Publishable Summary

Grant Agreement number: **314567**

Project acronym: **ENLIGHT**

Project title: **Enhanced Lightweight Design**

Funding Scheme: **Collaborative Project: Large-scale integrating project**

Date of latest version of Annex I against which the assessment will be made: 21.11.2012 (update by the first Request for Amendment submitted May 5, 2014)

Periodic report: **1st** ☐ **2nd** ✓ **3rd** ☐ **4th** ☐

Period covered: **from 01.04.2014 to 30.09.2015**

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[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

3.1 Publishable summary

One of the key societal challenges of today is the decarbonisation of the road transport. The challenge of decarbonisation must be met among others by significantly reducing the vehicles weight reversing the weight spiral of the last decades on the other hand. However the need for weight reduction in future EVs, without unduly compromising performance and safety, is even stronger since additional weight translates into either reduced driving range or in larger, heavier and more expensive batteries. Striving for reduced weight as the only objective will not necessarily result in a reduced environmental impact of the EV fleets of the future: Another two key and equally important drivers need to be pursued at the same time, namely affordability and life cycle impact minimization. Affordability is essential since it will allow for larger portion of the total EV fleet to adopt specific light-weighting solutions; and Life Cycle Impact effectively defines the total CO_2 impact over the lifetime of the vehicle.

Therefore, ENLIGHT aims to advance highly innovative lightweight material technologies for application in structural vehicle parts of future volume produced Electric Vehicles (EVs) along four axes: performance, manufacturability, cost effectiveness and lifecycle footprint. The main target is to develop viable and sustainable solutions for medium production volume EVs destined to reach the market in the next 8-12 years. In ENLIGHT each of the principal major weight-incorporating parts of a vehicle will be addressed directly by the five modules: a front module and central floor module, a front door, a sub-frame and suspension system as well as an integrated cross car beam as part of the firewall. The specific objectives of the ENLIGHT project are on holistic and integrated conceptual design and manufacturing concerning how the technologies and materials addressed (in combination with materials / forming/ joining processes coming from other previous and on-going projects) can be combined into a representative medium-volume EV by around 2020. This design is targeted to have a 20% additional weight reduction compared to the targets that are pursued in the complementary ALIVE proposal.

ENLIGHT targets an ultra-compact four-seated passenger as considered in the ELVA project. Based on this architecture, the five selected modules will be conceptually designed with respect to weight and CO2 balance over life-time. These designs will be evaluated and potential improvements assessed on vehicle level with respect to weight, safety and performance that result from the application the highly advanced material developed within ENLIGHT. The optimal combination of architecture & design, processes and materials requires a systemic technical cost modeling, ensuring sustainable solutions using LCA and accounting for externalities, while taking into account the necessary integration into the manufacturing strategy of each car manufacturer and supplier.

Within in ENLIGHT highly advanced materials such as thermoplastic matrix composite, fibre-reinforced composites, advanced hybrids and sandwich materials as well as composites based on bio-material and renewables will be developed to a stage that they are applicable at least in medium volume production. The material development will be complemented by investigating the required manufacturing and assembly technologies as well. The relevant technologies being developed or available outside of the project will complete the input for the multi-criteria decision-making process needed to select which technologies will be finally applied in the final ENLIGHT demonstrators of the five modules.

ENLIGHT advances innovative lightweight & low embodied CO2 materials and their related design, manufacturing & joining capabilities suitable for automotive industry which requires unique levels of affordability, mechanical performance and ecology. The project innovates computer-based as well as experimental validation approaches (and their combinations) to allow for a fast, efficient and reliable design process. ENLIGHT validates the solutions by

means of large scale level physical demonstrators to be evaluated experimentally in combination with a full vehicle virtual design and simulation. ENLIGHT will deliver

- highly innovative lightweight / low embedded CO_2 materials for their application in medium-volume automotive production,
- design capabilities for affordable medium-volume lightweight EVs,
- manufacturing and joining capabilities for affordable medium-volume lightweight EVs,
- experimental and simulation validation environments to enable rapid & reliable multi-parameter optimization when designing with these new materials,
- LCA and economic analysis taking into account all salient factors,
- 5 demonstrator modules (front module, suspension parts, door module, components for the cockpit/firewall section and the floor section), covering different distinguishing features of purpose-designed EVs.

With this ENLIGHT will accelerate the introduction of energy efficient BEVs by taking away "range anxiety". ENLIGHT would result in a considerable weight reduction compared to the present BEVs on the road whereby the vehicles weight correlates linear with the energy consumption. A weight reduction of 20% results in 20% less fuel consumption. As such, ENLIGHT will contribute to the green house gas reduction through lower energy consumption taken from the electricity grid, while diminishing the EU's geopolitical oil dependence.

Besides environmental impacts ENLIGHT results are important for the European competeveness as well. The European Union is still the world's largest car-producing area and car market, and its automotive industry is vital to Europe's sustainable development. Europe produces 29% (2010) of the global vehicles. In order the meet the challenges arising from the new markets in Asia and the policies defined worldwide to meet the global demands, the European automotive industry must recognise the worldwide technology trends by incorporating them into their own strategy on the one hand and by driving the market growth on the other hand. Lightweight design, highly efficient engines and efficient use of energy within the vehicles are among the most important global techno-logical trends to be addressed by the European industry.

The ENLIGHT OEM partners jointly produce 54% of the vehicles in the EU-27 countries and 24% of all the vehicles in the world. In this way ENLIGHT ensures an effective direct wide scale impact on the sector through the participating OEMs and their supplier networks.

The shortest term target market segment for ENLIGHT is the segment of mid volume (~30.000 units/year) premium vehicles (in 2020), which, selling at a premium price, are more likely (initially surely) to incorporate more costly components / modules into the vehicle structure. This will allow for the maturing of these advanced lightweight technologies in real market vehicles. Further re-search, know how from first application experiences and increasing economies of scale will then lead to lower unit costs and make the advanced lightweight technologies economically viable for mass volume electric (and ICE) vehicles in the next generational leap (in 2025), thus leveraging the benefits over the whole EU vehicle fleet.

In the second reporting period the focus was on the elaboration of the conceptual design of the five modules taking into account the new materials and adapted manufacturing processes. The development of the materials for those modules continued with the characterization and validation of the most suitable ones. For these materials also material models has been derived to be implemented in the optimization of the modules. In parallel, suitable manufacturing technologies were identified and adapted to the manufacturing of the modules.

For all **modules**, a detailed design was derived from the developed concepts. For all designs, significant mass savings of up to 50% have been estimated with reference to conventionally built parts. Also the dynamic characteristics have been assessed by Finite Element calculations, and for doors and front module crash behavior was assessed. Mostly, hybrid designs utilizing aluminum inserts together with CFRP or GFRP were investigated. It turned out that the mass of the aluminum parts contributes significantly to the overall weight. Thus, besides the further improvement of the dynamic and crash characteristics, also further weight savings by optimization of the aluminum parts is planned.

Related to different material applications and requirements, different aspects and types of material models were investigated and currently bein validated. Additionally the different vehicle modules are being assessed and optimized. At current status all modules have been evaluated based on predefined load cases. The different control arms and the cross car beam have been simulated on module level. The front doors, central floor structure and front module components haven been evaluated on full vehicle level, based on an intermediate status of the ALIVE model. Current results show promising performance but need for further optimization as well.

A further objective of **ENLIGHT** is the development of novel lightweight materials for applications in the modules. A list of all considered materials has been made available for all partners, along with a material database comprising all available properties of the considered materials. A special version of the material list comprises the parts requirements identified by WP1 partners and for every material it is indicated how good it fulfils the different requirements. Based on these documents, possible materials were identified for the different applications and discussions between material suppliers and designers were initiated on a bilateral basis to finalize the material choice. Material development work was at the same time proceeding at the different partners and has been finalized for most materials during the 2nd period.

With respect to joining and bonding of multi-materials, technologies has been identified and validated suitable for the manufacturing of the considered modules including the assembly sequences. Regarding manufacturing the modules, based on the selected materials suitable manufacturing technologies were identified including thermoforming, overmolding or hot stamping and rapid stamp-forming/compression molding. Furthermore, a manufacturing concept has been elaborating allowing to integrate piezo ceramic material into fiber composites in mass production. The concept is based on Tailored Fiber Placement. Finally, an innovative technique for efficient high volume RTM manufacturing is being elaborated.

Additionally environmental and economic evaluations were carried out by means of the **Life Cycle Assessment** (LCA) approach, to calculate and compare the five module design solutions. The 2nd period was dedicated mostly to data gathering for LCA and LCC analysis. The data collection was carried out for each life cycle phase (production phase, use phase and end-of-life) of each module by means of a questionnaire, database and literature review. LCA models by means of Gabi software and LCC models by means of a tailored tool have been developed as well.