules, as applied by the CEN.

g) "The Steering Committee shall elect from among the EuMaT membership, by means of a formal and secret vote, a Chairman, and up to three Vice-Chairmen, each with a mandate for three years, terminating at the Steering Committee following the three years period. The third Vice-Chairman shall have specific responsibilities of looking after the promotion and development of EuMaT and its activities in the new EU member states. The Steering Committee may also elect a Technical Advisor. The elections shall be organized by the Operating Agent. In the event of a resignation an election shall be organized by the Operating Agent for the next meeting of the Steering Committee.

For the position of EuMaT Chairman, only the Chairman and the Vice Chairmen will be eligible to seek election or re-election. In the case there are no candidates for the office of Chairman; candidates from among the Steering Committee voting members will be sought.

h) The Steering Committee shall advise the parties of EuMaT and the Operating Agent on the resources required for the actions.

i) The Steering Committee shall review periodically, the means of the Technology Platform and in particular of the Operating Agent and of the Business Agent.

j) The Steering Committee shall approve reports for publication upon proposal of the Task Groups.

k) The Steering Committee shall establish an Executive Group comprising the Chairman, Immediate Past Chairman, three Vice-Chairmen, Technical Advisor, Secretary and a Representative of the Operating Agent. This Group will be charged with the organization and implementation of the business of EuMaT in accordance with the strategy developed and agreed by the Steering Committee.

l) Requests for observer status on the Steering Committee from European Trade Organizations and Federations will be considered for approval on a case by case basis, by the voting members of the Steering Committee.

The updated list of members of the International Advisory Board is provided in the separate attachment to this document.

Article 4. EuMaT Secretariat- Operating Agent - Business Agent

4.1 General Provisions

The Operating Agent shall provide for the accomplishment of the tasks defined under point 4.2.

The Steering Committee will revise this agreement:

- should it no longer be possible for the Operating Agent to provide the necessary resources to support the actions required by the Technology Platform, or

- should the services of the Operating Agent be no longer considered to meet the requirements laid down in the present Terms of Reference

Such revision must be in agreement with Article 8.

The Business Agent will be organized in the due course according to the principles established by the SC and GA.

4.2 Definitions And Scope Of Tasks Of The Operating Agent (OA) And Business Agent (BA)

a) OA: Secretariat of the Steering Committee and Executive Group

The Operating Agent shall arrange for the secretariat of the Steering Committee (SC), and of the Executive Group (EG). This secretariat shall in the first instance:

1. Keep safely the archives of the SC, of the EG and of the EuMaT in general.

2. Take care of the organization of the SC and EG meetings and nominate a secretary for each meeting.

3. Take care of the actions necessary for a sound and transparent administration, such as the organization of the EuMaT elections, the update of EuMaT Business Management Plan (BMP) and the revision to the EuMaT Multi-Partner-Collaboration Agreement (MPCA) when requested by the EuMaT EG/SC, implementation of the strategy as defined by the SC etc.

4. Circulate the documents as requested by the SC, for example the minutes of the SC/EG meetings, calls for participation in activities covered under the EuMaT umbrella etc.

5. Handle requests from external organizations, committees etc. concerning the use of the name of EuMaT e.g. for conferences, taking the appropriate follow-up actions in the interest of EuMaT subject to the authority of the EuMaT EG/SC.

Should any of the above mentioned Committees or Documents (EuMaT EG, SC, BMP, and MPCA) be modified/replaced in the future, the above provisions shall apply to the modified/equivalent/substitute Committees/Documents, unless decided differently by the EuMaT Steering Committee.

b) OA: Daily Operation

The Operating Agent shall handle the day-to-day management of the Technology Platform and of its activities, in the first instance by:

1. collecting incoming membership applications/withdrawals and keeping membership records updated and recording attendance at EuMaT meetings and gatherings.

2. providing a focus point for requests incoming from members and non-members, taking action where appropriate and/or re-directing those messages to the relevant EuMaT officers or committees.

3. providing support to the EuMaT Task Groups for developing programs of work and bids for funding the work. This will not prevent the Operating Agent from participating in such activities.

c) OA: Dissemination of information

The Operating Agent, in liaison with the Executive Group and the Steering Committee, shall be responsible for the dissemination of the R&D results achieved within the EuMaT context, or made available by the IPR (Intellectual Property Rights) owners for dissemination through EuMaT. In particular, the Operating Agent shall provide the resources necessary for:

1. the preparation, publishing and distribution of the EuMaT Newsletters

2. the editing, publishing and distribution of EuMaT Bulletins and Technical Reports, based on the inputs of the R&D performers and/or results/information/IPR owners, and upon decision of the Executive Group

3. the development, updating and maintenance of the EuMaT Website

d) OA: Organization of the EuMaT Annual General Meeting

The Operating Agent, in liaison with the Executive Group, shall provide the resources necessary to support the host organization in organizing the High Level Board Meeting(ABM) and the Annual General Meeting (AGM), in the first instance by:

1. developing the ABM and AGM program

2. editing and distributing the necessary announcements of the event with adequate advance, along with the necessary information concerning logistic aspects, to be provided to the Operating Agent by the host organization

3. editing, publishing and delivering handouts for the Annual General Meeting

4. editing, publishing and distributing to all EuMaT members the proceedings of the Annual General Meeting.

e) OA: International Collaboration Activities

In liaison with the EuMaT EG/SC, the Operating Agent will support the Leader for International Collaboration Activities in monitoring the implementation of the EuMaT Memorandum of Understanding (MoU).

f) BA: Marketing of EuMaT and contribution to its development

The Business Agent shall provide the resources necessary for the marketing of EuMaT by means of adequate tools, such as for instance review Articles to be presented at Conferences or published in Journals, corporate presentations, exhibitions at Conferences and events.

4.3 Rights And Business Opportunities For The Business Agent

The Business Agent shall be allowed and encouraged to search and develop opportunities for the benefit and the promotion of EuMaT, such as organizing workshops, seminars and publications. All such initiatives shall be self-financed and shall have to be approved by the EuMaT EG/SC.

The Business Agent shall be allowed to pursue financial profit, from the above initiative or from other sources, for the purpose of financing its own activities, under the control of the EuMaT EG.

The Intellectual Property Rights shall not be transferred to the Business Agent, but will remain with the owners as long as EuMaT is run on a contribution-in-kind basis. Should this situation change as EuMaT evolves into an autonomous non-profit organization, the role of the Business Agent a propos this context may be re-assessed.

NOTE: As long the BA is not established, the above rights are with the Operating Agent.

Article 5. National Representatives & Technical Advisor

a) Each member representing a country at the Steering Committee may appoint a National Representative to operate the national EuMaT.

b) The National Representative, under the authority of the Steering Committee and in liaison with the Operating Agent, shall form the privileged interface between the EuMaT and the national industries and laboratories. They shall:

1. Make the EuMaT and its workings known to national operators

2. Facilitate contacts between parties of the EuMaT.

3. Relay calls for participation decided by the Steering Committee and drawn up by the Operating Agent.

4. Facilitate the creation of new Task Groups answering to the objectives of the EuMaT.

c) The Technical Advisor, elected by secret vote of the SC, shall be an expert in the field of advanced materials and technologies. His role shall be to advise the SC and TG's on all matters requiring a specific technical input. He will additionally play the role of Referee for the SC on technical matters. The appointment shall be reviewed as necessary by the Steering Committee. The Technical Advisor will be a

non-voting member of the Steering Committee.

Article 6. Focus Groups, Coordination Groups and Task Groups

The Focus Groups have established out of the EuMaT General Assembly during the Kick-off in November 2004. They will be confirmed during the Launch Event of EuMaT and the leaders have to be nominated which will be members of the Steering Committee:

FGI	Management and Coordination
FG II	Materials
FG III	Materials Production Technologies, Testing & Characterization
FG IV	Materials modeling
FG V	Horizontal issues – coordination groups

Coordination Groups will be established and the leaders be nominated and be members of the Steering Committee. The Coordination Groups are aligned with FP7 priorities:

1. Health
2. Food, Agriculture and Biotechnology
3. Information and Communication Technologies
4. Nanosciences/ technologies, Materials and New Production
5. Energy
6. Environment and Climate Change
7. Transport
8. Socio-economic Sciences and the Humanities
9. Space and Security Technologies

The Coordination Groups will determine the Materials priorities of these areas and then recommend R&D themes to the Steering Committee. They will do this with co-operation of other Technology Platforms and Projects to ensure sharing of best practice and to eliminate duplication

a) Task Groups may be created as a result of Coordination Group priorities or an initiative of the industry and/or laboratories or from a call for participation issued by the Operating Agent on behalf of the Steering Committee.

b) Task Groups are approved by the Steering Committee for a given task and shall have the following general features:

   1. A Task Group Chairman (TGC) chosen by the Task Group members with the approval of the Steering Committee. The Task Group Chairmen shall be selected primarily from industrial institutions. The Task Group Chairmen shall establish close contacts with the EuMaT Secretariat to ensure a good cooperation.

   2. The Task Group Chairmen shall attend the Steering Committee meetings in order to report to the Steering Committee and the Secretariat on the execution, difficulties and progress of their task. The Task Group Chairmen will not necessarily be voting members of the Steering Committee.

   3. Working procedures defined by the group itself as a function of the objectives and of the necessary resources characterizing the task. Such working procedures must be approved by the Steering Committee.

c) Participation in the Task Groups shall be open to any delegates who are from country organizations represented at the Steering Committee of EuMaT.

d) Organizations other than the undersigned parties (EU, Iceland, Liechtenstein, Norway, Switzerland and group of candidates for EU membership) of EuMaT multi-partner collaboration agreement may be invited to participate in tasks depending upon a vote of the Steering Committee. Such participation will be formalized by a case by case collaborative agreement for the task.

Article 7. Admission To And Withdrawal From EuMaT

a) Additional membership of the EuMaT shall be approved by the Steering Committee as laid out in Article 3.f of this agreement.

b) Any Party may withdraw from this Agreement at any time giving six months written notice to the Steering Committee.

Article 8. Contributions And Responsibilities

a) The parties agree to use all reasonable skill and care in carrying out their duties under this agreement. There will be no cash flow between the parties; however, each Party will allocate the proper funds for its activity in this EuMaT. This Article will change as a function of the evolution of the financial support of EuMaT.

b) Responsibilities of the Operating Agent.
In accordance with Article 4, the Operating Agent shall allocate its resources as necessary to ensure its functions as Operating Agent. It may also make additional efforts to execute the task programs by providing support for studies to be performed by organizations of the EU countries. The final contribution must be compatible with its existing resources for supporting EuMaT operations.

c) Contributions by parties belonging to the undersigned parties.
Parties participating directly shall contribute to the tasks covering individual costs of participation in the anticipated actions of these task groups, (such as required facilities, testing, computations, experts, evaluation tools, etc.)

d) Contributions by parties not belonging to the undersigned parties.
Institutions from countries which are not part of the EU, participating in specific tasks following specific agreements, shall cover their individual costs of participation and make contributions in kind. If such contributions in kind are not possible or not judged suitable or sufficient by the Steering Committee, they can be replaced by a cash flow. Cash will be redistributed by the Operating Agent to the share of the costs borne by the Task Group members involved. This redistribution will be approved by the Steering Committee.

Article 9. Information And Intellectual Property

a) This Article sets forth the provisions applicable to the publication, distribution, handling, protection and ownership of information and intellectual property relevant to and arising out of the tasks. Additional rules and procedures related thereto, where necessary, shall be adopted by the Steering Committee acting by vote in conformity with this Agreement.

b) The Parties who are signatories of a European Commission cost shared funded research program are asked to submit a final report of their work to EuMaT.

They are additionally invited to communicate their results to EuMaT for incorporation in European Standards activities. If such a transfer of information is acceptable then a clause to such effect should be introduced into the cost shared action contract.

c) Subject only to restrictions applying to patents, copyrights and proprietary information, the parties shall have the right to publish information arising from the tasks only after agreement given by the Steering Committee and the sponsors of the task.

d) For the purposes of this Article, proprietary information shall mean information acquired prior to, or outside of, the tasks of a confidential nature such as trade secrets and know-how (e.g. computer programs, design and test procedures and techniques, chemical composition of materials or manufacturing methods, processes, or treatments) which are appropriately marked, and provided that such information:

1. is not generally known or publicly available from other sources

2. has not previously been passed by the owner to others without obligation concerning its confidentiality

3. is not already in the possession of the recipient party without obligation concerning its confidentiality.

The parties shall take all necessary measures in accordance with this Article and the law of their respective countries to protect proprietary information provided to the Task Groups. It shall be the responsibility of the Party supplying proprietary information to identify the information as such and to ensure that it is appropriately marked.

e) Reports of all work performed under this Agreement and the results thereof, including studies, assessments, analyses, evaluations and other documentation shall be produced and compiled in a manner and format decided upon by the Steering Committee. Such reports shall be provided by the Operating Agent to the other parties for their own use.

f) The provisions of this Article shall survive termination of this agreement for a period of 5 years, if not decided otherwise by the Steering Committee.

Article 10. Liability

a) All parties shall use all reasonable skill and care in carrying out their duties under this agreement and shall be responsible for ensuring that the tasks are conducted in accordance with the applicable laws and regulations.

b) Each Party regards the other parties as free from all liability for any loss, damage or injury caused totally or partly by acts or omissions by itself or its subcontractors during the execution of the work carried out under this agreement.

c) Each Party is solely liable towards third parties for damages caused by it.

d) The European Commission will not answer for any possible consequences arising out of the use of the results of the work carried out under this agreement.

e) Any problem arising concerning liability shall be dealt with under the law of the country in which the event occurred.

Article 11. Legislative Regime

a) The collaboration is, and will be, only the result of the activities of a EuMaT of individual and separate legal entities and is not, and will not be, seen as the subject of an association as such under any law which will be applied to it.

b) Each Party shall use its best endeavors to facilitate the accomplishment of formalities involved in the movement of persons and the transfer of materials and equipment which shall be required for the implementation of the tasks.

Article 12. Applicable Law

This Agreement shall be governed by Belgian law, except as set forth in Article 10.e of this Agreement

Article 13. Resolution Of Disputes

a) Any dispute amongst the parties concerning the interpretation or application of this Agreement that is not settled by negotiation or other agreed mode of settlement shall be referred to a tribunal of three arbitrators set up according to the rules for conciliation and arbitration of the International Chamber of Commerce (ICC). The tribunal shall decide any such dispute by reference to the terms and conditions of this Agreement and any applicable laws and regulations. Its decision shall be final and binding on all parties concerned. Arbitration proceedings shall be held in English. Arbitration shall take place in Stockholm.

b) In the event of any dispute or disagreement arising over any technical matter relating to the execution of the tasks, the decision of the Steering Committee advised by the Operating Agent shall be final.

Article 14. Final Provisions

a) This agreement shall enter into force on <date> and shall remain in force for three years. It may be extended thereafter by the parties by a vote of the Steering Committee.

b) This agreement and its annexes may be amended at any time by the parties, to be approved by a vote of the Steering Committee. It is the intention of the EuMaT to evolve towards a more effective financial organization.

c) The original of this Agreement shall be deposited at premises of the Operating Agent and a certified copy thereof shall be furnished to each Party.

3.1. ATTACHMENTS

Attachment A: Preliminary list of members of the EuMaT High Level Advisory Board (Industry & Scientific) and the representatives of other TP's at EuMaT:

Nr.	Name	representing						
		Industry / position	European TP	Industry	Association	Politics	Nationality	Mirror platform
1.	Schütze	DECHEMA, Director Materials	SusChem		DECHEMA		D	D
2.			ESTEP					
3.	Siffert	Secretary EMRS/EMF			EMRS/EMF		EU	
4.	West-kämper	Director IPA	Manufuture	Production			D	
5.	Kurzyd-lowski	Deputy minister				Government, Poland	PL	
6.	Brockmeier	CEO EnBW Kraftwerke		Energy			D	
7.	Jones	CEO Alcan UK					UK	
8.	Miles	Deputy Director DTI				Government, UK	UK	
9.	Meneses		ESTP	(ESA)			EU	
10.	Falzetti	Inter. Affairs Deputy Manager CSM		Industrial R&D			IT	

(the above list is still under discussion of the high-level industry representatives)

Attachment B: Members of the EuMaT Steering Committee:

1. Dr. Eisele, BOSCH, Germany
2. Dr. Renner, BAYER Technologies, Germany
3. Dr. Maile, MPA, Germany

4. Prof. Basista, IPPT, Poland
5. Dr. Linsmeier, MPI Plasmaphysik, Germany
6. Prof. Bogaerts, Technologica, Belgium
7. Dr. Jovanovic, MPA Stuttgart
8. Prof. Kurzydlowski, Ministry of Science and Education, Poland
9. Dr. Schneider, Consultancy Services, Germany
10. Dr. Michael Heine, SGL Carbon Group

Confirmation and completion in due course.

Attachment C: EuMaT Representatives with other TP's:

1. EuMaT representative with the Technology Platform "Steel"
2. EuMaT representative with the Technology Platform "Aluminium"
3. EuMaT representative with the Technology Platform "Manufuture"
4. EuMaT representative with the Technology Platform "Industrial Safety"
5. EuMaT representative with the Technology Platform "Zero Emission"
6. EuMaT representative with the Technology Platform "Sustainable Chemistry"

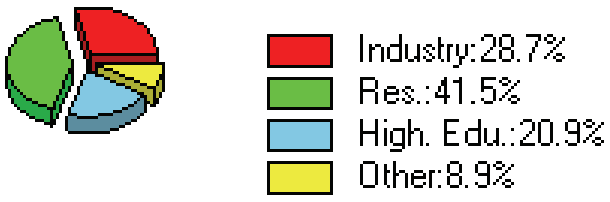
Attachment D: Ensuring Openness and Transparency of EuMaT

As all other European Technology Platforms (ETP's) EuMaT has also been requested to assure that the principles of openness and transparency have been implemented in practice by the platform. The following aspects are tackled and this attachment shows how the above principles are implemented in the organization of EuMaT:

- Openness
- Accountability
- Transparency

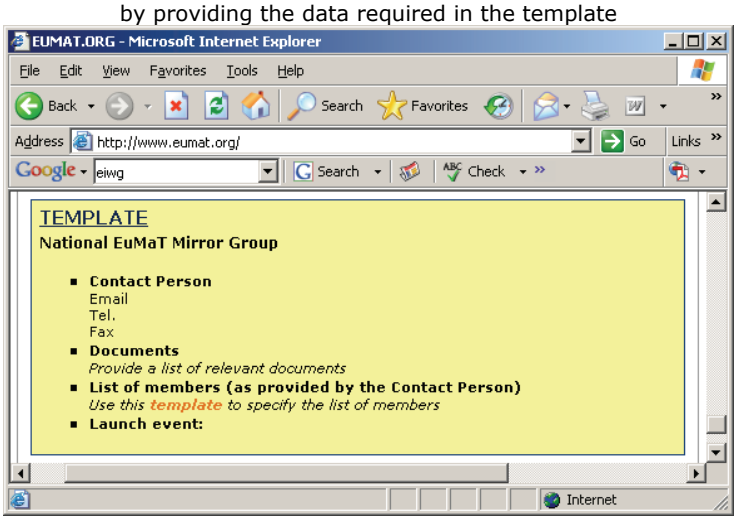
Openness is assured in the following way:

- Ensuring participation of all relevant stakeholders has been assured by means of sending the invitation to participate to more than 8,000 relevant addresses
- The kick-of meeting was organized in Brussels in order to facilitate coming of as many interested as possible and was attended by 135 participants
- For the "Editing Group" for the SRA all the registered members have been invited and 19 have remained as permanent members
- Each new version of SRA is put for comments to all the members (currently, March 2006, **433** members, out of which **72** 'core' partners)



- Other stakeholders are also be actively involved in the platform (including SME's, end-users and civil society) by means of professional organizations (e.g. DGM)

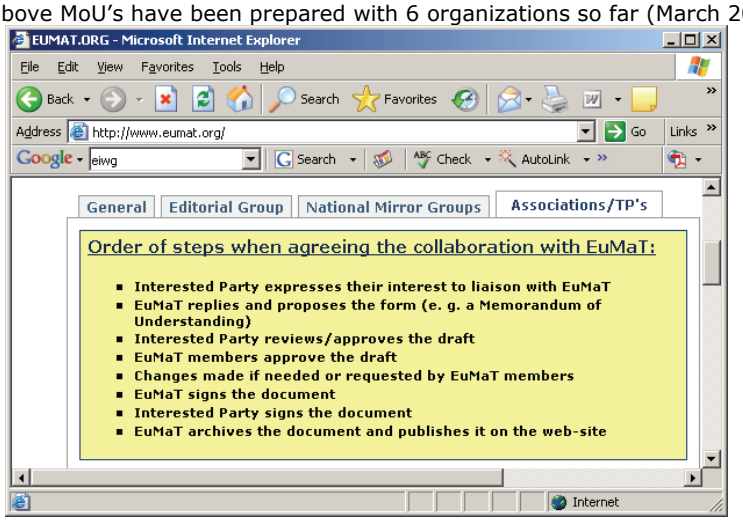
- National stakeholders are also be actively involved in the platform by the national platforms (currently covering 11 European countries) and were the new national groups can join EuMaT by providing the data required in the template



- As can be seen from the Attachment D of these Terms of Reference ("EuMaT Representatives with other TP's - status of Nov. 2005") a person has been dedicated from the side of EuMaT as responsible for liaison with other TP's.

- In addition a standard template for the MoU (Memorandum of Understanding) has been developed and used for liaison (see Attachment F)

  - The above MoU's have been prepared with 6 organizations so far (March 2006)



Accountability is assured in the following way:

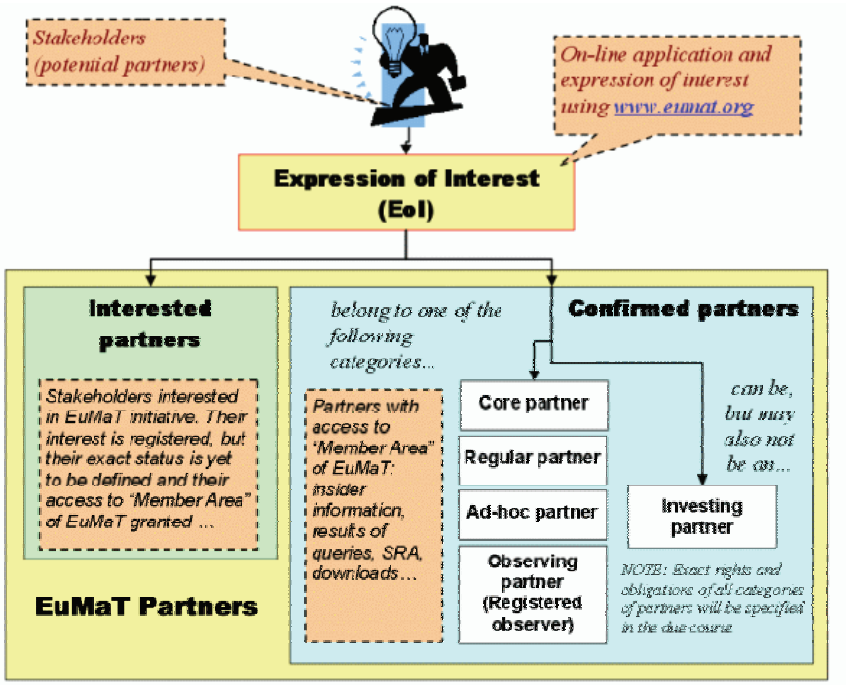
- The Terms of Reference of EuMaT provide the basic rules and responsibilities within the platform. Currently they are in the draft phase, i.e. can be still modified until the final constitution, but they nevertheless assure the representativeness of the governing board and provide the principles of rotation of its membership (see Article 3).

- All the activities of the Steering Committee, Advisory Board, Operating agent and, if founded in the future, the Business Operating Agent are subdue to the monitoring the measures of the platform, like, e.g.: logging of all meetings, logging of all official e-mails, logging and recording of the membership status and similar measures.

Transparency is assured in the following way:

- Virtually everything going on in EuMaT passes through the EuMaT web page: new members joining the group, new national platforms, new activities, meetings, documents drafted, … all this is not only post-factum placed on the web, it happens on the web, i.e. the page itself is used to produce these EuMaT deliverables.

- The above information is made available according to the participation level of each EuMaT member, all corresponding to the explanation given on the page:



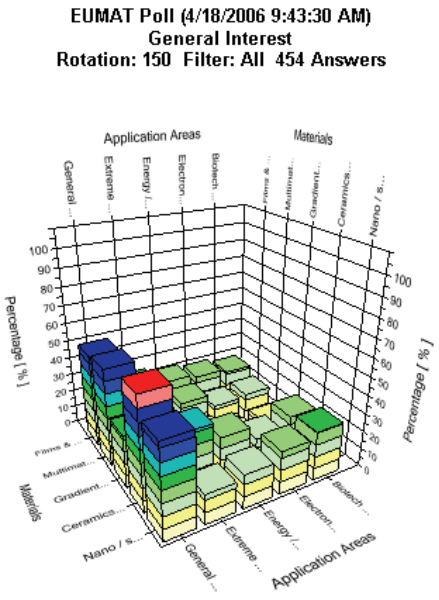
Annex III: Summary of interests in EuMaT and comments regarding the partners' wishes at the moment of joining EuMaT

Interests of EuMaT stakeholders gathered through the inquiry on the EuMaT webpage are summarized below (status of 18.04.2006, number of entries: 454).

General Interest - **All**

Priorities (in percentage, multiple selections over rows and columns allowed):

Materials >> Applied for:	Nano / small-scale / bioinspired	Ceramics & Composites / Polymeric	Gradient / Tunable / Selfhealing	Multimaterial (hybrid) systems	Films & Coatings
General engineering / Multifunctional	51.32	61.67	29.3	54.41	52.2
Extreme conditions	16.74	35.9	16.52	22.69	28.85
Energy / Power / Cryo	19.16	26.65	13.44	23.57	26.21
Electronics / Photonic / Microdevices	24.23	18.72	6.17	15.86	24.23
Biotech / Medicine / Eco	27.75	24.89	9.47	17.18	22.03



Horizontal Issues:

☐ Normalized?

Material Modelling	55.73%
Manufacturing / fabrication related material technologies (e.g. bonding, brazing, welding...)	64.54%
Material testing, characterization & qualification	75.99%
Impacts, risks, reliability & lifecycle	45.59%
Material data management, selection & optimization systems	33.92%
Pre-normative work, standardization	23.13%
Int. collaboration, education, technology transfer	68.72%

General Interest - **Industry**

Priorities (in percentage, multiple selections over rows and columns allowed):

Materials >> Applied for:	Nano / small-scale / bioinspired	Ceramics & Composites / Polymeric	Gradient / Tunable / Selfhealing	Multimaterial (hybrid) systems	Films & Coatings
General engineering / Multifunctional	50	60.17	32.2	58.47	50
Extreme conditions	17.8	34.75	13.56	24.58	33.9
Energy / Power / Cryo	21.19	27.12	13.56	23.73	28.81
Electronics / Photonic / Microdevices	20.34	15.25	6.78	11.02	17.8
Biotech / Medicine / Eco	16.95	11.86	5.08	11.02	13.56

EUMAT Poll (4/18/2006 9:43:30 AM)
General Interest
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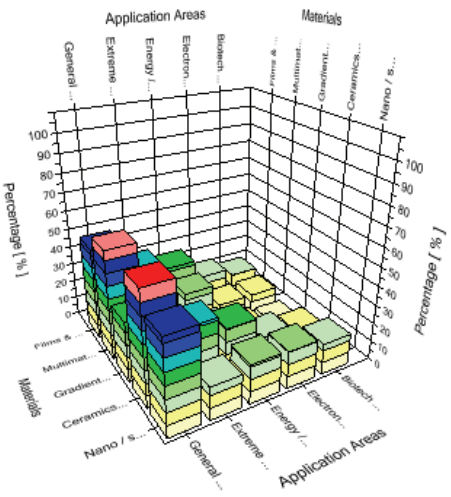

Horizontal Issues:

☐ Normalized?

Material Modelling	53.39%
Manufacturing / fabrication related material technologies (e.g. bonding, brazing, welding...)	77.12%
Material testing, characterization & qualification	71.19%
Impacts, risks, reliability & lifecycle	55.93%
Material data management, selection & optimization systems	42.37%
Pre-normative work, standardization	23.73%
Int. collaboration, education, technology transfer	57.63%

General Interest **– Core**

Priorities (in percentage, multiple selections over rows and columns allowed):

Materials >> Applied for:	Nano / small-scale / bioinspired	Ceramics & Composites / Polymeric	Gradient / Tunable / Selfhealing	Multimaterial (hybrid) systems	Films & Coatings
General engineering / Multifunctional	52.56	71.79	29.49	67.95	55.13
Extreme conditions	21.79	50	21.79	30.77	39.74
Energy / Power / Cryo	28.21	33.33	16.67	30.77	38.46
Electronics / Photonic / Microdevices	23.08	24.36	2.56	11.54	25.64
Biotech / Medicine / Eco	24.36	21.79	7.69	14.1	24.36

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General Interest
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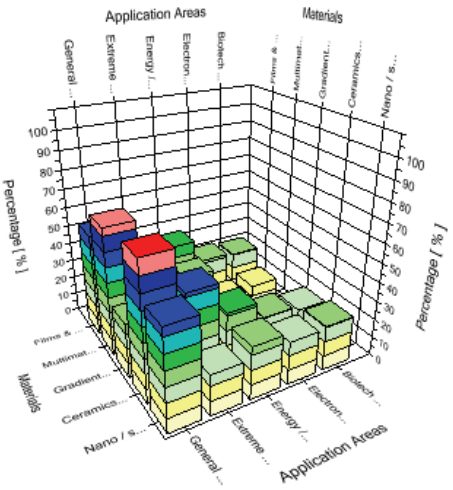

Horizontal Issues:

☐ Normalized?

Material Modelling	60.26%
Manufacturing / fabrication related material technologies (e.g. bonding, brazing, welding...)	76.92%
Material testing, characterization & qualification	85.9%
Impacts, risks, reliability & lifecycle	56.41%
Material data management, selection & optimization systems	41.03%
Pre-normative work, standardization	26.92%
Int. collaboration, education, technology transfer	66.67%

Future Plans – **All**

Priorities (in percentage, multiple selections over rows and columns allowed):

Materials >> Applied for:	Nano / small-scale / bioinspired	Ceramics & Composites / Polymeric	Gradient / Tunable / Selfhealing	Multimaterial (hybrid) systems	Films & Coatings
General engineering / Multifunctional	53.96	55.95	31.06	54.41	49.12
Extreme conditions	22.25	31.94	15.86	23.79	29.3
Energy / Power / Cryo	21.81	28.63	14.1	23.57	27.09
Electronics / Photonic / Microdevices	26.87	19.82	6.39	17.4	25.11
Biotech / Medicine / Eco	29.52	22.25	7.93	17.62	24.23

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Future plans
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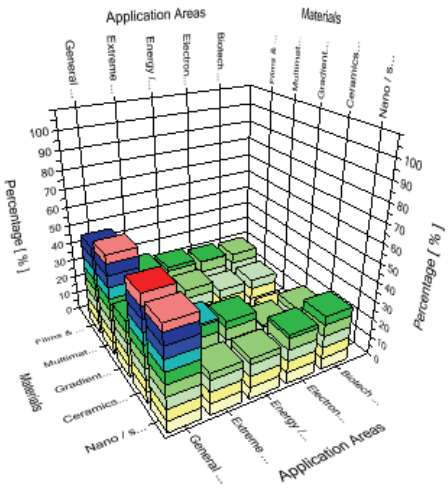

Horizontal Issues:

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Material Modelling	61.23%
Manufacturing / fabrication related material technologies (e.g. bonding, brazing, welding...)	63.66%
Material testing, characterization & qualification	75.55%
Impacts, risks, reliability & lifecycle	47.8%
Material data management, selection & optimization systems	34.36%
Pre-normative work, standardization	27.75%
Int. collaboration, education, technology transfer	65.86%

Future Plans – **Industry**

Priorities (in percentage, multiple selections over rows and columns allowed):

Materials >> Applied for:	Nano / small-scale / bioinspired	Ceramics & Composites / Polymeric	Gradient / Tunable / Selfhealing	Multimaterial (hybrid) systems	Films & Coatings
General engineering / Multifunctional	49.15	55.08	34.75	55.08	46.61
Extreme conditions	24.58	33.05	17.8	27.97	33.05
Energy / Power / Cryo	23.73	27.12	12.71	22.03	28.81
Electronics / Photonic / Microdevices	21.19	16.1	6.78	16.95	19.49
Biotech / Medicine / Eco	14.41	11.02	5.93	12.71	16.1

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Future plans
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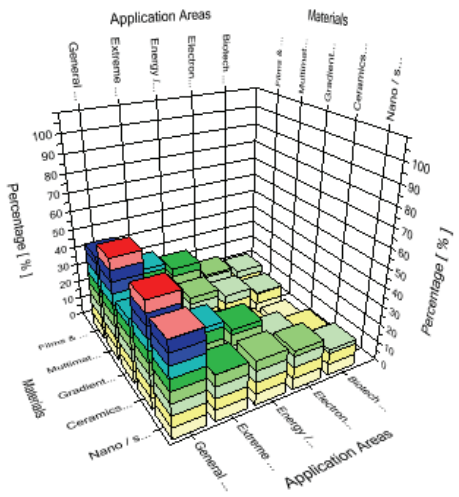

Horizontal Issues:

☐ Normalized?

Material Modelling	58.47%
Manufacturing / fabrication related material technologies (e.g. bonding, brazing, welding...)	77.12%
Material testing, characterization & qualification	72.88%
Impacts, risks, reliability & lifecycle	60.17%
Material data management, selection & optimization systems	43.22%
Pre-normative work, standardization	24.58%
Int. collaboration, education, technology transfer	54.24%

Future Plans – **Core**

Priorities (in percentage, multiple selections over rows and columns allowed):

Materials >> Applied for:	Nano / small-scale / bioinspired	Ceramics & Composites / Polymeric	Gradient / Tunable / Selfhealing	Multimaterial (hybrid) systems	Films & Coatings
General engineering / Multifunctional	56.41	65.38	34.62	70.51	46.15
Extreme conditions	32.05	46.15	25.64	34.62	41.03
Energy / Power / Cryo	30.77	43.59	19.23	33.33	34.62
Electronics / Photonic / Microdevices	25.64	26.92	8.97	20.51	24.36
Biotech / Medicine / Eco	32.05	26.92	7.69	21.79	24.36

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Future plans
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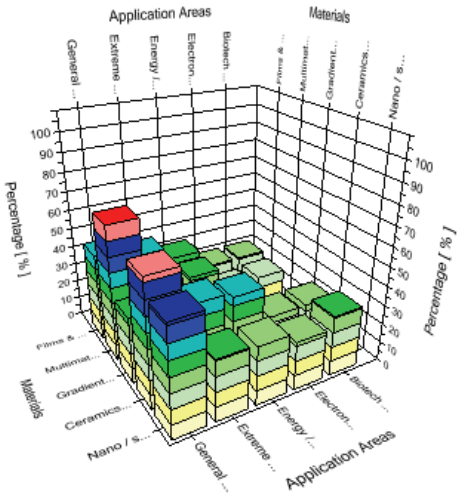

Horizontal Issues:

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Material Modelling	73.08%
Manufacturing / fabrication related material technologies (e.g. bonding, brazing, welding...)	73.08%
Material testing, characterization & qualification	88.46%
Impacts, risks, reliability & lifecycle	61.54%
Material data management, selection & optimization systems	50%
Pre-normative work, standardization	38.46%
Int. collaboration, education, technology transfer	67.95%

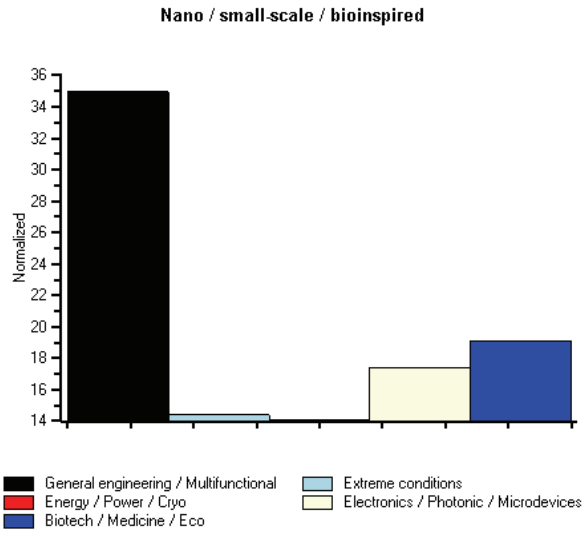
General Interest **- All**

Single Areas

Technology Area / Materials: Nano / small-scale / bioinspired

Display: Normalized

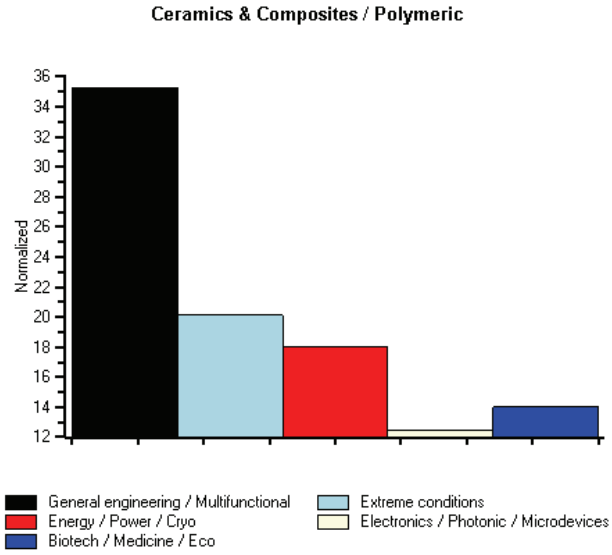
Applications >> Material:	General engineering / Multifunctional	Extreme conditions	Energy / Power / Cryo	Electronics / Photonic / Microdevices	Biotech / Medicine / Eco
Nano / small-scale / bioinspired	34.95	14.41	14.12	17.4	19.12



Technology Area / Materials: Ceramics & Composites / Polymeric

Display: Normalized

Applications >> Material:	General engineering / Multifunctional	Extreme conditions	Energy / Power / Cryo	Electronics / Photonic / Microdevices	Biotech / Medicine / Eco
Ceramics & Composites / Polymeric	35.28	20.14	18.06	12.5	14.03



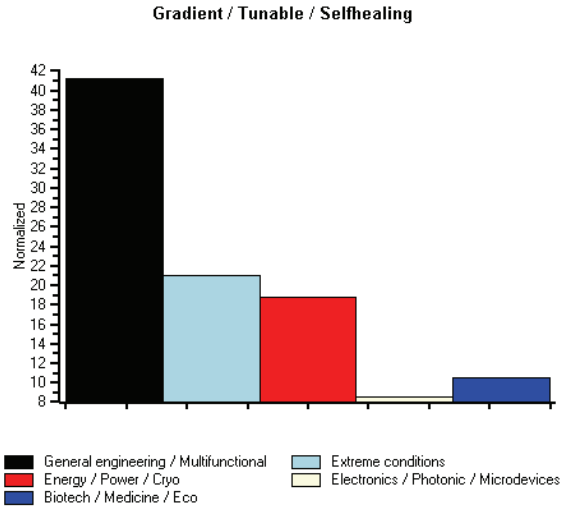
Technology Area / Materials

Gradient / Tunable / Selfhealing

Display

Normalized

Applications >> Material:	General engineering / Multifunctional	Extreme conditions	Energy / Power / Cryo	Electronics / Photonic / Microdevices	Biotech / Medicine / Eco
Gradient / Tunable / Selfhealing	41.23	21.05	18.71	8.48	10.53



Selected comments regarding the partners' wishes at the moment of joining EuMaT

Expressions of interest from EuMaT stakeholders gathered through the inquiry on the EuMaT webpage are listed below.

Nr.	Company	Country	EuMaT Member	Particular Interests
1.	AB Mikroelektronik GmbH	Austria	Wilczek	Automotive electronic will need in the future almost more components/ systems for underhood applications with high thermal stability. Because of the ban of lead by legislation soldering processes and solder materials became more critical to fulfill demands to quality and long term behavior. A new solder technology was investigated in EFSOT (GROWTH FP5 GIRD- CT-2002- 00838) program. The investigations result show weak properties of lead-free tin/ silver/ copper alloys at elevated temperatures which have been determined to be a possible replacement. The consortium considered that it will be necessary to continue with a new project with the task to develop new solder alloys using nanotechnologies to form controlled shapes of grain structures. Automotive business is one of the core markets in EC and the amount of electronics in cars will increase. If there is no solution for high temperature resistant interconnection technologies strong limitations are abided.
2.	ABAMOTOR Energía	Spain	Zabala	TEKNIKER informed us about this new initiative in the VII Framework program and TEKNIKER will represent us in the kick off meeting. ABAMOTOR Energía is a SME manufacturer of engines, gensets and motopums. The objective of the company is to reduce friction losses, corrosion, reduce emissions in engines. We are interested in materials resistant to wear and high temperatures, renewable fuels, hydrogen, biodegradable oils, reduction of noise, vibrations, etc. In design we are interested also in modeling tools, and new materials increasing the weight/strength resistance.
3.	Acciona Infraestructuras	Spain	Grávalos	Our main areas of interest focused in: 1. Advanced materials, 2. Information and Communication Technologies (ITC) applied to construction and engineering processes, 3. New and improved construction procedures, 4. Energy efficiency of buildings, 5. Environment and quality, 6. Underground construction, 7. Nanotechnology. In the area of advanced materials, the department concentrates on high performance concrete and fiber reinforced polymers. In the area of nanotechnology, we work to create materials with improved mechanical properties and to develop new functionalities in the construction sector. We are also working in other areas related to some of your material task groups like modeling, production, characterization etc.
4.	Adam Opel AG	Germany	Bender	I am interested in advanced materials. If new materials will be developed to improve the strength of existing components then I am very interested to join as a regular partner.
5.	AG der Dillinger Huettenwerke	Germany	Haralamb	Development and production mode of advanced compound materials including steel
6.	AICIA - Andalusian Association for Research and Industrial Cooperation	Spain	Paris	Research Group of Elasticity and Strength of Materials at AICIA has almost twenty years experience in theoretical, numerical and experimental analysis of composites and welded joints. In particular, at present moment we are very active in characterization of new composite materials for the aeronautical industry and in qualification of new structural components made from composites for this industry (including A380 development). With reference to composites, we would like to be active in development of damage mechanisms based failure criteria and new methodologies and techniques for characterization of composites and adhesively bonded joints involving composites. With reference to welded joints we would like to be active in development of new methodologies and techniques for prediction of stresses and deformations of these

Nr.	Company	Country	EuMaT Member	Particular Interests
				joints and of the behavior of these joints in presence of fatigue.
7.	AIJU	Spain	MARTÍNEZ-GARCÍA	We are interested in the development of new polymeric materials and formulations, and their characterization. Also in the dissemination and transference of knowledge and application to the companies, as we have more than 500 associated companies of plastic processors, toy manufacturers, mould makers, etc.
8.	AIMEN	Spain	Pérez	AIMEN is interested in contributing to the definition of the SRA and co-operate in R&D projects with European impact, especially in the following fields: welding, laser processing, characterization, surface & heat treatment, coatings.
9.	AIN	Spain	Rodriguez	Surfaces and interfaces of materials play a major role in the properties and functionalities of components, devices and tools. Particular attention will be paid to new methods of structuring and functionalizing thin layers at nanometric level in order to achieve new developments in the fields of optics, photonics, biocompatibility, medical diagnosis, as well as tribological and anti-corrosion behavior
10.	Alma Mater - University of Bologna	Italy	Scandola	We are actively involved in the development of: (1) Sub-micrometric electrospun polymer fibers for smart materials applications, (2) Nanostructured organic-inorganic (polymer-ceramic) hybrids, (3) Fully biodegradable (bio-recyclable) polymer-natural fiber composites for automotive and environmental applications, (4) Bio-resorbable polymeric materials for medical applications, (5) Environmentally friendly polymeric materials from renewable resources
11.	ALSTOM Power Ltd	Switzerland	Reigl	High temperature materials creep LCF HCF Ni base materials, steels Remark: In the following tables of interest etc, I could not find steels and Ni base materials, but I have to select s.th. to be able submit my data. Therefore I selected coatings, even when I am not interested in it presently.
12.	ALSTOM Power Ltd	Switzerland	Jung	Interests in testing and qualification of metallic high temperature materials and coatings (metallic and ceramic)
13.	ALSTOM Power Ltd	United Kingdom	Bullough	We have a strong interest in materials technologies for power generation, materials testing, databases and exchange. The EuMaT Platform sounds a good idea, although there is already industry bodies that cover the fields mentioned above. After further consultation, we may be interested to be involved more deeply.
14.	ALSTOM Power Ltd	United Kingdom	Vanstone	I am interested in materials technologies for more efficient steam turbines (high temperature materials and low temperature materials).
15.	APTL-CPERI-CERTH	Greece	Tousimi	The Aerosol and Particle Technology Laboratory (APTL) is part of the Chemical Process Engineering Research Institiute of the Centre for Research and Technology - Hellas. Research in the APTL is organized in the following areas: Nanoparticle and catalyst technologies, Solar-based hydrogen technologies, Emission control technologies for mobile and stationary sources, Particle and gas sensors and Computer simulation of aerosol and particulate processes. Concerning the materials aspect we are mostly interested in materials and related techniques for catalysts (automotive, environmental), sensors, fillers, pigments, composites, porous, nano materials, as well as for methods of manufacturing materials, such as Aerosol Spray Pyrolysis, SHS, LPSHS and mechanochemistry.
16.	ARC Leichtmetallkompetenzzentrum Ranshofen GmbH	Austria	Söllhinger	The ARC Leichtmetallkompetenzzentrum Ranshofen GmbH (LKR) is a non university research and development company with a strong focus on materials research in Austria. The process chain at LKR begins with the simulation of work procedures, continues with alloy development and processing, and ends with the manufacturing of prototypes, materials testing and characterization. Finally, the recycling process

Nr.	Company	Country	EuMaT Member	Particular Interests
				leads the chain back to its start. Our work is according to the slogan. "From the material to the component system" for aluminium and magnesium alloy. A new LKR activity is the Project "ALWS". LKR is the project leader for an Austrian light weight project called "Austrian Light Weight Structures (ALWS)."Sustainable Development of Light Weight Multi Material Structures" The main target of the project is to develop light weight multi material structures for different industrial needs. (transports, buildings, sports, electronics, robotics etc.) Characterization of materials under extreme environment, SME-oriented service
17.	Aristotle University of Thessaloniki	Greece	Kalogirou	Active participation in the 7th FP as coordinator of GRMAGNET, the Greek Network of Magnetism and Magnetic Materials
18.	ASTER Cons.p.A	Italy	Bonaretti	ASTER is core coordinator of HI-MECH. The Hi-mech District is intended to be an international research and innovation pole of excellence, specialized in the hi-tech mechanics, designed to attract economic and scientific resources to increase competitiveness, development, technical, industrial and economic skills within the regional territory. The creation of the Hi-mech District is a strategy developed by the Emilia-Romagna Region to strengthen the dynamics of the Regional manufacturing system concerning applied research, precompetitive development and innovation activities aimed at the enhancement of the technological content of manufacturing and at the development of the knowledge economy. The district architecture envisages the setting up of a network of laboratories working in three technological areas: 1) Design technologies 2) Materials and surfaces 3) Mechatronics and automation And in specific research areas, such as: Simulation and integrated design Noise and vibrations Sensors, actuators and automation systems for mechanical industry Mechatronics for mechanical industry Controlled atmosphere technologies, products and processes Surfaces and Coatings for Advanced Mechanics and Nanomechanics Nano-manufacturing Materials and processes for mechanical design Hi-Mech operating tools will be the so-called net-lab, i.e. Networked Laboratories that collect and share the best skills in the research areas and that contribute to the development of a critical mass around these areas, to achieve a degree of excellence in industrial research and to effectively transfer technology.
19.	ATECA	France	Delverdier	As partner in KMM-NoE program I will be interested to join EuMaT consortium. We are manufacturing innovative materials as Hollow Sphere and Metallic Felt.
20.	Atena Engineering GmbH	Germany	Buchheim	to be informed about the planned projects and interested in supporting activities as project co-ordination and project management and to pick up information of the international projects and to manage the information and communication between the stakeholders, as well as the support in submitting projects, writing reports, publications, to transfer the know how in international conferences, seminars, meetings.
21.	AVANZARE Innovacion Tecnologica	Spain	Gomez	Multifunctional materials for their use is extreme conditions for the industry: -Aeronautic -Space -Defense -Automotive Nanomaterials for their use in: -Electronics/Devices Biomaterials for their use in: -Medicine -Alternative for the surface finishing industry -Clean Factory (metal industry)
22.	BAM Federal Institute for Materials Research and Testing	Germany	Mueller	I like to contribute with my group in connecting reliability assessment of diagnostic methods to risk assessment and life time management of new materials and technologies
23.	BASF AG	Germany	Kessenich	As members of the working group for the European Technology Platform - Sustainable Chemistry (ETP-SC) and group member of BASFs Nanotechnology spokesman Prof. Iden, we would like to actively join the EuMaT initiative as observing partner.

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24.	BASF AG	Germany	Gomez	I am interested in looking for synergies between the EuMaT and the European Technology Platform for Sustainable Chemistry
25.	Bay Zoltán Institute for Materials Science and Technology	Hungary	Kálmán	research and development of different materials and material testing and characterization
26.	Bayer Technology Services GmbH	Germany	Renner	New materials... Standardization Reliability & Safety
27.	Bioforsk	Norway	Joner	Safe development and commercial exploitation of nanomaterials depend on a favorable view among citizens, and nanotechnology should avoid the pitfall that has hampered GMOs. To obtain this, the environmental fate and associated risks must be evaluated in a close collaboration between researchers in material technologies and environmental sciences and ecotoxicology. The present EoI aims at bridging the gap between these disciplines and informing the public of possible risks and actions that will reduce any such risk (waste treatment, recycling etc.). Any such environmental risk assessment must also take into consideration the benefits that a technology provides.
28.	C3M	Slovenia	Rodic	Our SME company can strongly contribute to the EuMaT initiative. In the last decade C3M has participated in 14 EU projects in the scope of FP5, BRITE/EURAM, EUREKA, COST, etc. Currently C3M participates in four FP6 projects related to materials and technologies.
29.	CADLM	France	Zarka	High Quality Low Cost Materials It is necessary to design materials to fit each purpose (multidisplinary, multilevel modeling, optimization of the formulation and the process)
30.	Cardiff University	United Kingdom	Borodich	I am interested in development of contacts with colleagues involved in modeling modern coatings at related phenomena at nano-scale
31.	CATT Innovation Management	Austria	Ruhmer	CATT is the official representative of the region of Upper Austria in supporting researchers and companies doing national and international R&D-projects. Therefore we are interested in getting information from you. We also can provide you with information from our partners in the area of engineering materials.
32.	CEA	France	SCHUSTER	I am responsible for new material programs and especially nanomaterials for energy, environment and health applications. I am also the future coordinator of the NANOSAFE 2 Integrated Project for "Safe Production and Use of Nanomaterials". My Idea is to make a strong link between this international project (Europe, US, China) and the EuMaT Platform. I could make a presentation of this initiative on November 29th. We are involved in a number of 6 FP projects concerning advanced materials: Extremat, Napolyde, Foremost, Charpan, Asterix, Smart, Nanosafe 2, Ionmet, and Nanohybrid...
33.	CEFIC	Belgium	Mours	I am the SusChem coordinator and as thus interested in possible collaboration/cooperation between EuMaT and SusChm
34.	CEIT	Spain	Gil Sevillano	CEIT is very interested in participating in this platform as a member of the core group. It has proven experience in nanostructured materials (ceramic nanopowders and bulk nanostructured metals by SPD), SiC-based composites, MMCs, FGMs, thin-films (nanolaminates), self-passivating carbon-based materials (fusion application) and ultra high strength steels, among others. Added-value skills of the Department are a wide range of experimental facilities, both for materials processing and characterization, as well as a broad expertise in the mechanical modeling of materials (plasticity of small volumes and fracture). Furthermore, it posses large experience in European projects (BRITE-EuRam, CECA, CRAFT and

Nr.	Company	Country	EuMaT Member	Particular Interests
				PROFIT). Moreover, it is strongly involved in the ExtreMat IP of the FP6: CEIT coordinates one of the four ExtreMat subprojects and has a strong contribution in the manufacturing of self-passivating carbon-based materials and in the thermo-mechanical modeling of MMCs for heat sinks. Finally, we have contacted two possible Spanish industrial partners (SENER and REPSOL), who have shown interest in joining the platform.
35.	Center for Experimental Mechanics, University of Ljubljana	Slovenia	Emri	Mechanics of time dependent materials, adaptronics, multifunctional materials, innovative polymer technologies, effect of thermo-mechanical boundary conditions on polymer structure formation, structural polymers, designing with polymers and composites.
36.	Center for Supercomputing, University of Kragujevac	Serbia and Montenegro	Filipovic	We would like to offer our capabilities in area of multi-scale and large-scale computational simulation in area of bio and nano materials. Computer simulation and modeling have become powerful tools for understanding the structure and properties of a broad range of materials. Simulations, both atomistic and continuum, are playing an increasingly prominent role in materials science, chemistry, engineering, molecular biology, and nanotechnology
37.	Centre de Recherche Public Henri Tudor	Luxembourg	Gillé	active and passive vibration damping in composite materials
38.	Centre for Materials Science and Engineering (CMSE)/UGent	Belgium	Van der Burght	The Centre for Materials Science (CMSE) combines the broad expertise in Materials Science available in Ghent University. The CMSE is a coordinating organization of 14 departments in the Faculties of Engineering Science, Science, Pharmaceutical Science, Bio engineering science and Medicine working together at an interfaculty and multidisciplinary level. Among the activities of the CMSE are research in the field of materials science and the industrial applications for a large variety of materials, such as metals, (bio) polymers, ceramic materials, composites, textiles, materials linked to concrete, biomaterials, semiconductors, coatings, chemicals, wood and wood-based materials. Many members are or have been involved in EU projects under FP5 and FP6. CMSE is initiating a new European Network of Materials Research Centres. One of the objectives is to facilitate cooperation in interdisciplinary research, development and training amongst member centers - from fundamental research to innovative application - e.g. within FP7 projects. Therefore we are very interested in participating in EuMaT.
39.	Centro di Cultura per l'Ingegneria delle Materie Plastiche	Italy	CAMINO	Interest in the area of multifunctional polymer nanocomposites
40.	Centro Ricerche FIAT	Italy	Pullini	Project manager of Centro Ricerche FIAT's Micro & Nanotechnologies dept. My R&D interests are in the frame of Micro and Nanofabrication of artificial materials either for sensing or actuation purposes. My group's research activities are in the MST for automotive applications (mainly power train) and investigate the results fallouts in the space, robotic, energy and biomedical fields.
41.	Centro Sviluppo Materiali	Italy	Falzetti	To be active partner and contributing to the future EuMaT TPE activity. CSM has a long experience of international R&D policy in the frame of Commission (DG-RTD) activity, further to be active members in several other TPE (Steel, Aeronautic, Energy).
42.	CERAM	United Kingdom	MacLachlan	CERAM is an RTO working with a large number of companies in materials development. PowdermatriX is a UK government supported network in advanced ceramics, powdermetals, hardmetals and magnetic materials based at CERAM and with over 200 member organizations. PowdermatriX is part of the UK Materials Knowledge Transfer Network. I have selected Ad-hoc partner as I am interested in finding out about your activities and believe we could contribute views and research interests of a wide range of UK stake-holders in the materials

Nr.	Company	Country	EuMaT Member	Particular Interests
				sector. Depending on the nature of these activities, I could be interested in a more active role.
43.	CESI	Italy	de Nigris	My Department carries out R&D projects in the field of materials for electrical components and devices at national level and at European level (e.g. Alternatives SF6) My interest in R&D activities on materials will further develop in the near future because we are setting up specific projects on eco-compatible materials for electrical components and advanced materials for new electrical devices
44.	CETIM	France	DJEAPRA-GACHE	All the activities in EuMaT fit to the actual or strategic development of CETIM in terms of materials and related activities to French mechanical industry.
45.	Chalmers University of Technology	Sweden	Rychwalski	Multi-functional polymeric coatings with carbon nanotubes; we are interested and can offer so-far facilities, knowledge, experience, methods. We want to collaborate to develop technologies to laminate surfaces, paper, and textiles.
46.	CIDAUT		Branco	The main of CIDAUT (Research and Development Center in Transport & Energy) is to increase competitiveness and industrial development of companies operating mainly in the automotive and energy sectors, but also in the railway and aircraft sector, strengthening their industrial fabric by increasing their technological capabilities, allowing the development of new products and processes. CIDAUT's activities are mainly focused on safety, product and process design and development, and environment
47.	CIDETEC, Center for Electrochemical Technologies	Spain	García-Lecina	We are interested in actively joining the EuMaT initiative. Our expression of interest are: -electrodeposition -corrosion -characterization of materials (morphology, structure, tribological properties,...) -composites -nanostructures multifunctional -anodisation -international collaboration, education, and so on
48.	CIE Automotive	Spain	Loizaga	Actually we have research actions in this areas in our company and we are looking for collaborate with other partners to innovate in material, processes and engineering
49.	CIME-EPFL	Switzer-land	Stadelmann	Novel materials development will require advanced characterization, not only microstructural but also functional. As an electron microscope (EM) specialist, I do think that novel EM instrumental development and interpretation tools are necessary.
50.	CIMNE	Spain	Salomon	Modeling advanced materials: properties, behavior, simulation, life-time Fiber-based composites High strength materials Dissemination
51.	CISM (International Centre for Mechanics)	Italy	Schrefler	CISM is interested in participating actively to the platform and it could be available either for carrying out thematic research or for the dissemination of the results. It actually will host KMM-NoE summer schools.
52.	CLEPA	Belgium	Pellischek	Industrial Production, Multifunctional Material Mechatronics, Nan-materials
53.	Corning S.A.S	France	Prassas	Advanced ceramics, Membranes, Glass & Glass-Ceramics, Sol-Gel, Hybrids, Thermoelectric ceramics
54.	Cranfield University	United Kingdom	Oakey, Tirovic	High Temperature Materials Nanotechnology Composites. With long experience in material modeling and engineering applications (having both industrial and research background), my/our interests are in particular related to high performance friction pairs, brakes and clutches. Areas of interest are : - multiscale modeling (bulk-macro-micro/nano) - design optimization of components when applying novel materials - testing procedures - life cycle cost optimization and reduction

Nr.	Company	Country	EuMaT Member	Particular Interests
				of environmental impact
55.	CSGI	Italy	Rolli	We are a public research organization working since many years in nanomaterials development in cooperation with several EU partners. We can contribute with our strong network of relations and our knowledge in nanomaterials technologies focused on structural materials
56.	CSIC	Spain	MONTERO	I am interested on materials and nanostructured materials for space applications, particularly low-secondary emission, anti-multipactor coatings. Space charging problems of dielectric materials. Photoemission properties of dielectric materials. X-ray photoelectron spectroscopy. Infrared Spectroscopy.
57.	CTCV	Portugal	Sousa Correia	Promote the production and use of advanced materials and added value applications of classical materials, whenever possible, produced by near net shape production techniques
58.	CTT AVANMAT	Romania	Piticescu	CTT AVANMAT s the first Romanian Center accredited with support from Romanian Ministry of Education and Research to actively participate in innovation of the advanced metallic, ceramic and composite materials production (synthesis of nanopowders, processing of nanopowders, thin films by chemical methods, their applications as intelligent materials for sensors and biomaterials). The experts of the group were involved in more NATO, FP5 and FP6 projects and are interested in contributing to innovative projects in the frame of FP7.
59.	DaimlerChrysler Research and Technology	Germany	Dürr	Fatigue life prediction of advanced aluminium alloys under thermo-mechanical and combined thermo-mechanical and high-cycle fatigue loading. Role to be taken in EuMaT t.b.d.
60.	Darmstadt University of Technology	Germany	Berger	High temperature materials; modeling; material characterization; life prediction
61.	DECHEMA	Germany	Schütze	-High Temperature Materials (Ni-base, Fe- base, Intermetallics, Ceramics) - High Temperature Protective Coatings (including Thermal Barrier Coatings and Corrosion Protection) -Coatings for Protection at ambient and intermediate Temperatures based on Nano-tech Methods For all: Development, Characterization, Manufacturing Processes, Quality Assurance, Modeling
62.	Department of Structural and Transportation Engineering, Faculty of Engineering, University of Padua	Italy	Majorana	The Department of Structural and Transportation Engineering is interested in participating as "Academic Partner" in the "core group" through Professor Bernhard Schrefler and the Head of Department, Prof. Carmelo Majorana and Transportation Engineering
63.	Dept. of Soldi State Physyics	Hungary	Beke	nanotechnology, solid state reactions, thin films, multilayers, shape memory alloys, noise analysis in materials science
64.	Deutsche BP AG	Germany	Simon	Looking for new materials to improve the lifecycle\reliability of equipment
65.	DGM	Germany	Schepp, Schneider	We would like to introduce and extend our network. Advanced materials for power generation Advanced manufacturing processes Reliability, high yield manufacturing Materials data Coatings Metallic foams
66.	DGTec	France	BARET	DGTec is a French SME working in the field of nanomaterials. DGTec develops nanomaterials of various inorganic compositions. DGTec also works on the processes and equipments required to elaborate these nanomaterials at an industrial scale. Of course, DGTec has interest in the safety of the nanomaterials, as well as in the production scheme as in the integration into products by the end-users which are its customers. DGTec has interest in joining the EUMAT PLATEFORM in order to participate to the elaboration of the strategy and the programs related to the nanomaterials, their production processes and

Nr.	Company	Country	EuMaT Member	Particular Interests
				their safety. I would appreciate to become a member of the EUMAT board.
67.	Dipartimento di Chimica Applicata e Scienza dei Materiali	Italy	Franzoni	- Particulate polymer composites with tailored properties for application in mechanical and building engineering. - Advanced composite materials from industrial wastes and by-products. - Sulfur-based advanced particulate composites. - Polymer and sulfur composites ageing.
68.	DLR-German Aerospace Center	Germany	Aoki	Fiber Reinforced Materials, e.g. CFRP, CMC, etc.
69.	DTG - University of Padova	Italy	Bonollo	DTG (University of Padova) is strongly interested in the technologies related to light metals and alloys, and their composites. The main technologies of interest are those solidification-related (casting, foundry, welding, etc). In particular, it is considered fundamental the set up of numerical models of such processes and the implementation into these models of nano-scale and micro-scale correlation between structure and final properties of materials
70.	DUNAFERR Danube Ironworks Company Innovation Management	Hungary	Csepeli	The Innovation Management of DUNAFERR Danube Ironworks Company is interested in applied research in the areas af steel continuous casting, hot rolling, cold rolling, hot dip galvanizing etc.
71.	Dunarea de Jos Univer-sity of GALATI	Romania	Benea	We are interested on Advanced Engineering Materials and Technologies especially on Nano and Micro Materials with application in industry and health
72.	EADS CCR	France	CINQUIN, Petiot	Interest in organic composite materials with improved durability and low manufacturing cost. Material, Processes and Structure activities covering metallic material & processes, organic composite materials & processes, mechanical behavior laws, modeling & simulation
73.	EADS Deutschland GmbH	Germany	Dalle Donne	Research on light metals, high temperature alloys and ceramics, welding and manufacturing processes, testing and structural assessment
74.	Ecole Nationale des Ponts et Chaussées	France	Caron	LAMI carries out research into materials and identification, using experimentation and theoretical and numerical methods. It mainly targets applied research in the civil engineering and transport fields.
75.	Ege University	Turkey	Yildiz	Development of advanced composite materials
76.	Elsyca	Belgium	Deconinck	We have experience in designing high quality electrochemical processes and products: - all kind of plating - electroforming - electrochemical machining
77.	EMF	Belgium	Koch	Dear ladies and gentleman, As the EMF coordinator of the engi-neering file I would appreciate very much to be regularly up-dated on the EuMaT initiative. The EMF will nominate a representative for joining your activities soon. With kind regards Hardy Koch
78.	EMPA	Switzer-land	Weidenkaff	EMPA is interested in participating in EuMaT as platform for functional materials development.
79.	EnBW	Germany	Bareiss	New materials for power plants
80.	ENEA	Italy	Celino	Innovations come also from a deep knowledge of materials for everyday use and from the capacity to design new materials. High performance computing and grid technologies combined with modeling techniques allow scientists to work together saving time and money on modeling materials on time and length scales that are very near to the real ones. I am

Nr.	Company	Country	EuMaT Member	Particular Interests
				interested in joining European networks that develop modeling techniques and use advanced informatics tools in nanotechnologies.
81.	Enginsoft	Italy	Odorizzi	As an engineering company with specific experience on CAD and CAM techniques, the interest of Enginsoft is mainly devoted to the development and use of numerical models and codes for simulating manufacturing processes. Among these processes, the main interest is for foundry, welding, forging, injection molding, extrusion and forming.
82.	Enterprise Ireland	Ireland	Hughes	I am currently developing a national research agenda in Industrial Technologies in Ireland. I would welcome the opportunity to work with EuMaT on this development in order to put the Irish research priorities in to the EuMaT agenda and take the EuMaT agenda to Irish Industry.
83.	EPPSA	Belgium	Clerens	Since new materials are on key component to modern and better performing power plants, our members would like EPPSA to be actively involved in this EuMaT TP.
84.	ESA	Netherlands	Meneses	The European Space Agency is defining a strategy for possible participation in Technology Platforms with affinities with the space sector, further to proposing a Platform on Space Technology as indicated in the progress report on Technology Platforms from February 2005. We would be interested in following more closely progress on the Platform you are responsible for, possibly participating in the next meeting that you organize. If you could inform me, (Rui Meneses) of the schedule for you next meeting, and also include me in any announcements for future events concerning your Platform. For any questions or clarifications please feel free to contact me.
85.	ETeCH Management GmbH	Switzerland	Mayer	ETeCH is interested to invest in platform oriented technologies emerging from Universities. Since materials often generate form the basis of such technology platforms - we have a high interest in the developments of advanced materials
86.	EUROGIF	Belgium	Mazzucchelli	EUROGIF represents the oil and gas service and supply industry in Europe and has also been working on materials applications and developments for the oil and gas industry. With this respect, we believe that our participation to EuMaT TP could benefit both our organization and the TP, since our company members will be interested in actively participating
87.	European Aluminium Asssociation	Belgium	Leroy	As secretary of the EAA Education & Technical Committee, I am in charge of following/facilitating aluminium-related collaborative RTD/educational initiatives at European level. In this context, I will follow closely the development of your TP and will report to my members. If any input from the European aluminium Industry is needed, I can act as the "official" entry point.
88.	European Commission	Belgium	Becker	My interest is in the whole activity - not in a specific technical domain.
89.	European Commission	Belgium	Van Goethem	EC Scientific officer in charge of nuclear fission RTD projects sharing common interests with EUMAT
90.	European Commission	Belgium	Steininger	All aspects of material related to pressure equipment
91.	European Commission	Spain	Vallés	As Head of the Materials Unit of DG RTD of the European Commission I am very interested in being informed about all major developments in relation with Materials Research.
92.	European Technology Development	United Kingdom	SHIBLI	Our company ETD is particularly interested in new materials for power plant (boilers, steam and gas turbines) and petrochemical industry. Development of new materials and their behavior is of interest.

Nr.	Company	Country	EuMaT Member	Particular Interests
93.	ExxonMobil Chemical	United Kingdom	Winnik	Keen to understand nature and width of proposed programme.
94.	Faculdade de Engenharia da Universidade do Porto	Portugal	Ferreira	Interested in the development of new materials for mechanical components
95.	Faculty of Mechanical Engineering Belgrade	Serbia and Montene-gro	Petrovic	Advance design and modeling of aeronautical structures. Technologies developed for design, manufacture, and test such structures.
96.	FAURECIA	Germany	DUMAZET	Interest for new materials and associated manufacturing technologies devoted to the automotive industry and giving positive answers for industrial drivers (cost, weight, safety and end-life recycling)
97.	Fidia S.p.A.	Italy	Meo	Fidia is a world leader in the design of milling machine tools and numerical controls, deeply involved in research. Among our main areas of interest are: innovative materials for the building of machine tools, innovative materials to be machined for moulds/dies, maintenance and diagnostics, open and component-based architecture for the software of numerical controls...
98.	First Welding Company, Inc.	Slovakia	Cimbak	FWC is interested in participating in work of the task groups of EuMaT in the field of Manufacturing Technologies (welding and surface treatment using laser, electron beam and plasma) and Pre-normative Work and Standardization.
99.	Forschungszentrum Jülich	Germany	Schubert	- all kinds of structure materials, - all kinds of advanced materials and new - developments for advanced components in energy systems (mainly for fossil fired power stations, fuel cells, advanced nuclear reactors and fusion reactors)
100.	Forschungszentrum Karlsruhe GmbH	Germany	Anson	The programme nano and micro systems at the Forschungszentrum Karlsruhe covers a broad range of nano and microtechnology research and development. High on the agenda is the setting up of a nano-micro facility. The NanoMat network for nanomaterials is coordinated from the research centre. We are particularly interested in being members of EuMaT. We expect synergistic effects to arise from being more involved in a broader materials community comprising stakeholders from many different aspects of that community.
101.	Fraunhofer IFAM	Germany	Rota	The aims of EuMaT fit perfectly in our research strategy! One representative of our institution will attend the Brussels meet-ing.
102.	Fraunhofer Institut Werkstoff- und Strahltechnik IWS	Germany	Hopfe	Development advanced surface technologies (coating, etching, surface modification), atmospheric plasma processing
103.	Fraunhofer Institut Werkstoff- und Strahltechnik IWS	Germany	Brenner	interests: - design, development & qualification of advanced materials - advanced production, processing and manufacturing - material and component testing material selection and optimization
104.	Fraunhofer Institute for Surface Engineering and Thin Films IST	Germany	Gäbler	The Fraunhofer IST is one of the worldwide leading R&D institutions in thin-film coatings. We have a high interest to strengthen material research topics in the European research area. Therefore, we would like to participate in EuMaT and to contribute to the strategic work, especially in the task-group 'Thin/thick films & coatings'.
105.	Fraunhofer-Institut für Chemische Technologie ICT	Germany	Kolarik	The expertise of the high temperature materials group of Fraunhofer ICT is the investigation on corrosion, oxidation, stress formation and phase stability of materials subjected to high temperatures during their service, e.g. gas turbines and boilers in electric power generation, heat resistances, etc. The core approach is in situ investigation by high temperature X-

Nr.	Company	Country	EuMaT Member	Particular Interests
				ray diffraction complemented by field emission electron microscopy. The group's interest is to offer research work on characterization, testing and lifecycle assessment of high temperature material components. As Fraunhofer, it is the group's daily work to perform applied industrial research based on demands from practice.
106.	Fraunhofer-Institut für Werkstoffmechanik IWM	Germany	Hollstein	Advanced Modeling on all scales: Modeling of Materials, Processes and Component Behavior; Material and Component Testing; Reliability and Safety
107.	Fraunhofer-Institute for Laser Technology	Germany	Gillner	New materials for Micro Technology and Medical Technology with related manufacturing technologies
108.	Fraunhofer-Institute for Structural Durability and System Reliability LBF	Germany	Bein	Development of Road Maps, Foresight Studies, Strategic Research Agenda on Materials Bringing in expertise on multifunctional materials, intelligent material systems, light weight design, system reliability and structural durability Coordinator of the IP "Intelligent Materials for Active Noise Reduction - InMAR" Coordinator of the materials group within EARPA (European Automotive Research Partners Association)
109.	Fraunhofer-Institute IFAM Dresden	Germany	Weissgaerber	EOI in the field of materials science and technology (multifunctional materials, nanomaterials, composites...)
110.	Fundación Inasmet	Spain	Onate	Please refer to comments by Dr. Javier Goni from INASMET. INASMET is regarded by CDTI (Madrid) and Spanish Ministry of Industry as the leading Materials & Processes Technological Research Centre in Spain. Information concerning our role in Spain and the contacts with Spanish industry can be provided. We offer our active contribution for the successful organization and development of the EUMAT initiative, and in particular we are confident and prepared to coordinate the Spanish Technology Platform.
111.	Fundación Inasmet	Spain	Egizabal	Inasmet is a research centre focused on the field of materials and processes. it is one of the most important RTD performers in Spain in terms of participation in European projects and wishes to reinforce its position collaborating actively in the design and development of the proposed Technology Platform
112.	FZ Jülich, Project Managemant Juelich	Germany	Schumacher	I am coordinator of the EU SMART project. In SMART partners from the U.K., France, Germany and Slovakia are developing roadmaps and analyzing foresight studies to find out what the future of materials science might be. I would suggest a link exchange between our websites. You will find more information about SMART under: www.smart-ssa.net. Please let me know if you are interested. Regards, Gerd Schumacher
113.	GAIKER	Spain	Dios Peón	I am interesting to collaborate in project about organic Smart materials and active polymers. Currently I am the coordinator of ACTIMAT project developed by Research Groups and University of Basque Country, (Inasmet, Cidetec, Ikerlan ….in total 10 partners).
114.	GAIKER	Spain	Larrauri	GAIKER is active in Materials Research since 1985. Particularly in Plastics and Composite Materials, and has participated more than 60 EU Funded Projects up to now. In the present time, GAIKER is also the Coordinator of ACTIMAT Strategic Project where 10 Organizations (6 Technology Centres and 4 University Departments) from the Basque Country University and Mondragon University are joining efforts for research and development in the field of Active and Smart Materials. GAIKER is interested in actively joint EUMAT Initiative and to bring to this initiative the output and capabilities of the ACTIMAT Group.
115.	Galbraith Consulting Limited	United Kingdom	Galbraith	I regret I have other commitments on 29th November which I have been unable to rearrange. I am a strong believer and advocate of the use of advanced composites for structural purposes and was responsible for the first offshore use of high strength / high stiffness carbon fibers to reinforce a steel struc-

Nr.	Company	Country	EuMaT Member	Particular Interests
				ture.
116.	German Aerospace Center (DLR)	Germany	Schmidt	DLR tried to establish a network of excellence (NOE) within the 6th European framework programme with 60 European partners from university and industry. The overall topic was CMC/C/C-SiC/Ox/Ox materials and its applications. This materials class should be a topic in the 7th FRP. We have already got many EOIs from our partners to join common research projects. These EoIs could be a good data basis for the task group.
117.	German Aerospace Center (DLR)	Germany	Saruhan-Brings	Institute of Materials Research of DLR involved in several material-related research areas which makes most of your activity themes. Thus, I believe that our contribution would be a value for EuMaT and we would increase our contacts and get better organized within a network.
118.	GKSS	Germany	Dogan	Materials research in the field of energy and transportation is the main activity of the Institute. The work undertaken involves materials characterization, testing, assessment and structural integrity for component life. Specialization in weldments, joined structures, high-temperature behavior and materials for hydrogen storage technologies.
119.	Hardy Advanced Composites	United Kingdom	Skene	We are particularly interested in inclusion of nano technology in composite materials
120.	Helsinki University of Technology - TKK	Finland	Gasik	The laboratory of materials processing (MVT) activities are concentrated in fields of powder metallurgy and advanced materials processing, fuel cells and catalysts, FGMs, thermodynamic data bank and modeling, light alloys and intermetallic composites development, processes simulation (CFD, FEM, etc.), environment and recycling, etc. It is internationally recognized for its work on materials design, processing and evaluation. It has experience in several EU projects like materials thermodynamics (SCIENCE), hard metals (IMT-3), biomaterials (GROWTH), high-temperature corrosion (GROWTH) and advanced light alloys (FP6). The laboratory annual turnover is about 1 MEuro, of which 75% are contract research.
121.	Hydro Aluminium	Germany	Hirsch	I took part in the pre-meeting in Stuttgart, also as a representative of the EAA (European Aluminium Assoziation) / ETC committee, which initiates an "Aluminium Technology Platform" that could cooperate with EUMAT.
122.	HYDROMOD	Germany	Pfeiffer	HYDROMOD is interested in specific materials applicable for instrumentation, sensors, equipment and other temporary and permanent installations in marine, coastal and inland water environments. HYDROMOD can contribute to the EuMaT initiative and project by background experience on aquatic environments as well as to material in-situ testing (also in extreme environments as in polar and deep seas).
123.	I. T. P.	Spain	Ostolaza Zamora	1.- New materials and processes for High Temperature Applications; from research to industrialization 2.- New stressing & lifing methods 3.- Standardization of Materials & Processes; from specs. to supply chain and Material Data base management 4.- Process modeling 5.- Development of new NDT techniques
124.	IFAM	Germany	Wöstmann	The main interest is to meet experts with the same interests for further discussions.
125.	IFTR	Poland	Siemaszko	I am interested in EUMAT activities as the coordinator of Polish Technology Platforms and participant of KMM-NoE
126.	Impol d.d.	Slovenia	Kevorkijan	R&D and industrialization of light metals (Al, Mg, Li) and composites based on light metals

Nr.	Company	Country	EuMaT Member	Particular Interests
127.	IMR SAS	Slovakia	Dusza	Development of advanced materials, ceramic/ceramic, metal/ceramic composites, nanocomposites and coatings for functional and structural applications. Microstructure characterization and testing of advanced materials, reliability and life-time prediction.
128.	IMWF Universität Stuttgart	Germany	Schmauder	Multiscale materials modeling of composites (MMCs, coated materials, bimaterials) and interfaces on the macro, micro and nanoscale including dislocation as well as crystal plasticity based models.
129.	INCAR Instituto Nacional del Carbon, CSIC	Spain	Menéndez	The Institute has a research group specialized in C/C composites, with wide experience in preparation and characterization through European projects and collaborations with European and American aerospace Industries.
130.	INCAR Instituto Nacional del Carbon, CSIC	Spain	TORRECILLAS	I would be interested in participating in Group III; if needed I could lead or assist with the preparation of contents
131.	INCDIE ICPE-CA	Romania	Kappel	Our institute is oriented to material research and technology transfer. We are interested to line up our activities to the European objectives.
132.	Indesit Company	Italy	Polverini	I'm interested in advanced materials and technologies future trends, especially for applications in the household appliances area
133.	Industrias Alegre	Spain	Garcia	We are a company involved in the thermoplastic sector. We design the plastic the parts, we make the injection tools and we do inject the parts as well. We are very interested on new materials for injection machines.
134.	inegi	Portugal	Reis	Development of new materials plasticity models in the field of sheet metal forming
135.	INESCO Ingenieros	Spain	Cicero	We would like to participate in all those activities related with the security of materials, structural components and structures. Also on the research of the application of new materials to engineering.
136.	InnoMat e. V.	Germany	Leonhardt	fabrication (casting Ti, Al; production of composite materials with polymer, ceramic and metallic matrices; surface by thermal spraying and plasma technologies), modeling, characterization, research and development
137.	Institut de Soudure (IS)	France	Boucher	A wise initiative to promote the necessary research in material field in parallel to nano materials and technologies.
138.	Institut Químic de Sarrià (IQS)	Spain	Colominas	Functional Coatings and Materials Thin Films for hardness, wear corrosion, etc. Nanostructured surfaces
139.	Institute CNR di Tecnologie Avanzate per l'Energia	Italy	Staiti	Development of new composite materials based on nanostructured carbons and solid electrolytes to be used as electrodes together with solid electrolyte membranes in solid state super capacitor devices. These devices, which use solid materials, have higher level of safety, higher life-time and easier production process.
140.	Institute for Materials Science, Welding and Forming	Austria	Ghanimi	We are interested in research work in the field of joining (esp. welding) of advanced materials.
141.	Institute for Nuclear Research	Romania	Andrei	I am interested in ELECTROCHEMICAL SURFACE ENGINEERING OF ADVANCED MATERIALS AND APPLICATIONS FOR THE INTEGRITY ASSESSMENT AND RELIABILITY OF STRUCTURES
142.	Institute for Static and Dynamics of Aerospace	Germany	Deuble	Testing of new materials, Environmental Testing, Prediction and Simulation of Fatigue, Non-Destructive Testing,

Nr.	Company	Country	EuMaT Member	Particular Interests
	Structures / University of Stuttgart			Manufacturing procedures for composite materials, multi-axial testing, light-weight construction with composites
143.	Institute of Engineering Materials & Biomaterials, Silesian University of Technology	Poland	Sitek	The main interests are: materials design including: the one of metal, ceramic, polymer and composite materials also nanostructrual ones and the ones coated by thin coatings, gradient ones and achieved in PVD
144.	Institute of Lithuanian Scientific Society (ILSS)	Lithuania	Ulbikiene	ILSS is Centre of Excellence on Self-formation and Applications first of all in microelectronics, PV and FC areas. Self-formation as theoretical technology is suitable tool for generating application driven technological solutions. On nano scale Self-formation can be presented as wet nanotechnology capable to predict new structures for concrete applications. Our interest of participating in EuMaT work is to present and transfer knowledge available in our institution for solving problems formulated by EuMaT Platform.
145.	Institute of Materials and Machine Mechanics	Slovakia	Izdinsky	Our Institute has been involved in the development of metal matrix composites, metallic foams, intermetallics and thin coatings for 4 decades. We deliberately support any activity leading to the employment of these advanced materials in structural applications.
146.	Institute of Metals and technology	Slovenia	Jenko	Advanced metallic materials structural materials
147.	Institute of Nonferrous Metals	Poland	Woch	The Institute of Non-ferrous Metals (IMN) is the leading R&D unit in the Polish non-ferrous metal industry. The structure of IMN covers both: research departments as well as experimental plant for processing of metals. The activity of research departments is focused mainly on: soft magnetic amorphous and nanocrystalline alloys, metal powders and nanopowders, metallic and composite electric contacts, brazing alloys and functional, metal based, materials. Institute's Light Metal Division develops new aluminium based alloys for automotive industry.
148.	Institute of Structures & Advanced Materials	Greece	Diamantakos	Fiber-based composite materials. Aeronautical materials. Modeling of advanced materials and structures. Materials production technologies. Dissemination
149.	Instituto de Ciencia de Materiales de Sevilla (CSIC)	Spain	Agustin R.	We are interested in joining this initiative and collaborate with its implementation. Our scientific and technological interest focus on the development of new materials and processes in the field of the thin film and coatings. Optical and other functional thin films (magnetic, etc.), diffusion barrier and protection layers and coatings are the main topics of our expertise. Nanomaterials thin film composites are our more recent fields of interest. We also have interest in the development of new plasma processes and surface treatments of materials (e.g., atmospheric pressure plasmas, etc.). Our Institute is sponsored by both the CSIC (Spanish Research Council) and the Univ. of Sevilla and have activities in both research (fundamental and more application driven, this latter contracted with industries) and training activities. Therefore, our contribution could be at the two levels, research and training and education. We are open to any initiative in these two aspects.
150.	Instituto de Tecnología Cerámica	Spain	Arnaldo	We are very interested in this meeting because we are involved as partner in the Network of Excellence "Knowledge-based Multicomponent materials for Durable and Safe Performance".
151.	Instituto Superior Tecnico- Tecn. Univ. of Lisbon	Portugal	Salvador Fernandes	I would be very much interested in participating in R&D projects related with the development of new materials / new coatings.
152.	Instituto Tecnológico de Aragón	Spain	Jiménez-Caballero	We have been informed from one of our client companies about EuMaT and the November kick-off meeting. After visiting your web we consider EuMaT a highly interesting initiative and

Nr.	Company	Country	EuMaT Member	Particular Interests
				we would like to get additional information on activities and the different types of membership. A very brief description of our centre is included below, but we could provide you any additional information as required. The Institute of Technology of Aragón (ITA) is a technological centre created in 1985 by the Aragonese government in Spain. The centre has an objective to provide support to industrial companies for the development of RTD projects, acting as centre for technological transfer. In addition, the Institute makes available to companies, especially SME's, a number of technical services as mechanical and chemical testing, rapid prototyping or calibration. The Area of Mechanical Engineering and New Materials, it is the largest one of ITA, with 95 people (most of them high degree engineers) working in research and product development projects for industry in fields as advanced material modeling, reliability of automotive components, development of accelerated test methods for automotive components, or the design of mechanical components and systems using new materials. The Area includes large testing facilities and a Specific Centre for Elevator Industry with several testing towers.
153.	IPPT Institute of Fundamental Technological Research	Poland	Dolinski	Scientific interest: stochastic modeling of fatigue phenomena in multicomponent materials, reliability analysis of structures Cooperation with relevant industry
154.	IPPT Institute of Fundamental Technological Research	Poland	Basista	advanced engineering materials, in particular metal-ceramic composites, functionally graded materials, intermetallics
155.	IRMM - JRC - EC	Belgium	Roebben	My interest in EuMaT is to get informed about the priority research areas in materials engineering, so as to better define the priorities in our activity of production of certified reference materials.
156.	ISF - Welding and Joining Institute	Germany	Woeste	Research projects concerning - joining - materials - simulation - repair
157.	ISMEP/Supméca	France	Benjeddou	I would like to strengthen the research theme of "smart materials and their applications" as a new topic for EuMaT topics
158.	Italdesign-Giugiaro	Italy	Rodino	Interest in deployment of non-conventional materials and multi-material components related to vehicle architectures and structural design. Interest in nano-scale components for automotive applications.
159.	ITC sa	Greece	Loupis	Reliability of materials and processes. Quality control and testing processes and standards
160.	ITC-Instituto de Tecnología Cerámica	Spain	Rodriguez	I would like to take part in different discussion groups: - Discussion Group I: Setting up and operating the Technology Platform and Funding the TP - Discussion Group III: Scope of work: Methods and Technologies for Engineering Materials-Production, Testing, Characterization and Qualification. - Discussion Group IV: Horizontal issues-dissemination, standardization, education, impacts, risks and reliability. - Discussion Group V: Scope of work: Horizontal issues-Concerning of running/future projects, collaborations; national platforms: Spain, Poland, Germany.
161.	IWT Aachen	Germany	Langenberg	IWT is acting in materials research and transfer of research into practice. Within EUMAT initiative IWT will be interested in engineering application of metals and welding. Future application with respect steel constructions, pressure vessels, off shore, transportation and energy are of special interest. Opportunities to use results for implementation into standardization are important.
162.	Jönköping University	Sweden	Svensson	Research and education in the area of advanced cast materials for components in aluminium- magnesium and cast iron. One of the largest groups in Europe in this area. Casting innovation Centre, in Jönköping. Industry, R&D (Swedish Foundry

Nr.	Company	Country	EuMaT Member	Particular Interests
				Association) and Jönköping University. More than 30 research-ers. Material orientated research.
163.	Jozef Stefan Institute	Slovenia	Novak	Special interest in nano-structured materials, functionally graded materials, etc.
164.	K.U.Leuven	Belgium	Van Acker	The materials technology department of Vito has as mission to introduce and implement a sustainable use, processing and re-use of materials, by developing innovative technologies and offering specialized materials testing. This includes the development of advanced materials and their production technology on the one hand, and a continuous care for the sustainability of these materials and processes and their life cycle on the other hand. These activities fit very well with the EuMaT idea. Therefore, Vito's materials technology department is highly interested in jointly defining research priorities for the next generation of materials and processes.
165.	KEMA Nederland BV	Nether-lands	Van Vulpen	Materials for Power Generation Industry
166.	Kompetenzzentrum Neue Materialien Nordbayern GmbH	Germany	Faul	There are several initiatives in Europe dealing with material science & technology and it is of great interest, to get information from these networking activities and the potential topics of FP7
167.	Laboratory of Technology and Strength of Materials	Greece	Pantelakis	I am interested in actively joining the EuMaT initiative as a regular partner.
168.	LCC Engineering & Trading GmbH	Switzer-land	Glettig	In the "Internet Society" research information has very little value and travels quickly. In the global bazaar of research information only approx. 1% of research data/information/knowledge is converted in products and applications. As a result of that we do not develop new indus-tries and job opportunities for highly qualified people. Many European research organization researches for the research sake. Very few scientists realize that "value creation" should be the focus in their work. Potential "buyers" decide whether or not something is of "value". Creating knowledge for Professors as "buyers" is not ideal and will not solve the "European problem" In our fields of technology we are experimenting with new business models (concept Collaborative Network Organizations, Zaibatsu etc.) that merge researcher together with product developers to bring new technologies to the market faster. We also provide market research and project management.
169.	Liverpool John Moores University	United Kingdom	Ren	I am interested in research works on material modeling, development of foams or multilayered materials, new materials for biomedical applications, material characterizations
170.	LNEC	Portugal	Salta	Participation in research networks and workshops and to have information of new projects in the fields: sensors for degradation monitoring in reinforcing steel structures, development. -new coatings for metallic materials protection - Metals forum -nanotechnologies for building materials development
171.	M4 Technologies Ltd	United Kingdom	Archibald	I am involved in the 'eminate' centre which is a new initiative aimed at providing open access for industry to a suite of state-of-the-art fabrication and characterization equipment located in Nottingham, UK. 'eminate' focuses on the growth, synthesis and evaluation of micro and nano-structured materials and coatings, and is set to revolutionize and revitalize areas of traditional industrial strength across many sectors in particular pharmaceuticals, medical devices and engineering.
172.	Material Technology Institute	United States	Hodge	I can not attend the kick-off meeting but am interested in participation. Our association funds research to solve problems of mutual interest to the chemical process industry. We believe that much can be accomplished by working together around

Nr.	Company	Country	EuMaT Member	Particular Interests
				the world.
173.	Materials Engineering Research Laboratory Ltd (MERL)	United Kingdom	Harris	Will be attending the kick-off meeting in place of Dr Rod Martin who has already registered.
174.	Materials Engineering Research Laboratory Ltd (MERL)	United Kingdom	Martin	We are partners in KMM-NoE + EXTREMAT and led 3 materials related in FP5. Materials Engineering is the core business of MERL
175.	Max-Planck-Institut für Plasmaphysik	Germany	Linsmeier	Our primary interest is the representation of the partners within the ExtreMat IP in EuMaT.
176.	MBN Nanomaterialia SpA	Italy	Matteazzi	Nanomaterials in powders and bulk semi finished and finished shapes
177.	Metso Powdermet Oy	Finland	Liimatainen	Our company has an interest to influence via this organ and cooperation to European R&D investments on materials technology
178.	Mettler Toledo	Switzer-land	Tellenbach	Materials for transducers. Highest precision magnetic and elastic properties. Standards, directives around RHOS. Corrosion protection and coatings.
179.	MHEST	Slovenia	JENKO	as a representative of Slovenia in FP6 3rd priority - NMP (PC and NCP)
180.	Mining University Leoben/industrial liaison department	Austria	Kriszt	The Mining University Leoben is focusing on research and on higher education of advanced engineering materials and technologies. We are engaged in these topics in a comprehen-sive manner. Research area spread from materials design & modeling, development, characterization, manufacturing & processing, application to recycling and life cycle assessment. So we are interested in participating in the activities of EuMaT, aiming to join dynamic tasks groups as well as supporting horizontal issues.
181.	Mondragon Goi Eskola Politeknikoa	Spain	Aurrekoetxea	The overall research objective at Modragon Goi Eskola Politek-nikoa, MGEP, is to create the scientific base on which the next generation of fast-growing smart materials and structures field will be established. Smart materials and structures involve so many technically diverse fields that it is quite common for one field to completely misunderstand the state-of-the-art in other fields that is why a multidisciplinary research team composed by researchers of the Mechanical Engineering, Manufacturing, Electronics and Computational Departments is formed. The re-search team is organized around three interdisciplinary core competencies: 1. Smart Materials: Magnetorheologic fluids; hybrid active composites 2. Smart processes: On-line Control of Drawing and Blanking Processes and of Quality 3. Smart structure: Vibration control; impact and fatigue resistance improvement MGEP participates in the ACTIMAT consortium (www.actimat.org) supported by the Basque Government.
182.	MPA University of Stuttgart	Germany	Maile	Material Testing and Modeling Material Behavior under high loading rates; development, characterization and standardization of engineering materials and technologies
183.	MTS Consultants	Belgium	Van de leest	textiles: easy-clean/self-clean technology on natural and poly-meric fabrics sol-gel technology: surface modification and nanotechnology proton conducting membranes nanoparticles for photocatalytic applications
184.	MTU Aero Engine GmbH	Germany	Smarsly	1. Strategic Research Agenda 2. Dynamic Material Topic Cen-tered: Nanostructured materials, multimaterial systems, FGMs, films and coating, high temperature materials, materials for microdevices, catalytic materials 3. Modeling 4.Materials Production Technologies 5. Dissemination, 6 Collaboration
185.	National Council of	Italy	Prosperi	I'm interested in developing chemical-functional surfaces of

Nr.	Company	Country	EuMaT Member	Particular Interests
	Research			technologically important materials as Si and Si3N4
186.	National Hellenic Research Foundation	Greece	Cefalas	157-nm TECHNOLOGIES AND MATERIALS: Processing and fabrication of materials at 157 nm is superior to the use of laser light at longer wavelengths with major improvement of properties and functionality of different materials for a variety of applications: 1. Fabrication of DNA bio-chips with enhanced sensitivity (MICROPROTEIN project, 5th- GROWTH). Research will be focused on new bio-compatible polymers with improved functionality and processes. 2. Research for new polymers -towards the 30 nm node. (CRISPIES project, 5th IST- SOARING project, 5th IST). 3. Fabrication of nano-structured magnetic films and nano-dots with enhanced magnetic properties, (well defined structures-stochiometry). 4. Intermetallic alloys for hydrogen storage, (enhanced absorptivity of H by intermetallic alloy films fabricated by PLD at 157 nm).
187.	National Institute for Lasers, Plasma and Radiation Devices (NILPRP)	Romania	Alexandrescu	The activity of he Laboratory of Laser Photochemistry LLP) from NILPRP (Laboratory Head Dr. Ion Morjan) currently addresses nanostructured materials synthesis and characterization for foreseen applications such as catalysis magnetism, biomedicine etc. By employing the versatile and powerful laser pyrolysis, iron and carbon-based nanoparticles (iron carbides, gamma iron oxides, nanocarbons, fullerenes etc) and nanoforms (encapsulated nanoparticles, nanofibers, nanorods, nanotubes etc) as well as titanium oxide nanocomposites has been obtained. Recent efforts address silicon polymer embedded iron nanoparticles with high thermal stability. The applied characterization methods highlight new properties of these nanomaterials such as sensory, photocatalytic, magnetic, drug delivery, etc. Recent progresses are based on in-situ and ex-situ dispersion techniques of the prepared nanobodies. LLP Laboratory is highly interested to join as active partner European projects, European Networks and Technology Platforms in the frame of Nanomaterial science and applications.
188.	National Physical Laboratory	United Kingdom	Gee	We are engaged in many areas of advanced materials concerned with the development of measurement methods for the assessment of materials properties and long term performance.
189.	National R&D Institute for Welding and Material Testing	Romania	Farbas	Our institute is interested to participate in this project as partner. Our specific tasks will be established in the field of welding and material testing of the new materials.
190.	National Technical University of Athens (NTUA)	Greece	Charitidis	This is to certify our interest in participating to EuMaT on behalf of consortium of academic and industrial partners from Greece, which are active in research and development in surface protection of materials
191.	NCSR Demokritos	Greece	Vekinis	An excellent initiative to forge specific road-maps for the development of many materials-critical technologies. I am already involved in the ExtreMat IP and therefore I am fully in support of EuMaT!
192.	NEN	Netherlands	Stikvoort	pre-normative work and standardization dissemination dynamic material-topic-centered task groups
193.	NetComposites	United Kingdom	Bishop	This is an excellent initiative and we would like to have the opportunity to bring to the table our experience of materials technology foresight exercises and the broad composite materials industry
194.	New Metals and Chemicals Ltd.	United Kingdom	Buchgraber	Development and production of carbon fiber/carbon matrix composites Development and production of high performance insulation materials (polyimide foam honeycombs, silicone foams and silicone foam composites)
195.	NewRail	United Kingdom	Carruthers	NewRail works on the development and application of novel materials and processing technologies in the land transport sectors (rail, tram, bus, truck, trailer, etc.). NewRail also

Nr.	Company	Country	EuMaT Member	Particular Interests
				coordinated the Framework 5 thematic network, COMPOSIT (www.compositn.net), which examined the future use of composites in the transport sectors including the necessary research priorities. Hopefully the findings from COMPOSIT, as well as the developed network of researchers, designers, manufacturers and end-users from the European transport sectors, can provide a useful input to EuMaT.
196.	NNC Ltd	United Kingdom	Keenan	Derek Buckthorpe of NNC Ltd. is involved with the EXTREMAT, VHTR-IP and GCFR-STREP projects in the areas of materials science and technology.
197.	Norwegian University of Science and Technology	Norway	Stören	The EuMaT covers the core actives of our department as well as part of the University Focus Area; Materials Technology:, which are: - Multiscale, through process modeling and simulation from cradle to cradle (with aluminium and commodity plastics as special research activities) - Ecodesign as the "operational agent" for implementing the philosophy, principles and methods of industrial ecology in the design and development of materials, processes and products.
198.	NTPC Ltd.	India	Hirani	I am interested in residual life of materials & life extension of the materials being used in coal & gas fired power generation plants.
199.	Nuclear Research Institute Rez plc	Czech Republic	Vitoch	1) New proposals and projects in the area of development, qualification and testing of advanced materials (metals-plastic materials, non-metallic materials also) including their aging - Dr. Bohumil BARTONICEK, bob@ujv.cz, NRI Rez plc, Division of Integrity and Technical Engineering (DITE). 2) New proposals and projects in the area of development, qualification and testing of new materials for PbBi reactor (primary) coolant - Dr. Anna BROZOVA, bro@ujv.cz, NRI Rez plc, DITE.
200.	Nuclear Research Institute Rez plc	Czech Republic	Bartonicek	Engineering polymers, radiation resistant materials, metals-plastic, ageing simulation, life-time assessment, material testing, qualification, international cooperation. Testing lab for stability of non-metal materials in operation.
201.	NV Bekaert SA	Belgium	Sijnave	Bekaert seeks sustainable profitable growth based on its two core competencies: advanced metal transformation and advanced materials and coatings. Bekaert aims to consolidate its position as both market leader and technological leader in selected segments around the world. With its broad range of high technological products, systems and services, Bekaert offers high added value for its worldwide clientele. Based in Europe with its headquarters in Belgium, Bekaert generates sales of more than €2.5 billion, employing 17000 people in over 120 countries. Our main task group of interest is group III - Dynamic Material - Topic-Centered Task Group, with focus on nanostructured materials, multimaterial/hybrid systems, thin films and coatings, high strength and corrosion resistant materials.
202.	OCAS	Belgium	Hörzenberger	Development of high tech (coated) steel products for industrial applications is performed within Arcelor at the R&D centers in Belgium, therefore interest to be in the list of core partners (next to Arcelor France).
203.	ONERA	France	Khan	I am particularly interested both in the development and characterization of advanced materials, including high temperature materials (metallic, composite, and hybrid).We also have considerable interest in multifunctional materials, technologies etc., both from an experimental and modeling standpoint.
204.	Ove Arup & Partners Ltd	United Kingdom	Butcher	As design consultants, Arup have broad range of interests from building design, bridges and other civil engineering structures, vehicle design, medical products. Partners in FP6 Superlight Car programme.

Nr.	Company	Country	EuMaT Member	Particular Interests
205.	Oxford nanoScience	United Kingdom	Smith	I am a materials scientist, working in the area of the atomic scale characterization of advanced materials. Together with colleagues, I started an innovative high technology company (Oxford nanoScience Ltd.) which makes equipment for 3-D atomic scale microanalysis.
206.	PandA Europe	United Kingdom	Longford	New materials, processes and understanding are needed to ensure reliable interconnections can be achieved in future electronic systems. The need to develop new and advanced joining technologies, new materials and refined processes for this is now the single most important aspect that will determine a sustainable product in all areas of industry.
207.	Patria Aviation Oy Engines	Finland	Salonen	Repair and overhaul of gas turbine components (Hot section component). Using different methods (welding, Brazing, Thermal Spraying etc.).
208.	Paul Scherrer Institut	Switzerland	Van Swygenhoven	materials by structure modeling mechanical properties magnetic properties neutron and X-ray analysis methods
209.	Pera Innovation Ltd	United Kingdom	Kemp	I organize activities on behalf of UK government to benefit industry. EG ENGENEX event - environmentally aware vehicle engineering; also assist UK companies to participate in EU R&D, and other technology partnership activities. Experience of working at CEC, I would be interested in being a member of steering group type activities (professional background in light metals and composites for aero and auto)
210.	Pitesti University - Research Center for Advanced Materials	Romania	DUCU	We represent a national consortium in the field of surface engineering of advanced materials. We applied the project proposal in this field to the Romanian national programs "Research of Excellence" based on FP7 Technology Platforms. We are interested in Dynamic Task Groups (Thin/Thick films and coatings, Nanostructured materials, Catalytic materials, Tasting, Characterization and Qualification) and in Permanent Task Groups (Pre-Normative Work and standardization, Data systems)
211.	Plastal	Italy	Ferrarese	Development of polymeric blends based on nanoparticles and/or long glass fiber. Development of surface treatments with improved aesthetic properties and low environment impact. Mainly automotive sector.
212.	Politecnic University of Ancona	Italy	Manescu	We are interested in participating in different European level activities and projects - we can offer our expertise in the field of non-destructive material and bio-material testing. We use powerful and modern X-ray, synchrotron and neutron scattering techniques for the analysis: microtomography, small angle scattering, diffraction , etc.
213.	Politecnico di Milano	Italy	Redaelli	I am from the Dept of Bioengineering of the Politecnico di Milano, which is the largest Technical University in Italy, and I am writing on behalf of a group of colleagues. We would like to be involved in the area of Biomaterials. Our interests and possible contributions in this area are mainly in the technological area and include (functionalized) scaffolds, design and realization of drug delivery systems based on hydrogels and/or polymer/biopolymer blends, membranes for selective species transport, molecular imprinted materials, nano-particles, micro-particles for drug and targeted cell delivery, and modeling both at the nanoscale (molecular modeling/dynamics) and at the micro-scale (diffusion and permeability with CFD).
214.	Politecnico di Torino	Italy	Ferraris	Joining of ceramics and ceramic matrix composites together or to metals, their characterization, for applications in the fields of energy production (nuclear energy, SOFCs), aeronautics and aerospace, biomaterials and photonics.
215.	Politecnico di Torino	Italy	Belingardi	ACTIVITIES: material modeling, material characterization (static, fatigue and impact tests), international collaboration,

Nr.	Company	Country	EuMaT Member	Particular Interests
				education and technology transfer MATERIALS: metals, light-weight metals, and fiber reinforced composites, sandwich materials, cellular materials, adhesive bonding, and ceramic joining.
216.	Praxair Surfcae Technologies s.r.l.	Italy	Vita	we are interested in organic materials bound to modify surface energy by means of appropriate plastic/elastomer coating materials and that can outperform or improve performance given by standard materials like fluoropolymers or silicone-based polymers
217.	PyroGenesis SA	Greece	Vardavoulias	As Managing Director and Chief Technology Officer of PyroGenesis SA, I express the interest of our company to be a partner in the EuMaT initiative. PyroGenesis introduces new materials technologies into the Greek industrial market. Our specific interest is in Thermal Spray Technologies, Nanostructured powders and coatings, Sol-Gel Technology, Metal Injection Molding and Innovative electrolytic coatings
218.	Quantech ATZ	Spain	Neamtu	I am interested in developing industrial software for nonlinear numerical simulation of composite structures
219.	Rapra Technology Ltd	United Kingdom	Gaddes	Specific interest lies in Thermoplastic and Thermoplastic composites, Biopolymers
220.	Regional Government of Emilia-Romagna	Belgium	Piccinetti	Regional Government of Emilia-Romagna is strongly committed to nanotechnology and mechanical engineering
221.	REPSOL YPF	Spain	Jiménez Mateos	Inside of our business, there is a dedicated company (REPSOL YPF Lubricantes y Especialidades, S.A.) in our holding for which one of its business is specialties derived from our refining activity. Part of this products are carbonaceous materials, in which development as advanced materials we have been working intensively for more than 20 years in own projects and collaborative projects inside national and European frameworks. In fact, some of the core group members (as it is the case of Schunk) have been our partners in some of those projects. On the other hand, other company of the holding, Repsol Química S.A., which is that carrying out the petrochemical activity of the holding, has a large experience in the development of advance materials based mainly in polyolefins, and therefore is very interested in participating in this platform. In short, several areas of REPSOL YPF are involved in the development and production of advanced materials, and therefore are very important to us to participate in this platform through our R&D unit (Dirección de Tecnología).
222.	RESCOLL Technological Center of Materials	France	SIPOS	We work applied research in fields as polymers and adhesives, composites and surface treatment of aluminum (mainly for the aeronautic industry).
223.	RHI Refractories, R&D Leoben, Austria	Austria	Djuricic	I am interested to contribute on the shaping of the roadmap in this very important field (the progress in the engineering materials will determine entire progress in future society). I experienced research work in many European countries, Institutes, JRC and Industry in very wide area of the ceramic materials and nanomaterials.
224.	Robert Bosch GmbH	Germany	Köhne	I am interested in the lobby work of EuMaT concerning the EU.
225.	Rockfield Software Limited	United Kingdom	Dutko	The EuMaT initiative is in line of our current & future R&D and commercial activities in the area of development and application of software tools using Finite/Discrete Element Method
226.	Rolls-Royce Deutschland	Germany	Großmann	to be defined after the Kick-off Meeting
227.	Rolls-Royce plc	United	Small	Interested to find out how EuMaT develops. If relevant RR

Nr.	Company	Country	EuMaT Member	Particular Interests
		Kingdom		would look to fully join and participate.
228.	SAT TECNOLOGIA	Spain	Sanz	To build consortium for R&D project developing advanced Materials for industrial application on Automotive, Railway, Energy and Equipment
229.	Schunk Kohlenstofftechnik GmbH	Germany	Weiss	We are a manufacturer of fiber-reinforced materials for low and high temperature applications. Therefore, we have an ongoing interest in all activities dealing with research and development of composite structures for typical high-tech applications in industry, transportation, energy, and space applications. Furthermore, we are also supplier of high performance CVD-coatings based on different systems. Consequently, activities of oxidation resistant composite structures are one of the main interests for our company.
230.	SENER	Spain	VINALS	Engineering materials for aeronautical and space (this means, composites, nano materials ...).
231.	SGL CARBON	Germany	Fischer, Heine	Materials by structure Materials by application
232.	Shell Global Solutions B.V.	Nether-lands	Visser	Use of NDT inspection techniques in this areas
233.	Siemens AG	Belgium	Roelants	I am supporting a colleague from Corporate Technology who will actively participate because Siemens has interests in these research activities.
234.	Siemens AG	Germany	Lampenscherf	materials modeling, nanostructured materials, thick coatings (TBC), high temperature materials, composites; Nanomaterials Protective Coatings Ceramics for harsh environments Electronic ceramics Phosphors Material Modeling
235.	Siempelkamp Prüf- und Gutachtergesellschaft mbH	Germany	Joensson	Connection of experiences in the FGM development (personally) and cast iron modification (company) with experiences in testing of temperature and time depended material properties, esp. creep/fatigue behavior and experiences of weld characterization (company)
236.	Sika Services AG	Switzer-land	Burchardt	Joining Technology/Bonding Bonding is a cross functional technology for all application areas and materials
237.	Silesian University of Technology	Poland	Dobrzański	The main interests are: materials design including: the one of metal, ceramic, polymer and composite materials also nanostructrual ones and the ones coated by thin coatings, gradient ones and achieved in PVD
238.	SINTEF	Norway	Mo	SINTEF supports initiatives towards European Technology Plat-forms on materials science and technology, including functional and structural materials
239.	Slovak Academy of Sciences, Institute of Construction and Architecture	Slovakia	Sladek	We are interested in modeling of multifunction materials on macro and nano scale size. Modeling and numerical simulations of new composites and FGM´s, development of new finite elements for solution of multiphysical field problems (electro-thermo-structural) in the new materials.
240.	Somacis PCB Industries SpA	Italy	Di Gregorio	The R&D Dpt. of Somacis is mainly interested in: - polymers used for the realization of optical waveguides: acrylates, olefins, polycarbonate, epoxy, polyimides, etc... - New and innovative materials to be used as substrate for PCBs (more then FR4) - more in general: all innovative materials concerning innovation of process and innovation of product in the field of PCB production. Somacis R&D Dpt. is interested to take part as a partner in R&D projects within the VI & VII FP in the above mentioned issues.
241.	Stress Engineering Services (Europe)	United Kingdom	Brear	We are interested in building on our expertise on conventional materials to address these advanced materials and technolo-gies. Our particular expertise and interest is in the

Nr.	Company	Country	EuMaT Member	Particular Interests
	Limited			development of materials performance models compatible with risk/reliability based philosophies of asset management
242.	Sulzer Markets & Technology	Switzer-land	Haering	Technological trends in new materials, surface engineering and coating solutions
243.	Sulzer Metco	Switzer-land	Nicoll	Sulzer Metco is one of the largest companies in the world dealing with surface layers and coatings from PVD, plasma nitriding to all types of thermal spray. For the later we need new material concepts in order to develop new material processing routes and functional layers.
244.	SUPSI-DTI	Switzer-land	Ortona	high temperature ceramic materials ceramic matrix composites
245.	Tallinn University of Technology	Estonia	Kulu	Participation in R&D projects in the field of advanced materials and technologies, technology transfer.
246.	Technical University of Catalunya	Spain	Caner	We are a group of highly research oriented people in mechanics of materials at all levels of observation, from nano scale to micro scale and further on to macroscopic continuum scale. We have established track record in terms of international journal publications, as well as strong ties with research universities in the US. Thus we have the capability to interact with other research groups in EuMaT and as a result contribute to the evolution of efforts to improve the EU-funded research possibilities that we all can take part in.
247.	Technical University of Denmark	Denmark	Somers	I am interested in the EUMAT initiative in order to consider whether we would play an active role in the future.
248.	Technology Centre AS CR	Czech Republic	Fryček	I am preparing the study for the Council of R&D of Czech Republic about TP and I am taking part at emergent national chemical platform. NTP for EuMaT (or other name) should also arise. The initiative part for this is expected soon. Please let me know, if You support associated NTP's. Formerly, I am chemist (material engineering) with experiences of thin film growth (Si, SiC, oxides, organics).
249.	Tecnatom	Spain	Marcelles	Tecnatom interest in EuMaT initiative is mainly related with NDT, including material characterization, asset management, lifetime assessment and risk based/informed inspection and maintenance. The objective sectors of our work are (non-exclusively) power generation, petrochemical and transport, aircraft and train.
250.	TEKNIKER	Spain	Igartua	TEKNIKER is interested in the field of materials (light materials, nano, hybrid materials) , their manufacturing processes (coatings, castings,..), tribology and tribocorrosion applied to automotive, aeronautic, biological systems,. Modeling applied to simulation of the behavior of the components in real systems. TEKNIKER is participating in COST 532 Tribotechnology of engine and transmission components, and COST 533, biotribology and the Virtual Tribological Institute. TEKNIKER has a lot of contact with big as well as SMEs and has already sent information of this action to CIE Automotive in Spain and DaimlerChrysler from Germany. Since TEKNIKER has a lot of contact with SMEs (Keronite, Enginsoft, Magma, Abamotor...), further contacts will be made with SMEs to involve to this action.
251.	The Polish National Energy Conservation Agency	Poland	Wnuk	The Polish National Energy Conservation Agency (KAPE) actively acts as the governmental implementing body in the field of energy efficiency and renewable energy sources. KAPE provides expertise in the field as above and participates in R&D EU and national projects. Particular attention is paid on modern technologies implementation.
252.	ThyssenKrupp VDM	Germany	Hattendorf	High temperature materials, high strength, corrosion resistant materials, self -passivating materials

Nr.	Company	Country	EuMaT Member	Particular Interests
253.	Trodat GmbH	Austria	Gladysz	international collaboration
254.	TRW Automotive	Spain	Giménez	Light materials, New processes for light materials, New processes of behavior by virtual simulation ... all in Automotive, mainly linked with safety and comfort.
255.	TU Chemnitz, Institute of Composite Materials and Surface Technology	Germany	Mucha	Contributions as research performer (microstructural analytics, objectifying macroscopical performance, labor scale fabrication) in the fields of composite materials and coatings (Polymer-/Metal-/ Ceramic- matrix composites, applied Joining technology)
256.	TU Dresden (Dresden Univ. of Technology)	Germany	Gampe	participation in task group III, specific interest in: hybrid materials, high-temperature materials in addition task group IV and VI
257.	TUBITAK Marmara Research Center	Turkey	Baykara	As the leader of the Materials Institute of TUBITAK Marmara Research Center of Turkey, we would like to be a very active member within the platform in the following areas of materials technologies: Processing of advanced ceramics and composites; advanced functional coating techniques; advanced sensor materials; electronic materials and electromagnetic technologies; light materials, Al, Ti and Mg; precision casting, nanostructured materials and carbon technologies. We have been maintaining very close contact and collaboration with industry particularly SMEs.
258.	TURBOCOATING	Italy	Rizzi	Coating Developments and Surface treatments for Energy/aeronautical applications
259.	TURBOMECA	France	Dominique	Development of advanced materials and associated technologies for gas turbine engines.
260.	TWI Ltd	United Kingdom	Oakley	My organization is interested in advanced metals, ceramics, polymers and composites, and particularly the joining, structural integrity and NDT aspects of these materials.
261.	TWI Technology Centre (Wales) Ltd	United Kingdom	WALLACE	I am particularly interested in establishing R&D priorities in the specific area of material and component testing.
262.	UMICORE	Belgium	Vyncke	We are on the list of core group of industry stake holders
263.	Univ Politecnica Madrid	Spain	Guemes	Advanced composite materials: CFRP Light alloys Advanced processes: RTM, automation composites manufacturing.
264.	Universidad de Alicante	Spain	Louis	As director of the Instituto Universitario de Materiales de Alicante (IUMA) I strongly support this idea.
265.	Universidad Politecnica de Madrid	Spain	OCANA	Large experience in theoretical analysis and experimental characterization of high power/high intensity laser processing applications, principally welding and surface treatments. Special interest in micro fabrication techniques. The active involvement for participation as core partner can be considered in view of the technology transfer objectives of the home institution
266.	Università Politecnica delle Marche	Italy	Rustichelli	We are interested in participating in different European level activities in order to offer our knowledge in the field of non-destructive material and biomaterial testing.
267.	Universitat de Girona	Spain	Costa	Light-weight composite materials Modeling Damage and lifetime prediction Experimental testing of composite materials
268.	Universitat Politècnica de Catalunya	Spain	Anglada	Structural integrity and reliability of materials Fatigue of Materials Nanocomposites Surface engineering Mechanical characterization of surfaces and coatings etc.

Nr.	Company	Country	EuMaT Member	Particular Interests
269.	Universitat Rovira i Virgili	Spain	Siperstein	Our interest is in modeling thermodynamic and transport properties of materials, in different scales, ranging from atomistic, nano, and mesoscopic.
270.	Université Catholique de Louvain	Belgium	Proost	Being a member of a highly intensive research group, who has been actively involved in the EU 6th framework program, it has become clear that joining research efforts on a European level has become indispensable, both from the viewpoint of support as from scientific advancement and exchange.
271.	Université Libre de Bruxelles	Belgium	Geerts	I am interested to join EUMAT as coordinator of the NAIMO project funded under priority 3 of FP6. NAIMO is currently the largest research initiative in materials for organic electronics, i.e. more than 2000 PM and a budget of € 23000000. It aims at combining nanomaterials with nanofabrication. More at http://www.naimo-project.org/homepage/homepage.html
272.	University College Dublin	Ireland	Ivankovic	Behavior and failure of polymers and adhesives: Rapid crack propagation along pressurized plastic pipes. Process zone evolution in brittle fractures of polymers. Failure prediction of adhesively bonded joints. Bulk and cohesive zone characterization of polymers. Polymer processing and residual stresses. Blood flow in deforming arteries. Effects of blast impact on internal organs. Modeling of solid-fluid interaction problems. Development of FV method for structural and interdisciplinary applications.
273.	University College London	United Kingdom	Stoneham	Please note that I retire in 2005, so (even though my projects continue and I shall have Emeritus status) my personal involvement will be shorter term. My successor here will probably want to be involved, and I shall try to make this happen.
274.	University of Applied Sciences Aargau, North-western Switzerland	Switzerland	Hofmann	Dear Madams and Sirs The institute for informatics (ifi) works in the field of applied computes science with experience both in technical/scientific simulation and design of information systems. We are involved in projects in the 5. EU-FP, COST-actions (APOMAT: Automatic Process Optimization in Material Technology) and national research projects. Our main focus is in the field of application integration (AI) of technical/scientific applications into information systems for improved data management, ease of data accessibility and automated process flows.
275.	University of Aveiro	Portugal	Ferreira	I am involved in materials technologies and innovation, which are closely related to targets established for the EuMaT. I strongly believe that we could give an interesting contribute to increase the European competitiveness.
276.	University of Bologna	Italy	Berti	- New catalytic systems for the synthesis of terephthalate polyesters and BPA polycarbonate. - Chemical modification of polycondensates by reactive blending with functional monomers - Molecular and thermal characterization of blends and copolymers prepared by reactive blending of polycondensates - Synthesis, characterization and use of telechelic ionomers - Synthesis and characterization of sulfur containing polymers
277.	University of Bologna	Italy	Munna	I am interested in the EuMaT initiative, as the EU relations advisor for the University of Bologna, and my intention is to coordinate the effort of our University to contribute to the work of the Platform.
278.	University of Greenwich	United Kingdom	Pericleous	I am interested in the modeling of new materials and process routes, through the complete range of scales. Currently involved in FP6 IP IMPRESS project
279.	University of Heidelberg	Germany	Daubinet	I would like to attend the meeting on the 30th May to gain a better insight into the activities of EuMaT

Nr.	Company	Country	EuMaT Member	Particular Interests
280.	University of Hertfordshire	United Kingdom	Chrysanthou	I am mainly interested in advanced production, processing and manufacturing and materials testing. Member of KMM NoE.
281.	University of Miskolc	Hungary	Tisza	My department (Materials Science and Materials Processing Technologies) is interested in both materials science aspects and in various materials processing technologies, particularly in metal forming, heat treatment and welding. We have wide industrial cooperation in Hungary; we do scientific research in the above fields in various national and international projects, including EU 5 and 6 framework projects, NATO SfP and bilateral projects mainly with German, British and French institutions.
282.	University of Novi Sad	Serbia and Montenegro	Plancak	As a professor and researcher in the field of Metal Forming Technologies, I am very much interested in the proposed project. Special interests in the field of Material Production Technologies, Material Forming Technologies, Near Net shape forming, Tribology, Material properties, virtual prototyping. Participant in different national and international research projects (bilateral, FP6, WUS...).
283.	University of Santiago de Compostela	Spain	Fernández	Development of Biodegradable Synthetic Lubricants for refrigeration with CO2 based on their Thermo physical Properties in order to fulfill the Kyoto Protocol Biodegradable lubricants at extreme conditions Pressure equipment, High Pressures Modeling Thermodynamic and Transport Properties of materials Coatings Room Temperature Ionic liquids
284.	University of Sassari	Italy	Paroni	I am very much interested in the multiscale mechanical modeling of advanced materials.
285.	University of Southampton	United Kingdom	Starink	We in principle support EuMaT, but of course need to first assess what is actually going to come out of it. Areas of interest: Advanced Micro- and Nanostructural Materials Engineering Aerospace Materials Nanostructuring of Light Metals Composites Ship structures Electron microscopy MEMS Surface Engineering
286.	University of Vigo (Spain)	Spain	Martin	My field of interest is basically modeling of advanced materials and macro and micro scale simulation (including multiscale analysis, dynamical systems, hydrodynamic behaviors, pattern formation...). I would really like to be informed about the dynamic materials group future plans, interest and priorities. I am also interested in joining the EuMaT initiative though I do not know to what extend. I'd like to receive more information about what sort of collaboration is available for my research areas.
287.	Vienna University of Technology	Austria	Hellmich	I heard of EuMaT at the Kick-off meeting of KMM-NoE. If the research work we perform in the framework of KMM-NoE turns out to fit simultaneously in EuMaT, we would very much appreciate this. In order to find out, we would like to be kept informed.
288.	Vigo University	Spain	Garcia	I am working in modeling thermo physical properties such as, volumetric behavior, phase equilibriums, viscosity behavior of oils at several temperatures and pressures
289.	Vilnius University	Lithuania	Zukauskas	I am interested in materials research and applications of inorganic semiconductors (nitrides) and organic materials for advanced light-emitting devices. I represent a Lithuanian National Consortium "ORGELITA", which aims at building of an R&D cluster for organic optoelectronic in Lithuania.
290.	VITO	Belgium	Meneve	As a well-established research organization in the field of applied materials S&T, we wish, also by the participation in the EuMaT initiative, to continue our innovation role at the EU level.
291.	VTT Industrial Systems	Finland	Holmberg	- As a member of COST Materials Technical Committee I am interested in the advanced materials field broadly. - As a chair-

Nr.	Company	Country	EuMaT Member	Particular Interests
				man of COST 532 Tribology Action including 30 European countries I am especially interested in tribological materials and applications. - Special expertise: tribology, surface engineering, thin coatings, modeling of coated surfaces. - VTT is interested to contribute as a research partner in the above research fields.
292.	Warsaw University of Technology	Poland	Kurzydlowski	The coordination of research activities is needed especially in view of efficient transfer of new materials to diversified industrial recipients
293.	Willems & van den Wildenberg BV	Netherlands	van Hooff	Currently involved in - the preparation of a European Aluminium Technology Platform - development of a European Nanotechnology Roadmap - numerous EU RTD projects on (new) materials
294.	Wölfel Beratende Ingenieure GmbH + C.. KG	Germany	Friedmann	smart materials, FEM, Optimization, Testing, Health Monitoring, Risk Assessment, Material Data, Materials Characterization
295.	WTCM	Belgium	den Haaf	Machining of new materials for the automotive, aerospace industry