1.- Executive Summary (1 page)

The e-light project has run for three years, focusing on developing an innovative lightweight architecture for urban EV. The work has been revolved around three main areas: requirements to be complied, materials and manufacturing, and the performance of the designs in terms of structure, vibrations and safety.

The main findings of the project have been:

1. Developing a methodology to short the requirments from the Original Equipment Manufacturer (OEM) to be translated into engineering language and to define the properties to be achieved by the materials and the designs.
2. A deep analysis of most appropriate materials, and their most efficient manufacturing processes to be used by the automotive industry. This work led the consortium to define the decision matrices and to present a methodology that will support automotive industry with a powerful tool in the design of EV.
3. An innovative design, composite intensive (Carbon Fibre Reinforced Polymers) that actually achieves 50% weight reductions when compared to the starting point of the project, which was an actual EV earlier developed by Pininfarina in metallic spaceframe.

The knowledge generated by the project, has been summarised and presented in the form of three public guidelines to support SME in the automotive supply chain to increase their competitiveness and understand the lightweight design that will drive newly introduced EV.

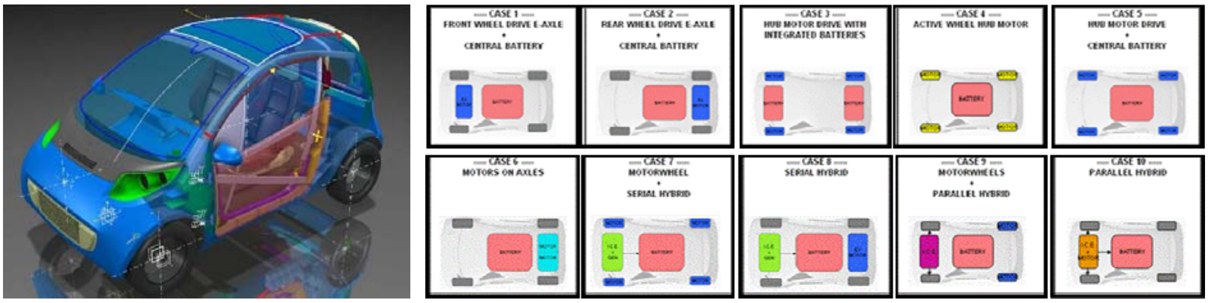
Three different guidelines have been completed:

1. General design guidelines/requirements: The project results, and main findings, in terms of the most suitable materials and their use in the developed architectures, the modules to be used in the EV, and the manufacturing techniques have been summarised and presented in this document. The document also provides designers with general recommendations with regards to the further study of body in white solutions for urban EV. This document will support industry designers in altomotive industry to achieve lightweight EV architectures minimizing costs and manufacturing times, and maximising production.
2. General Safety requirements: The document provides a summary of current safety and testing procedures that should be applied to EV without changes, European and USA standards have been analysed and a detailed list of new requirements for electric motors, power electronics and battery packs safety has been produced, with special attention paid to crash behaviour.
3. Testing procedures recommendations: This document summarised the assessment to be performed in the early stages of the design phase, since an accurate assessment of vehicle requirements is key to the definition of targets for new vehicle concepts. To achieve this objective a combination of industrial experience, detailed objective testing, specialised computed aided engineering and dynamic analysis tools are needed. The proper way to combine these skills is presented in this document to support evaluating new EV concepts.

2.- Project Context and Main Objectives (4 pages max.)

The project targets urban electric vehicles. Their specific peculiarities in several areas make necessary to study new solutions specifically designed for them. Therefore, e-light aimed at exploring all the aspects and requirements needed for designing optimal electric vehicle architectures. This approach proposes a methodology that will support designers to achieve lightweight design. Advanced metallic materials, reinforced composites, joining and manufacturing technologies, as well as modularity, ergonomics and safety are the main topics considered within this project.

This project is using the Pininfarina NIDO electric vehicle as the starting point to decrease the weight of the body in white by analysing new materials and technologies. Electric vehicles have a different cost-benefit ratio when compared to internal combustion vehicles. By using the NIDO, and decreasing substantially the weight of its architecture, while maintaining the safety, modularity and ergonomics, the partners will develop a design methodology for electric vehicles. e-Light has monitored and analysing the safety regulations for electric vehicles that are being reviewed. This methodology, together with the testing requirements for components, materials and joining technologies, was used as the core for the design guidelines.



On the left: Pininfarina NIDO concept, used as starting point. On the right: different configurations analysed.

The specific e-light technological and measurable objectives to improve the NIDO concept are:

- Architecture development with a maximum vehicle weight of 600 kg (without batteries), a maximum body in white weight of 200 kg, (although this target was decreased to 150 kg. after month 18) and an electric motor in the range from 25 to 35 kW.
- Ergonomics of developed EV architecture: on board space 4 passengers.
- Suitable and feasible joining technologies and manufacturing processes for the multi-material EV architectures developed.
- Equivalent performance to an IC vehicle architecture (improved compared to quadricycle and as close as possible to class A) regarding crash, fatigue and NVH.

e-Light has used the knowledge and experience obtained achieving those targets to produce design guidelines and testing procedures. Those will allow companies working in the automotive supply chain to increase their knowledge, and will be oriented to SMEs. This will increase their competitiveness by providing those companies with a technological added value.

e-Light is a small focussed collaborative project funded by the EC under the FP7. There are 7 partners in the project (CIDAUT, USFD, Tecnalia, Ricardo, EAST-4D, Pininfarina and PVF) from 5 different countries, and it has a budget of 2,938,649 €.

The technical objectives of the project has been broken down in the following technical objectives:

1. Identification of architectural requirements for EV architectures to be developed, focusing on lightweight for different battery and electric motor configurations (front or rear stand alone, wheel in hub). The main themes to be studied in order to achieve lightweight are modularity, ergonomics and safety requirements.

   Modularity of new electric propulsion systems allows innovative architectures. Those architectures present several advantages, when compared to conventional vehicles, especially increasing the accessibility and the on-board space. Other advantages those architectures present are improved aerodynamic efficiency, as well as improved safety by means of having the possibility of placing those modules and components in the most efficient way without IC vehicle's thermal, mechanical and geometrical limitations. One relevant issue regarding future EV architectures is the effect that battery volume and mass will have deciding the optimal EV architecture design.

   Electric powertrains allow having very compact elements and components connected to each other by electric plugs and refrigerating conduits. The successful integration of such elements into the EV architecture designed in the E-Light project will have several important advantages over ergonomics and modularity. Those advantages will be studied and optimized to achieve lightweight. Finally, the mechanical, thermal and geometrical limitations due to electric powertrains are less than those due to ICE. The total amount of components, and the range of temperatures those components will have under service conditions, are less than those from ICE, which will also be taken into account.

2. Identification of optimal multi-materials solution to become part of the EV architectures to be developed. In EV the cost-benefit ratio for materials in order to achieve lightweight is very different from conventional vehicles, due to the higher cost of the battery pack while in IC vehicles a small increase in engine power is enough to cover extra weight. In order to demonstrate the industrial feasibility of those materials, the most suitable and feasible joining techniques and manufacturing processes will be studied. Technical and industrial feasibility for multi-material EV architecture is needed to ensure the impact of E-Light project results, as well as their industrial implementation by the European automotive industry.

   The effect of the vehicle mass when accelerating and stopping in town and city conditions is another area where the mass of the electric vehicle will have considerable influence on vehicle performance.

   If the vehicle brakes this energy is converted into heat. In light vehicles the losses associated with continually creating and then losing kinetic energy are much less. Apart from the importance of minimising vehicle weight, it is also important to try to minimise the moment of inertia of rotating components, as these store rotational kinetic energy. In conclusion, mass reduction in Electric Vehicles is an imperative necessity so light materials not yet considered for mass production shall be taken into account. An exhaustive technical and economical feasibility analysis for new materials considering the lower volumes of the electric vehicles in the short and medium term as well as a Life Cycle Analysis must be realized for the alternative materials. It will be the first step in the aim of reducing the weight.

3. Optimal geometries and designs for designing EV architectures will be analysed, taking into account previously studied architectural requirements and materials. The performance of those architectures from structural, safety, noise and vibration points of view will be studied.

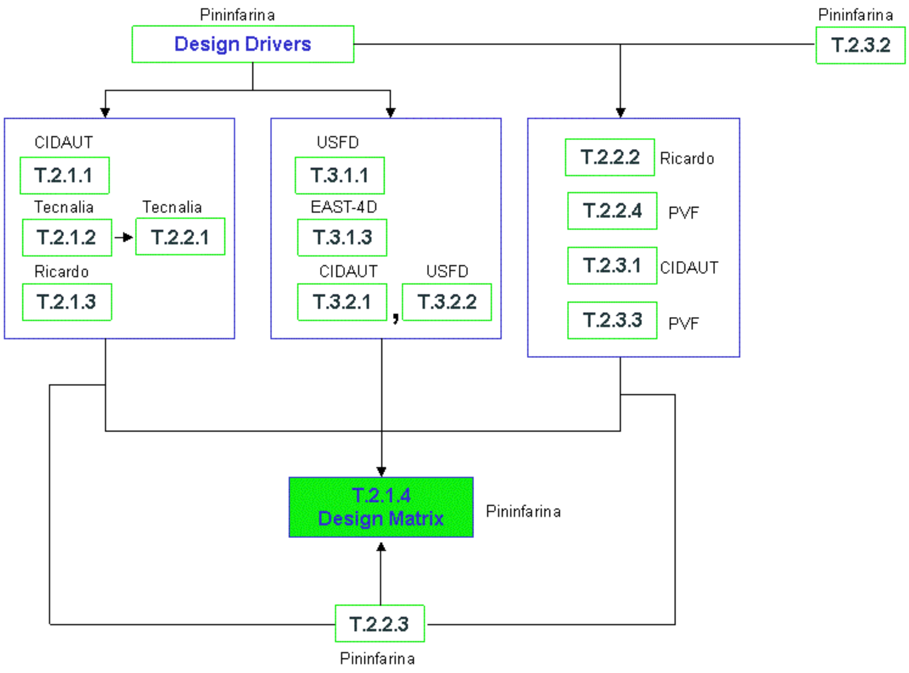
In order to guarantee the performance of designed EV architectures, structural, crash and energy absorption, and noise and vibration simulations will be run over the models for those EV architectures developed in E-Light project. Those simulations will save time and costs associated with prototyping and testing these EV architectures, and allow validating the identification of EV architecture requirements and the materials and joining techniques needed to manufacture them.

4. Definition of design methodology and testing procedures to develop general design guidelines and testing procedures, to guide automotive designers towards more sustainable, lightweight, modular concepts from the very beginning of the design process. The results from E-Light project will be summarized in two documents, "General Design Guideline for EV architectures" and "Testing procedures and recommendations for EV architecture design". Those documents and the cost-benefit analysis, together with the technical feasibility study, will be the basis for future EV architecture design processes.

3.- Description of main Scientific and Technical Results (25 pages max.)

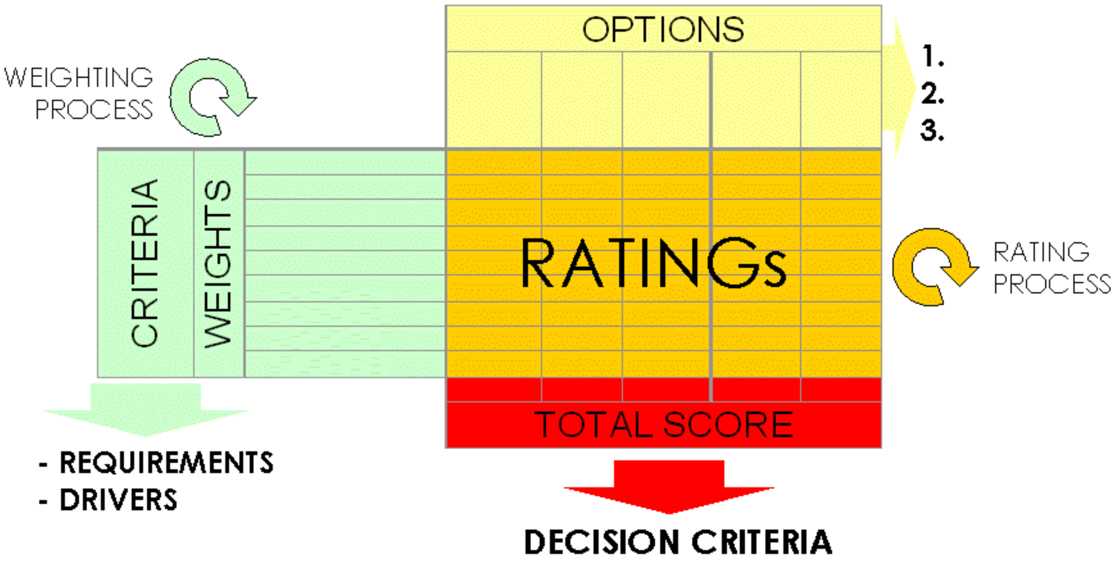
The initial activities of e-Light were centred on exploring and developing new Electric Vehicle (EV) architectures from a structural point of view. Those took into account the lack of restraints such vehicles presents when compared to conventional vehicles equipped internal combustion engines. The influences that those architectures have on the Ergonomic, Modular and Safety aspects were covered by e-Light. Those results, together with an analysis of most suitable advanced metallic and reinforced composite materials and their joining technologies were used in defining the overall architecture to be analysed in the finite element simulations that will start on the second half of the project. At the end of the project, the information on materials, simulation and designs will be summarised in Design Guidelines and Testing Procedure Recommendation documents for the automotive industry.

The first activity, carried out during e-Light, was addressing lightweight design by exploring the differences regarding conventional ICE architectures. In particular, the requirements for future EV set the basis of the whole work and defined the Design Drivers and the Design Matrix. The design drivers defined by Pininfarina as vehicle manufacturer, together with the results of reinforced composite and metallic materials study, and the analysis done on safety and functional modules allowed the partners to define the design matrix. The definition and development of these was a team activity, different partners' involvement, as well as the relationship with regard to the material and manufacturing processes analysis can be summarized in the following scheme:



During the kick-off meeting, it was agreed to develop the Design Drivers from a business case currently ongoing at the Pininfarina premises; the advantage of working on a real car is to use the information and data necessary to perform the further analysis in the future work packages based on an industrial case. These Design Drivers, described in deliverable 2.1, were enhanced to include driver performance expectations.

Taking them as basis, a preliminary Design Matrix was created. This Matrix is an instrument that cross-references different solutions against a list of key factors; each factor has been characterized by a score (weight). The solutions were ranked through the weighted scores. In this way, the best solution could be identified and selected for the next steps. A general diagram of such tool is shown in the following image.



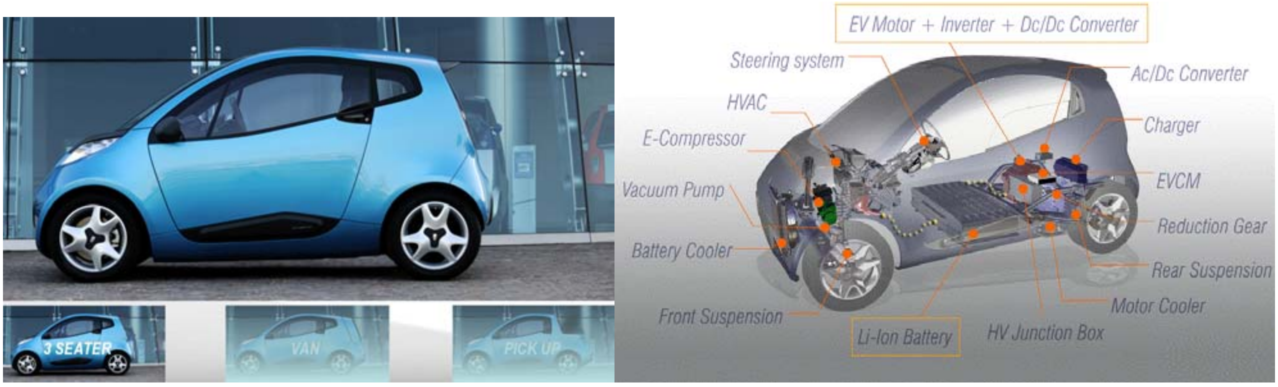
The process adopted to assign values to each design matrix follows a Trade-Off process. Some of the scores have already been evaluated for Pininfarina's internal business case; the others were, and will be, defined during the e-Light project. This fact means that the Design Matrix is a living document, evolving through the execution of the work packages, and it will be updated and diffused regularly. Finally, it allowed the most appropriate configurations to be easily chosen to be defined in later stages of e-Light.

Parallel to the definition of the Design Drivers, a detailed analysis of the state of the art was made covering the following technologies:

- Battery pack
- Electric Motor
- Powertrain
- Materials & Technology

The results from this study were used as starting points for further considerations in the definition of the Design Matrix, in addition to the engineering consideration made to identify the best solution for EV architecture to be pursued and optimized.

The business case considered is not derived from an ICE vehicle, but it has been conceived directly as an EV. It is an A-segment city car, which is fully electric, has 2 + 1 places, 2 doors, a modular rear end for van version (and eventually pick-up version) with high safety standards.



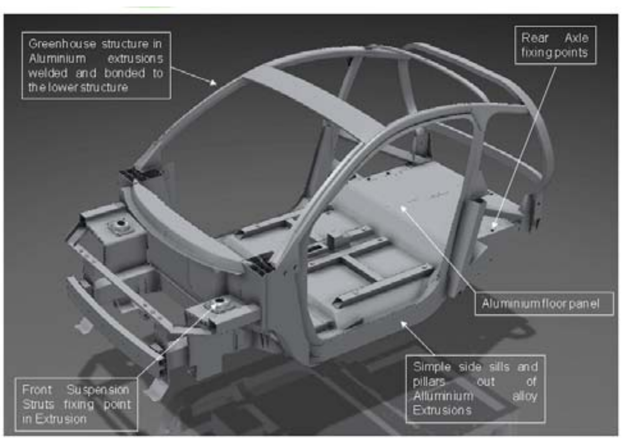
Pininfarina NIDO, used as starting point for the e-Light project

This modularity / flexibility and production technology permit the development of a product family with diverse uses and optimized investment & costs to ensure the competitiveness of the product. Mass production is foreseen for small series (500-1000 vehicles/year), due to the niche in which Pininfarina targets its business case.

Of course other possibilities were investigated, but the most innovative of them are still at the prototype stage, so they could present a heavy industrial risk. At the end of the second year, and through careful simulation studies carried out on the third year of the project, e-Light came out with an innovative design, including a door ring in composite materials. The prototyping of such design is out of the scope of e-Light, nevertheless, USFD, Pininfarina and Cidaut agreed on following the e-Light results on Evolution (http://evolutionproject.eu) to achieve prototyping of e-Light results and implementation of those in an EV.

The traditional concept of Body in White is revised, being decomposed into an Underbody and a Space frame; this breakdown allows for the specialization of conventional systems, redefining their functions and missions. This solution is highly flexible, allowing the creation of different shapes and types of vehicles for substitution or addition to a limited number of structural elements and skin panels. The multi-material architecture approach puts the overall vehicle's functionalities first, and then splits them into sub-modules and parts, selecting the optimal material on a part-by-part basis based on overall vehicle performances. Savings in weight as well as increases in efficiency contribute directly to the size of the batteries which are both heavy and expensive.

The Space Frame consists of a skeleton structure, made of extruded and curved profiles which are mutually joined, carrying the external skins which have an aesthetical function; it is dimensioned for a specific structural target, which is defined by the ergonomics of the vehicle. Currently the Space Frame is made in Aluminium with as many extruded parts as possible, as shown below:



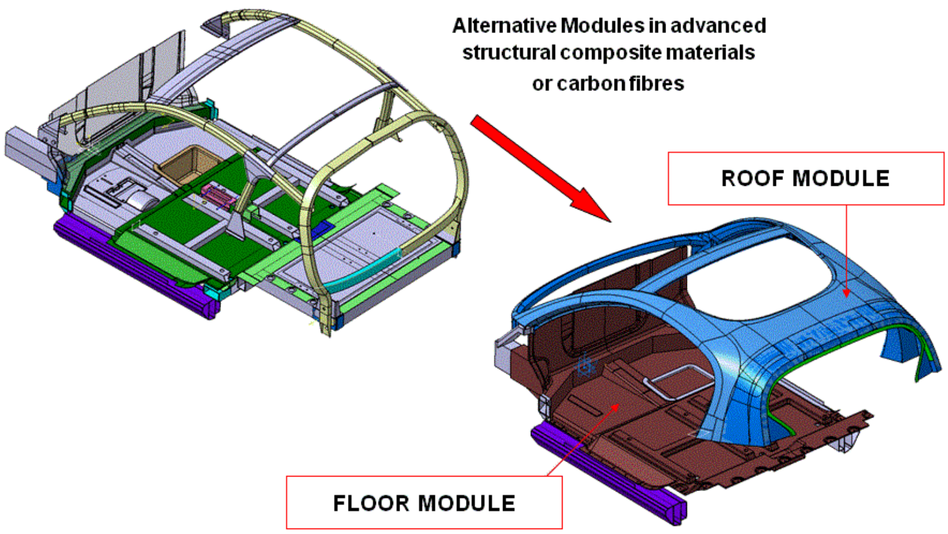
Original architecture for the NIDO (used as starting point for e-Light)

General structural performances, crash behaviour, handling and mechanical support will be demanded of the **Under-body**, where the modularity will be guided by the maximization of functions for each component and the possibility to set up several vehicles with a single platform, changing the geometric characteristics (pitch, track width, height).

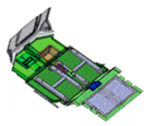
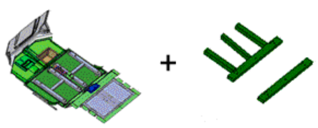
There are several possible solutions for the underbody The current plan is to make it in Al, like the Space Frame, but there are several possibilities to be explored during the e-Light project, based on lightweight materials.

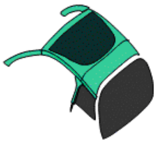
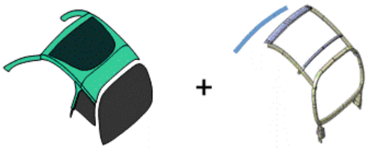
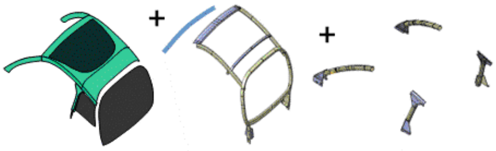
The structural part of the body can be divided into two parts, as shown in the following image:

1. Floor module (front underbody)
2. Roof module (upperbody)



For each part an analysis of structural functions was performed, decomposing the system in subsystems. Results are summarized on the two next tables, one for the Underbody, the other for the Upperbody:

Solutions to be explored	Technological considerations
Semi-structural solution 	In this case a 2° level frame exists, so these functions (semistructural): . Components fixing . Shape closure to contribute to the distribution of efforts can be done by **one or two skin of composite materials**. The firewall could be a separated element. The complete solution must be glued to the Aluminium structural frame of 1° level.
Structural solution 	In this case the structure (2° + 3° level) must complies these functions: . Components fixing . Shape closure to contribute to the distribution of efforts . Seat fixing . Distribution of crash effort of 2° level The firewall could be a separated element. The complete solution must be reinforced respect to the semi-structural case, so it could be a sandwich solution composed by a **composite skin, a filler and carpet**. Into the filler it could be possible to insert metal reinforcement and metal plate for fixing elements. The complete solution must be glued and screwed to the Aluminium structural frame of 1° level.
Unibody solution 	In order to satisfy all the structural function of the floor module, a **monococque element in composite materials or carbon fibers**, which integrate the firewall could be explored. Examples: Mc Laren MP4-12C, BMW Megacity, Alfa Romeo 4C.

Solutions to be explored	Technological considerations
Semi-structural solution 	In this case a 2° level upper frame exists, so the solution can be made by **skin+reinforcements panels in composite materials** The skin panelmust be glued to the reinforcement one; skins must be glued to the Aluminium upper frame , and reinforcements must be glued and screwed to this structural module. Examples: Webasto roofs for Renault and PSA
Structural solution 	In this case the structure (2° + 3° level) must complies these functions: . Replacement of upper Aluminium frame (M1 vehicles small series) . Aesthetical refinement (A-class) of exterior skin . Fixing areas of inner skin The complete solution could be a sandwich solution composed by a **composite shell + filler** Into the filler it could be possible to insert metal reinforcement to replace some structural tubes. The complete solution must be glued and screwed to the Aluminium structural frame of 1° level.
Unibody solution 	In order to satisfy all the structural function of the roof module, a **monococque element in composite materials or carbon fibers** could be explored; further reinforced element could be inserted for roll-over performances.

As it is explained on the section dealing with WP4 work, this initial approach was later improved by developing the Door-ring approach, developing a highly composite intensive central body with two aluminium sections, one on the front and another on the rear parts of the architecture.

The design matrix used in the next activities of e-Light is reported as follows:

KEY DRIVERS \ ARCHITECTURE		--- CASE 1 --- Semistructural			--- CASE 2 --- Structural			--- CASE 3 --- Unibody		
		SOL 1	SOL 2	SOL 3	SOL 4	SOL 2	SOL 3	SOL 1	SOL 2	SOL 3 .....
Costs	Development									
	Validations									
	Investments									
	Unit									
Production	Availability suppliers									
	Assembling									
Timing	Product development									
	Product manufacturing									
Engineering	Function integration (fixing and flanges inserction etc)									
	Modularity									
	Undercuts management									
Style	Style edge and cut management									
Weight	Weight									
Proototypes	Significance of prototype solutions									
Quality	Surface quality (A-class)									
	Stability (both during process and during vehicle life)									
Other parameters	EMC compatibility									
	Recyclability									
	Fire resistance									

Regarding the results from the different materials to become part of urban EVs, the main results achieved by e-Light can be summarised as follows:

Reinforced composite materials:

A Trade-off of materials model was developed applicable to the development of urban electric vehicles. Technical requirements, preferred design concepts and manufacturing processes were taken into account, all of them direct results of the work performed in analysing the requirements of EVs.

The weights applied to each selection criteria depended on the type of company, state of the art, component, and market context. For this reason, in each case they have different values. Similarly, sometimes it was necessary to modify the resolution or scale scores to differentiate more clearly the different options.

The application of decision matrices to select materials for the process of developing (Electrical Automotive Market) can reduce the arbitrariness, provide traceability in decision-making and facilitate the participation of more people and points of view. This gives more confidence in the decision.

Since the methodology developed is a first version, its use will make it possible to identify areas for improvement to be implemented in later versions, and in different type of vehicles. This methodology will become one section of the design guidelines to be produced at the end of e-Light.

During the project, it was considered that for the first selection of optimum materials it was not necessary to work with quantified technical criteria (e.g. mechanical or thermal properties). After that, it will be necessary to have more detailed information on the materials, to choose the most suitable concepts for the architecture. And his information, together with the feedback resulting from the simulation analysis of the architecture performance, will provide the necessary information to fully define and perform the cost-benefit and the life cycle analysis.

The main objective of the composite material study was not to develop a database of such materials, but to advance in identifying the product development methodologies to reduce the risk of taking wrong decisions during the early stages of work, endangering the technical feasibility and competitiveness of the final product.

Finally the Trade-off was identified and prioritized; two main families of materials were chosen according the defined criteria:

- Technical thermoplastic materials for injection and GMT processes. To ensure critical technical requirements of materials (Mechanical behaviour, joining capability and ageing or durability)
- Thermoset materials for liquid moulding processes (RTM-Var, Casting and RTM). To ensure economical feasibility for short runs

In both cases pre-finished sheet (GMT and SMC) was the best scored regarding the preferential design concepts. Depending on that concept (Sandwich structure or Hybrid structure) the process to be prioritized is low or high pressure.

Metallic materials:

The main result achieved, in this study of advanced metallic materials, was to establish a short list of materials susceptible to be used in the BIW of the e-project vehicle.

It was concluded that the aluminium has a great potential to be used in almost all the processes considered:

- The extrusion of 2xxx, 6xxx and 7xxx series is suitable to be applied in the BIW structure in competence with the high strength steels. In the e-light project 6005 A T6 will be considered for the extruded components.
- The rolling of 6xxx series is suitable to be used in body panels going in competence with some plastic materials. In the e-light project 6111 T4 will be considered for panels.
- The aluminium processed by high die pressure casting has the limitation of the high cost of the tooling that makes it application for low series unaffordable.

- The moulding of 3xx series is also suitable for some structural parts of the body in white. In the e-light project AlSi7Mg will be considered.

The magnesium alloys were rejected to be applied for structural components, although some other uses were found in internal structures and components' covers.

The MMCs were estimated as not suitable for their application in the e-light project, due to their lack of application in structural components and the high cost of the rest of possible applications.

The analysis of the high strength steels shown their great potential to be applied in the BIW structure, but in competence with extruded aluminium. It is important to notice that in the case of a hybrid solution steel-aluminium the galvanic corrosion should be studied in the joints of both materials.

This short list of materials will be used in the life cycle and in the cost-benefit analysis as well as in defining the simulation model, New EV design dynamics to select the most suitable materials attending to sustainability, cost and mechanical behaviour criteria.

<u>Joining techniques and manufacturing processes</u>:
The values of the matrices used in this analysis were extracted directly or indirectly from the descriptive of materials, processes and joining technologies. The process selection was mainly based on the underlying design concept and the degree of integration. A list of process discriminators helps to make the trade-off between performance and assembly cost:

- Size & Access Limitations
- Joint Quality & Tolerance
- Investment & Operational Costs
- Equipment, Tooling & Labor Requirements
- Process Performance (Production Rate & Lead Time)

The assembly architecture and integration of parts during concept design of the product were determined. While considering all the assembly cost drivers, it has to be decided whether the product will have an integral or modular design. Both concepts need to meet design requirements, which in turn will affect performance and producibility.

A major strategy to reduce cost in composite fabrication was the integration of parts. While trying to keep the part performance (strength & stiffness) constant, various degrees of integration were evaluated in terms of their costs. In general, the higher the part count, the more labor intensive is the assembly. A further cost driver were the joining methods used to assemble composites. For example, co-cure, which also can be described as "soft" assembly because most of the components are still flexible and possess more degrees of freedom than their rigidly assembled counterparts. Co-cure are can reduce delays and costs due to over constraints and tolerance build-up. However, higher integration can create increased manufacturing risks since the potential scrapping of a part becomes progressively more expensive.

Minimizing assembly costs was identified as a design function and this must include proper consideration and identification of all cost drivers:

- Production Volume
- Process Cycle Time (Non-recurring & recurring)
- Number of Components
- Fastening Method
- Accessibility
- Shimming & Surface Preparation

- Dimensional Tolerance
- Labor & Equipment Rates
- Productivity & Utilization
- Quality & Rework Rate

The number of parts in an assembly has a significant impact to the total assembly cost. Generally, the goal is to generate a design with the minimum number of parts, while achieving the necessary functionality at the same time. Less parts results in reduced assembly operations and less assembly material (fasteners, adhesives). Less assembly material also contributes to weight savings. However a more integrated structure tends to create a more complex design, which makes access more difficult. Lack of accessibility can also limit the use of automatic fastener installation technology. A more complex design requires also complicated and expensive tooling.

<u>Overall architecture designs analysed during the project</u>:
The vehicle configuration will be used to define the simulation model (CAD and CAE) that will be simulated in the dynamic, structural and safety analysis to demonstrate the performance of the lightweight design. Within architecture designs analysis, the following results were achieved:

Definition of the electric motor size targets: capable of achieving an acceleration from 0 to 50kph in 7 seconds while achieving a recuperation from 20 to 60kph better that its ICE equivalent in second gear. The maximum speed was set in 120kph, and the slope climbing capacity the vehicle should be able of going up a 20% slope with a constant speed of 40kph. Those targets implied that the motor power needed is 30kW.

Definition of the battery size targets: In order to be able to cover a minimum distance accepted by the users, while having the smallest influence on the overall vehicle weight, several calculations were done using a mathematical model to define a battery size of 23kWh. The target for the range is 120km as a minimum and 150km recommended. The performance of such battery was compared using the European, American and Japanese driving cycles.

For the design of the vehicle architecture other issues were considered. The weight distribution, braking capacity and dynamic behaviour were studied for an urban electric vehicle, defining a weight distribution of 55% weight in the front axle when the vehicle is unloaded; a maximum braking distance of 13.5m when the vehicle speed is 60kph and a maximum braking distance of 37.5m when the vehicle speed is 100kph. Also other general characteristics were defined, attending at the dynamic behaviour of the vehicle, such are a good stability, a centre of gravity height, a maximum lateral acceleration higher than 0.7g, and a under steer behaviour.

All vehicle configurations defined previously on the project were studied. The results previous analysis were compared through dynamic and weight analysis. The different characteristics of motor location, stand-alone, in wheels, and in the rear axle were compared in terms of modularity, ergonomics, safety, costs and weight to conclude that the most suitable configuration of the future urban electric vehicles is a 4 seat lay-out with a rear wheel drive axle, and that the vehicle will have a central battery.

Finally, the current situation regarding the Electro-Magnetic Compatibility of electric vehicles was studied. This is a very complicated issue that will require a full analysis, but that is out of the scope of e-Light. Nevertheless, a general analysis of feasibility was performed concluding that the proposed configuration is feasible from the point of view of EMC/EMI.

The initial activities of e-Light were centred on exploring and developing new Electric Vehicle (EV) architectures from a structural point of view. Those took into account the lack of restraints such vehicles presents when compared to conventional vehicles equipped internal combustion engines. The influences that those architectures have on the Ergonomic, Modular and Safety aspects were covered by e-Light. Those results, together with an analysis of most suitable advanced metallic and reinforced composite materials and their joining technologies were used in defining the overall architecture to be analysed in the finite element simulations that started on the second half of the project. At the end of the project, the information on materials, simulation and designs have been summarised in Design Guidelines and Testing Procedure Recommendation documents for the automotive industry.

The first activities, carried out during e-Light second term, were focused on finalising the EV architecture design. The Life Cycle Assessment (LCA) and the Const-benefit Analysis that were delayed on the first part of the project were carried out once the final design was completed and the materials and manufacturing techniques were defined.

The performance of the design in terms of Structure, Safety and NVH were determined and with the information coming from those analyses the EV design was modified to improve the lightweight as well as to include a composite intensive configuration. The modifications on the layout of the EV architecture and the inclusion of composites made reports on LCA and Cost-benefit analysis being delayed until the final EV design was completed. Finally, the guidelines for the EV Design, EV Safety and its Testing were completed and the knowledge generated in e-Light was included in them.

Second term started by analysing the structural and fatigue performances of the chosen EV architecture. In parallel the crash behaviour was also carried out.

In order to ensure the crashworthiness of the e-Light design, several impact calculations were made including the most common situations included in the directives and regulations. So the first step was to analyse all the crash legislation and normative, this information and the main tests to be performed are summarized in Deliverable 4.2. This analysis was made taken into account three main groups of tests: the ones included in the European legislation, the ones included in the North American legislation and the one included in the Consumer Information Programs. After that, the selection of the most representative and critical frontal, lateral, low speed and rear impact were selected to be simulated on the e-light vehicle in order to optimize the designed BIW.

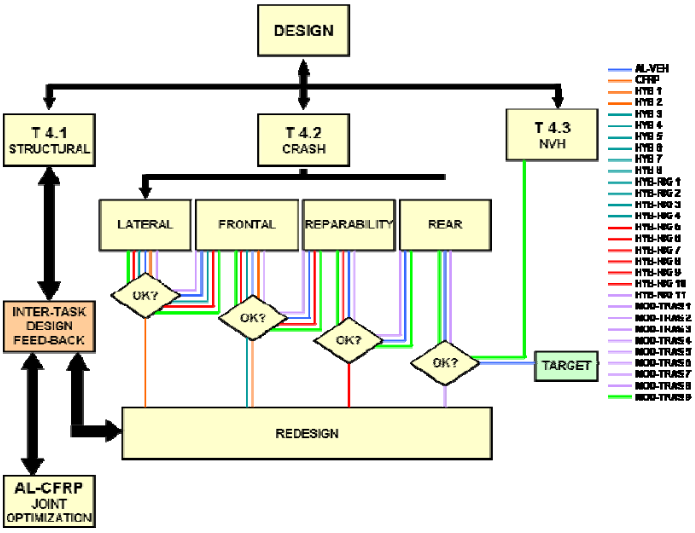
It is important to notice that, after a deep analysis, the pedestrian tests have not been considered. The main reason is that the results of this kind of tests depend mainly in the hood, the windscreen and the front bumper, and none of these components are included in the BIW (actually, they are out of the scope of the project), so no change from the original model from Pininfarina was to be made.

Once the crash tests were decided, several simple calculations were made to validate the concept. A simplified model was built in order to know if the carbon fibre was suitable to the body in white manufacturing. The calculations made on the simplified model were useful to achieve the following conclusions:

- The thickness analysis has demonstrated that a side protection bar is needed to fulfil the lateral impact requirements.

- The CFRP body in white is suitable for lateral crash.
- The section assessment made over the simplified model has allowed the selection of the most suitable ones.

Once that the concept was validated, a methodology was establish to optimize the BIW, minimising the weight and ensuring the fulfilment of all the crash requirements. The methodology can be summarized in next figure.



Methodology for mass optimization according to crash requirements

It is important to indicate that along the crash optimization several design iterations were made taken into account the results from the optimization process carried on during task 4.1: Structural Integrity, and also the results obtained from the analysis of the joint between aluminium and CFRP (this analysis is explained in detail in Deliverable 5.2).

The starting point for Work Package 4 was the aluminium design of Pininfarina Nido. In order to fix crash behaviour targets, the aluminium model was simulated in all the crash configurations considered: lateral, frontal, reparability and rear. After that, a black metal approach for CFRP was analysed. The black metal approach consists in changing the material properties maintaining the same geometry. As expected, the result of the black metal approach was very poor. But the analysis of the results was very useful to decide that a hybrid solution was needed with CFRP for the central part of the vehicle, and aluminium for the frontal and rear components absorbing the impacting energy.

Some hybrid structures were calculated considering frontal and lateral impact. Once the lateral requirements were covered, special attention was paid to frontal impact. Due to the difficulty of fully defining the frontal requirements, some simplifications were done in the simulation model. The most important one is that the BIW has been considered as a rigid body, and that all the efforts were focused in the optimization of the frontal aluminium structure.

After fulfilling the frontal requirements, a full model was calculated to make sure that the simplification was not too optimistic. The next step was simulating a low energy crash, because it is not allowed that in a low speed crash some structural components got broken. Again the rigid body simplification was used and the thickness of different frontal aluminium components was optimized to avoid the breakage of any CFRP part.

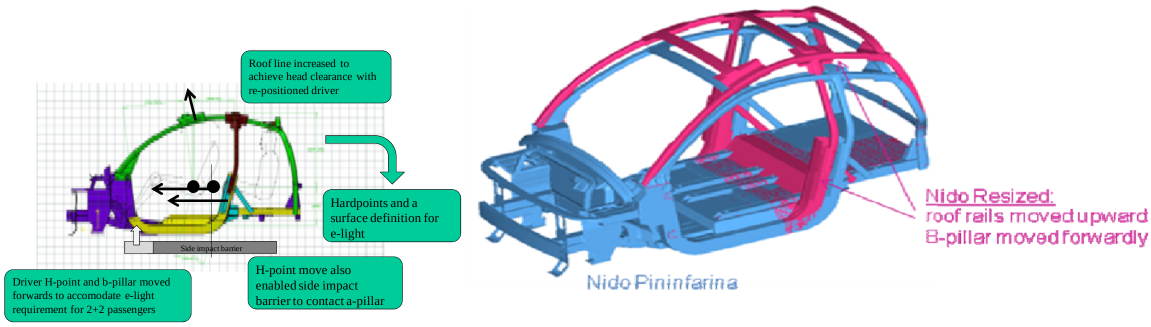
Once the low energy requirements were fulfilled, the rear crash behaviour optimization started, and after nine new iterations all the targets were achieved.

The criterion for the vehicle optimization was to improve the behaviour of the initial design made in aluminium. Also special emphasis was made on ensuring the battery's safety. In the most critical tests: frontal, side and rear impacts a special analysis was made in order to ensure that no deformation of the battery casing would happen. The batteries are protected by structural beams and there is a safety space between the battery casing and the beams. In the worst case scenario, the displacement of the beams was 9mm, less than half of the safety gap (20 mm).

At the same time, and as shown in Figure 1, the structural and vibrations analysis was carries out. Although originally was planned as a single task, the design of the e-Light architecture required several loops in order to achieve its potential for weight reduction, as well as to include the peculiarities of the composite materials and the manufacturing methods.

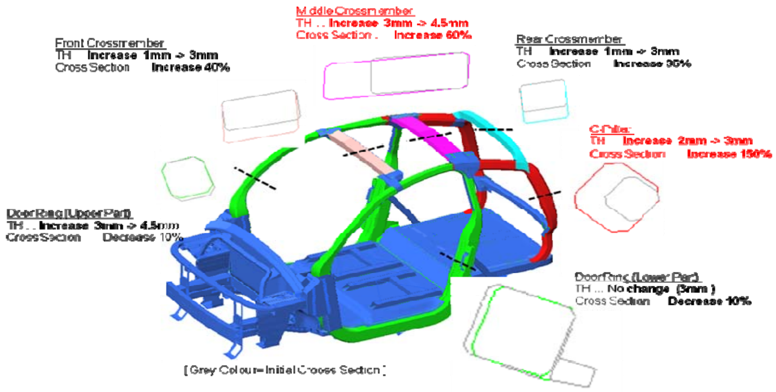
A concept for a lightweight body structure for electric vehicle has been developed, using a combination of design skills, CAE optimisation and CAE validation tools. The e-light structure was based on an existing aluminium spaceframe structure (as explained the Pininfarina "Nido"), primarily selected to provide basic layout, package and hardpoint data.

A brainstorming process was used to generate a number of potential concepts and possibilities for the CFRP structure. An evaluation process was then used to select a design concept for further CAE validation and development. Initial development of the e-light structure was based on the requirements to achieve complete vehicle crash performance. This is reported in Deliverable 4.2, "Report on the energy absorption capabilities and crash performance of electric vehicles".



Vehicle size and package study and changes from Nido to e-light, on the left. The image on the right shows Re-sizing of Nido, before and after

Further development of the structure was then undertaken with respect to structural stiffness, durability and Noise, Vibration and Harshness (NVH). An advanced and complex multi-domain parametric CAE optimisation approach was applied to assist in developing the CFRP structure. The optimisation considered a large number of input variables such as structural member cross section size, CFRP thickness and CFRP fibre orientation angle. In some cases, the large number of design variables resulted in optimisation convergence issues and a simpler, two-step approach was required.



Example of the changes of selected cross sections proposed by the numerical optimizer.

The final, optimised CFRP e-light solution achieved a 50% mass reduction when compared to the baseline "Nido" design. The stiffness, NVH and durability targets were all achieved.

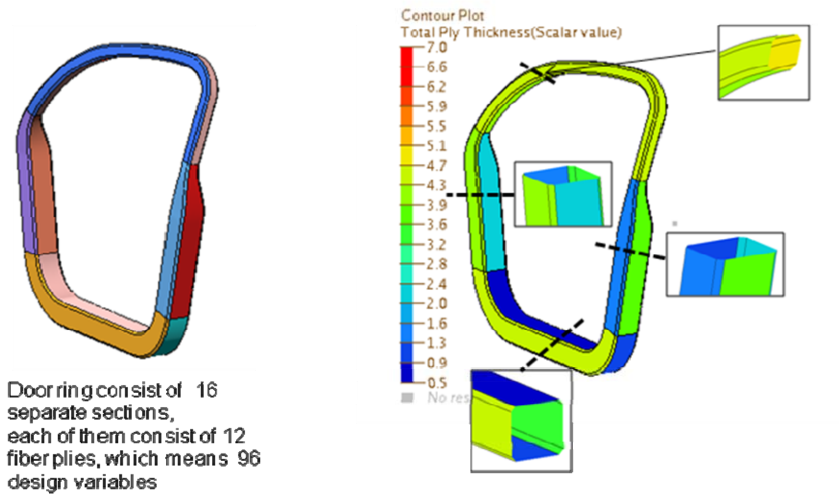
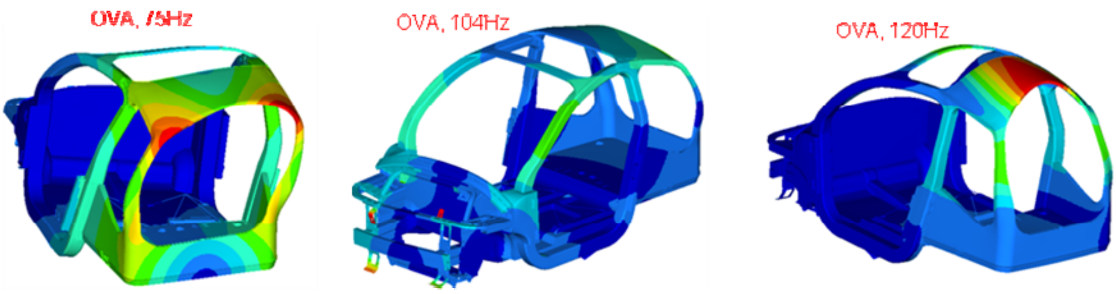


Figure 4.- Detail on the door ring approach, innovative CFRP design of e-Light architecture

Further development of the structure was then undertaken with respect to structural stiffness, durability and Noise, Vibration and Harshness (NVH). The approach for NVH analysis and the subsequent performance is detailed on Deliverable 4.3.

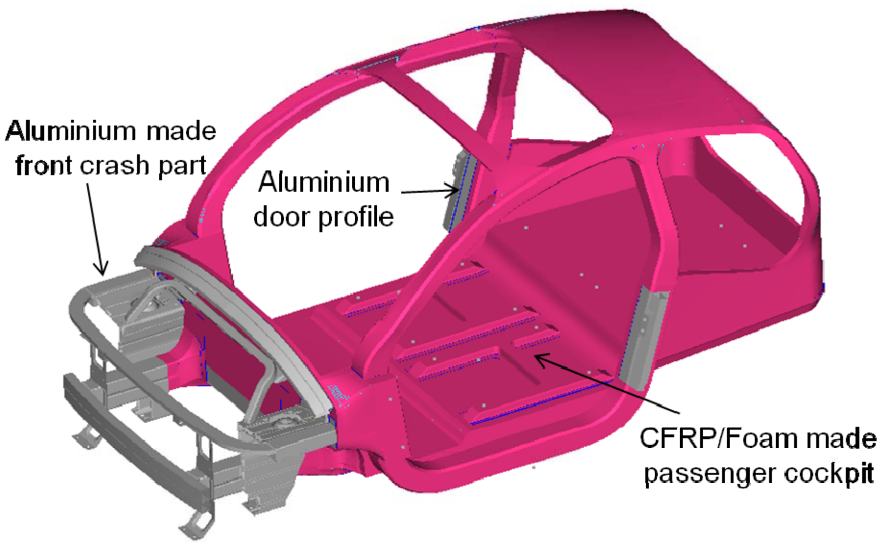
An advanced and complex multi-domain parametric CAE optimisation approach was applied to assist in developing the CFRP structure. The optimisation considered a large number of input variables such as structural member cross section size, CFRP thickness and CFRP fibre orientation angle. In some cases, the large number of design variables resulted in optimisation convergence issues and a simpler, two-step approach was required.



Final e-Light desing performance, BIW, OVAs. Distribution of displacement amplitude at loading point Rear Top Strut, Z-Direction, 75Hz, 104Hz and 120Hz.

The final, optimised CFRP e-light solution achieved a 50% mass reduction when compared to the baseline “Nido” design. The NVH performance of e-Light was generally better than the reference Nido. Some assumptions in the analyses were made with respect to interior noise simulations and the lack of closures (doors). Also the specific NVH characteristics of electric machines were not considered within the analysis. Both assumptions are potential areas of consideration for further analysis.

After the analyses, the final design for the e-Light architecture was achieved. A concept for a lightweight body structure for electric vehicle composite intensive was developed using a combination of design skills, CAE optimisation and CAE validation tools.



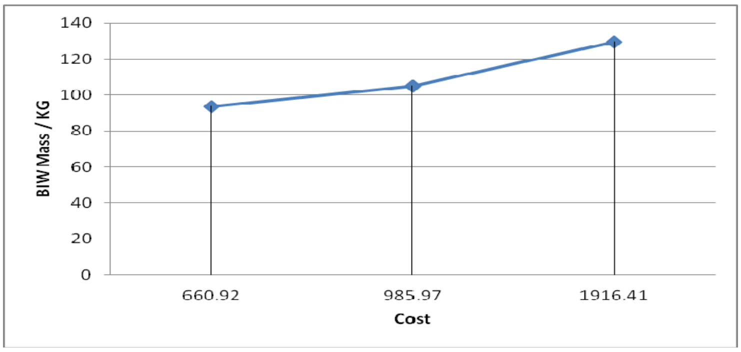
Final design of BIW structure, also called as e-Light-2.

Once the design was finalized, pending tasks from WP3 were able to be finished, the life cycle assessment and the cost-benefit analysis were carried out resulting in:

The aim of the cost-benefit analysis was to determine if a composite version of the E-light BIW structure could be cost competitive with a low cost aluminium intensive BIW. From the results it was seen that up to production volumes of 10,000 vehicles the aluminium intensive BIW is the most cost effective. Although the CFRP BIW structures do reduce in price, as the production quantity increases, due to the fact that the tooling needs to be replaced after 10,000 cycles this price will not reduce further. It was also seen that using a lower cost CFRP material it is possible to reduce the overall BIW cost by up to 50%.

The composite BIW achieved an important weight reduction but is more costly to produce and that as the production level goes up, from 1000 to 10,000, the cost of the aluminium intensive BIW is 71% of the original cost whereas the composite version is 96%. Due to a smaller reduction for the composite version there is actually an increase in the effective cost for the weight reduction as the production volume goes up.

The composite version is currently only at 89% of the original aluminium BIW weight. Earlier it was stated that a 36% reduction in the BIW should be possible. If we calculate the cost, assuming a 36% reduction, the composite version is actually cheaper to produce than the aluminium version. It can also be calculated that the two BIW designs break even at approximately 105kg or, effectively, at a 29% reduction.



Plot of composite BIW cost related to BIW mass

The aim of the life cycle assessment was to determine whether aluminium or carbon fibre reinforced polymer had the greatest environmental impact when used to produce the body in white of a concept electric vehicle. The results showed quite clearly that in almost every impact category, the manufacturing stages of the CFRP BIW structures had a greater impact than that of the aluminium BIW. However, once the full life cycle is taken into consideration, the environmental impact of the aluminium BIW becomes greater than that of the CFRP structures. This suggests that the weight saving achieved by manufacturing the BIW using CFRP has the most significant effect, and essentially begins to counteract the substantial manufacturing impacts. Whilst the revised CFRP structure has a greater environmental impact than the original design, the improvements in structural performance are substantial – and the BIW remains lighter and maintains a lower environmental impact than the predominantly aluminium structure.

The sensitivity analysis further supports these conclusions, by showing that the assumptions made did not bias the results. However, it also provides a vital insight into how environmental impact could be reduced in all three BIW structures – i.e. by manufacturing in countries with a cleaner electricity mix, or by using a greater proportion of recycled aluminium.

It must be stated that whilst these results enable conclusions to be drawn concerning the BIW, the limited scope of the LCA does not represent the full electric vehicle. If a further study were to be conducted, focusing on optimizing the concept as a whole, then a more detailed LCA would have to be carried out, most likely including capital goods as well as the other vehicular components. Not only this, but the EcoInvent database was lacking several important component materials included in the BIW structures – most notably carbon fibre. Whilst these absent profiles were constructed using data from available literature, they would be more accurate and of greater consistency with the other profiles once they have been included in the database.

After finishing the design, and perform the LCA and cost-benefit analyses on the final e-Light architecture design, the knowledge generated, as well as th different steps recommended towards a lightweight design for urban EV were summarised in the project guidelines. Three different guidelines were completed:

4. <u>General design guidelines/requirements</u>: The project results, and main findings, in terms of the most suitable materials and their use in the developed architectures, the modules to be used in the EV, and the manufacturing techniques have been summarised and presented in this document. The document also provides

designers with general recommendations with regards to the further study of body in white solutions for urban EV. This document will support industry designers in altomotive industry to achieve lightweight EV architectures minimizing costs and manufacturing times, and maximising production.

5. General Safety requirements: The document provides a summary of current safety and testing procedures that should be applied to EV without changes, European and USA standards have been analysed and a detailed list of new requirements for electric motors, power electronics and battery packs safety has been produced, with special attention paid to crash behaviour.
6. Testing procedures recommendations: This document summarised the assessment to be performed in the early stages of the design phase, since an accurate assessment of vehicle requirements is key to the definition of targets for new vehicle concepts. To achieve this objective a combination of industrial experience, detailed objective testing, specialised computed aided engineering and dynamic analysis tools are needed. The proper way to combine these skills is presented in this document to support evaluating new EV concepts.

The project reached its end on December 2013 although some delay in reporting was encountered. The Deliverables have been uploaded and the public reports are available through the project website.

Currently the project results are being used in several on-going FP7 projects in the field of Green Vehicle, EVoultion, UrbanEV, and Behicle are the most relevant ones. Cidaut, Pininfarina, Tecnalia and USFD are developing the e-Light designs to demonstrate feasibility of design by producing prototypes.
The door ring designed in e-Light will be prototyped by USFD, Pininfarina and Tecnalia in the Evolution project (http://evolutionproject.eu/).

4.- Potential Impact: socio-economical and wider society impacts, adding main dissemination activities (10 pages)

The expected main scientific and technical result will be a comprehensive description of the knowledge and methodologies used in designing a lightweight architecture for urban EV. The project focuses on defining the design drivers, design matrix and the influence of safety and modularity. The metallic and reinforced composite materials, as well as the joining and manufacturing techniques will also influence the chosen model. The performance of the model and the feedback from the simulations to the life cycle and the cost-benefit analysis will determine the information and detailed the methodology.

These knowledge and methodologies will be summarised in three documents:

- General Design Guidelines for EV architectures.
- Safety aspects related to new EVs and their influence on vehicle architectures.
- Testing procedures and recommendations for EV architecture design involving the new materials and joining techniques.

The e-Light project aims to support the European automotive industry, especially it the SMEs in the supply chain by providing these companies with the knowledge and methodologies to design architectures for EVs. The project results, in the form of comprehensive guidelines and procedures will allow those companies to face the challenge of adapting their businesses to a new type of vehicle.

E-Light results will have a significant impact in enhancing the European automotive industry competeviness, allowing a closer and improved relationship between OEMs and large companies in this industry with the SMEs in their supply chain. By increasing their knowledge, e-light will facilitate European SMEs in the automotive market to consolidate their position while improving their adaptation towards the new requirement of electric mobility.

The e-Light results aim to support and boost the European automotive industry competitiveness, especially their SMEs, to continue being a pillar of the European economy, representing 3% of Europe's gross domestic product, 7% of employment in the manufacturing sector and 8% of EU governments' total revenue.

The results are illustrated by a new EV architecture design, performed over a current existing EV from Pininfarina. The design has achieved 50% weight reduction in a feasible way. The developed architecture is better from a structural and safety points of view, while it is economically feasible for the assumed vehicle production.

The project has focused on defining the design drivers, design matrix and the influence of safety and modularity. The metallic and reinforced composite materials, as well as the joining and manufacturing techniques will also influence the chosen model. The performance of the model and the feedback from the simulations to the life cycle and the cost-benefit analysis have determined the information and detailed the methodology.

In order to progress with the achieved designs, some of the partners (Tecnalia, Pininfarina, USFD and Cidaut) have decided to follow the findings and results from e-Light into real prototypes to be applied on EV. The FP7 on-going projects Behicle, Evolution, Urban-EV, and FreeMOBY will directly benefit from the knowledge generated in the project. And in the Evolution project USFD, Pininfarina and Cidaut will prototype the door ring designed in e-Light validating the results.

Main dissemination activities:

Among other activities, the consortium developed a project logo, a web page and a specific website, as well as the draft of a newsletter (three numbers were issued), finally publications, fairs and workshops are reported here.

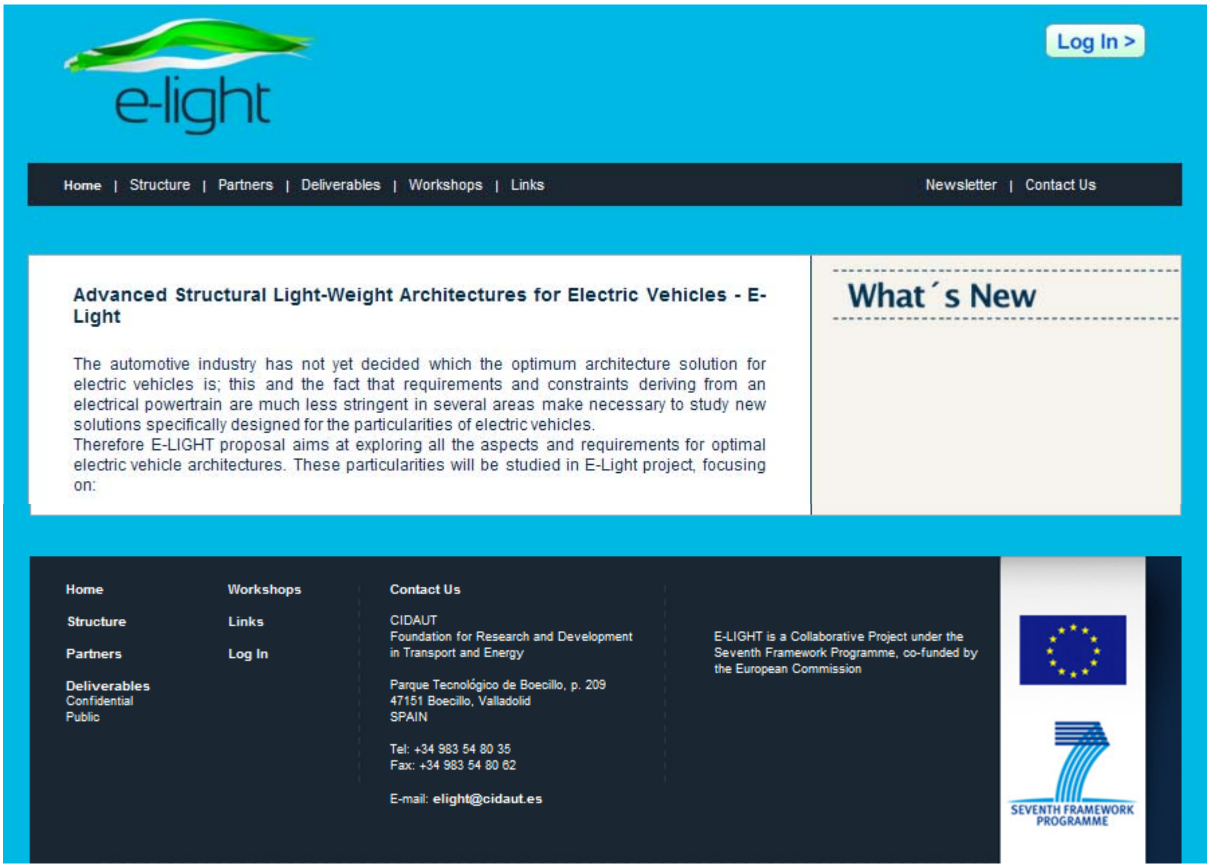
Project logo and identity: From the early stages of the project, a project logo was designed to communicate the project identity. This logo has been used on the website, as well as in any other dissemination materials, including the presentations and documents.
This logo will be included in all documents related to the project by any partner elaborating them. Currently, there is a colour version of the logo, shown in the following image, while different chromatic versions will be designed in order to assure the best visibility of e-Light identity with independence of the type of media used.

e-light

The selection of the colours to be used in the logo was made taking into account international standards and basic design rules to ensure that it is easy to reproduce while having a high visibility.

Slideshow Presentation: A commercial MS-PowerPoint presentation template has been created to be used as a dissemination tool on public presentations and as an attachment in the targeted mailing, proving concise and attracting information on the project. The main objective of this template is to attract the attention of the industrial and scientific sectors by presenting a common style according to the project logo and website. A complete template for the presentation has been defined by the coordinator including the project's logo, fonts and main colours. This template also includes the EC and FP7 logos to indicate the co-funding by the EC through the 7th Framework Programme.

Project Website: The main public dissemination platform for the project is the website. All relevant information regarding the scope of the project, the partners in the consortium and the expected results is listed in this site. Information on relevant events as well as contact with the project coordinator can also be easily found.
The web site also allows the consortium to announce all news and progresses made in the project, presenting several documents informing about achievements than can be directly downloaded.
A fact sheet with the main features of e-Light, including the objectives and description of the project was produced after the review meeting. This document is also available in the public web site, and can be downloaded and used as an introductory tool to present the project.
The address is: http://www.elight-project.eu In the following images, different functionalities and lay-out are shown:



A project brochure was developed to introduce and present the e-Light project and to disseminate its main objectives, while only giving basic information about the project. The leaflet is made available on the project website for downloading and printed copies are available for dissemination purposes at events, at which the consortium, or single e-Light partners, has attended. A total of 1,100 paper copies were printed off for the workshops and for general dissemination goals. The contents of the project brochures included the Logos (e-Light project, 7th framework programme, European Commission); Short description of e-Light project objectives; Partners list (company logos, nationality, people in charge of the project, e-mail addresses).

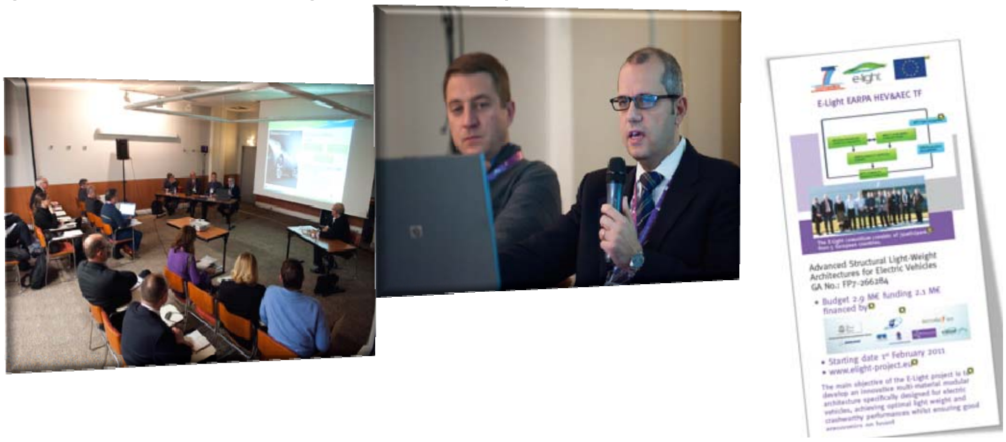
Project billboard: For the presentation of the e-Light project at Project Workshops, a large advertising structure has been created in the optimised design of a single screen, so that the writing and design of "e-Light in a nutshell" come all together.

Project posters: The project posters are available in the occasion of events (paper-medium). In term of target groups, the posters are addressed to the direct and indirect beneficiaries of the project's ouputs. The languages used for the posters are national languages for disseminating the project at a local level and/or English for international dissemination.

Annual newsletters are disseminated through the relevant technological communities with the main project findings and other results of the e-Light project. First and second newsletters were focused on the progress achieved by the project while the last one presented the project final workshop held at EVS27 and in which the results achieved by the project were presented. The planned time to release the newsletter was on July 2012; on April 2013; and on January 2014. Although a one month delay was produced on the third and final newsletter. They are only be available on the Internet, incl. an on-line version for the project website, but no printed versions will be issued.

Conferences and workshops: Throughout the duration of the project, e-Light partners have disseminated the achievements and developments to the relevant scientific communities, focusing in the automotive design area.
Cooperation with other EC projects in related areas has been searched due to the wide interest of decreasing the CO_2 emissions and promoting the mass roll-out of EV in Europe.

- The e-Light project has also been presented in Mobilis International Conference, held in Belfort, France on November 2011. Mobilis was attended by 571 persons related to mobility, from which a 45% attended on behalf of industrial companies. Within this event, the e-Light project displayed a billboard. A large advertising structure was created, in the optimized design of a single screen, so that the writing and design of "e-Light in a nutshell" came all together. For the presentation of our project on the occasion of Mobilis, e-Light participated on the 16th of November to a workshop on reducing electric vehicle's weight (http://www.mobilisconference.com/uploads/2011/pdf/Cidaut_Mobilis11_WkS_A3.pdf). In this workshop Michelin and BMW played an important role. The following images were taken during the workshop:



Images showing the first Project Workshops and the brochure

- The 2nd Project Workshop was held in France in the end of 2012 at MOBILIS. With the anticipated future demand and growth in urban electric vehicles (EV), there is a strong requirement for automotive suppliers and small and medium enterprises (SME) to advance their knowledge and capability in lightweight and modular vehicle design. Two large carmakers (FIAT, PSA Peugeot Citroën) and one important automotive supplier (RICARDO) took part in the workshop. This workshop was also under the patronage of the S_LIFE European project (transnational synergies and co-operation initiatives for sustainable vehicle along the life-cycle). MOBILIS is PVF's annual 2-day international conference and showcase on "the future of mobility". It welcomes around 500 visitors every year in one city of Alsace or Franche-Comté regions. With its workshops and meetings, MOBILIS pursues the goal to make international cooperation progress and favour reflections, business opportunities and future innovative projects. It is also a place dedicated to networking between businesses and research laboratories. More information on Mobilis can be found in the event website: http://www.mobilisconference.com/

Images from 2012 workshop held at Mobilis

The Final project workshop was held in Barcelona (Spain) in November 2013 in the framework of the 27th edition of the International Electric Vehicle Symposium (EVS). EVS 27 has been the most successful edition ever with over 4,000 visitors from 58 different countries, 1,300 congress attendees and 232 international exhibitors that met up in Barcelona to promote the electric transport industry and tackle its future challenges. It has been a showcase for the leading manufacturers to exhibit their electric vehicle models, such as the Volkswagen e-UP!, the Nissan Leaf, the BMW i3 and the Renault ZOE as well as for the sector's new technology providers to show the latest innovations like wireless charging facilities, to name but a few. More information on the event website: http://www.evs27.org/ As part of EVS 27 there were several sessions planned to more specifically support "European and International Projects Dissemination". This new category, making its debut in EVS 27, responds to the need to reveal the growing number of global proposals that, from different approaches, advocate electromobility. The topics cover activities across all fields related to battery, hybrid and fuel cell electric vehicles, as well as topics related to market deployment, business models and public policies. The time slot of the whole session was 80 minutes and the number of speakers per session was 5, each of them had a maximum of 10 minutes for his presentation. The last 20

Figure 22. Pictures from the final workshop of e-Light held at EVS27.

- The project was presented to the research community in EARPA's (European Automotive Research Association) meeting held in Brussels on October 2011.

- At a National level, the project has been widely presented in Spain. On the Green Car Initiative held in Valladolid on October 2011 the project was publicly presented to the Industrial and Research communities.
- Two reports on the status of the project within Cidaut's newsletter (distributed to more than 1000 industrial partners in almost every research field)
- Presentation on the e-Light achievements at ELVA's final workshop in Turin, Italy. 23-24 May 2013.
- 11th July 2012 – presentation of e-light at the GCI clustering event held in Brussels.
- Some partners of the e-Light project are currently involved in other European initiatives through which the learnings of e-Light are directly promoted and take to the prototype atage:
  - USFD, CIDAUT, TECNALIA and Pininfarina are involved in the EVolution project, whose objective is to develop new materials which will significantly reduce the weight of the new generation of hybrid- and electrical vehicles. It is a research project funded by the European Commission under the 7th Framework Programme. EVolution project website: http://evolutionproject.eu/
  - PVF is involved in the S_LIFE project, whose objective is to develop transnational synergies and co-operation initiatives for sustainable vehicle along the life-cycle. Recycling of composite materials is one of the project's topics. It is a research project funded by the European Commission under the 7th Framework Programme. S_LIFE project website: http://s-life-project.eu/

- Also, a press release of the project was presented in CABIRO, an article explaining the objectives of the project, and the kick-off meeting was published and distributed to more that 200 industrial partners.

Proyecto

Cidaut diseña estructuras más ligeras y resistentes para los nuevos vehículos eléctricos urbanos

El proyecto E-Light investigará las ventajas de nuevos materiales

Una de las prioridades, dentro del Plan Estratégico de Transporte de la Comisión Europea es la sostenibilidad del transporte por carretera en la Unión Europea. Es dentro de este plan estratégico donde se enmarca la iniciativa Green Car, destinada a superar las barreras tecnológicas para la implantación del Vehículo Eléctrico de forma masiva en las ciudades de la Unión.

A lo largo de 2010, la Fundación Cidaut lideró la preparación de una propuesta para la realización de un proyecto de I+D dentro de esta iniciativa, el proyecto E-Light. El objetivo del proyecto es el diseño de estructuras para los nuevos vehículos eléctricos urbanos, de modo que éstos sean más ligeros y resistentes, aumentando su funcionalidad y autonomía y, por tanto, facilitando que su aceptación por parte del consumidor sea mayor. Este proyecto es clave para poder configurar la movilidad del futuro en las ciudades, haciéndola más sostenible a través de la introducción de diseños que tengan en cuenta las características y peculiaridades de los vehículos eléctricos. En dichos vehículos no existirá ni motor de combustión ni sistema de escape de gases, de modo que las limitaciones clásicas de diseño asociadas no existirán, permitiendo diferentes configuraciones que aumenten la ergonomía y uso del espacio interior.

Los nuevos vehículos eléctricos urbanos presentan otra característica única, es posible introducir nuevos materiales en su diseño, tales como aceros especiales, aleaciones de aluminio y magnesio, plásticos reforzados, e incluso fibra de carbono, que tradicionalmente no se han empleado en el diseño de estructuras de automoción por tener una relación coste-beneficio desfavorable.

En este proyecto, además de la Fundación Cidaut, colaboran Tecnalia (España), East-4D (Alemania), la Universidad de Sheffield y Ricardo (Reino Unido), el cluster de automoción Pole Vehicle du Futur (Francia) y Pininfarina (Italia).

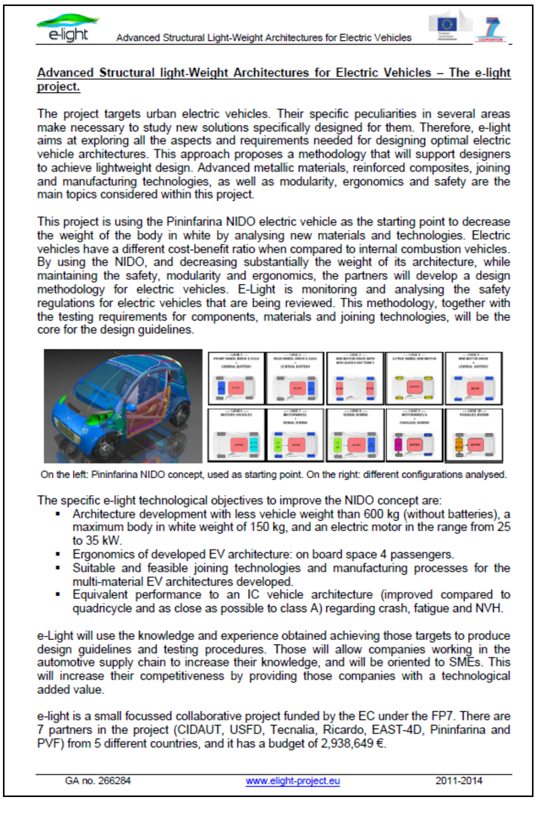
GUÍAS DE DISEÑO

Cidaut lidera este proyecto al supervisar todos los aspectos técnicos del diseño de los nuevos vehículos eléctricos urbanos incluyendo materiales y seguridad, así como encargándose de difundir los resultados obtenidos en el proyecto para asegurar que tengan el máximo impacto en el ámbito industrial. El proyecto, que cuenta con un presupuesto de 2,84 millones de euros, está financiado por la Comisión Europea, a través del VII Programa Marco, expediente nº FP7-266284, siendo uno de los proyectos aprobados dentro de la iniciativa Green Car. Los responsables de este proyecto desarrollarán un modelo de arquitectura multimaterial buscando el peso mínimo, que sea industrializable y con un costo reducido. Para alcanzar este resultado, no sólo se estudiarán los materiales, sino también los procesos de unión y ensamblaje, de modo que los elementos de la estructura puedan unirse de modo sencillo y eficaz. A partir de este diseño, se redactarán una serie de recomendaciones diseño, y de ensayo, que permitirán a los ingenieros de automoción el planteamiento de nuevos vehículos eléctricos más eficientes y ligeros, con diversas funcionalidades que incluyan no sólo el transporte de pasajeros, sino también el de mercancías en el ámbito urbano.

Asistentes a la reunión de inicio del proyecto E-Light.

Entre los valores positivos que ofrece esta investigación, destaca la participación de todos los actores necesarios para su desarrollo y finalización, aportando experiencia tanto en los diversos materiales que formarán parte de la estructura como en su unión y ensamblaje para poder ser aplicados a la industria del transporte.

Nº 37 Abril-Junio 2011 Cabiro 17



e-light Advanced Structural Light-Weight Architectures for Electric Vehicles

Advanced Structural light-Weight Architectures for Electric Vehicles – The e-light project.

The project targets urban electric vehicles. Their specific peculiarities in several areas make necessary to study new solutions specifically designed for them. Therefore, e-light aims at exploring all the aspects and requirements needed for designing optimal electric vehicle architectures. This approach proposes a methodology that will support designers to achieve lightweight design. Advanced metallic materials, reinforced composites, joining and manufacturing technologies, as well as modularity, ergonomics and safety are the main topics considered within this project.

This project is using the Pininfarina NIDO electric vehicle as the starting point to decrease the weight of the body in white by analysing new materials and technologies. Electric vehicles have a different cost-benefit ratio when compared to internal combustion vehicles. By using the NIDO, and decreasing substantially the weight of its architecture, while maintaining the safety, modularity and ergonomics, the partners will develop a design methodology for electric vehicles. E-Light is monitoring and analysing the safety regulations for electric vehicles that are being reviewed. This methodology, together with the testing requirements for components, materials and joining technologies, will be the core for the design guidelines.

On the left: Pininfarina NIDO concept, used as starting point. On the right: different configurations analysed.

The specific e-light technological objectives to improve the NIDO concept are:

- Architecture development with less vehicle weight than 600 kg (without batteries), a maximum body in white weight of 150 kg, and an electric motor in the range from 25 to 35 kW.
- Ergonomics of developed EV architecture: on board space 4 passengers.
- Suitable and feasible joining technologies and manufacturing processes for the multi-material EV architectures developed.
- Equivalent performance to an IC vehicle architecture (improved compared to quadricycle and as close as possible to class A) regarding crash, fatigue and NVH.

e-Light will use the knowledge and experience obtained achieving those targets to produce design guidelines and testing procedures. Those will allow companies working in the automotive supply chain to increase their knowledge, and will be oriented to SMEs. This will increase their competitiveness by providing those companies with a technological added value.

e-light is a small focussed collaborative project funded by the EC under the FP7. There are 7 partners in the project (CIDAUT, USFD, Tecnalia, Ricardo, EAST-4D, Pininfarina and PVF) from 5 different countries, and it has a budget of 2,938,649 €.

GA no. 266284 www.elight-project.eu 2011-2014

- Project Showcase at Hanover Fair / MobiliTec in Hanover, 2013. An international project showcase was held in Hanover (DE) in April 2013 at Hanover Fair / MobiliTec business event. In 2013, 147 exhibitors showcased the future of mobility in more than 5,000 square meters, including PVF being an ambassador of the e-Light project. The MobiliTec 2013 event welcomed 26,900 visitors.

Figure 20. PVF show case at Hanover Fair / MobiliTec in Hanover, 2013 in which e-Ligth was displayed and presented.

Collaborative Workspace (Netvibes): The dissemination manager (PVF) created an internal web based workspace to manage the dissemination aspects of the project, as well as to monitor the relevant information regarding new materials, lightweight design and recent developments in EV related areas. This powerful tool allows the consortium to share information and documents, schedule activities and meetings as well as enhance the different working teams to improve their efficiency by allowing sharing news, information while save time by using a single common tool.

For the duration of the project PVF has implemented this tool by using Netvibes. Their technical website is available at http://elight.netvibesbusiness.com/ this can be accessed by e-Light partners upon authentication. No content of the web based tool is made public or publicly linkable for un-authenticated download. Netvibes provides the following collaborative features:

- Document repository
- Meeting calendar
- issue/activity tracking
- News related to EV
- Space for large file transfer and exchange

This collaborative space provides also services for user management and role management, as well as distribution groups and access control policies. The system also automatically sends notifications of each activity performed to all relevant members, thus all partners are always kept up to date of all project progresses. The system is backed-up nightly to an off-site and on-line backup service.

Some screenshots of the user interface are here reported to highlight the key functionalities.

Example of the Netvibes tool established by PVF to manage the dissemination

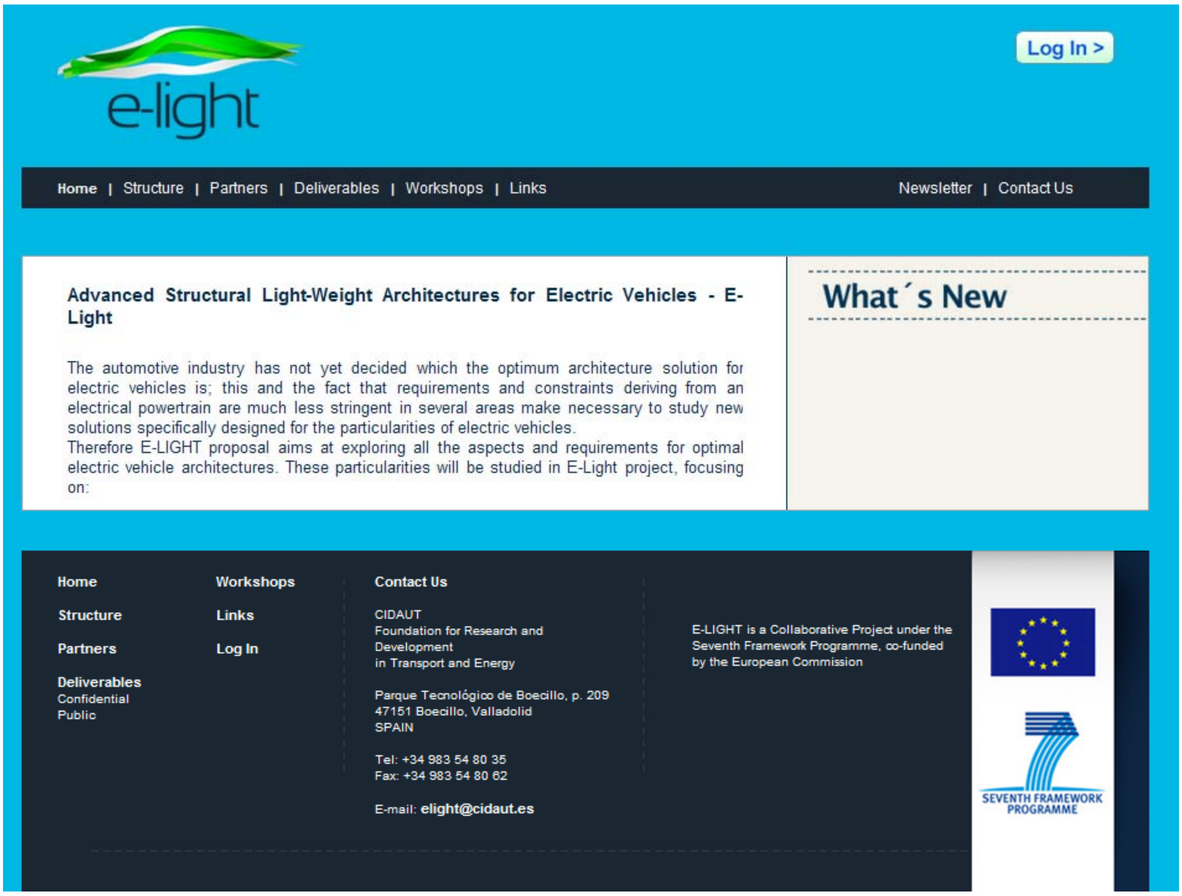
5.- Project website + relevant contact details

Development of the Project website, if applicable

The e-Light website was established in February 2011. It aims to provide information on the main activities and results of the project, on project related events and announcements, i.e. workshop announcements, but also to provide news regarding EV and lightweight design to the public.

The target audience is the research, scientific and industrial public, although the general public is welcomed to read their contents. Its focus, for dissemination and exploitation purposed is the automotive industry supply chain. The website can be accessed through http://www.elight-project.eu/

The main page of e-Light website is shown in the following figure:



e-Light Website Main Page

Within public website, an private area was created in order to ensure project relevant data transfer between the different partners, especially those sensitive or of large size (such are CAD and CAE models)

Contact details:
Coordinator details: Dr. Esteban Cañibano, +34 983 548035, luipra@cidaut.es
Project contact: elight@cidaut.es

A2: List of dissemination activities

- Project logo and identity: From the early stages of the project, a project logo was designed to communicate the project identity. This logo has been used on the website, as well as in any other dissemination materials, including the presentations and documents.
- Slideshow Presentation: A commercial MS-PowerPoint presentation template has been created to be used as a dissemination tool on public presentations and as an attachment in the targeted mailing, proving concise and attracting information on the project.
- Project Website: The main public dissemination platform for the project is the website. All relevant information regarding the scope of the project, the partners in the consortium and the expected results is listed in this site. Information on relevant events as well as contact with the project coordinator can also be easily found. The address is: http://www.elight-project.eu
- A project brochure was developed to introduce and present the e-Light project and to disseminate its main objectives, while only giving basic information about the project
- Project billboard: For the presentation of the e-Light project at Project Workshops, a large advertising structure has been created in the optimised design of a single screen, so that the writing and design of "e-Light in a nutshell" come all together.
- Project posters: The project posters are available in the occasion of events (paper-medium).
- Annual newsletters are disseminated through the relevant technological communities with the main project findings and other results of the e-Light project. First and second newsletters were focused on the progress achieved by the project while the last one presented the project final workshop held at EVS27 and in which the results achieved by the project were presented. The planned time to release the newsletter was on July 2012; on April 2013; and on January 2014. Although a one month delay was produced on the third and final newsletter. They are only be available on the Internet, incl. an on-line version for the project website, but no printed versions will be issued.
- Workshop 1: The e-Light project has also been presented in Mobilis International Conference, held in Belfort, France on November 2011.
- Workshop 2: The 2nd Project Workshop was held in France in the end of 2012 at MOBILIS. With the anticipated future demand and growth in urban electric vehicles (EV),
- Workshop 3: The Final project workshop was held in Barcelona (Spain) in November 2013 in the framework of the 27th edition of the International Electric Vehicle Symposium (EVS). The project was presented to the research community in EARPA's (European Automotive Research Association) meeting held in Brussels on October 2011.
- Conferences: At a National level, the project has been widely presented in Spain. On the Green Car Initiative held in Valladolid on October 2011 the project was publicly presented to the Industrial and Research communities.
- Conference: Presentation on the e-Light achievements at ELVA's final workshop in Turin, Italy. 23-24 May 2013.
- Congress: Project Showcase at Hanover Fair / MobiliTec in Hanover, 2013. An international project showcase was held in Hanover (DE) in April 2013 at Hanover

Fair / MobiliTec business event. In 2013, 147 exhibitors showcased the future of mobility in more than 5,000 square meters, including PVF being an ambassador of the e-Light project. The MobiliTec 2013 event welcomed 26,900 visitors.

- Conference: 11th July 2012 – presentation of e-light at the GCI clustering event held in Brussels.
- Networking: Some partners of the e-Light project are currently involved in other European initiatives through which the learnings of e-Light are directly promoted and take to the prototype atage:
  - USFD, CIDAUT, TECNALIA and Pininfarina are involved in the EVolution project, whose objective is to develop new materials which will significantly reduce the weight of the new generation of hybrid- and electrical vehicles. It is a research project funded by the European Commission under the 7th Framework Programme. EVolution project website: http://evolutionproject.eu/
  - PVF is involved in the S_LIFE project, whose objective is to develop transnational synergies and co-operation initiatives for sustainable vehicle along the life-cycle. Recycling of composite materials is one of the project's topics. It is a research project funded by the European Commission under the 7th Framework Programme. S_LIFE project website: http://s-life-project.eu/
- Press release of the project was presented in CABIRO, an article explaining the objectives of the project, and the kick-off meeting was published and distributed to more that 200 industrial partners.
- Press: Two reports on the status of the project within Cidaut's newsletter (distributed to more than 1000 industrial partners in almost every research field)
- Management Tools: Collaborative Workspace (Netvibes) for dissemination management

B2: List of exploitable results

Exploitable Result(s)	Title of the Exploitable Result(s)	Dissemination level	Exploitation form
Exploitable Result 1	Decision matrix methodology	CO	REPORT
Exploitable Result 2	C-ring design for urban EV	CO	CAD and Know-How
Exploitable Result 3	Material and manufacturing + assembly processes	CO	REPORT
Exploitable Result 4	Guidelines for design	PU	REPORT