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SLC

**Sustainable Production Technologies of Emission reduced
Lightweight car concepts (SuperLIGHT-CAR)**

Integrated Project

Priority 6.2: Sustainable Surface Transport 2B

Publishable Final Activity Report

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Project execution

1. Summary of project objectives and results

SuperLIGHT-Car is a collaborative Research & Development project, running from 2005 to 2009, where 37 leading organisations from 9 European countries have worked together to bring lightweight automotive technologies closer to high volume car production.

The SuperLIGHT-Car project, with a total budget of more than 19 million EUR, has been co-funded by the European Commission under the 6th Framework Programme.

The SuperLIGHT-Car project cuts away 35 % of the weight in mass-produced compact cars.

The European project SuperLIGHT-Car demonstrates one efficient solution for the distribution of dissimilar materials in an existing compact class vehicle. As the project comes to a conclusion, it can display an impressive car-body weight reduction of 35 % in a compact car that can be produced at 1000 units per day.

The European automotive industry is world leading in technologies for energy efficiency and CO₂ reduction in vehicles; important factors for an industry that seeks to radically reduce its environmental footprint. One key to reinforce these strengths is to decrease the vehicle weight, and thereby the fuel consumption. The concept of lightweight vehicles is nothing new; sports cars have been produced with lightweight materials for decades. Yet steel remains the main material of mass-produced cars, due to the lack of technologies for bringing lightweight vehicle production up to scale.

The SuperLIGHT-Car project has successfully tackled the challenge of a feasible car-body concept suitable for high volume production, with an achieved weight reduction of 35 %. A multi-material approach was used where each specific body part is made from the most suitable material to fulfil the requirements while minimising the weight. The car-body is composed from aluminium, new steel, magnesium, and fibre reinforced plastics. Appropriate design and manufacturing technologies were developed to allow for the production of high volume series. The body-in-white concept developed by SuperLIGHT-Car has exceeded the initial target and offers, with a weight of 180 kg, a weight reduction of 101 kg compared to the reference car (Golf V), showing an equivalent performance. The full body-in-white prototype was recently presented at the international

conference "Innovative Developments for Lightweight Vehicle Structures", where it was enthusiastically received by the automotive industry.

The SuperLIGHT-Car concept also demonstrates economic potential. Originally targeted at €5-10 per kg of weight saved, the final additional cost landed at € 7,8 per kg of weight saved. Based on the expected fuel savings of 0.3 – 0.5 l/km that the SuperLIGHT-Car concept implies, a fully economic solution would require a reduction of the additional cost to € 5 per kg of weight saved. Future research based on the findings of SuperLIGHT-Car is expected to overcome this economic challenge, while advancing lightweight technologies even further. Clearly, the SuperLIGHT-Car consortium has taken a significant step towards the sustainable mass-produced vehicles of tomorrow.

2. Pictures of the SuperLIGHT-Car prototype



3. Project website

<http://www.superlightcar.com>

Dissemination and use

1. Multi-material design guidelines

Brief description of the result and stage of development

The multi-material design guidelines are a catalogue of all related results achieved within SLC. That includes a list with mechanical properties of the latest available materials; all investigated joining methods containing information about properties, limitations, results of joint testing, information about corrosion etc. Getting new joining methodologies into serial production is always related to the prediction possibilities in the virtual environment. This catalogue is the latest information bundle for anyone who is involved in multimaterial design approaches, at OEMs, suppliers as well as research institutes.

Use and possible market applications

IKA will include it in its own products and services.

These guidelines will be directly used in upcoming research projects within public funded projects as well as industrial partners.

Barrier for commercialisation and collaboration sought or offered

To be up to date this catalogue has constantly to be filled up with the latest developments and research information. A provider has to create and identify a business model to realise that. Another possibility is to set up a follow-up public funded research project to use the catalogue and to keep it up to date with related information.

Intellectual property rights granted or published

IKA has not and will not request any patent regarding this result.

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2. Materials and technologies catalogue

Brief description of the result and stage of development

The main results consist in the knowledge how to better employ the materials on a modern BIW in order to reduce the overall weight. The catalogue is strictly interconnected with the design operation and has been used to fill the design methodology applied in the project.

The catalogue is ready and has been implemented in the selection criteria codes developed within the SP1.

Further research needed and collaboration sought or offered

The database should be updated depending on new materials and technologies that are facing as the industrial application. The database should be a know-how that could grow

during the time. The approach could be internal to each company, or shared (also in terms of research and exploitation) together with other companies.

In CRF's opinion, this research should be done together with other organisations, like the SLC partners and non-SLC partners like: other RTD companies.

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3. SLC prototypes

Brief description of the result

To show the feasibility of the SuperLIGHT-Car concept and to gain in operating experiences, several prototypes have been built up. These prototypes are not only testing objects but learning supports too.

Several technologies have been demonstrated by producing parts under prototyping and industrial like conditions. This includes:

- Warm formed Magnesium roof panel and front and rear roof crossbeams (in AZ31 Mg).
- Roof crossbeam middle in carbon fibre reinforced plastic pultrusion technology
- Tunnel press hardened steel part with lengthwise integrated tailor welded blank technology
- Tunnel reinforcement as press hardened steel with tailor rolled blank technology
- Front longitudinal rail using aluminium tailor welded blank technology

The biggest and most important prototype is a complete body in white (BIW) with a 1:1 scale (see Figures 1 and 5). This BIW have been engineered with the materials, material grades, gauges and joining methods as defined in the project. However, to actually build the final model a feasibility study of the individual parts has to be carried out. For all aluminium parts a finite element simulation is done.

Advanced joining technologies are the key for cost-efficient high-volume assembling of multi-material structures. The joining work in the SuperLIGHT-Car project was focussed on:

- continuous joining (welding/brazing), in particular optimisation towards high strength steels as well as aluminium with laser and laser induction, and multi-material solutions with hybrid technologies;
- cold joining (adhesive structural bonding, pulse magnetic welding, friction spot stir welding) well suited for multi-material joints (and steel-aluminium joints);
- mechanical fasteners and insert techniques;
- high speed joining (>3m/min) enlarging process tolerances (hybrid welding) for mono-side access joining on thinner wall hollow section (profile, roll formed hollow section);
- body assembly sequence optimisation.

In the SuperLIGHT-Car BIW prototype following joining methods and quantities were used:

The prototyping work package has been a great opportunity to test during the assembly of the prototype the proposed solutions and to compare for example the forming simulations with the real behaviour of the pieces. Moreover the joining methods defined in the theory have been tested and validated or optimised during the assembly phase.

The repartition of the materials used in the SuperLIGHT-Car BIW concept is (see Fig. 1):

The concept developed by SuperLIGHT-Car has exceeded the initial target and offers with 180 kg a 35 % (101 kg) theoretical weight reduction compared to the reference car. The BIW prototype weights 171 kg. That corresponds to a 39 % weight reduction. The difference between the theoretical (CAD based) and the prototype weight can be explicated by the gauge reduction during the deep drawing process, which is not considered in CAD.

For the purpose of exhibition, presentation and easier transportation the BIW has been mounted on a transport and exhibition pedestal.

Beside the BIW, two front-end prototypes have been assembled (see Figure 3). One of them has been prepare and mounted like the BIW on a transport and exhibition pedestal (see Figure 4).

Assembly of front end physical demonstrator was performed by using multi-materials joining techniques. Precision positioning of shaped parts was ensured by assembly station with 0,3 mm geometrical accuracy. This was checked by 3D metrological measurement on assembled front end. Different joining techniques were used : 2K adhesive glue ensures continous joining needed for body high structural integrity. Self Piercing Riveting & Screwing ensure clamping of assembled dring adhesive glue reticulation. Cold Metal Transfer and Melt Inert Gas weld brazing were successfully used for joining Hot Press Steel parts as rocker transverse beam with Aluminium long front rail.

The two main prototypes will be used for exhibition by the partners. The second front-end prototype is available for further tests or analyses.

A forth was a half front-end composed of 23 parts, amongst other the TWB aluminum longitudinal front rail, the magnesium cast strut tower and the press hot formed front floor. This prototype has been tested on a fatigue test rig. The results of this analyse is presented in a separately result exploitation information form.

Specific corrosion test and evaluation of surface protection methodologies have been done at laboratory level on specimens.

Stage of development

All the prototypes have been completed and are now available for exhibition. Joining conditions and album of photos during assembling operations have been delivered and are usable by all partners for further light weight body structures.

Innovative surface protection technologies are under development, but this is out of the SLC project scope, sicne the activity was focused only in scouting and evaluating the new technologies.

Further research needed and collaboration sought/ offered

In addition to the vehicle body, systematic lightweight design concepts have to integrate equipment, chassis, engine and electronics. Sustainable concepts which benefit from secondary lightweight effects will play a decisive role in future car design. With the SuperLIGHT-Car BIW-prototype the demonstration of a lightweight BIW for series production has been made. Now further research and development work are needed to develop around this BIW a optimal sustainable car concepts.

Moreover the further research an development works could be focused on a reduction of the lightweight costs. The lightweight performance is indeed unfortunately attended by a production cost increase. The parts production costs for the SuperLIGHT-Car body concept are about 7,8 € per kg saved. The joining methods add an average cost of about 2,0 € per kg saved. It is VW's oppinion that this research should be done individually by VW.

According to RNLT further research is needed on atomization of assembly. Many assembly operations were performed manually to save time. Further industrialization for high cadence production would require to use atomatization by robotic with trajectory adaptation. Some low speed joining technique may be replaced by high speed joining such as Self Piercing Riveting aluminium by laser overlap welding, arc weld brazing by laser weld brazing. According to RNLT, this research should be done in collaboration with non-SLC organisations, like machine tool suppliers.

According to CRF, the final SLC BIW could be furhter investigated in terms of commercial solutions for the BIW corrosion protection. This research should be done with non-SLC organizations like specific RTD centre or suppliers of Corrosion Protection Solutions.

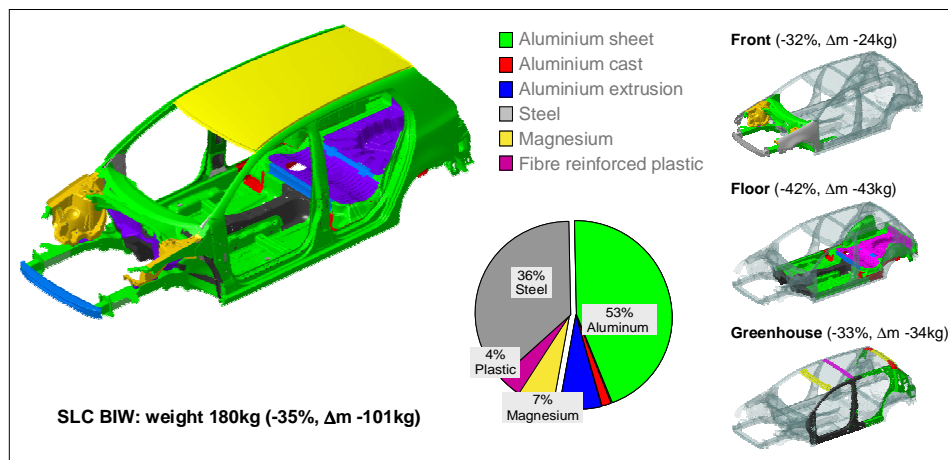


Figure 1: Weight repartition in the SuperLIGHT-Car body structure



Figure 2: Impressions from the prototyping shop

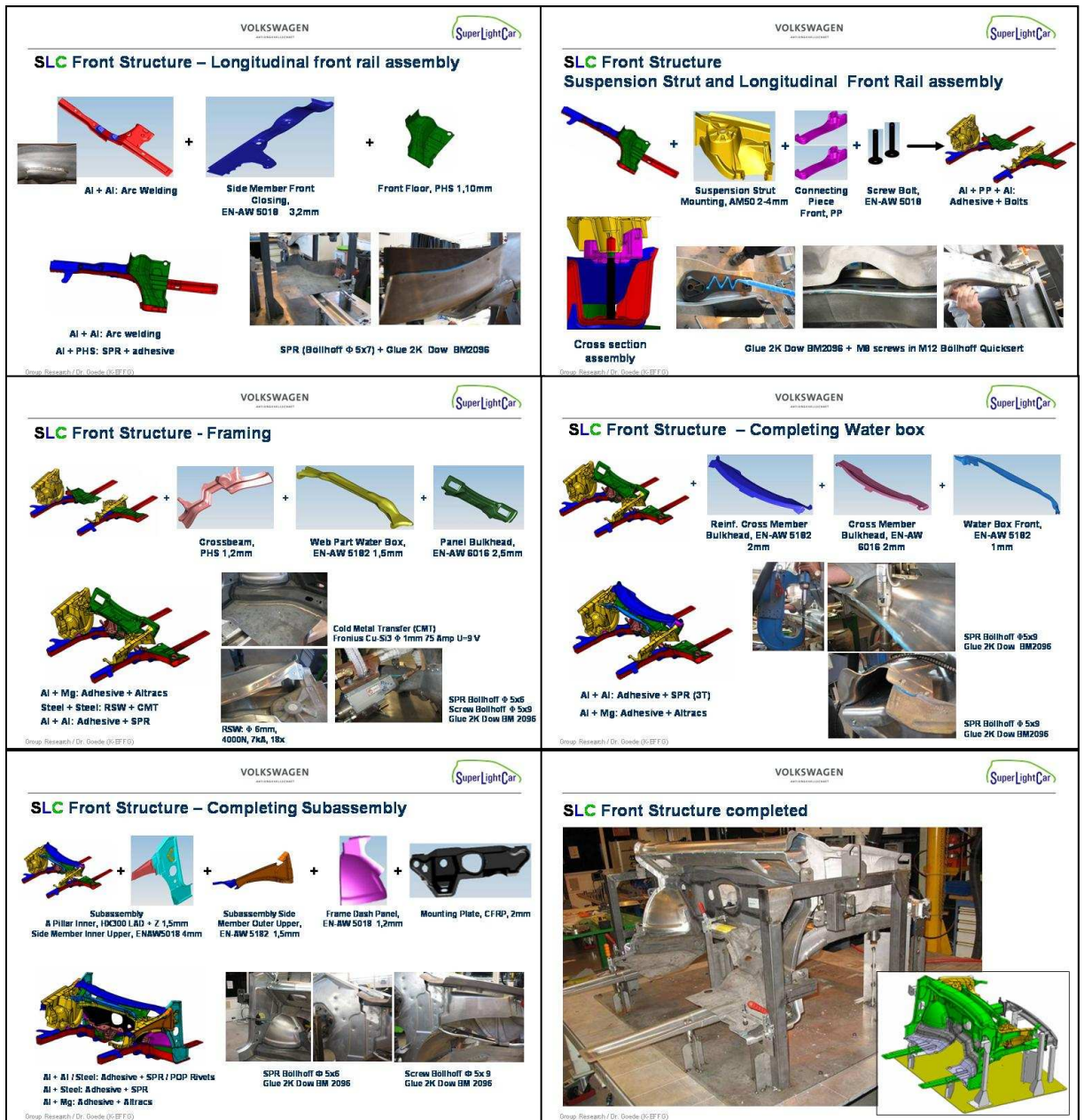


Figure 3: Assembly sequence (from left to right and up to down) of the SuperLIGHT-Car front end prototype



Figure 4: SuperLIGHT-Car front-end prototype during an exhibition

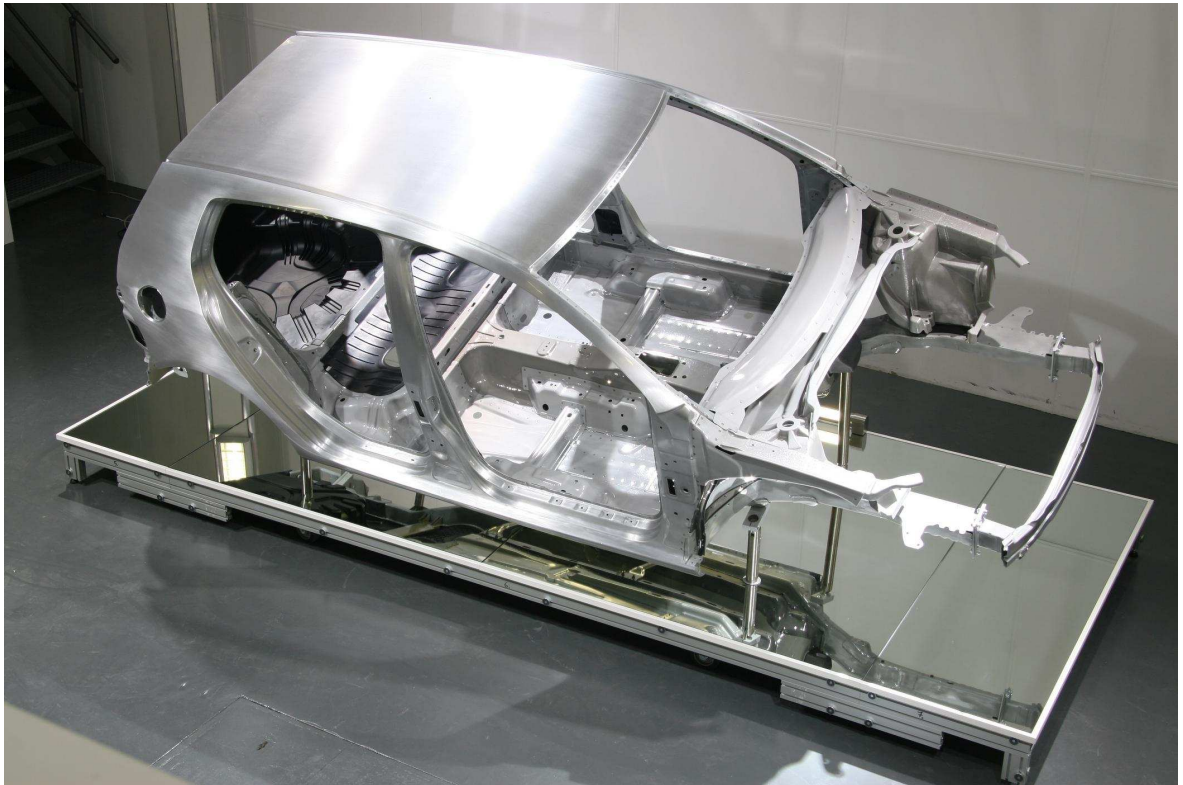


Figure 5: SuperLIGHT-Car body in white prototype



Figure 6: Front end front view with aluminum bumper assembled by MIG welding, magnesium strut tower assembled by adhesive glue and screwing

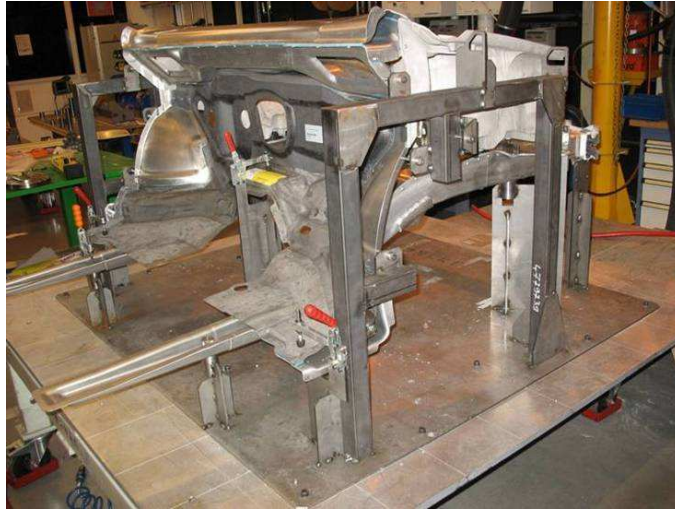


Figure 7: Rear lateral view of front end positioned on assembling station to ensure geometrical accuracy



Figure 8: Front end lateral view with longitudinal front rail assembled by adhesive glue + self piercing riveting , inner A pillar reinforcement and upper long front member assembled by adhesive glue + self piercing riveting



Figure 9: Front end rear view with hot press steel rocker transversal beam assembled by CMT weld brazing, water boxes assembled by adhesive glue + self piercing riveting, Carbon Fiber Reinforced Composite mounting plate joined by adhesive glue.

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