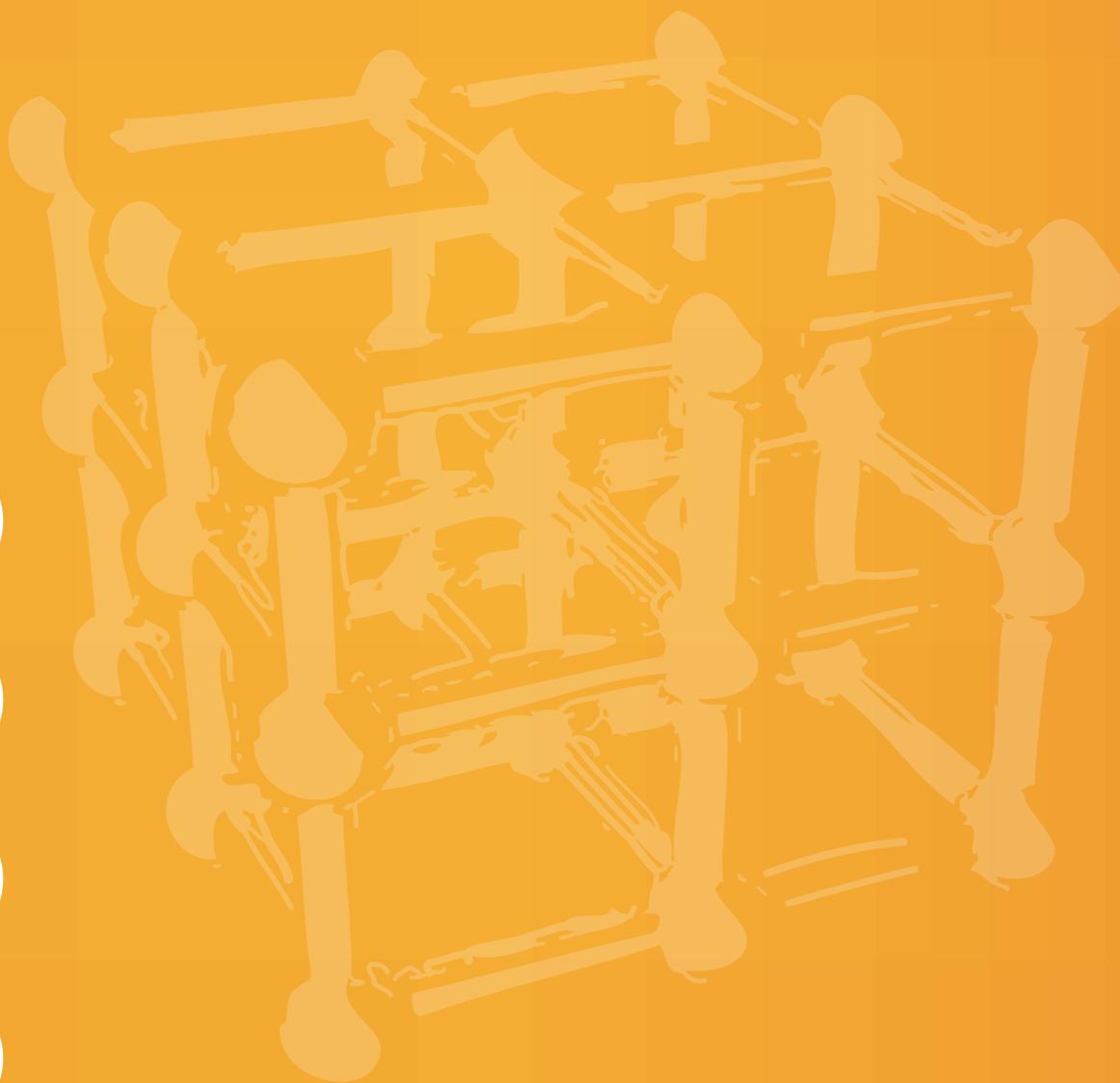


STRATEGIC RESEARCH AGENDA 2012



AUTOMATIVE



CONSTRUCTION



RAILWAYS

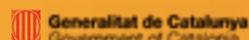


HEALTH
AND
BIOMATERIALS



AERONAUTICS

With the support of:



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One hundred Catalan public and private entities such as: companies, company associations, universities, research centers and TECNIO members that carry out R&D and Innovation in advanced high performance materials, have participated in the SRA. They are listed below.

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ABSTRACT

Connect-EU Materials brings together Catalan stakeholders in the materials sector to foster the Catalan participation in the 7th Framework Programme and in the future Horizon2020.

This document is the first Strategic Research Agenda (SRA) of the Group Connect-EU Materials and presents a common agenda for the technical research and innovation priorities related to materials needed to embark upon Catalan and European challenges in the transport, construction and health sectors.

This SRA provides decision makers with clear, integrated research and innovation priorities that are based on consistent system approach, and includes recommendations for future implementation.

MATER	GLS CONSORCIO DEL HORMIGÓN SL
MECANOTUBO SA	GONVARRI
MMM	GREA
MOL-MATRIC	GROBER
NEOS SURGERY	HIDROALUMINIO
PEGUFORM	HORMIPRESA
POLIURETANOS SA	HYDRO BUILDING SYSTEMS SL
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VILARDELL PURTI	MAPRO
XARMAE	

CONNECT-EU INITIATIVE

The Connect-EU Initiative was set up by Catalan industry and academia to promote Catalan participation in the European Seventh Framework Program. Connect-EU joins the main Catalan research actors in thematic groups to support their interests in European R&D funding Programs (The 7th Framework Programme, Horizon 2020, JTI, PPP, Eurostars, etc.).

ACC1Ó, the Agency which supports Catalan private sector competitiveness, and AGAUR, the Agency for Management of University and Research Grants, have supported the creation of 15 Connect-EU Groups aiming to gather R&D interests and needs from 15 different strategic sectors and position them towards EU programmes and policies. These 15 independent working groups integrated by all stakeholders (companies, clusters, universities, research centres) involved in scientific and technological sectors in Catalonia will be responsible for confronting this challenge.

The Connect-EU groups have been competitively evaluated by objective criteria of representativeness and impact in FP7. Their main functions are:

- Report generation of common thematic strategic agendas.
- Collaboration with NCPs.
- Representation at the European Technology Platforms
- Promotional Activities at the regional level
- Provide Evaluation Experts
- Participation in events at the regional and European level

1. CONNECT-EU MATERIALS

1.1 MATERIALS IN CATALONIA - SECTORS TO BE SUPPORTED

Materials technology influences the competitiveness of not just the material technology industry but practically all industrial sectors. Investments in materials provide opportunities to succeed in global markets and to create new spear head technologies and products. Catalan companies and academia are very aware of this. This is evidenced by the fact that the Materials NMP Programme is the third programme with most participation in Catalonia and includes an important level of private sector participation.

New materials technology solutions serve as a catalyst for other industries existing and enable the creation of technology for new innovations. The Group Connect-EU Materials focuses its interests in the application of high performance materials in the following 5 sectors:

- Automotive: The automotive industry has a very important role in the Catalan economy accounting for 10% of gross domestic product. It represents 40% of the Spanish automotive sales and generates 100.000 direct jobs, and 100.000 indirect jobs. 80% of produced vehicles and 60% of produced components are exported.
- Railways: With 150 companies based in Catalonia it represents 40% of Spanish production and 40% of Spanish employment in the sector (11.000). It has an annual turnover of approximately 1.000 million EUR.
- Aeronautics: It is a strategic sector for Catalonia and is supported by the Catalan Administration. It is mainly focused on the manufacture components. From 2000 until 2010, the aerospace turnover in Catalonia grew from 1% to 5% of the Spanish aerospace sector. Catalan participation in ESA programmes is around 9% of the Spanish participation.

- Health and biomaterials: It is considered a very strategic sector due to the leading edge medical sector in Catalonia. Manufacturers have moved to more customised and personalised product solutions. Catalan companies cover, mainly, the demand of dental applications but also work on bone regeneration, anti bacterial materials and drug release.
- Construction: There was a high growth of the sector during period 1998-2006, with 2,5 million people employed in the sector in Spain. Activity (public and private) has dramatically slowed down since the financial crisis. The sector is trying to capitalize through R+D and innovation.

A cross-disciplinary approach is taken at all times with regard to aspects such as the environment and energy related to materials.

1.2 SRA

This document is the first version of the Strategic Research Agenda of the Group Connect-EU Materials. It offers a global vision of the innovation and R&D needs of the Catalan entities that carry out research in advanced materials for each of the above mentioned 5 sectors.

1.3 PRELIMINARY ACTIVITIES

During the year 2011 the Group Connect-EU Materials has organised 6 workshops to identify the R&D and Innovation priorities from the participants of the Group to be included in the SRA.

It has also contributed to the public consultation on the Green Paper: Framework of European Funding for Research and Innovation (Horizon 2020) and the consultation on the ERA Framework: Areas of untapped potential for the development of the European Research Area (ERA).



2. MAIN INDUSTRIAL NEEDS AND RELATED R&D CHALLENGES

2.1 MATERIALS FOR AUTOMOTIVE SECTOR

The automotive industry is dedicated to responding to the mobility needs of individuals and those of society as a whole. It has to face a broad range of challenges including: the supply of energy and resources; global climate change and the environment; health and safety; and increased global competitiveness of the road transport industry leading to economic growth and high quality employment in Europe. The research and innovation in new advanced materials is crucial for the achievement of these objectives.

The Catalan companies cover the whole supply chain from the design of the vehicle to its manufacturing and testing.

This chapter presents an overview of the Group Connect-EU Materials' research and innovation priorities for each of the major societal needs, i.e. decarbonisation, reliability, safety and global competitiveness. The research and innovation priorities for addressing society's needs with respect to the future vehicles are categorised into the following four research and innovation areas:

1. Structural parts and Safety
2. Reducing energy consumption and recovery of energy
3. Propulsion systems powertrains and batteries
4. Efficiency and Comfort

These priorities are aligned with the priorities established by the European Technology Platform ERTRAC (European Road Transport Research Advisory Council) in its SRA 2010 and with the priorities of ESTEP (European Steel Technology Platform) and with Horizon2020 Challenges.

They are also aligned with the Research Plan 2010-2013 (PRI) developed by the Catalan Government

and aimed at promoting innovation projects for businesses.

In table 2.1.1 a list of priorities for the automotive sector is presented. It is also indicated for each of them, the suggested period of time in which the topics might be published in a call.

MATERIALS FOR AUTOMOTIVE SECTOR	SHORT TERM			MID TERM			LONG TERM			Keywords
	2012	2013	2014	2015	2016	2017	2018	2019	2020	
1. STRUCTURAL PARTS AND SAFETY										
THEME 1: New materials for car body shell and external panels										lightweight materials, UHSS, alloys, composite, hybrid
THEME 2: New tooling and forming and cutting operations										forming, drawing, cutting, coatings, tools, computer modelling, materials
THEME 3: Joining different materials										joining, aluminium, steel, composite, hybrids, welding, corrosion
THEME 4: Highly recyclable cars at a sensible cost										rational design, car concept, recyclable, environment, cost
THEME 5: Application of composite materials in structural and functional parts										composites, structural parts, functional parts, automotive, recycle, automation
THEME 6: Production of structural parts powder metallurgy techniques										powder metallurgy, structural parts, mechanical properties
THEME 7: Introduction of metallic foams for weight reduction										metallic, foams, machining, weigh reduction, automotive
THEME 8: High temperature alloys and plastics for engine applications										exhaust system, alloys, high temperature, thermal fatigue, corrosion
2. REDUCING ENERGY CONSUMPTION AND RECOVERY OF ENERGY										
THEME 1: Materials for waste heat recovery.										waste heat, recovery, electricity, thermoelectric, materials
3. PROPULSION SYSTEMS, POWERTRAINS AND BATTERIES										
THEME 1: Permanent magnets for electric vehicles.										permanent magnets, electric vehicles, motors
THEME 2: Lighter conductors based on copper alloys.										cooper, cables, weight
THEME 3: Safe and light battery systems with improved performance.										battery, weight, packaging, crash, isolation
THEME 4: High-energy density Supercapacitors										energy storage, supercapacitors, peak
THEME 5: Post Lithium-ion technologies.										battery, electric, vehicle, post Lithium-ion
THEME 6: New H2 and C1 economy and fuel cell use in electrical vehicle.										H2, C1, fuel cell, electric, vehicle, cathode, anode, materials
4. EFFICIENCY AND COMFORT										
THEME 1: New lighting systems for electrical vehicle.										lighting, electric, vehicle, LED, comfort
THEME 2: Smart window										window, thermal, infrared, energy

Table 2.1.1 List of priorities for the automotive sector

2.1.1 STRUCTURAL PARTS AND SAFETY

THEME 1: New materials for car body shell and external panels

Catalan automotive companies show a clear interest with short-term plans for the introduction of lightweight materials into body shell parts. Some of the companies of the automotive productive value chain already produce and develop specific parts in advanced lightweight materials.

However, substantial introduction of new lightweight parts is expected within the next few years. Weight reduction, reduced consumption and increased crashworthiness are the main drivers for the design and production for the vehicles of the future, with safety as the main backdrop.

Catalan companies and RTD performers foresee carrying out specific R&D on the application of lightweight materials, for instance Ultra High Strength Steels (UHSS), Al alloys, composite materials, etc in automobile construction. There is a clear need for **greater knowledge regarding the behaviour of these materials**, and also their **proper integration considering hybrid combinations**. This could lead to the development of new and more efficient and safer concepts of automobile structures for green vehicles.

Keywords: lightweight materials, UHSS, alloys, composite, hybrid

THEME 2: New tooling and forming and cutting operations

The substantial and effective **introduction of advanced materials** such as the ones previously mentioned depends not only on the nature of the material but also on the available technologies for transforming it. Catalan automotive companies show a clear interest for obtaining greater knowledge of the industrial processes. Operations such as **forming, drawing and cutting of these materials require further R&D**, in order to design productive technologies which are far more efficient. **The application and development of advanced coatings** for the tools may bring great advances in terms of durability and productivity. **Computer modelling of industrial processes is also very relevant.**

The development of more accurate and specific materials for tools and also the innovative development of new or improved operations will lead to an increase in productivity and in enhancing the quality of the final products (i.e. finer accuracy in the external panels of the car, etc.).

Keywords: forming, drawing, cutting, coatings, tools, computer modelling, materials

THEME 3: Joining dissimilar materials

Producing lighter and safer cars depends on the quality of the new materials to be adopted for body shell and external parts and the optimized design. Ensuring the **intimate and strong joining of the different parts** is a key issue to guarantying the integrity of the vehicle. Catalan companies identify a clear challenge regarding the **joining of different materials, for instance Al and Steel or composite hybrids. New joining or welding technologies should be developed** and prepared for this purpose. The quality of the joining, integrity and corrosion resistance are some of the main issues to be taken into account.

Keywords: joining, aluminium, steel, composite, hybrids, welding, corrosion

THEME 4: Highly recyclable cars at a reasonable cost

Vehicle architecture nowadays is complex, consisting of many different structural and functional parts, made up of many different types of materials. Some of these materials are metal alloys, mainly for structural support and furthermore new materials could strongly enter within the near future. Also polymeric parts, foams and hybrid materials complete this wide spectrum of materials.

The Connect-EU Catalan automotive participants identify a relevant need related with the rational design of cars. Making cars lighter and safer is not only necessary but making them cheaper to produce and more easily recyclable. Therefore it is necessary to work on the **development and the optimisation of new car concepts with low environmental impact, high recyclability, eco-designed and with low repair costs.**

Keywords: rational design, car concept, recyclable, environment, cost

THEME 5: Application of composite materials in structural and functional parts

Traditionally, vehicle structural and critical parts have been metal designed and produced. The different automotive steels are well known and safe in terms of design and reliability. Over the last few years, other metal alloys such as Al alloys, have been adopted by some automotive producers for both integral or hybrid construction of vehicles.

Catalan automotive producers also see a **great opportunity with the introduction of composite materials in the automotive structural and functional parts**. Currently, the use of composite parts in commercial vehicles is limited to non-structural parts such as supporting surfaces for locks, spoilers, etc.

Composite materials are lighter and they can offer a good mechanical compromise. However additional knowledge

has to be developed and gained by the sector through specific R&D in order to be able to produce reliable and safer parts. This issue implies also aspects such as the **development of safer, reliable and cheaper composite parts with higher mechanical performance; the standardisation and the automation to produce composite parts**; etc. that will help the carmakers to effectively introduce such materials in their designs.

On the other hand, there are some specific applications where the structural components are working at high temperatures. In order to use **composite materials for structural applications subjected to high temperatures**, new composite materials have to be developed.

In addition environmental aspects are very relevant. Improving the ability to recycle composite materials is a must.

Keywords: composites, structural parts, functional parts, automotive, recycle, automation

- **THEME 6: Production of structural parts powder metallurgy (PM) techniques**

Powder metallurgy (PM) techniques are widely used for the production of specific automotive (e.g. bearings) parts that should offer good resistance while not being critical in structural terms. PM techniques are cost effective in producing simple or complex parts.

Connect-EU Materials identifies a clear challenge in the **PM techniques with regards to the production of parts with higher mechanical compromise**. R&D is required in order to improve and further develop PM technology in order to ensure production of critical parts is feasible through PM techniques which will be cheaper to produce.

Keywords: powder metallurgy, structural parts, mechanical properties

- **THEME 7: Introduction of metallic foams for weight reduction**

Some of the most important car manufactures in the world, which are based in the USA, are studying the application of **metallic foams for specific automotive parts**. These foams are applied to specific parts of powertrains, coping with thermal and integrity requirements and at the same time bringing an important weight reduction to the component.

Some of the Catalan Connect-EU Materials participants have identified a clear interest in carrying out specific R&D on this issue. Initial work has been carried out in this direction. Further R&D should be supported in order **to get knowledge about the transformation of these materials at industrial level (machining, etc.)**. In addition modelling of these materials is difficult however reliable

tools for simulation could be produced in order to ensure the extensive use of these materials in car applications.

Keywords: metallic, foams, machining, weight reduction, automotive

- **THEME 8: High temperature alloys and plastics for engine applications**

The current vehicles with internal combustion engines and hybrid vehicles can benefit from weight reduction in exhaust pipes. However, this requires **developing new alloys to work at high temperatures and with greater resistance to thermal fatigue and corrosion**. This new alloys would allow to increase the life and reliability of the exhaust system and to reduce its total weight.

For the last section of pipe where the temperature of the flue gas is lower, the **incorporation of lighter non-metallic materials** should be studied.

Keywords: exhaust system, alloys, high temperature, thermal fatigue, corrosion

2.1.2 REDUCING ENERGY CONSUMPTION AND RECOVERY OF ENERGY

- **THEME 1: Materials for waste heat recovery**

Waste heat conversion into electricity by thermoelectric materials suited to each temperature range, taking into account their abundance, availability and price would need to be studied. Design of devices based on thermoelectricity with innovative geometries and new materials with higher zT figures in order to improve their efficiency.

There is a clear need identified for alternatives to increase the utilisation of waste heat in vehicles like on-board cooling and minimization of cold-start.

Keywords: waste heat, recovery, electricity, thermoelectric, materials

2.1.3 PROPULSION SYSTEMS, POWERTRAINS AND BATTERIES

- **THEME 1: Permanent magnets for electric vehicles**

The permanent magnets are an essential component of electric motors. These materials work at relatively high temperatures and the aging phenomena of such varies exponentially with temperature. Therefore, it is necessary to **develop new magnetic materials which can work in a wider temperature range**, while controlling all the phenomena of relaxation or loss of magnetic properties.

Keywords: permanent magnets, electric vehicles, motors

- **THEME 2: Lighter conductors based on copper alloys**

The Connect-EU group has identified the need to develop **new materials based on copper alloys which allow producing thinner cables**, to reduce the car's weight and therefore also decrease the car's cost. Therefore these new materials should have better mechanical properties over pure copper, and which should minimally affect the conductivity.

Keywords: cooper, cables, weight

- **THEME 3: Safe and light battery systems with improved performance**

Market introduction and convenient use of vehicles with an electric powertrain depend mainly on the costs and performance of these vehicles. Safe operation certainly has to be secured for all automobile applications. The key component for both performance and cost of an electric vehicle is the energy storage system. Nowadays it is expected that the energy storage system over the near term will be a lithium-based battery system.

It has to be taken into account that a battery system includes, other than the battery cells, components for interconnections and packaging as well as electrical and thermal management equipment. All these additional components have a significant influence on the overall volume, weight and cost of a battery system that have to be reduced.

Battery test facilities are required for giving a better technological support for new development and improved applications.

The packaging of the battery needs to be improved. The packaging should be **lighter to reduce the weight of the vehicle, it should also have a good crash behaviour** that avoids the apparition of short circuits and that isolates the battery from the rest of the vehicle in case of a collision. It is also important to develop new materials to reduce the number of layers that are currently necessary for fulfilling the requirements of electrical isolation, thermal conductivity and crash resistance.

Keywords: battery, weight, packaging, crash, isolation

- **THEME 4: High-energy density Supercapacitors**

As complementary energy storage devices, capacitors can provide high currents during peak demands which would be unattainable by the simple use of batteries. The intrinsic higher power density of conventional capacitors however is hindered by their low energy density. **Low-cost supercapacitors** (Double Layer, Electrochemical etc) **need to be developed to feature higher specific energies while keeping their high specific power**.

Keywords: energy storage, supercapacitors, peak

- **THEME 5: Post Lithium-ion technologies**

To be able to overcome the performance hurdles of Lithium-ion technologies in the long term, already today it is necessary to **investigate post Lithium-ion technologies for further improvement of the overall performance of electric-powered vehicles**. This research must encompass basic cell research on materials in order to ensure availability with lower costs and higher energy density, considering also manufacturing issues, cell design and packaging, and recycling and life-cycle aspects according to the operational requirements and usage of the vehicles.

Keywords: battery, electric, vehicle, post Lithium-ion

- **THEME 6: New H2 and C1 economy and fuel cell use in electrical vehicle**

In the electric vehicle, one of the most important aspects is the range, which depends largely on the capacity of the batteries. To extend the range of the electric vehicle and to guarantee the HVCA, one solution is the use of independent units of power.

These autonomous units of power, based on fuel cells (PEMFC and SOFC) operate using fuels such as hydrogen, methanol, ethanol, etc. The quality of the **fuel cell depends largely on the materials of the cathode and anode**. It is necessary to carry out research on these materials **to increase life and performance and to reduce costs**.

Keywords: H2, C1, fuel cell, electric, vehicle, cathode, anode, materials

2.1.4 EFFICIENCY AND COMFORT

- **THEME 1: New lighting systems for electrical vehicles**

Systems based on **LED for external and internal illumination**. New smart control systems for illumination. Studying the optical effects (e.g. interior lighting) to improve comfort. Great attention has to be paid to the thermal dissipation of LEDs.

Keywords: lighting, electric, vehicle, LED, comfort

- **THEME 2: Smart window**

Research and Development is required in Smart window and bodywork materials for **efficient energy management** of the electrical vehicle thermal properties (e.g. infrared absorption and reflection, thermal capacity etc.)

Keywords: window, thermal, infrared, energy



2.2 MATERIALS FOR THE RAILWAY SECTOR

The railway sector in Catalonia has, on the one hand, an important industrial base inherited from the old rolling stock manufacturing companies, and secondly, with companies in the automotive sector showing a growing interest in participating in railway construction where they can provide their innovations. In addition, various technology centers and universities offer their experience, growing in the field of railway technology, with a desire to participate in collaborative projects. The cluster Railgrup groups the majority of the Catalan railway sector, integrating the industry, government, transport operators and technology centers.

The railway network of Catalonia, structured around the new high speed line from the French border, in the near future will play an important role as a gateway for rail services to the rest of the Iberian Peninsula, both for passengers and freight. The recent inclusion of the Iberian corridors in the TEN network (Trans European Network), integrating ports, logistics areas and railroads in UIC gauge ensure the increased participation of railways in the transport market.

The railway construction sector has so far suffered, a lack of innovation, inherent to the railway system, focusing on known and proven solutions, ruling out the introduction of new materials, especially in the critical elements related to railway safety.

The foreseeable future of the railway with maximum speeds of 400 km/h or more in passengers and freight trains of great length, forces the industry to raise the use of new materials, lighter and more resistant to respond to new challenges without compromising the safety, reliability, competitiveness and environmental friendliness inherent to railways.

This chapter presents an overview of Grup Connect-EU Materials priorities related to the Railway Sector and categorised into the following three research and innovation areas:

1. Special ferrous alloys
2. Polymers and composites
3. Nanomaterials

MATERIALS FOR RAILWAY SECTOR	SHORT TERM		MID TERM			LONG TERM			Keywords	
	2012	2013	2014	2015	2016	2017	2018	2019		2020
1. STRUCTURAL PARTS AND SAFETY										
THEME 1: Light-Weight, Eco-friendly composite materials for train structural applications.										lightweight materials, alloys, composite, hybrid
THEME 2: New steels, alloys and composite materials for traction and crash elements, especially for conception of new automatic couplings.										lightweight materials, alloys, composite, hybrid
THEME 3: New steels, alloys and composites materials for rolling elements.										steel, composite, hybrids, corrosion
2. POLYMERS AND COMPOSITES										
THEME 1: Light-Weight, eco-friendly, cost-effective, fire-resistant according with new European standards materials for train interior application.										lightweight materials, composite, hybrid
3. NANOMATERIALS										
THEME 1: Coatings development to improve the vandal resistance of railways cars, interior and exterior.										coatings, nanomaterials

Table 2.2.1 List of priorities for the railways sector

These priorities are aligned with the priorities established by the European Rail Research Advisory Council (ERRAC).

In table 2.2.1 a list of priorities for the railway sector is presented. It is also indicated for each of them, the suggested period of time in which the topics might be published in a call.

2.2.1 SPECIAL AND FERROUS ALLOYS

- **THEME 1: Light-Weight, Eco-friendly composite materials for train structural applications.**

From classical conception of the steel structures used in the rolling stock, this evolved to the use of mixed structure where steel and aluminum are currently used. The next step required is the introduction of new structural concepts and materials, in order to give further weight saving. In this sense, this topic is targeted to the research for the **introduction of composite structures or mixed aluminum-composites structures to be implemented in the manufacturing of rolling stock.**

The research materials and processes must focus on the **cost-effectiveness**, as the railway industry is very demanding in terms of production cost, while improving or keeping mechanical behavior of current solutions.

The proposed material will have also need to consider the **recyclability and LCA (Life Cycle Analysis)** as important factors, as well as the use of renewable raw material, such as natural fibers and bio-resins.

In terms of being new material, it will also be beneficial to see the introduction of real time structural health monitoring in the component's manufacturing processes. The technical solution will have to focus on the fact that weight saving means an increase in train capacity in terms of the number of passengers or load carried.

The results of the project should lead to the deployment and use of new and better materials for railway structural applications and energy saving through weight saving. They would also improve the industry competitiveness by saving cost with new materials and processes and improve the LCA in the railway industry.

Keywords: Light-Weight, thermal, Eco-friendly, composite material, train

- **THEME 2: New steels, alloys and composite materials for traction and crash elements, especially for conception of new automatic couplings.**

Despite in the use of self-propelled rolling stock for passenger trains, where multifunctional automatic coupling (traction, crash, pneumatic, electric) are used, the locomotive and merchandise rolling stock are still using manual coupling screws with caps. The manual coupling is limited in its maximum load and also by the slope of the line; these two factors will limit the length of the merchandise trains in its payload capacity.

The introduction of automatic coupling for locomotives and hauled material is a target in Europe for the medium term. The introduction of automatic coupling can be initiated through the creation of **a new standard for automatic coupling which address the material to be used to serve in relation to complete train configurations**, point to point, should become the standard for Europe.

The aim is to: i) increase the load capacity, including lines with high slope, ii) increase the length of a train up to the new standard of 750 m, iii) facilitate the introduction of a European standard for automated coupling, iv) reduce the manpower cost in operations to modify the train composition or traction change, v) to eliminate the dangerous tasks due to manual coupling and to introduce the electrical connection in merchandise rolling stock giving new functionalities to this type of rolling stock.

Keywords: New steels, alloys, composite material, automatic couplings, trains

- **THEME 3: New steels, alloys and composite materials for rolling elements.**

The conception of new rolling stock at high speed, more than 350 Km/h, would be advisable to reduce the non suspended mass to limit the wear of rails on ballast. This would happen through **increasing the structural properties of rolling elements under mechanical stress**. In merchandise rolling stock the target is to limit the wear of rail, as well as to increase the load capacity for an unchanged maximum load per axis.

It is desirable to introduce sensing to inform in real time about the structural health to be integrated in maintenance programs such as "Damage Tolerance".

That would allow to increase the maximum speed in passenger trains, to increase the load capacity in merchandise trains, to reduce maintenance costs and to reduce the risk for structural failures.

Keywords: New steels, alloys, composite material, rolling stock, rails, trains, stress, wear

2.2.2 POLYMERS AND COMPOSITES

- **THEME 1: Light-Weight, eco-friendly, cost-effective, fire-resistant in relation with new European standards for materials for train interior applications.**

According with the vision of ERRAC for the future railways, the industry will have to work and adapt in the direction of: energy efficiency, environmental protection, improved product life cycle assessment, improved train design; all these while keeping or increasing the competitiveness of the railway industry.

In this sense this theme is aimed to develop **new materials or processes to be used for manufacturing of components to be used in the construction of passenger car interiors**. The solutions to be implemented can use lightweight metal components as well as polymeric composites and plastic resins.

The key factors to be taken into account for the new materials or for process developments are:

1. Save weight with respect to current solutions.
2. To be recyclable.
3. Consider the energy efficiency for the whole product life cycle.
4. Vandal resistant
5. Fire resistant according to new European standard EN45545.
6. Modularity for car interior standardisation.
7. Consider multifunctional interior components.

Research should focus on developing commercially viable solutions well beyond the state of the art. The research activities shall include a credible validation and demonstration of the proposed solution by implementation of prototypes to be tested in relevant scenarios.

Technical, performance, health, environmental and economic factors must be duly considered in the justification of the choice of the new solution.

It would be beneficial if the materials used could be produced from renewable sourced raw materials. The proposals should follow a life cycle approach at both the level of material and selected products/applications. This includes assessment of health and environmental impacts, Life Cycle Assessment in accordance with the ILCD handbook, 9 economical viability, and development of routes for recycling and/or reuse.

Keywords: Light-Weight, eco-friendly, cost-effective, fire-resistant, composite material, metals, polymers, train, interior

2.2.3 NANOMATERIALS

- **THEME 1: Coatings development to improve the vandal resistance of railways cars, interior and exterior.**

Vandalism in urban and suburban railway networks result in recurrent costs and diminish the railway operators capacity, in terms of units available for services, as those units must be repaired.

Thus the high cost incurred by those actions can be evaluated from the point of view of the cost of repair as well as from the operatorless service capacity, so then generating, potentially less service level.

The aim of this theme is to research new solutions, in terms of **new coatings to limit the effects of actions from vandals and to create a more cost effective solution when repairing the consequences of these actions**.

In this sense the research shall focus on the development and demonstration of new coatings and its characterisation through test developments. This topic shall also result in industrial application on a train, which can be demonstrated at prototype level during the development of the project.

Keywords: Coatings, vandalism, railways, train

2.3 MATERIALS FOR AERONAUTIC SECTOR

Aeronautics and air transport should be considered as a strategic economic and social domain to ensure the future of European integration, independence, prosperity, and competitiveness in the global economy. Research and innovation in these sectors are key to maintaining Europe's capacities and competitiveness and it is time to align efforts towards a new long-term vision for this sector.

The Advisory Council for Aeronautics Research in Europe (ACARE) is the platform that sets the basis for the future of the aeronautic sector in Europe since the start of the new millennium. Their strategic documents have a leading influence on aeronautical research and are paving the way for significant improvements at all levels of aeronautics. Global environment and safety are two of the main key aspects in the future of the European aeronautic sector. The objectives in these areas pursue a reduction of

structural weight in order to reduce the emissions, a substantial progress in the reduction of the environmental impact of the manufacture, maintenance and disposal of aircraft and related products and the increase of the passenger's safety in a new dimension of comfortable and cost-effective travel.

This chapter presents an overview of Group Connect-EU Materials research and innovation priorities for each of the major societal needs in the aeronautic sector. The research and innovation priorities for the sector are classified into the following four areas of interest:

1. Structural assembly
2. Safety and sustainability of aeronautic structures
3. Manufacturing processes
4. New materials for aerospace

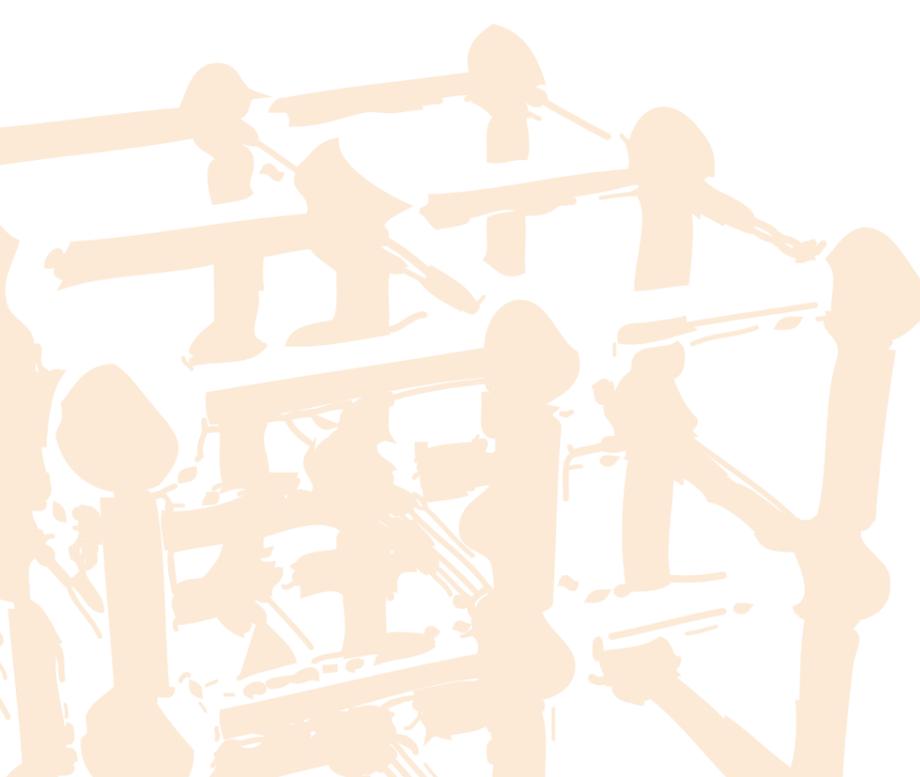
The following topics and themes are considered key in the consecution of European aeronautic sector objectives and of special interests for the international competitiveness of the Catalan aerospace sector.



In table 2.3.1 a list of priorities for the aeronautic sector is presented. It is also indicated for each of them, the suggested period of time in which the topics might be published in a call.

MATERIALS FOR AEROSPACE	SHORT TERM			MID TERM			LONG TERM			Keywords
	2012	2013	2014	2015	2016	2017	2018	2019	2020	
1. STRUCTURAL ASSEMBLY										
THEME 1: Composite materials. Analysis of composite joints										composite materials, joints, composite-metal joint, material compatibility
THEME 2: Metallic welding										manufacturing, metallic materials, welding, assembly
2. SAFETY AND SUSTAINABILITY OF AEROSPACE STRUCTURES										
THEME 1: Composite materials. Maintenance strategies										maintenance, composite materials
THEME 2: Composite materials. Recyclability										recyclability, composite materials
3. MANUFACTURING PROCESSES										
THEME 1: Composites materials. Out-of-autoclave										autoclave, composite materials, manufacturing, lean time, time efficiency
THEME 2: Composite materials. Manufacturing processes										manufacturing process, composite materials
THEME 3: Testing equipment. Improving efficiency										test, test facilities, test procedures
4. NEW MATERIALS FOR AEROSPACE										
THEME 1: Smart materials										smart materials, electronics, embedded sensors, embedded electronics
THEME 2: Coating										metallic parts, ceramic parts, coating

Table 2.3.1 List of priorities for the aeronautic sector



2.3.1 STRUCTURAL ASSEMBLY

- **THEME 1: Composite materials. Analysis of composite joints**

This research activity is devoted to the analysis of new techniques of design, simulation and processing of composite-based joints. The increment on the use of composite materials across the aircraft section requires the **improvement of the use of compatible joint composite-composite, as well as composite-metal.**

Keywords: composite materials, joints, composite-metal joint, material compatibility

- **THEME 2: Metallic welding**

Although the composite materials are becoming more and more important in the aeronautical construction, the associated manufacturing lean time makes it impossible to build each new aircraft using this material. The research activity will focus on emerging manufacturing and assembling technologies which will help to reduce the total weight of the aircraft. The use of metallic welding signifies a **significant reduction of the manufacturing complexity (reduction of the number of pins), as well as the reduction in weight of the aircraft.** On the other hand, welding produces a material continuity which can denote safety issues in case of failure. The research on welding methodologies which find the best trade-off among all these issues is of key importance.

Keywords: manufacturing, metallic materials, welding, assembly

- **THEME 2: Composite materials. Recyclability.**

This research activity is devoted to the study of **new resin formulation for composite materials which enables a good rate of recyclability.** The final goal is to be able to recycle 100% of the composites installed on the aircrafts. Chemical formulation must fit with the aero structure requirements of strength, light-weight, weather-proof etc. Research can also focus on the production processes (pre-preg, filament winding, etc) in order to enable the use of a specific type of resin.

Keywords: recyclability, composite materials,

2.3.3 MANUFACTURING PROCESSES

- **THEME 1: Composites materials. Out-of-autoclave.**

This research activity will focus on the development of new materials and techniques which facilitate the manufacturing of composite components without the use of autoclave. New studies and development of resins, which enable the appropriate properties regarding curate processes, but also regarding mechanical properties of the final part, must be developed.

This research activity focuses on the **reduction of lean time and reduction of manufacturing cost of composite materials parts.** Applicability to aeronautical field is a plus due to the potential increment of manufacturing pace of aircrafts.

Keywords: autoclave, composite materials, manufacturing, lean time, time efficiency

- **THEME 2: Composite materials. Manufacturing processes.**

The use of composites materials in aeronautics is increasing in an affordable rate from the point of view of its manufacturing process. Out-of-autoclave is a concept becoming more and more important. In parallel, **new manufacturing processes** should be investigated to **accelerate the lean time, while ensuring the desired shape and properties, and of course, quality.** Equivalent manufacturing processes as those existing for metals or other types of resins, such as forming or stamping, could help to produce better parts and better accuracy in out-of-autoclave composite materials. The main goals of the research would be to seek a reduction of manufacturing time and cost as well as the use of standard formats (flat plate for example), etc.

Keywords: manufacturing process, composite materials

2.3.2 SAFETY AND SUSTAINABILITY OF AEROSPACE STRUCTURES

- **THEME 1: Composite materials. Maintenance strategies**

The research activities will deal with the maintenance procedures to repair a damaged composite fuselage/wing. Repair procedures must be easily applied in situ, while ensuring the readiness of the repaired part. While experience from other similar applications can be used for practical application, a better understanding of the real behaviour of the repaired part must be obtained. Both real test and numerical models must be improved.

The research is seeking an **improvement of field reparation to obtain a cost benefit, as well as a reduction in the disruption of the airline operations.**

Keywords: maintenance, composite materials

• **THEME 3: Testing equipment.**
Improving efficiency

This research activity is to focus on the reduction of the time and cost of physical tests. Two main activities are planned; the first one is the development of test facilities which are able to easily manage the new design requirements, the second one is to integrate new technologies on the test bench which enables a reduction of the costs associated with the physical test. IT, and other numerical solutions are previewed as the two main issues to deal with, but other technologies or methodologies can be integrated in order to reduce the lean time of the physical tests. Issues related to simplification of the prototypes are also considered.

The research will help to **improve the competitiveness while improving the cost and time efficiency of the physical test procedure.**

Keywords: test, test facilities, test procedures

2.3.4 **NEW MATERIALS FOR AEROSPACE**

• **THEME 1: Smart materials.**

Light-weight materials, such as composites or plastics, can be easily integrated with electronics to upgrade the comfort on a passenger cabin. Such an application of electronics can be extended to the structural components of the cabin in order to enlarge the size of the windows, increase/decrease the sun light level, and reduce the radiation levels within the cabins for the crew and passengers. New designs by the principle European manufacturers ,have already defined such applications. New materials which enable these characteristics must be investigated. Combinations of composite and metallic layers, sheet or honey-comb formats, the potential use of electronic devices as integrated lights, or sensors must be defined.

Keywords: smart materials, electronics, embedded sensors, embedded electronics

• **THEME 2: Coating.**

Metallic components within an aircraft engine suffer thermal loads combined with internal tensions, vibrations and a large number of loads. Engine parts must keep a safety level while being a light-weight component. Such a trade-off is not easily solved. The use of light-weight materials is a well known issue, but new coatings for metals and ceramics are demonstrating that high requirements can be reached. The research must focus on the **investigation on coatings which helps to upgrade the thermal resistance, the strength resistance, the reduction in weight**, etc.

Keywords: metallic parts, ceramic parts, coating

2.4 **MATERIALS FOR HEALTH SECTOR (BIOMATERIALS)**

Biomaterial products can be inorganic, organic or synthetic in nature, and are mainly used to interface with biological systems to treat, amplify or replace any tissue, organ or function of the human body.

Biomaterials components in orthopaedics can take the form of bone filler products, degradable fixation products, such as pins, screws, scaffolds or discs. They were initially developed for craniomaxillofacial purposes. However, further research and development into the versatility of the biomaterial components has shown that they could be used to improve biocompatibility and tissue integration, to reduce the number of interventions needed, to release drugs etc. The use of biomaterial components has been particularly useful in orthopaedic and dental applications.

Contemporary life style changes and an increasing ageing of the population have become the most important reasons which can explain why the regenerative medicine technologies constitute one of the most important and rapidly growing markets in the orthopaedic industry, along with improving post operative outcomes (avoiding infections, stimulating the tissue integration of the implants, etc.).

Increasing patient expectation and greater recognition of the types of fractures have modified the product portfolio and marketing platform. Manufacturers have moved to a more customised and personalised product solution.

The Catalan companies mainly cover the demand for dental applications. The companies supplying most of the orthopaedic products in the Spanish Market are multinationals.

This chapter presents an overview of Group Connect-EU Materials research and innovation priorities for each of the major biomaterials areas, such as: low elastic modulus alloys and materials, calcium phosphate cement based biomaterials, biofunctionalisation of metallic biomaterials and antibacterial materials, among others.

The research and innovation priorities for addressing society's needs with respect to health and biomaterials are divided as follows:

5. Bone Regeneration
6. Antibacterial Materials
7. Metallic Biomaterials
8. Drug Release

In table 2.4.1 a list of priorities for the health sector is presented. It is also indicated for each of them, the suggested period of time in which the topics might be published in a call.

BIOMATERIALS	SHORT TERM		MID TERM			LONG TERM			Keywords	
	2012	2013	2014	2015	2016	2017	2018	2019		2020
1. BONE REGENERATION										
THEME 1: Investigation in new injectable and magnesium phosphate cements for bone regeneration, with porous, high strength and/or fast setting properties										injectable, calcium, phosphate, magnesium, cement, bone, regeneration, porous, strenght, foam
THEME 2: Biofunctionalised implant surfaces: biomoleculcule adhesion, treatments and coatings to improve the integration of the implants and to enhance the tissue integration										biofunctionalize, surface, implant, bone, regeneration, adhesion, coating, integration, sissue
THEME 3: Calcium phosphate glasses and resorbable scaffolds for tissue engineering applications (tissue and bone regeneration) are also interesting for the enterprises, but not as much as the previous ones										calcium, phosphate, galss, scaffold, tissue, engineering, bone, regeneration
2. ANTIBACTERIAL MATERIALS										
THEME 1: Antibacterial materials for prevention of infections and bacterial colonization in implants and prosthesis, as well as for reducing the infection rate in dental implantations										antibacterial, antimicrobial, infection, bacteria, implant, proshtesis, prevention
3. METALLIC BIOMATERIALS										
THEME 1: Antibacterial materials for prevention of infections and bacterial colonization in implants and prosthesis, as well as for reducing the infection rate in dental implantations										antibacterial, infections, bacteria, colonization, implant, prosthesis
THEME 2: Superelastic and shape memory biocompatible alloys										shape, memory, alloys
THEME 3: High wear resistant materials to improve the bone fixation devices and joint prosthesis										high, wear, material, fixation, bone
Theme 4: Porous metallic coatings for uncemented prosthesis integrations in order to improve the mechanical retention of the prosthesis.										porous, metallic, coating, prosthesis
4. DRUG RELEASE										
THEME 1: Drug delivery systems and coatings										drug delivery, bone, regeneration
THEME 2: Manufacturing dental and joint prosthesis by means of CAD/CAM technologies										cad/cam

Table 2.4.1 List of priorities for the health sector

2.4.1 **BONE REGENERATION**

- **THEME 1: Investigation into new injectable calcium and magnesium phosphate cements for bone regeneration, with porous, high strength and/or fast setting properties.**

The ability of CPC to form pastes able to set in contact with aqueous solutions (e.g. the body fluid) offers a great advantage over other materials as they can be used as **injectable materials in in vivo situations**. In addition, modification of the formulation of cements allows obtaining a wide range of cements with specific properties. The present topic covers the design of **new formulations capable of rendering cements with controlled properties** in terms of mechanical properties, resorbability and setting properties, in order to **improve bone regeneration**.

Keywords: calcium, magnesium, phosphate, cements, bone regeneration.

- **THEME 2: Biofunctionalised implant surfaces: biomoleculcule adhesion, treatments and coatings to improve the integration of the implants and to enhance the tissue integration.**

The biological response to biomaterials and devices is controlled largely by their surface chemistry and structure. **Surface treatments of biomaterials** allow retaining the key physical properties of a biomaterial while modifying only the outermost surface to influence the biointeraction. This topic covers **all surface modifications methods: biological, mechanical and physicochemical applied to improve the material integration**.

Keywords: biofunctionalised, implant, surfaces, coating, tissue integration.

- **THEME 3: Calcium phosphate glasses and resorbable scaffolds for tissue engineering applications (tissue and bone regeneration) are also interesting for the enterprises, but not as much as the previous ones.**

One of the main requirements in tissue engineering is to provide a **scaffold (tridimensional structure) able to support bone ingrowth** and at the same time with the ability to **degrade as new bone is being formed**. In this topic the aim is to prepare **bioactive materials based on calcium phosphate glasses with controlled reabsorbability** for tissue engineering applications.

Keywords: Calcium, phosphate, scaffolds, bioactive, materials.

2.4.2 ANTIBACTERIAL MATERIALS

- **THEME 1: Antibacterial materials for prevention of infections and bacterial colonization in implants and prosthesis, as well as for reducing the infection rate in dental implantations.**

A significant proportion of materials and implantable devices used in medicine becomes colonised by bacteria and becomes the focus of a device-related infection. This problem may be reduced if the concepts and methods of modern **biofilm microbiology** can be inculcated **into the development process for antibiofilm biomaterials**. The **development of materials with inherent antibacterial surface properties** or the incorporation of conventional **antibiotics into the material to prevent the biofilm formation** could be considered in this topic.

Keywords: Antibacterial, materials, biofilm microbiology, surface.

2.4.3 METALLIC BIOMATERIALS

- **THEME 1: Low elastic modulus materials (metals and composites) to reduce the stress-shielding phenomenon in bone fixation devices and joint prosthesis.**

The mismatch in the elastic properties between the metals used in orthopaedics and the bone is responsible for bone resorption and implant loosening in load bearing applications. The **development of new biocompatible low elastic modulus materials** is one promising strategy **to improve the material integration and the long term success of implants** and prosthesis fixed to the bone tissue. Also these new materials have to fulfil other requirements such as biocompatibility, corrosion resistance, low ion release, mechanical strength, etc.

Keywords: low, elastic, modulus, materials, bone, fixation, prosthesis.

- **THEME 2: Superelastic and shape memory biocompatible alloys.**

The development of **new alloys with special properties** such as **superelasticity** and **shape memory** for **biomedical applications** (cardiovascular, bone fixation, orthodontics) will be treated in this area.

Keywords: superelastic, shape, memory, alloys

- **THEME 3: High wear resistant materials to improve the bone fixation devices and joint prosthesis.**

Wear is one of the most important factors which influence the **long-term results** of joint prosthesis (hip, knee, elbow, etc). Despite wear reduction the durability of the prosthesis itself, the particulate debris generated during the materials wear, fretting or fragmentation induces an inflammatory reaction affecting the longevity of the articular replacement. In this sense it is necessary to **develop new materials and surface treatments to reduce the wear rate and increase the long term performance of joint replacement prosthesis**.

Keywords: wear, materials, bone, fixation, prosthesis

- **THEME 4: Porous metallic coatings for uncemented prosthesis integrations in order to improve the mechanical retention of the prosthesis.**

Combination of different physicochemical treatments allows obtaining **potentially bioactive** surfaces. These surfaces modify protein and cells interaction with substrate. Basically, **some metallic coatings allow improving the integration of metallic prosthesis** in short- and mid-term.

Keywords: coatings, uncemented, prosthesis, integration

2.4.4 DRUG RELEASE

- **THEME 1: Drug delivery systems and coatings**

This subject covers all the systems based on biomaterials developed **to release drugs in a controlled manner**. It includes membrane-controlled reservoir device where the active agent is released to the surrounding environment through a membrane by diffusion or systems where the therapeutic agent is dissolved in the base material matrix.

Keywords: drug, delivery, coatings, membrane

- **THEME 2: Manufacturing dental and joint prosthesis by means of CAD/CAM technologies.**

The **necessity to produce custom-made prosthesis and implants using industrial processes based on CAD/CAM technologies** has several clinical advantages. The advances on materials science, materials processing techniques and software applications are essential to spread the CAD/CAM technologies in the medical device industry.

Keywords: dental, prosthesis, implants, CAD/CAM

2.5 MATERIALS FOR THE CONSTRUCTION SECTOR

The construction sector in Catalonia, as is the case in the rest of Spain, is at an extremely critical phase. Construction companies are producing approximately half the output reached in 2007, therefore demand for building supplies is at an alltime low while competitive pressures keep growing. Development of new products and the improvement of existing ones on offer may be a vital strategy while waiting for an upturn in the market.

The range of products consumed by the building industry is highly varied, so the possible paths for research are also abundant. What we have summarised here does not cover the whole spectrum of construction products, but the type of products that are frequently found in the Catalan production processes.

Three research and innovation areas have been identified:

- Structures, where the main objective revolves around the idea of lighter buildings.
- Health and comfort, around the concept of reducing noise and potentially harmful substances.
- Environment, looking at ways to reduce waste and gaining a benefit from the idiosyncrasies of local climates.

These lines are not original in a strict sense, as they are reported on in other research priority documents such as the ones produced by Energy-Efficient Buildings PPP, E-CORE-ECCREDI or the European Construction Technology Platform. Therefore it must be stressed that the themes that follow are a consequence of both the product portfolio of the Catalan industry and the priorities that this industry detects in the markets.

In table 2.5.1 a list of priorities for the construction sector is presented. It is also indicated for each of them, the suggested period of time in which the topics might be published in a call.

MATERIALS FOR CONSTRUCTION SECTOR	SHORT TERM			MID TERM			LONG TERM			Keywords
	2012	2013	2014	2015	2016	2017	2018	2019	2020	
1. INCREASING EFFICIENCY IN STRUCTURES										
THEME 1: Laminar Concrete										UHPC, Concrete, Composite, Fibres, Laminar concrete, High Performance Concrete, Additives, Lightweight structures, Lightweight components
THEME 2: Insulation materials compatible with thinner structures										insulation, energy efficiency, aerogels, vacuum insulated panels, VIP, thin insulation
2. INCREASING HEALTH AND CONFORT IN BUILDINGS										
THEME 1: Integrating noise control										acoustic layers, acoustic comfort, composite, noise control, multifunctional layers
THEME 2: Thermal comfort in summer conditions										thermal comfort, summer comfort, energy efficiency, sustainability, composites, reflective coatings, reactive materials, hydroponics, high performance insulation
THEME 3: Zero-toxicity building materials										sick building, biomaterials, non toxic materials, healthy building
3. REDUCING ENVIRONMENTAL IMPACT										
THEME 1: Zero-waste construction methods										environmental impact, waste, zero-waste, environmental efficiency, construction methods, clean technologies, clean construction, clean factories, sustainable design
THEME 2: Waste as a building component										eco-design, recycling, waste recycling, low environmental impact
THEME 3: Thermal storage										thermal comfort, thermal storage, energy efficiency, sustainability, PCM, phase change materials, latent storage, thermal mass, thermal regulation, Energy saving
THEME 4: CO ₂ capture										eco-design, low environmental impact, CO ₂ , Carbon capture, sustainability

Table 2.5.1 List of priorities for the construction sector

2.5.1 INCREASING EFFICIENCY IN STRUCTURES

Building practices in Spain favour a widespread use of concrete and brickwork, two materials that need a large amount of raw material and weight to achieve the desired levels of structural strength. This is largely inefficient: heavy elements increase stress on the structure and consume valuable building space. At the same time, it well proven that the Spanish market, including Catalonia, still demands buildings with a solid feel that concrete and brickwork can provide. Manufacturers are interested in products that combine lightness and solidness.

• THEME 1: Laminar concrete

The latest advances in **cements, additives** and **fibres** allow for new **composite** formulations known as Ultra High Performance Concrete (UHPC). Experimental work so far has proven that it is possible to cut in half the thickness of concrete elements. The technology is there, but its full potential remains to be explored. For instance, reduced weight makes it possible to manufacture bigger elements that may simplify the execution process on site. Thinner elements are also interesting for the market of renovation and repair.

Keywords: UHPC, Concrete, Composite, Fibres, Laminar concrete, High Performance Concrete, Additives, Lightweight structures, Lightweight components

• THEME 2: Insulation materials compatible with thinner structures

This is closely related with the points discussed above. The improvement of insulation standards means thicker insulation boards in walls, roofs and floors. So there is no sense in reducing the thickness of structures while insulation remains the same or, pushed by the new building codes, tends to increase. The industry is looking into different alternatives such as **aerogels** or **vacuum insulated panels** (VIP)

Keywords: insulation, energy efficiency, aerogels, vacuum insulated panels, VIP, thin insulation

2.5.2 INCREASING HEALTH AND COMFORT IN BUILDINGS

Traditionally, the type of approach of Spanish and Catalan building codes regarding the quality of living conditions in buildings has been rather narrow, focusing only on thermal issues, and more specifically on heating demand in winter. Nowadays there is an increased awareness for other parameters such as; thermal comfort in summer

conditions, noise and air quality. The latest standards have recently been taken into account, and the local industry is still adjusting its offer and is open to new developments.

• THEME 1: Integrating noise control

The current way of designing building envelopes uses a layer for each function: a structural layer, a thermal layer, a finishing layer, etc. The acoustic layer is then the latest addition in order to comply with the newest building standard. The industry is looking into **composite** materials that tackle two or more functions at the same time as a way to simplify this problem.

Keywords: acoustic layers, acoustic comfort, composite, noise control, multifunctional layers

• THEME 2: Thermal comfort in summer conditions

The latest energy statistics prove that the bigger peaks of electricity demand in Catalonia happen during the summer months as air conditioning has become much more common in households. Therefore there is a reasonable potential for methods to reduce the energy consumption in summer in Southern European countries, particularly passive means to cut down the thermal load in buildings. This may be a niche for **reflective coatings**, lightweight boards (made of **composites, concrete** or **ceramics**) to be used as shading or as external layers for cavity walls, **reactive materials** that change their physical behaviour according to parameters such as temperature or humidity, and **hydroponics** and other advanced methods for growing vegetal walls and roofs.

Keywords: Thermal comfort, summer comfort, energy efficiency, sustainability, composites, reflective coatings, reactive materials, hydroponics, high performance insulation

• THEME 3: Zero-toxicity building materials

The list of building materials that have been declared suspicious of causing sick building syndrome (SBS) is far from irrelevant. The industry is looking into **biomaterials** as a safer source for adhesives, fibres, coatings, additives, colorants, etc.

Keywords: sick building, biomaterials, non toxic materials, healthy building

2.5.3 REDUCING ENVIRONMENTAL IMPACT

At present it is possible to say that the Spanish building industry has at its disposal reliable methods for measuring environmental impact both at the design stage (projects

to be built) and at the operational stage (buildings in use). The obvious next step is that developers will make use of these measurements as part of their decision process when choosing a new project or a renovation operation. Most probably, public developers will be the first ones into these practices. Manufacturers of building materials will have to familiarise themselves quickly with the environmental performance of their products and redesign their offer accordingly.

THEME 1: Zero-waste construction methods

Traditional construction methods generate a substantial amount of waste on site as a consequence of the extensive manipulation (mixing, cutting, joining) that building materials require. Most of it could be avoided with the use of pre-assembled, made-to-measure elements, produced off-site using flexible manufacturing techniques. Once again, last-generation **concrete** is a good starting point for its potential to be shaped individually.

Keywords: environmental impact, waste, zero-waste, environmental efficiency, construction methods, clean technologies, clean construction, clean factories, sustainable design

THEME 2: Waste as a building component

Construction is a generator of waste but it is also a potential reclaimer of waste. This is hardly a new concept, but the effective advance in the field of waste recycling for manufacturing building materials has not met the expectations yet. There is already some early evidence that some **waste-derivatives can replace certain raw components in clay and concrete manufacture** with little or no effect in performance.

Keywords: Eco-design, recycling, waste recycling, low environmental impact

THEME 3: Thermal storage

Buildings are exposed to thermal stress in a cyclic way; for instance, in the Catalan climate they overheat during the day while during the night there is a temperature deficit. The answer can be materials that absorb thermal energy and release it afterwards, for instance, **phase change materials** (PCM) or other materials for **latent storage** and materials with **thermal mass** properties.

Keywords: Thermal comfort, thermal storage, energy efficiency, sustainability, PCM, phase change materials, latent storage, thermal mass, thermal regulation, Energy saving

THEME 4: CO₂ capture

Buildings and some civil engineering objects have large surfaces in contact with the atmosphere. These surfaces can be used for extensive **CO₂ capture** and afterwards for storage or for controlled release in order to reuse it.

Keywords: Eco-design, low environmental impact, CO₂, Carbon capture, sustainability

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