PROJECT FINAL REPORT

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Final publishable summary report

Executive summary

The ALIVE project (*Advanced High Volume Affordable Lightweighting for Future Electric Vehicles*) run from 2012 to 2016 with the aim to develop key vehicle lightweighting technologies based on advanced metal and hybrid materials. ALIVE intends to apply its developments to near-future electric vehicles (EV) to be introduced into the market from 2020 and at a level of technology readiness that would enable mass production.

Affordable weight reduction is one key factor for a more intensive market introduction of electric vehicles. For an EV with 200km range (and with battery capacity of 200–300Wh/kg) the allowable costs of weight saving would be round 8€/kg saved (= 10$/kg saved). For this cost level, more than 40% of lightweighting seems to be obtainable. However, further weight reduction leads to an exponential cost increase. The key objective of ALIVE is to achieve a **significant reduction in the weight of electric cars destined for mass production with minimal additional costs.** Specifically it is targeting a 45-50% weight reduction of the Body-in-White (BiW) comparing to benchmark state-of-the-art EVs recently introduced to the market, as well as a 25-30% weight saving in the hang-on parts, chassis and main interior sub-systems.

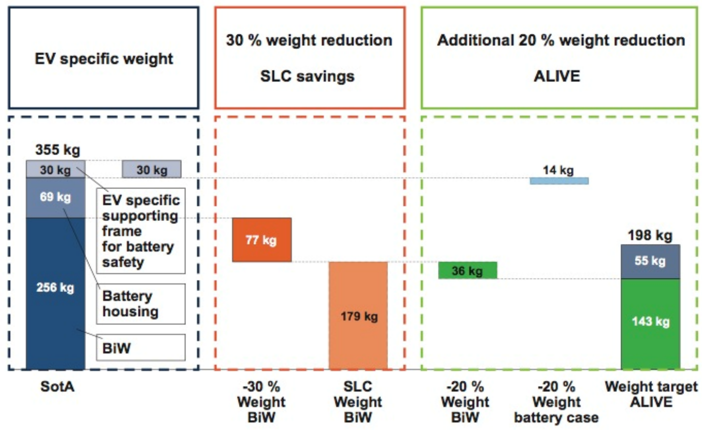


Fig.1: Weight targets for the ALIVE project

The design, simulation and optimisation phase for multi-material design gave plenty of challenges, due to its complexity both in terms of achieving crash safety requirements, as well as in terms of striking a balance between a series manufacturing technologies and prototyping technologies. The final design of the demonstrator vehicle is a multi-material approach using novel HSS and aluminium grades, together with cost effective fibre reinforced plastic for the roof and battery housing concepts and the lightweight doors (both front and rear) as an advanced multi-material concept. New technologies have been developed and selected, e.g. in-situ casting of the front sub-frame including CFRP and extruded aluminium profiles or the semi-hot formed upper C-pillar node.

ALIVE has achieved relevant weight improvements for the 4 modules targeted (BiW, chassis, hang-on parts, interiors). Most relevant is in the BiW, with a final weight of 229 kg (35% improvement), while the other modules ranged between 15-55% weight reduction. Even though did not reach the ambitious initial targets, safety, cost efficiency and applicability of solutions were prioritised. The results are very positively welcomed by the industry and especially the participating OEMs.

The project has been presented in the most relevant events, including EUCAR, EVS, TRA and the AEBD. The final joint SEAM workshop in September 2016, during the Aachen Engineering Body Days celebrated the conclusion of ALIVE and the SEAM cluster. The event, which gathered partners from the ALIVE, ENLIGHT and EPSILON projects, also counted on the presence of the EC Project Officer, Mr. Maurizio Maggiore, as well as other industry experts.

Fig.2: ALIVE consortium with the demonstrator

Project context and objectives

Overall project objectives

ALIVE aims to **develop key vehicle lightweighting technologies for application to near-future electric vehicles** to be introduced into the market from 2020 up to a level of technology readiness that would enable mass production (around 1000 vehicles / day). The key objective is to achieve affordable solutions for vehicle weight reduction (around €15k selling price excluding battery or €20-25k including battery) **targeting a further 20% weight reduction of the Body-in-White (BiW) compared to the 30% weight reduction already demonstrated in recent EU funded RTD projects**, with respect to benchmark state-of-the–art EVs recently introduced to the market, while achieving also substantial weight savings with the hang-on parts, chassis and main interior sub-systems.

WP1 objectives

The objective of WP1 is to design a weight-optimized structural electric vehicle including BiW, chassis, heavy interior and closures, based on an architecture sourced from either the ELVA project or the E-Light project, or on an architecture that is a combination of such ELVA/E-Light sourced architectures. The work covers very high levels of functional integration (battery case into floor structure, heating / cooling channels into chassis or BiW parts, interior heavy parts with floor parts. Furthermore the work takes into account the need to offer above five-star NCAP (European New Car Assessment Programme) safety performance (as expected to be required by 2020). The task is not a straightforward design of one fit-for-purpose design solution; rather it is a broad exploration of materials combinations, functional combinations and other lightweighting approaches that can help achieve the highly ambitious weight-saving objective. The design will include a full specification of used materials for each part as well as of joining technologies.

The work is guided by the need to allow for modular build-up of parts to accommodate different drivetrains, battery capacities and interior / upper structure concepts using as a reference criterion a production volume of approx. 1000 units per day. The weight reduction will be achieved by combinations of the advanced materials being applied, innovative functional integrations being adopted and conceived, and novel component designs that are intrinsically lower weight (for example, thinner seats which allow for reducing the overall length of the vehicle while maintaining passenger space and comfort).

The approach is divided into several main steps that are common for each area of the vehicle:
Firstly the architecture & design targets are established (by screening e-LIGHT and ELVA architectures and from those explore new vehicle architectures). Next, the weight targets for this architecture are set and allocated to each submodule, at a level of at least -20% compared to an SLC-level of technology being applied to this adopted architecture. This is expected to be -45% compared to the current SotA EVs (eg. Nissan Leaf). Then the entire design team will agree upon performance requirements for each of the parts in the structural vehicle (static & dynamic stiffness and strength, crash performance, NVH, cost, surface qualities, corrosion resistance, etc. Subsequently each module team will start the design of components & sub-systems of BiW, chassis, hang-on parts and interior with first approaches, thus generating geometries, and initial materials choices. Materials data is sourced from suppliers with regard to existing materials and from WP3 and WP4 for the novel materials developed in WP3. With those geometries and materials data an initial overall vehicle evaluation (NVH, crash) is executed, followed by a multi-attribute optimisation of the BiW concept (application of sensitivity mapping methods). Once this has been completed, a second round of optimizing geometries and (combinations of) materials takes place, followed by a final overall vehicle evaluation (NVH, crash) which then leads to last optimizations and then to a freeze of final design to be prototyped (virtually tested)

In all steps specific requirements/demands for EV such as range, crash and thermal management will be considered. Through this process the Design Lead Team together with all other WP1 partners will define the final content of the concept in terms of materials' mix and parts' geometries (supported by material and technology experts) ensuring that the BiW concept fulfils the objectives such as the optimisation of weight, crash, stiffness / static, NVH, cost, manufacturing / assembly and also durability/ fatigue for most relevant parts.

WP2 objectives

The principal aim of these activities to be conducted in this work package is the virtual performance assessment and validation of the vehicle design options developed in WP1. As such WP2 and WP1 will be conducted in parallel and essentially constitute the two fundamental stages required in the definition of a validated design solution while drawing on the information concerning the selection of advanced materials and the definition of manufacturing processes which are the aims of WP3 and 4 respectively.
The virtual performance assessment activities to be performed in WP2 will involve numerical simulations using a range of state-of-the-art tools and methodologies including:

- Multi Body Simulation (MBS) for numerical loads generation (local loads for components used for strength and fatigue evaluation as well as for testing),
- Finite-element (FE) analysis to determine the quasi-static, dynamic and modal behaviour of flexible components
- Non-linear FE for crash analysis
- Statistical Energy Analysis (SEA) to assess the acoustic performance

Furthermore a holistic simulation methodology will be developed to enable the implementation of the various design concepts, materials and manufacturing technologies into one simulation environment in such a way that it can be used for vehicle dynamics, fatigue, crash and NVH purposes, representing a leap in terms of simulation efficiency.

The approach to be adopted will cover the following aspects in respective tasks:

- Material models including multi-material systems: Developing appropriate, reliable and accurate material models for advanced materials such as ultra-high-strength steels, Al and Mg alloys, and in particular FRPs for which representative models still do not exist in most simulation environments;
- Models for joining technologies: Representing the combination of dissimilar materials e.g. FRP and Al for which conventional joining techniques such as welding are not applicable;
- Development of a holistic simulation environment: Implementing the various design concepts, materials and manufacturing technologies into one simulation environment;
- Validation of simulation environment: Calibrating the numerical models through comparison with measured experimental data;
- Performance assessment on component and sub-system level: Supporting the design and the optimization of sub-groups at sub-system level;
- Full scale vehicle simulation on all attributes: Determining the vehicle performance on the full-scale level with respect to all relevant attributes.

WP3 objectives

The main objective of this project is to reduce the structural weight of the body-in-white (BiW), chassis and heavier interior by using different classes of materials: light alloys, composites, polymers, advanced steels and multi-functional materials and the application of their manufacturing processes: forming and joining technologies, cost-effective assembly and modularity.

To realise this task, we would have to adapt selected material classes; to develop manufacturing, joining and bonding technologies; to characterize the materials by using those technologies and, finally, to realise manufacturing and assembly strategies.

WP4 objectives

WP4 is the central work package for testing, characterisation and validation within ALIVE. The testing and validation will be performed on coupon level, sub-system level and on vehicle level introducing advanced test strategies for accelerated testing. Attributes considered are static and dynamic properties of materials, components and sub-systems, fatigue behaviour under defined environments as well as crash and NVH properties.

All test specimen, components or sub-systems will be delivered from other work packages. The test program (e.g. attributes to considered, environmental conditions, load program) will be defined together with all OEMs and suppliers involved taking into account concepts for accelerated testing.

In order to validate the material and simulation models (WP2) as well as the material and manufacturing technologies, coupon tests will be performed. This will be done as benchmarks by defined partners only to obtain reproducible and reliable data. The measurements on coupons will be fed back to WP2 and WP3 for validation purposes and optimisation. With respect to WP3, coupon testing will be performed for different stages of the development process (iteratively).

Testing and validation on sub-system and vehicle level will be done on limited number of demonstration parts to assess e.g. the fatigue strength, crash and NVH behaviour. The parts to be tested will be provided by WP5.

WP5 objectives

Deliver realistic experimental validation modules that allow for static, dynamic and crash performance validation on the module level (see task description T4.4). Combining each of these modules into a full vehicle demonstrator, representing lightweight technologies focusing on the four main weight determining structural areas of the EV: heavy interior, body-in-white, chassis and hang-on-parts.

The demonstrator build-up is split into several levels and phases. Initially and in parallel to the design and optimisation loops in WP1, the work in WP5 focuses on the identification of realistic yet cost effective production routes for all structural parts and their joining processes. Gradually in WP1 the design of components will be frozen and released to WP5, which then starts the mould design and prepares for component production. The WP5 will deliver duplicates of some of the smaller modules to allow WP4 to perform various very realistic tests. On top of these modules destined at partially destructive testing, one full structural demonstrator will also be assembled that will allow for non-destructive testing on the whole vehicle level.

WP6 objectives

The goal of WP6 is the generation of appropriate and reliable LCA models for the new ALIVE materials and production technologies and an easy-to-use assessment of design alternatives. Therefore, data on the materials themselves, their production and the manufacturing of automotive parts out of these materials has to be analysed from an environmental perspective with respect to:

- High-strength steel
- Aluminium alloys
- Magnesium alloys and
- Innovative composite materials

Detailed data will be supplied by the project partners via questionnaires. The material production and the manufacturing of parts will then be modelled in the LCA software "GaBi". In an interaction step, the results will be discussed with the project partners to emphasize the most relevant steps in the production from an environmental perspective by applying an easy-to-use web-based tool (GaBi i-report). It will enable the partners to understand the most critical steps in production and give them indication, where the production should be improved or even a switch to another material is indicated to improve environmental friendliness. To avoid "shifting of burdens" meaning e.g. that a material or production process is improved but then maybe lead to higher environmental impacts in the utilization or recycling phase, it is important to consider the whole life cycle of an automobile. Therefore, beside production of materials and manufacturing of parts, we will consider the automobiles utilization phase. We will also include the automobiles end-of-live.

To carry out the LCA assessment in WP6, information is collected from the project partners about related issues. The information we will need to carry out WP6 is collected by questionnaire that will ask about material compositions of the ALIVE materials and energy use, emissions, yield used materials and auxiliaries for the production of parts. The effort per partner to fill in the questionnaire is not budgeted separately here in WP6 but rather is made inside WP1 and WP3 by all relevant partners.

The ALIVE technologies will be modelled in the software system "GaBi". GaBi contains the world's largest life cycle inventory library based on industry data and is therefore ideally placed to leverage our extensive knowledge of processes and materials to devise the specific datasets required for ALIVE technologies. Within the project, we can build on this data to efficiently model the technologies and materials under consideration. So we do not have to start from "nothing" but concentrate on the new innovative materials and technologies in ALIVE and ensuring efficient and reliable LCA datasets with a suitable effort.

LCA data in LCA software tools is usually not self-explanatory. Typically, LCA experts are required to interpret data and derive design requirements out of it. To enable project partners to assess and optimize the environmental impacts properly, we will apply a web-based tool, the "GaBi I-report". This tool combines the whole LCA know-how with an easy-to-use web interface. The GaBi i-report has the full LCA models and data in the background but allows the user to work with pre-defined scenarios to assess the effects of design changes immediately, considering of course the whole life cycle of an automobile. If, for example, a new innovative material is applied, which has higher efforts in the production but then due to a lower weight, big advantages in the utilization phase and/or recycling, designers will be able to see results immediately.

The assessment of environmental issues will be expressed by so called "environmental impact categories". Those aggregate the huge amount of emissions, energy or resources consumptions into a few meaningful numbers. Examples include the following:

- Primary energy demand (which is strictly speaking not an impact category, but anyway relevant)
- Greenhouse gas emissions
- Abiotic resource depletion

WP7 objectives

WP7 will communicate the ALIVE objectives and results to a wide range of target groups, making use of a set of target-group adapted and tailor-made communication tools. Due to the importance of this spread of knowledge, all ALIVE partners are involved in this work.

The overall aim is to spread the project findings to a wider group of industry actors, from the transport and materials sector, to public actors, in particular research organisations and academia, and the wider public. Dissemination approaches, target groups and communication tools will be described in detail in the ALIVE communication and dissemination strategy that will be developed at the beginning of the project.

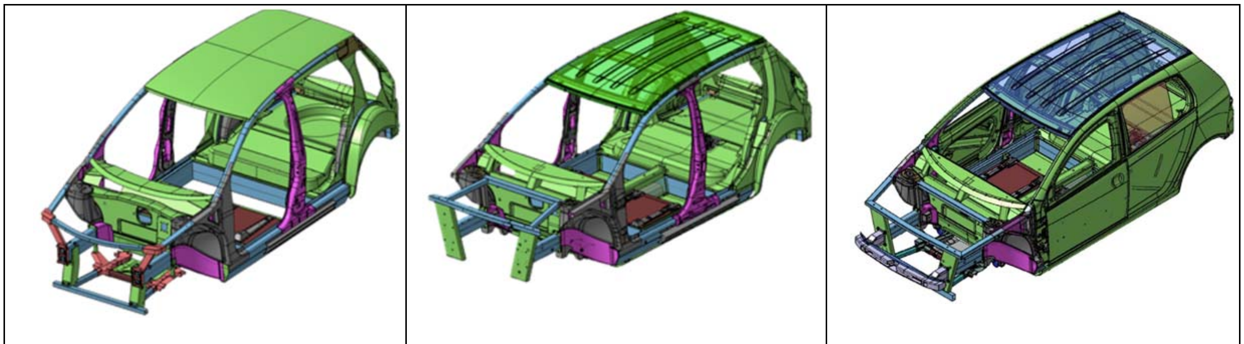
Furthermore, this work package will ensure to extrapolate the results generated mainly on the basis of passenger cars also to other material applications. In particular this will be targeted to heavy vehicles such as trucks and buses. This work package will also deliver a first plan for industrialisation of the materials, products and processes developed.

WP8 and ***WP9*** are the management and coordination WPs and are summarised in a separate section.

Main S&T results/foregrounds (not exceeding 25 pages),

Summary

The first preliminary crash simulation (EuroNCAP ODB) showed a poor behaviour of the structure. As a consequence, an optimization process resulting in a redesign followed: aluminium alloy cast nodes were redesigned or substituted by high strength steel parts; the sub-frame and its connection to the bottom area was redesigned; the buckling behaviour of the front longitudinal members was improved; and the C-pillar area was also redesigned to improve static bending and torsional stiffness. Simulation work was divided into 3 focus areas in order to facilitate the optimization process: front crash behaviour, side impact cases and rear crash case.



Design evolution BiW Sept14 – June 2015 (design freeze)

Fig.3: Design evolution BiW ALIVE (from September 2014 until design freeze in June 2015)

The table below provides an overview of the weight estimations in the final design freeze compared to the weight achieved in MS1, as well as the reference and targets defined. As further explained in the subsequent tasks, it is important to highlight that the overall reference vehicle adopted is the one designed in the ELVA project with some minor modifications (from now on referred as ELVA modified).

Module (sub-modules)	Lead partner	Reference weight	Target weight (% reduction)	Weight in 1st design - MS1 (% reduction)	Weight at final design freeze-MS2 (% reduction)
1. Body in White	VW	355 kg (SotA)	198 kg (45%)	178 kg (50%)	229 kg (35.5%)
2. Chassis					
2.1 Front subframe	Porsche	11.8 kg	9.4 kg (20%)	9.3 kg (21%)	8.6 kg (27%)
2.2 Rear twist beam axle	Cosma	21.0 kg	17.0 kg (20 %)	16.0 kg (24 %)	17.8 kg (15.23%)
3. Hang-on parts					
3.1 Front doors	Daimler	17.10 kg	9.0 kg (47.5%)	*Not defined*	9.5 kg ** (44.4%)
3.2 Rear doors	JLR	11.8 kg	6.2 kg (52%)	*Not defined*	5.38 kg (54.4%)
*3.3 Tailgate **	MEI	13,7 kg	10,3 kg (25%)	10,3 kg (25%)	8,8 / 6,7 kg (36% / 51%)

4. Interiors					
4.1 Front seat	Faurecia	15.5 kg	10.8 kg (30%)	*11.3kg (27%)*	10.8 kg (30%)

** No functional prototypes, only show parts have been delivered. Additional weight potential by reduction of loadcase targets with still functional liftgate. At the weight of 8.8 kg it is achieved the performance defined by VW. At the weight of 6.7 kg it is achieved a functional liftgate based on MEI experience, without fulfilling VW specifications.*
*** Weight including joining components*

Relevant improvements have been achieved in all the sub-modules, with some of them clearly exceeding the target set. Specifically on the BiW, though, it was not possible to achieve the stringent target at design freeze, due to the need to design a structure compliant with crash demanding requirements. Some relevant re-design activities had to be undertaken after design freeze:

1) Design of BiW as lightweight design for high volume series production with appropriate production technology and tooling.
2) Redesign of parts that cause high tooling costs (deep drawing parts) for “easy to manufacture parts”, e.g. metal sheet bending parts.
3) Redesign of structure to be able to use existing parts as carry over parts (cop), e.g. side panels for both left and right hand side (tooling for one side panel costs several hundred thousand Euro).

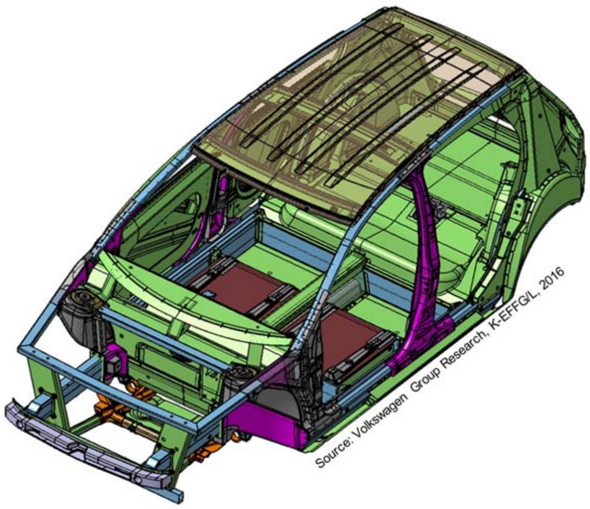
More details on the major S&T results achieved are provided below specifically per each WP.

WP1

The ALIVE project is focusing on affordable lightweight design for vehicles produced in high-volume production (1000 vehicles per day). In the deliverables 1.1 till 1.2 all necessary specifications and requirements are described. Main objective is a target weight of the body-in-white of 200 kg (including the battery case), which fulfils the safety requirements concerning the crash scenario’s described in WP2 (following chapter).

The final design of the ALIVE BiW fulfils all crash and stiffness requirements; however, the weight target of 200 Kg could not be accomplished. The weight of the BiW is now 229 Kg which is 14% higher than targeted. But in the view of the coordinator this is still a good result, e.g. comparing this to weights of BiW’s of actual series production vehicles.

The design of the BiW is a multi-material approach using high strength steel and aluminium grades. In addition cost effective fibre reinforced plastic was applied. This caused the application of various and sometimes not well established joining technologies. The consortium developed a common assembly strategy which allows to manufacture the demonstrator BiW’s with the quality necessary to not only present a structure but to conduct destructive testing, too.



Material	Colour
Al-Extrusion	Blue
Al-Sheet	Green
Al-Cast	Orange
St-Sheet (cold)	Grey
St-Sheet (warm)	Magenta
FRP	Brown
Magnesium	Dark green

Source: Volkswagen Group Research, K-EFFG/L, 2015

Fig. 4 Final Lightweight Vehicle body Concept

The front body concept is designed with three loadpathes to lead crash loads into A-Pillar, sill and foot well cross member. It consists of high strength Longitudinal Member of hot formed steel, a front structure of Aluminium and a Cross member Subframe of die-casted and extrusion Aluminum. The Strut rings are made of Magnesium.
Upper body consists mainly of Aluminum sheets and extrusion profiles. A-pillar and B-pillar are made of hot formed high strength steel (RM > 1800 Mpa). By this the wall thickness could be reduced from 2 mm to 1.8 mm which led to a weight reduction of 1.9 kg.

CRF developed two concepts for the roof made of fiber reinforced plastic. Further details of design can be found in the following chapter WP2. The FRP roof is bonded to the body in white by gluing.

To integrate the battery case an innovative concept was found: the Battery-Cover-Plate made of Thermoplastic GFRP has integrated Fixing Elements for the Seat Rails. Bracings from Bottom and the Cover-Plate with bolts close simultaneously the electrical connections. Aluminum Cross members with Deformation Elements for Crash Protection and to stiffen the BIW form the battery case. By Intrusion of the Sill the Battery-Cover will moved but not be damaged.

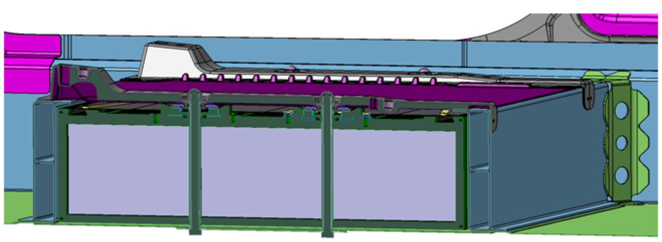


Fig. 5 Battery case – Concept of Integration

The doors have been designed as Aluminum concept, Fig. 6. The front door shows three load paths and consists of 13 components, mainly 5000 and 6000 Aluminum alloys. The weight target could be achieved with a weight status of 9.5 kg. The rear door with two load paths consist of 12 components with similar Aluminum distribution. The inner sheet panel is laser welded as one part. Status weight is 5.4 kg, target was 6.2 kg. A higher weight reduction of 13% could be achieved.

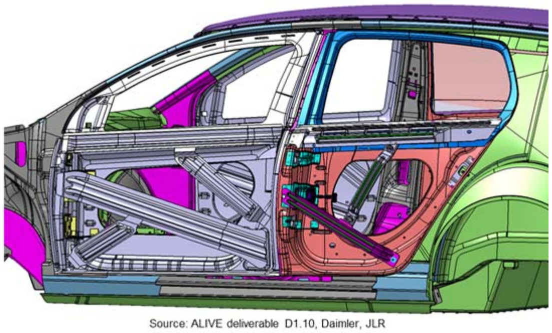


Fig. 6 Light weight door concept

The objective of the ALIVE seat development is to reduce the seat structure weight by 30% compared to a current Golf VII seat, which is at 15.5kg.
To achieve that weight target of 10.8kg, Faurecia developed a lightweight structure concept based on modular lightweight components: The latest mechanisms generation combined with lightweight modules, called ‘bricks’. Those technology bricks are complex developments of a new part design, the dedicated manufacturing process and the linked assembling solution. All mechanisms and lightweight bricks can be combined individually as the weight reduction target for future seats requires. Those lightweight bricks came together with general structure design optimizations like headrest integration and closed profiles for highly loaded parts like the backrest side members.
The used materials are mainly steel in a wide range of grades up to AHSS 1400M, but also aluminum, glass-fiber-reinforced polyamide PA6 GF30 and particular foam EPP.

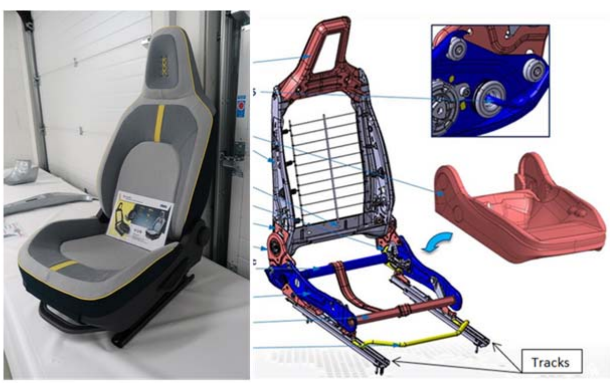


Fig. 7 Light weight seating concept (Faurecia)

WP2

Principal aim of the simulation activities of WP2 was the virtual performance assessment and validation of the vehicle design options developed within the project (in WP1).
This was done for the concerned vehicle solutions, on component and sub-system level, as well as on full-scale level, w.r.t. all relevant disciplines/attributes, which means crash, static, NVH and fatigue analyses.
Before entering the above mentioned assessment phases, preparatory activities were needed and developed within the WP, i.e.:

- generation of model cards for the advanced materials selected on ALIVE vehicle;
- development of models for the involved joining technologies (RSW, MIG, FDS and Adhesives);
- Set-up of a holistic simulation environment, permitting the integrated and centralized management of the numerical models required by the different simulation disciplines.

The created numerical models were indeed validated, through dedicated experimental testing at coupon level, by considering specimens representing the combinations material/joining technique used on ALIVE vehicle.

	Pre-holed PHS-on-Al	Al-on-Al		
Joining Technique	**Flow Drill Screwing**	**Resistance Spot Welding (RSW)**	**Metal Inert Gas Welding**	**Adhesive Bonding**
Static & NVH	Solid elements + RBE3		Dependent mesh + rigid elements	Solid elements + RBE3
Fatigue	CBEAM + RBE3		Dependent mesh + rigid elements	Solid elements + Tied contact
Crash	Solid elements + Tied contact Cohesive elements		Solid elements + Tied contact + different material card for HAZ Cohesive elements	Solid elements + Tied contact Cohesive elements

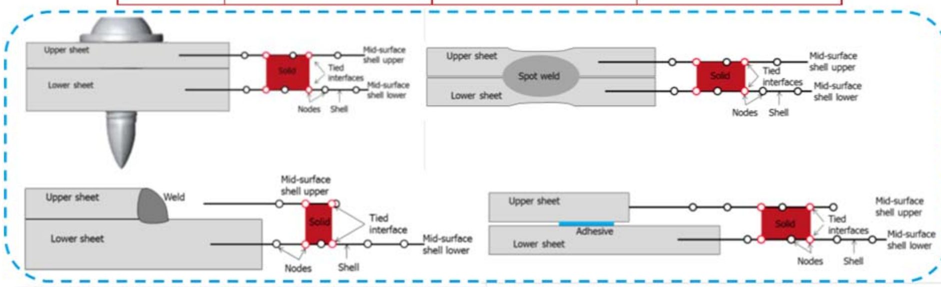


Fig. 8 - Numerical models of joining technologies, created for selected techniques and each discipline

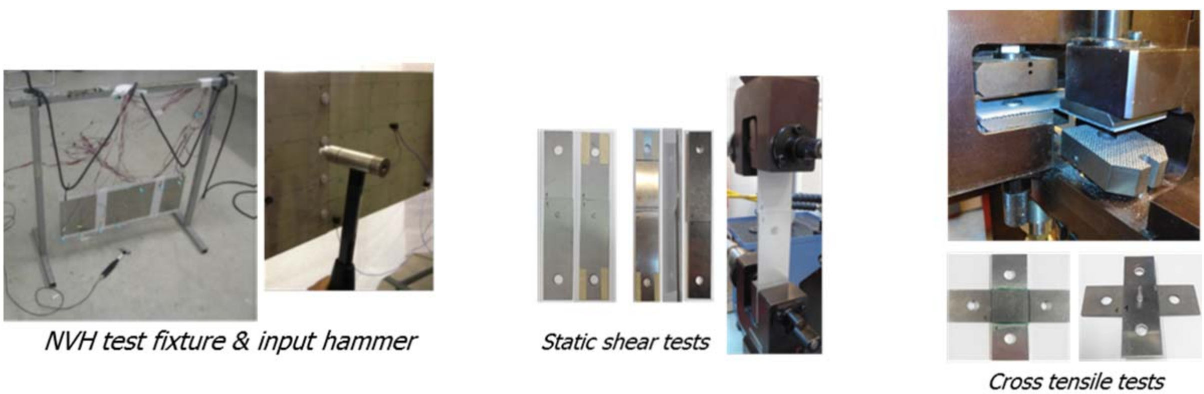


Fig 9 - Examples of experimental testing at coupon level, for joining models validation

Moreover, the operational use of the holistic simulation environment demonstrated the possibility to accomplish relevant timesavings in model preparation phases (40 to 70 % less w.r.t. classical «manual» approach).

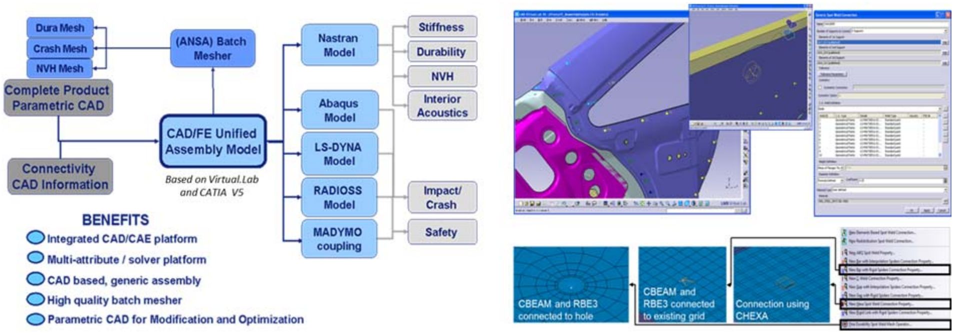


Fig 10 - Holistic simulation environment: functional schema and example of application (front door)

The performance assessment task on sub-system level involved mainly 3 vehicle modules, namely composite roof, chassis subframe and front doors.

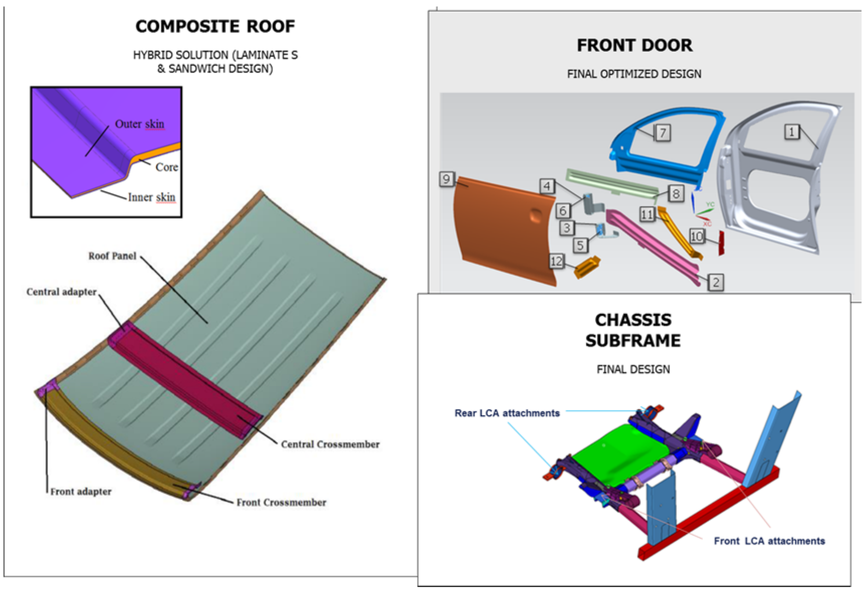


Fig 11 - Vehicle modules assessed on sub-system level

Composite roof design was driven by roof crush strength (FMVSS 216 a) and side pole impact (FMVSS 214) standards, with static torsional, flexural and modal analyses taken into account, too.

An hybrid solution was selected at the end for the realization of the final ALIVE roof prototypes, consisting of a sandwich structure and glued aluminum cross-members (two 0.5 mm thick thermoplastic GFRP laminates with an internal pressure stable polyester nonwoven core of 3 mm). Chassis subframe final design originated instead from several evolutionary steps applied to a previous structural concept taken from the past EC project ELVA: through static and dynamic analysis on the isolated subframe, adequate stiffness's of suspension lower control arm attachments were pursued in order to ensure good handling and avoidance of vibrational problems at full vehicle level.

Front door design was optimized by considering different evolutionary steps, each one being evaluated against 6 main load cases: door sagging & over opening, cross member & window frame stiffness, outer panel oil canning and door global eigenfrequencies.

Full-scale vehicle simulations were conducted to assess the adopted solutions w.r.t. agreed reference targets for each attribute, according to the vehicle design evolutionary loops: for the crash performance assessment, front and side Euro-NCAP current impact configurations (ODB, FWRB, AE-MDB and Pole) plus FMVSS 301 rear collision were considered.

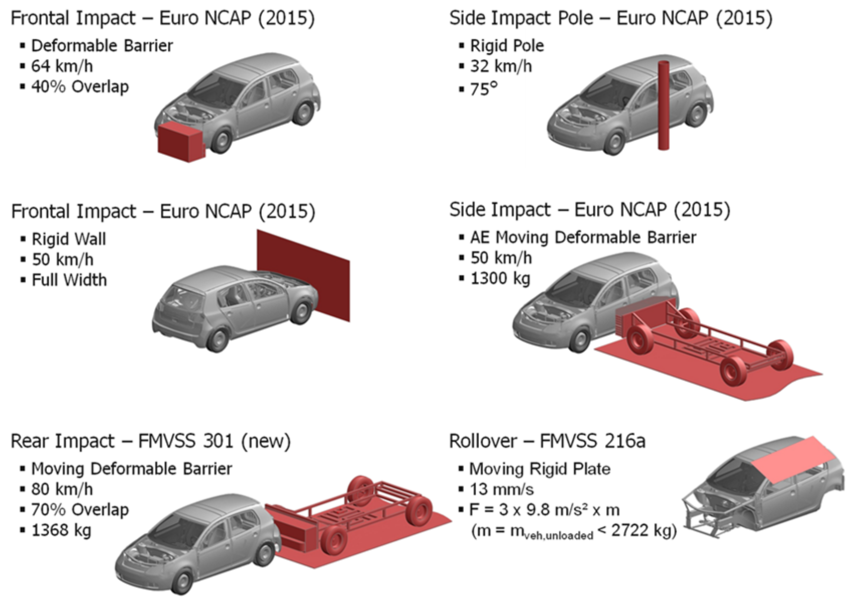


Fig 12 - Reference impact configurations for crash simulations

Manufacturing data coming from process simulations were included on vehicle crash model, too, for the final design verification.

Static stiffness performance assessment (in bending and torsion classic BiW tests set-up), structural dynamics and NVH analyses (free-free modes of BiW with added masses of each relevant vehicle sub-system) and fatigue analysis (w.r.t. reference loading events, i.e. bad road, handling test course, load change shock and race course, each one with its own duration and number of repetitions) completed the assessment on the final solution.

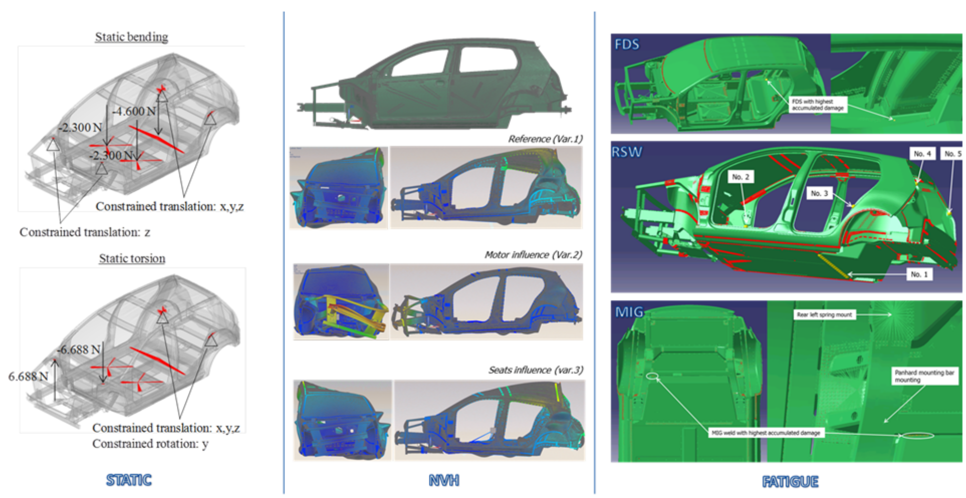


Fig 13 - Static, NVH and Fatigue analyses

Structural performance targets fixed for each relevant discipline were almost entirely achieved with the final vehicle design: in few cases exceptions were accepted because of the limited deviations and/or the possibility to manage them through other classical vehicle systems/solutions (not included within ALIVE perimeter, like for example side airbags).

WP3

Main objective of this WP was to provide state of the art materials, to adapt selected materials and to develop new materials especially for the use in the ALIVE project, to reduce the structural weight of the body-in-white, chassis and heavier interior parts. For the application of these materials, it was required to develop the manufacturing, the joining and bonding technologies, to characterize the materials by using those technologies and finally to realise manufacturing and assembly strategies.

During the project, the materials database started in the first period has been updated with more material data. The database was at the end filled with material data of about 100 different materials (steel, aluminium, magnesium and plastics). This document represents a **useful synergy and joint development** within the SEAM cluster and between the ALIVE and ENLIGHT projects, so that both projects were able use the parameters from the material database. Whereas ALIVE provided all information and data for the metals and some plastic parameters, ENLIGHT completed the database with information for plastics, fibres and resins and also fibre reinforced plastics.

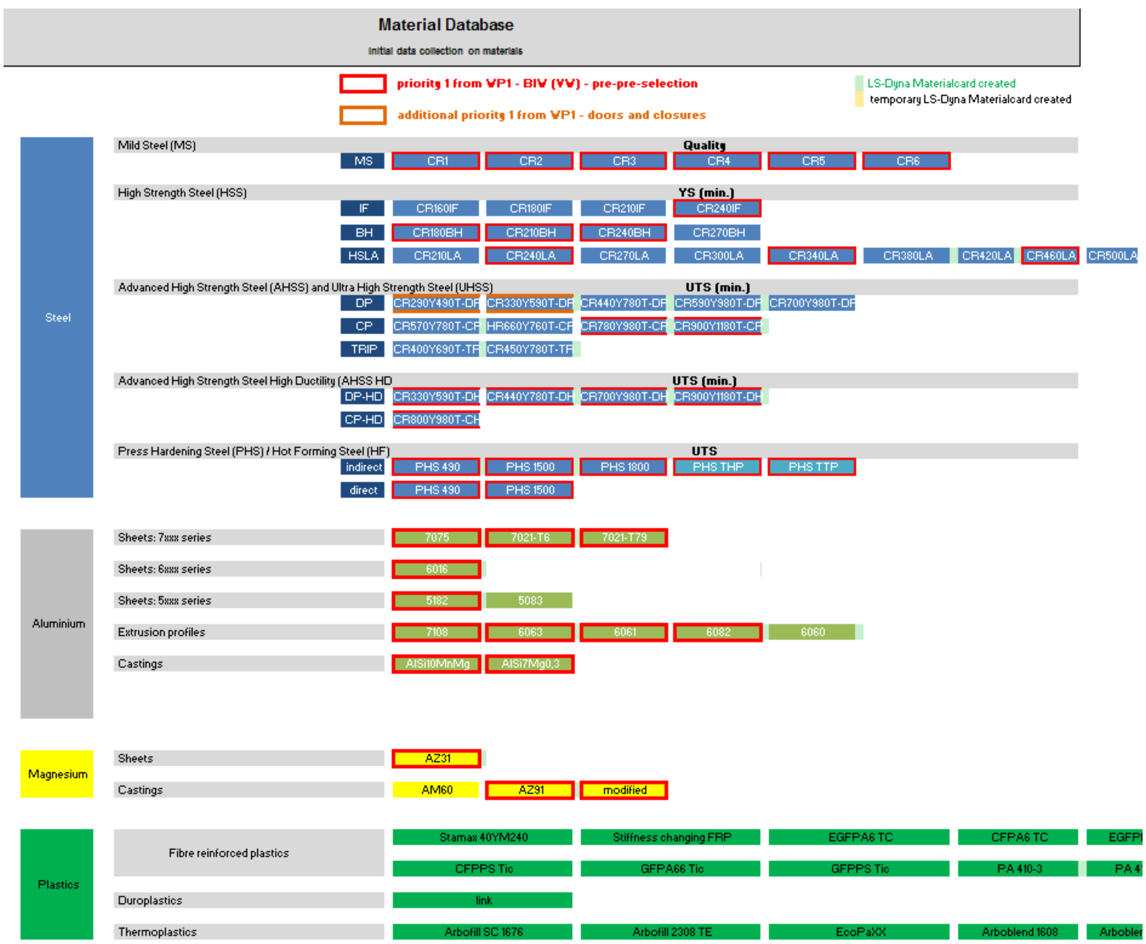


Fig. 14 Overview of the ALIVE-ENLIGHT materials database

Together with WP1 materials for all components had been selected and validated by forming simulations, crash calculations and joining possibilities. This was done in several iteration loops as long as the selected material fitted best to the requirements and targets of the project.

The main activities of task T3.1 were to provide full materials data to WP1 and WP2 for the ready developed materials by adding this data to the material database, the development and basic characterisation of AHSS steel grades of 3rd generation with improved formability and to develop and characterize a press-hardening steel grade with a tensile strength of 1800 MP and to perform forming experiments for the steel grades foreseen for the use in the ALIVE vehicle.

Forming of AHSS with improved formability

AHSS of 3rd generation (so called *ahss high-ductility* or HD grades) have a significantly better formability than the conventional and already well known AHSS of 1st generation (*ahss classic*). This is noticeable especially in the total elongation A_{80}, the work hardening (n-value) and the forming limit curve (FLC). In the figure below the minimum guaranteed total elongations (A_{80} according to ISO 6892-1) are shown for selected HD grades (compared to the respective conventional grades). Here, the differences between conventional and HD quality are very clearly recognizable.

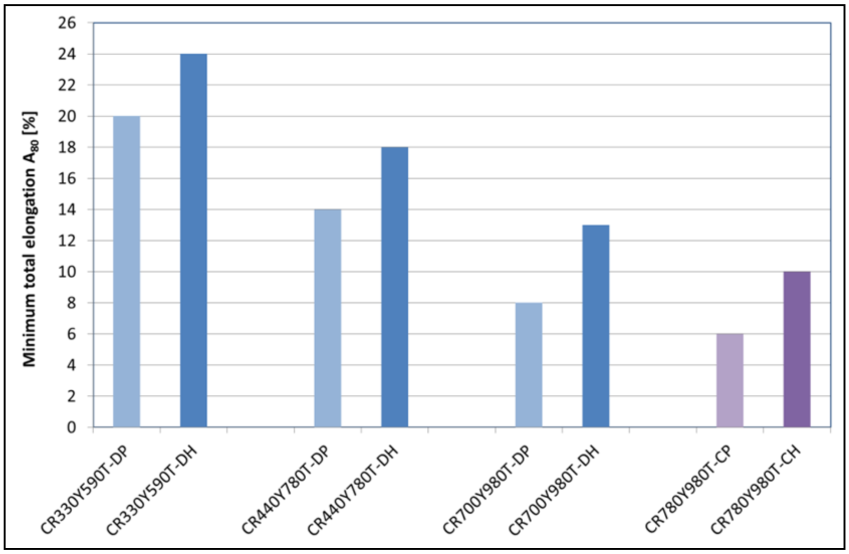


Figure 15 Comparison of conventional grades (with the extensions -DP and -CP) vs. HD grades (with the extensions -DH and -CH) in terms of the minimum total elongation A_{80} (longitudinal to the rolling direction).

Forming experiments with "Smiley" – tool

The trials with the model tool "*smiley*" were carried out on a 630to press with a blank holder force of 900 kN. With this tool four embossments can be stamped in different shape and depth into the part. The blanks were oiled with 1.5 g/m² PL61 to ensure the comparability of the single experiments. The formability was evaluated at the critical regions (see both figures below) for different AHSS of 1st and 3rd generation. Based on the results (see fig. 77 and fig. 78 below) the improved performance of the HD qualities can be shown with this tool.

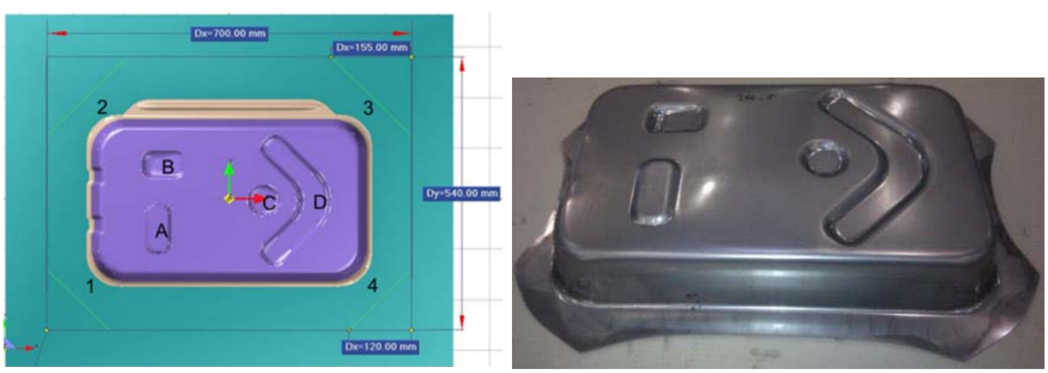


Figure 16: Critical regions on the tool (left) and drawing part (right).

grade	thickness [mm]	cracks: embossments				cracks: corners			
		A	B	C	D	1	2	3	4
CR440Y780T-DP	1.5								
CR700Y980T-DH	1.5								
CR700Y980T-DP	1.45		X		X	X	X		X
CR780Y980T-CH	1.4				X				
CR780Y980T-CP	1.5	X	X		X	X	X		

Figure 17: Results for the „smiley" – tool.

During the ALIVE project all planned steel grades were brought at least to a pilot production and material for part production was delivered to the partners.
The following paragraphs describe the actual status of the material development, their properties and availability of the AHSS and UHSS grades.
All usual AHSS and UHSS grades of 1st generation up to 1180 MPa (and even conventional grades according to VDA 239-100) were already available at the beginning of the project.
Regarding the AHSS of 3rd generation with improved formability various grades have been developed. These are also cold-formable grades with tensile strengths up to 1180 MPa. The focus here is on the dual phase high ductility grades for complex components but also complex phase high ductility grades were considered. After a period of lab scale sample productions several large-scale productions were carried out with good results for e.g. DP780HD, DP980HD, DP1180HD und CP1180HD. The target values for the mechanical properties (yield strength, tensile strength and in particular the total elongation) could be reached and the sample characterisation was finished.
To show the improved elongation and better formability forming experiments with model tools were performed.

Table 1: Cold rolled dual phase steels (IP = inner part, OP = outer panel, DT = drawing-type), testing in longitudinal direction

Steel grade[*)]	Common name	Surface	YS [MPa]	TS [MPa]	EL [%]	t [mm]	Part	Forming
CR290Y490T-DP	DP490	UC/EG/GI	290-380	490-600	≥ 24	0,6-2,0	IP, OP	DT
CR330Y590T-DP	DP590	UC/EG/GI	330-430	590-700	≥ 20	0,65-2,0	IP, OP	DT
CR330Y590T-DH	DP590 HD	UC/EG/GI	330-430	590-700	≥ 24	0,65-2,0	IP, (OP)	DT
CR440Y780T-DP	DP780	UC/EG/GI	440-550	780-900	≥ 14	0,8-2,0	IP	DT
CR440Y780T-DH	DP780 HD	UC/EG/GI	440-550	780-900	≥ 18	0,8-2,0	IP	DT
CR590Y980T-DP	DP980	UC/EG/GI	590-740	980-1130	≥ 10	0,9-2,0	IP	DT
CR700Y980T-DP	DP980	UC/EG/GI	700-850	980-1130	≥ 8	0,9-2,0	IP	DT
CR700Y980T-DH	DP980 HD	UC/EG	700-850	980-1130	≥ 13	1,0-1,6	IP	DT
CR900Y1180T-DH	DP1180 HD	UC/EG	900-1150	1180-1350	≥ 10	1,0-1,6	IP	DT

*) Nomenclature of the DP HD grades in accordance to VDA 239-100; mechanical properties of the DP HD grades according to voestalpine

Table 2: Cold rolled TRIP steels (IP = inner part, DT = drawing-type), testing in longitudinal direction

Steel grade	Common name	Surface	YS [MPa]	TS [MPa]	EL [%]	t [mm]	Part	Forming
CR400Y690T-TR	TRIP690	UC/EG/GI	400-520	690-800	≥ 24	0,8-2,0	IP	DT

CR450Y780T-TR	TRIP780	UC/EG/GI	450-570	780-910	≥ 21	1,0-1,6	IP	DT

Table 3: Cold and hot rolled complex phase steels (IP = inner part, BT = bending-type, RF = roll forming), testing in longitudinal direction

Steel grade*)	Common name	Surface	YS [MPa]	TS [MPa]	EL [%]	t [mm]	Part	Forming
CR570Y780T-CP	CP780	UC/EG/GI	570-720	780-920	≥ 10	0,8-2,0	IP	BT, RF
HR660Y760T-CP	CPW760	UC/GI	660-820	760-960	≥ 10	2,0-3,0	IP	BT, RF
CR780Y980T-CP	CP980	UC/EG/GI	780-950	980-1140	≥ 6	0,9-2,0	IP	BT, RF
CR780Y980T-CH	CP980 HD	UC/EG	≥ 780	≥ 980	≥ 10	1,0-1,6	IP	BT, RF
CR900Y1180T-CP	CP1180	UC/EG	900-1150	1180-1350	≥ 5	0,9-1,6	IP	BT, RF
CR900Y1180T-CH	CP1180 HD	UC/EG	≥ 1000	≥ 1180	≥ 7	1,0-1,6	IP	BT, RF

*) Nomenclature of the CP HD grades in accordance to VDA 239-100; mechanical properties of the CP HD grades according to voestalpine (actual target values)

For the press-hardened steels the indirect process with phs-ultraform 490, phs-ultraform 1500 and also tailored properties is already state of the art. To extend the family of press-hardened steels a grade with tensile strength of 1800 MPa in press-hardened condition has been developed. During the ALIVE project the highest strength grade phs-ultraform 1800 were produced in a pilot production with the needed thicknesses for parts production.
The actual status of hot forming steel grades is shown in the following table.

Table 4: Cold rolled manganese-boron steels (IP = inner part, PH = press hardening, DF = direct forming), TS in hardened condition

Steel grade	Surface	Process	TS / MPa	t / mm	Application	Forming	Status
phs-ultraform 490	GI	Indirect	460-640	0,8-2,3	IP	PH	Serial production
phs-ultraform 490	GA	Directform	460-640	1,0-2,0	IP	DF	Pilot production
phs-ultraform 1500	GI	Indirect	1350-1600	0,8-2,3	IP	PH	Serial production
phs-ultraform THP	GI	Indirect	500-700	0,8-2,3	IP	PH	Serial production
phs-ultraform TTP	GI	Indirect	800-1000	0,8-2,3	IP	PH	Serial production
phs-ultraform 1500	GA	Directform	1350-1600	1,0-2,0	IP	DF	Pilot production
phs-ultraform 1800	GI	Indirect	1750-2000	1,0-2,0	IP	PH	Pilot production

As all defined steel grades are now available at least in a pilot production status voestalpine were ready for supplying the ALIVE partners with the needed steel material for the prototype production.
Based on the material selection in cooperation with design (WP1) and simulation (WP2) voestalpine supported the defined part producer with the steel grades for the ALIVE body.

In task T3.5 to accomplish the main goal expected in the ALIVE Project, i.e. to obtain an electric vehicle achieving affordable solutions for weight reduction, CIDAUT has worked into the development of a new casting process for the production of automotive components with high requirements by means of the use of magnesium alloys. A series of stages that included: process design, process prototyping and testing at CIDAUT's premises were done to accomplish this goal.

Magnesium alloys have the main advantage that they are the lightest of the used metal alloys, one-quarter the mass of steel and two-thirds the mass of aluminium, and have the best strength to weight ratio of the most commonly used structural metals.

Moreover, the advantage of the new process is that we have solved the main drawbacks that the magnesium casting processes presents:

- Sand casting: it is a process with a low production rate and a high melt oxidation due to a turbulent filling

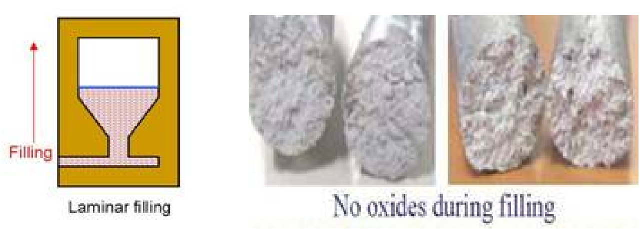
Main problems encountered in sand casting process

- High pressure die casting: it is a high volume series production, but with high problems with gas porosity due to the high velocities produced during filling

Main problems encountered in high pressure die casting process

With the new magnesium technology developed by CIDAUT these drawbacks have been avoided when compared to magnesium current casting technologies. The main characteristic of the process is the use of an electromagnetic pump to impulse the molten magnesium inside the sand mould. A counter-gravity and controlled filling is possible with this device, which implies no turbulences during the filling stage, and as a conclusion no oxides or gas porosity are present in the final parts.

Furthermore, some metallurgical techniques have been accomplished with treating magnesium alloys with grain refiners to improve final microstructure. Refinement and modification treatments would be applied to molten magnesium and thus improve the quality requirements expected.



Laminar filling and without oxides with magnesium electromagnetic pump technology

Magnesium casting process in laboratory scale

Additionally this technology has the advantage that it is possible to manufacture high magnesium performance components with a low cost technology, mainly due to low tooling costs and due to its high productivity (due to the automatic sand moulding process).

Task T3.6 was particularly relevant with the development and assessment of the joining sequence. Looking at the assembly process it becomes clear, that especially the joining processes between the steel front corner assemblies and the aluminium assemblies' bulkhead and central floor were the most challenging. Further on the assembly process between the large aluminium assemblies like the rear wheel housing and the rear end were also particularly challenging concerning the tolerance chain.

WP4

The main objectives of the work performed in this WP4 was to determine the characteristics of different lightweight materials and different joining technologies regarding crash, fatigue and NVH behaviour. Therefore test on different specimen, components, subsystems and finally the BiW were performed.

Test strategies for accelerated testing
At the start the test scenarios and test conditions especially of coupon tests were developed in order to provide sensible results for the modelling for the crash, fatigue and NVH calculations. Subsystem and BiW test scenarios were developed to provide data for the validation of the numerical models and to confirm the overall lightweight potential of the ALIVE prototype. To optimise the fatigue testing strategies for an accelerated testing were developed by sophisticated high frequency test rigs and methods to accelerate multiaxial testing by deviation but damage equivalent load programs also including environmental test conditions. As a result for the multiaxial fatigue testing with numerical calculations to optimise the number of repetitions of the different load signals a damage equivalent and shortened load program can be derived. In reality this will mean to allow for some deviations and, in case of the multiaxial shaker testing, to perform some additional measurement bevor the testing.

Characterisation and testing of coupons
Coupon test of the various materials and manufacturing technologies were carried out to provide feedback and information to especially WP2 focussing on providing material model parameter information and joint model parameter information. Furthermore the holistic simulation environment developed also in WP2 is validated making use of measurement results generated. Various novel metallic materials are tested according to their fatigue, tensile and NVH behaviour, as well as a number of different joining techniques.
Materials and joining techniques tested have been selected in close discussion with mainly WP1 and WP2 partners.

Materials under test:
- Press hardened steels: phs-ultraform 1500 and phs-ultraform 1800
- AHSS high ductility: CR900Y1180T-DH (DP1180 HD) and CR440Y780T-DH (DP780 HD)
- Aluminium 6016-T4 and 6082-T6
- Magnesium

Joining techniques under test:
- Flow drill screwing (FDS)
- Resistance spot welding (RSW)
- MIG welding
- Bonding

Attributes tested:
- Strain controlled fatigue
- Static/dynamic tensile behaviour
- Dynamic NVH behaviour

Deliverable 4.3 comprises a very detailed reporting on test procedures adopted and test results obtained. Furthermore, parameters were identified/extracted to feed into the numerical models.

Testing and characterisation on sub-system level

Components and subsystems which were build using the materials and joining technologies investigated before were tested under crash and fatigue. In order to determine the salient performance characteristics of the new, lightweight components and sub-systems developed within the project, the experimental analysis also has focused on identifying their principal dynamic properties, in particular the stiffness (through FRF measurements or crash deformation) and modal damping characteristics.

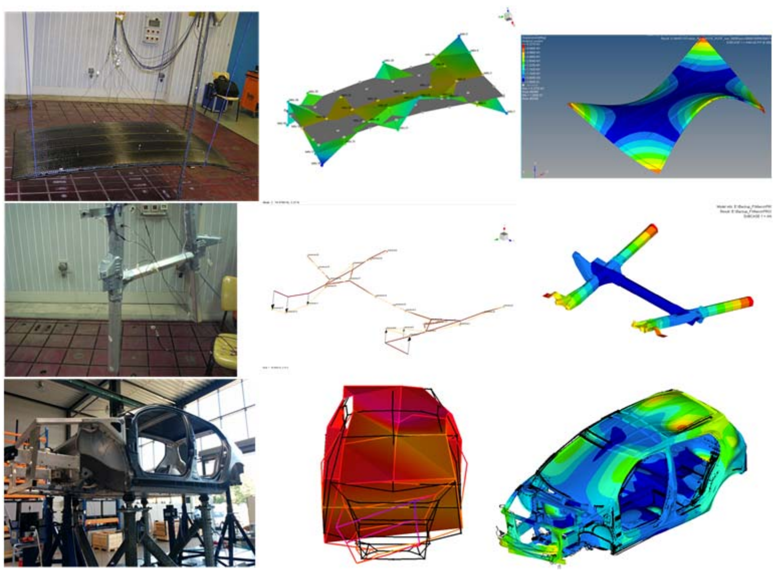


Fig 18: Components test set up, examples of experimental mode shapes and corresponding numerical eigenmodes

As one of the tested materials Aluminum has been widely used in automotive industry since 2000 but the current trend is to exploit a multi material strategy in order to define the right placing of the different materials. Some enablers of this approach are promising technologies for joining steel and Al that have been tested. The most promising seems to be the FDS (Flow Drilling Screw) with respect to RIVTAC technology.

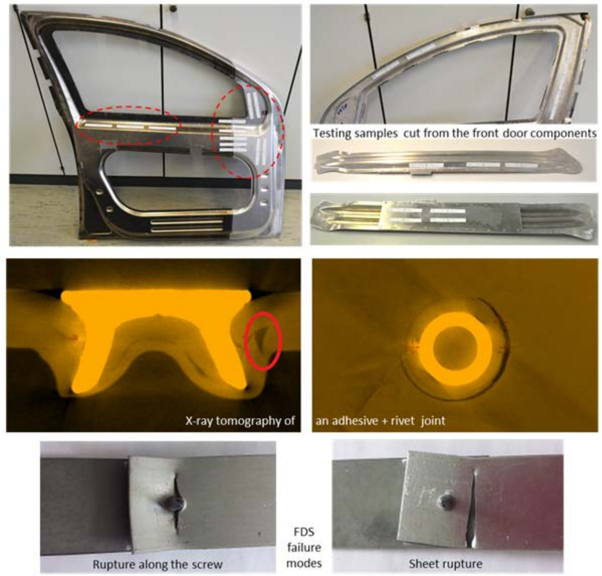


Fig 19: Activities on aluminum door and new joining techniques

Aluminum parts with new materials have to be tested carefully for strength and durability as the new lightweight approach needs to be feasible for all the performances and the results are encouraging from many point of views. Some corrections are maybe needed but the benefit in terms of weight saving and the overall good performances are good news for the new vehicle design. But steel is not a material to forget. The recent studies and enhancements of performances for Advanced High Strength Steel witness a renewed interest on new trade off for this material. The work on B pillar and hat profile are there to show the progress of the new steel materials. Moreover tailored blanks or laser welding are enlarging the mixing of different steel material grades. Composite parts are increasing their relevance on the vehicle and the roof of the ALIVE vehicle shows a good compromise with respect to a steel roof. The same overall behavior of the BIW is really closed to current production global modes.

Full vehicle testing and validation

The BiW was finally tested regarding to NVH, crash and fatigue characteristics. Testing with different load sequences with respect to dynamic properties and durability was done for the front section of the BiW on a multiaxial shaker table. The focus was to measure the transfer functions between accelerations and local strains to verify the proposed methods for the accelerations of this kind of testing.

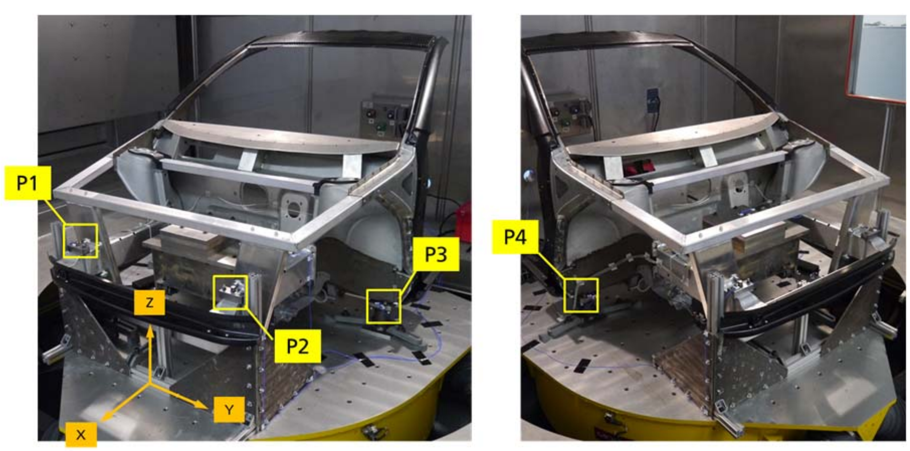


Figure 20: Test setup on the multi-axial shaker table and position of acceleration sensors

Summarising testing with different load sequences with respect to dynamic properties and fatigue was done for the front section of the BiW on the MAST. The focus was to measure the transfer functions between accelerations and local strains to verify the proposed methods for the accelerations of this kind of testing. It became obvious that an approach to evaluate local fatigue only on the acceleration input signals of the test rig is not sufficient. A sensible approach to reduce test time is to measure the transfer functions between the accelerations at different points of the system and local strains at the hotspots. These transfer functions differ for different frequency areas. With these functions it is possible to calculate the impact of a change of the load input accelerations (scaling of acceleration values, increasing of frequencies, cutting of sections out of the load-time histories - omission) on the damage content for the different sections of the test sample.

Additional tests under crash loads were performed using crash test facilities. The results were mainly used to validate the results of the numerical based crash calculations of task 2.6. As real life crash tests a front impact against a rigid barrier (according to Euro NCAP), a side pole impact (according to Euro NCAP) and a modified rear impact (related to FMVSS301) were performed.

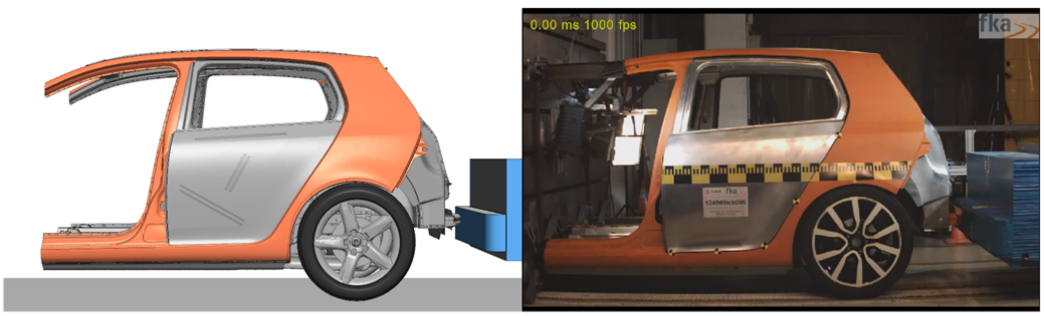


Figure 21: Simulation validated model t = 0 ms

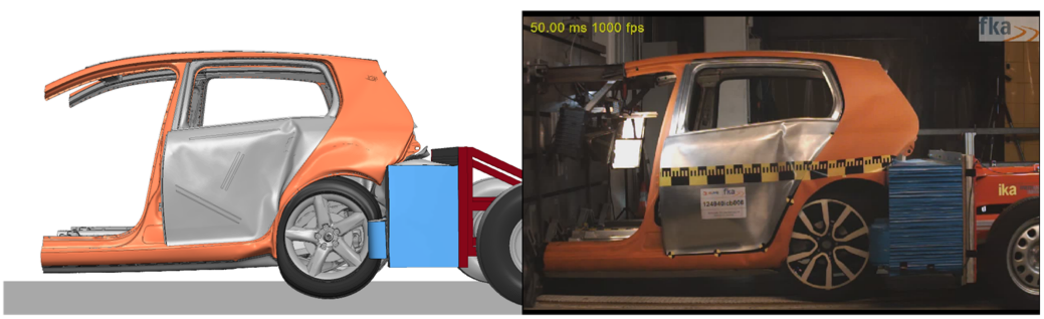


Figure 22: Simulation validated model t = 50 ms

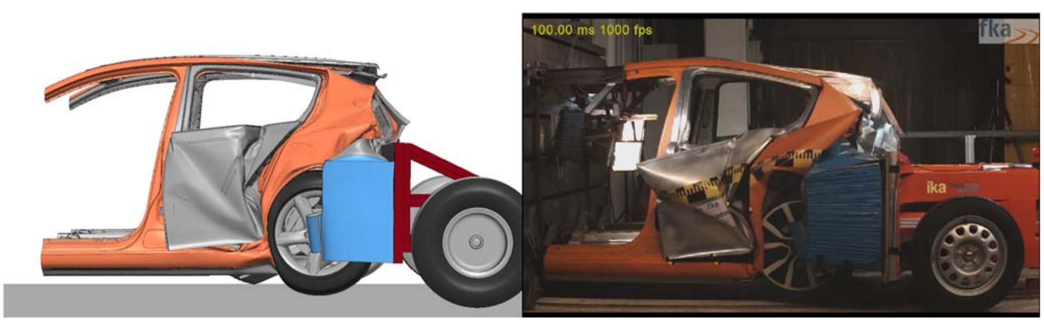


Figure 23: Simulation validated model t = 100 ms

It can be concluded, that a good correlation is achieved in the frontal crash scenario. The main effects are modelled and are comprehensible. Main divergences between the base model simulation results and the test results are based on not expected failure in the main front long member material. Also the designed connection between upper long member and shotgun was too weak. Further differences occur in the behaviour of the tyre model. The tyres in the simulation behave a lot more elastic. This can be explained by a closed air volume of the tyre model. A detailed model of the tyres was not foreseen in the frame of the project. The main effects are adapted in the validated model and the performance is confirmed.

Furthermore the BiW was tested regarding to NVH. The test setup consists of a BiW with and without doors suspended by 4 air springs placed at the side skirt to create a free-free boundary condition and excited by 2 shakers with uncorrelated random signals. The main focus of this work is to validate the numerical results obtained within the work of task 2.6.

Figure 24: BiW with doors on the test rig. Suspended by 4 air springs (blue arrows, zoom bottom left) and 2 excited by 2 shakers (red arrows, zoom bottom right)

The NVH studies performed and results obtained within the framework of this deliverable suggest that the model of the BiW without attachments used in deliverable D2.6 is in good agreement with the physically built BiW. This conclusion is drawn from the comparison of a simulated and an experimental modal analysis of this BiW.

From all these investigations it can be inferred that the chosen materials mix and its application to the mass market production are not unfeasible and only minor modifications are needed to fully withstand with complex vehicle specifications that are currently set by the design department of the OEMs.

WP5

Magna was defined to build up one demonstrator vehicle including the doors and closures, the chassis and the driver´s seat. During the project from simulation side the demand came up to test physical bodies or modules (frontend, rear-end) to evaluate the simulation results. Due to this fact a frontend module and a rear-end module and an additional complete body were built to evaluate the simulation results. They were delivered to the institutes involved in testing.

Before making the prototypes and the demonstrator Magna was involved in defining and optimizing the assembly sequences together with Benteler. This work was basis to be able to produce all the needed modules with the defined budget and within the timeframe.
Magna also gave its input regarding joining techniques and made some sample testing with spot welded aluminum sheets.

Jigs and devices based on the released design were developed and produced. Regarding the welding seams in the floor area of the body, it was necessary to produce a turntable to rotate the complete body upside down. It is forbidden to weld aluminum overhead because of the danger of molten material falling onto the worker, on the one hand, and poor welding seam quality on the other.

The bodies and modules were produced on a measuring plate. That is the standard method for producing bodies with a very limited edition to be cost efficient. Planning the prototype production we saw that one challenge is the schedule and we had to produce in two shifts.
That is unusual because we had to teach two teams and handing over the data from one team to the other was very important.

Finally the project gave us the chance to extend our know how in multi material application regarding joining and prototyping. Following slides show a photo documentation of prototyping the body-in-white demonstrators PT1 and PT2 for testing in work package WP4.

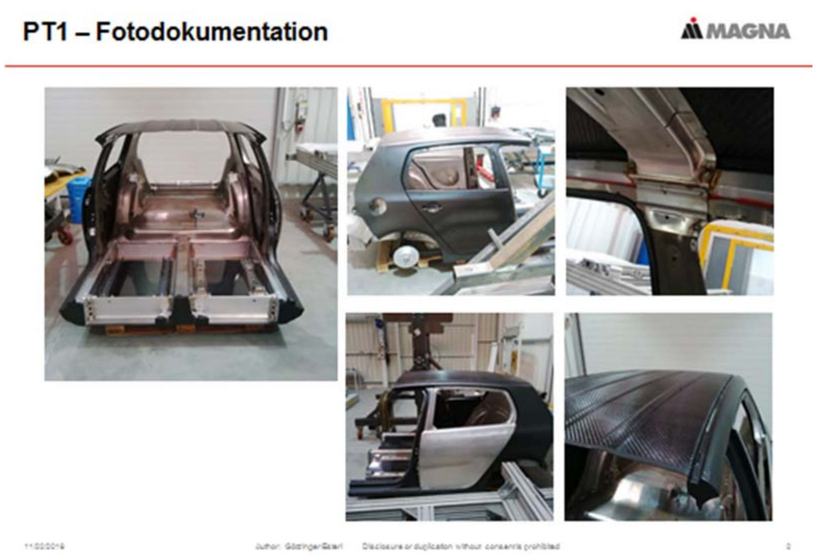


Figure 25: ALIVE demonstrator, photos of prototyping and assembly process

Figure 26: ALIVE demonstrator, photos of prototyping and assembly process

Demonstrator of hang-on parts (assemblies)

The components of both the front and rear doors are shown in Fig.27. Except the impact beam all components are made of 5000 or 6000 aluminium alloys. They are formed at room temperature. The one-piece inner panel of the front door uses a tailored welded blank of 2.0/1.2 mm. It is cold formed with only one mould. In a series manufacturing process two moulds will be used to achieve better quality. The impact beam of 7000 alloy can only be formed at elevated temperature. The forming process is developed in a cooperation between Daimler, AMAG and Magna.

Fig. 27 Tailored welded blank (2.0/1.2 mm, left) with a laser weld seam and the cold formed inner panel of the front door (right).

The aluminium components are joined together by adhesive and rivets, remote laser welding, spot welding and hemming. The final assemblies are shown in figure below.

Fig. 28 The assemblies of the front (left) and rear door (right)

The prototype tailgate consists of polymer components (Fig. 29 left). For the prototype a laser sintered frame reinforcement is used. In assembly process adhesive bonding is mainly used. The final prototype can be seen in Fig. 29 right.

Fig 29 Exploded view of the prototype tailgate (left) and the final assembly (right).

WP6

The objective of WP6 is threefold, including assessment of ALIVE materials, the ALIVE vehicle and the set up of a LCA tool for ALIVE vehicle screening.

In a first step WP6 analysed the materials, especially steel, aluminium, magnesium and composite materials used in within the ALIVE project. The results are included in Deliverables D6.1. to D6.6. The materials include the materials in the ALIVE material database, cf. WP3.

Deliverable 6.7 applied the findings to the entire vehicle. The results are shown in the following table.

Table 5: LCA results ALIVE vehicle vs reference

		Production	Battery Production	Use Stage	End of Life Stage	Total excl. Credits	Credits	Total incl. Credits
GWP [kg CO_2-e]	**Vehicle (Reference)**	1575	1465	5911	78	9028	-853	8175
	Vehicle (ALIVE)	2448	893	3602	94	7037	-1527	5510

AP [kg SO2-e]	**Vehicle (Reference)**	6.0	17	30	0.04	53.00	-3.3	50
	Vehicle (ALIVE)	10	10	18	0.04	39.00	-6.9	32
EP [kg PO4-e]	**Vehicle (Reference)**	0.5	0.6	1.6	0.005	2.742	-0.27	2.5
	Vehicle (ALIVE)	0.8	0.4	1.0	0.004	2.134	-0.42	1.7
POCP [kg C2H4 -e]	**Vehicle (Reference)**	0.7	2.1	1.7	0.003	4.507	-0.48	4.0
	Vehicle (ALIVE)	0.7	1.3	1.1	0.002	3.041	-0.47	2.6
PED total [MJ]	Vehicle (Reference)	22145	20003	127704	330	170182	-7637	162545
	Vehicle (ALIVE)	42540	12191	77831	225	132787	-27115	105672
PED non ren [MJ]	Vehicle (Reference)	20730	17895	105523	261	144411	-7823	136588
	Vehicle (ALIVE)	34536	10907	64313	181	109936	-20344	89592
PED ren [MJ]	Vehicle (Reference)	1415	2108	22181	68	25772	185	25957
	Vehicle (ALIVE)	8004	1285	13518	45	22852	-6771	16080

The analysis revealed a clear benefit of the ALIVE vehicle compared to the reference in all assessed impact categories. Additionally a web based scenario tool has been developed to assess the environmental performance of the ALIVE vehicle during the design phase based on key parameters. An explanation and manual of the tool is provided in D6.8, the login details for the tool are provided in D6.9.

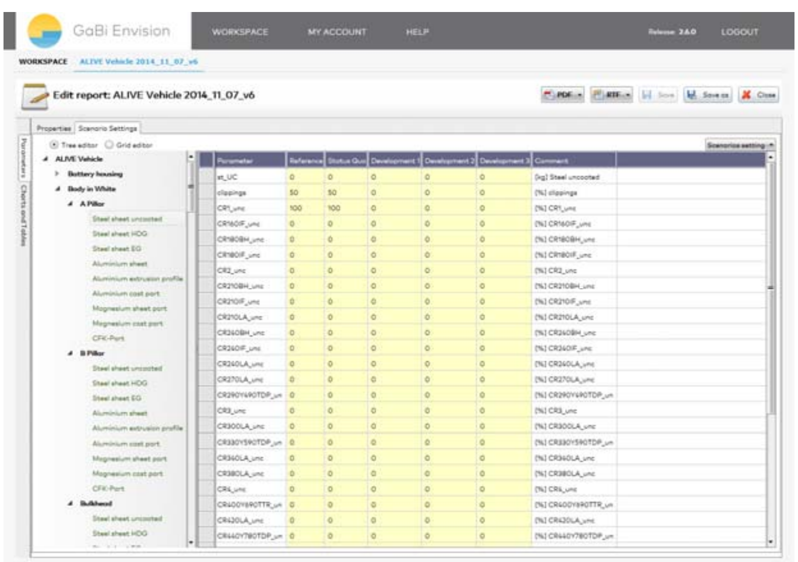


Figure 30: Screeshot ALIVE i-report

WP7

The overall aim of WP7 was to spread the project findings to a wider group of industrial representatives, from the transport and materials sector, to public actors, and the wider public. Therefore the partners focused on defining the dissemination strategy for SEAM as well as creating the "cluster identity".

The ALIVE and SEAM dissemination strategy was prepared in coordination with ENLIGHT, Matisse and SafeEV. A logo has been developed for the projects and common templates for deliverables and presentations were provided. An ALIVE brochure was designed and provides general information in a representative manner. The brochure was used to increase the awareness of the project.

A project website was developed and updated regularly with content (www.project-alive.eu). The ALIVE website has accounted for 2.075 visits after project completion, this is translated into a positive average of about 250 visits/month. Additionally, the ALIVE subsection of the SEAM cluster website was set up (www.seamcluster.eu). ALIVE partners have presented the project at relevant external events and conference across Europe. The information about publications and dissemination activities is also available on the ALIVE website in the section results.

The results out of ALIVE are compressed in an educational material module for use in an academic and industrial course.

The SEAM Liaison team established in the 1st period has consisted of the four project coordinators (Jens Meschke, VW – ALIVE; Thilo Bein, LBF –ENLIGHT; Roland Wohlecker, FKA – Matisse; Andreas Teibinger, ViF – SafeEV) and three partner representatives (David Storer, CRF; Christian Sahr, ika; Laszlo Bax, B&W). Aiming at supporting the Liaison team, the SEAM Project Office was also set up, consisting of Thilo Bein from LBF and Harilaos Vasiliadis from B&W.

The main goal of the SEAM PO and Liaison team has been the harmonisation of the developments of the 4 projects, increasing the opportunities to identify synergies and leverage knowledge generated, while broadening the impact of the SEAM cluster dissemination as the largest lightweight initiative in Europe. Some relevant synergies and connections achieved have included:

- Technical integration between projects: e.g. intrusion beam developed in Matisse into ENLIGHT and ALIVE door modules; doors developed in ENLIGHT into ALIVE; front hood developed in ENLIGHT into ALIVE.
- Input provided during the definition of H2020 work programmes for 2016-17, via the European platforms and associations linked to the partners (EUCAR, EARPA, ERTRAC, etc.).
- Utilising partner booths at fairs and tradeshows to disseminate SEAM materials (e.g. JEC Europe to showcase modules developed during the ENLIGH project).

SEAM Cluster newsletter #1, September 2014

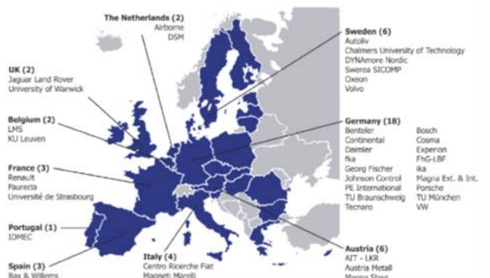
SEAM cluster newsletter
Issue 1, September 2014

SEAM

ENLIGHT ALIVE
SafeEV MATISSE

The SEAM cluster (www.seam-cluster.eu) is the largest European RTD cluster on lightweight vehicle design. It was established to strengthen coordination and harmonisation between four related projects, SafeEV, ENLIGHT, ALIVE and MATISSE, and also to coordinate and execute joint dissemination and exploitation activities.

SEAM consists of 47 partner organisations from 10 EU countries. It is supported by €19 million from the EC's Seventh Framework programme, and leverages more than €30 million in total from private and public R&D investments. Since the beginning of the four 'founding' projects, two more have begun - epsilon and urbanEV. Updates on these newer projects will be found in forthcoming newsletters.



ALIVE

Since the projects inception, the ALIVE team has focused the bulk of its efforts on the initial generation of lightweight, multi-material concepts for the body in white, chassis, doors & enclosures, and interior parts.

The completion of the project's first 3D model of the innovative EV concept marks the first major highlight.
The project's most significant achievement to date is the completion of the first 3D model of the innovative body in white concept. This model will be optimised throughout the coming year and will finally be produced as a complete demonstrator vehicle upon the project's completion.

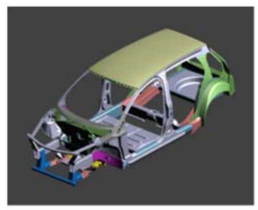


Fig. 2: The ALIVE electric vehicle body-in-white multi-material concept

ENLIGHT

Notable progress from ENLIGHT has been made in both material modelling and vehicle simulations – the latter being completed in cooperation with ALIVE. Going forward, ENLIGHT will build on the same module geometries and specifications as ALIVE, but with a view to attaining further weight reductions. Eighteen months into the project, the conceptual design of the considered modules has been completed.

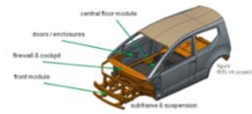


Fig. 3: The ENLIGHT electric vehicle modules

The ENLIGHT project has been presented in a number of events and conferences either by itself or as part of the SEAM cluster, including the EVS27 in Barcelona and the Aachen Body Engineering Days. In the near future, the consortium will present their work at the 16th European Conference on Composite Materials (ECCM16) in Seville and at ISMA 2014. The project's

SEAM Cluster newsletter #2, July 2016
Issued when the ALIVE demonstrator and the ENLIGHT prototypes were available.

SEAM Cluster Newsletter

Issue 2 July 2016

SEAM

ENLIGHT ALIVE
SafeEV MATISSE

The SEAM Cluster consists of four partner projects (SafeEV, ENLIGHT, ALIVE, MATISSE) and two associated projects (epsilon, URBAN-EV) involving novel ideas in the automotive sector that attempt to push developments in electric and alternative vehicles and lightweight design further. The SEAM cluster is heading towards finalisation of its projects.

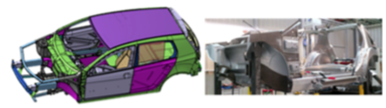
The clustered projects have been running for three years, and considerable developments have been achieved since the last newsletter. On the 25 September 2015, MATISSE and SafeEV delivered their final presentations on the project and the outcomes from their respective work packages.

The progress of the ALIVE and ENLIGHT projects was evaluated by the European Commission and selected technical experts on the 3 and 4 of March. These projects are entering their final period with just less than six months remaining. This newsletter highlights the achievements and developments of the four projects thus far.

Join the SEAM cluster discussion on LinkedIn today!

ALIVE

Full-EV multimaterial design, including a 35% weight reduction for BiW



ALIVE prototype, Body in White

The **ALIVE** project (Advanced High Volume Affordable Lightweighting for Future Electric Vehicles) recently presented their full Electric Vehicle (EV) model design, based on novel lightweight steel and aluminium alloys, and hybrid components.

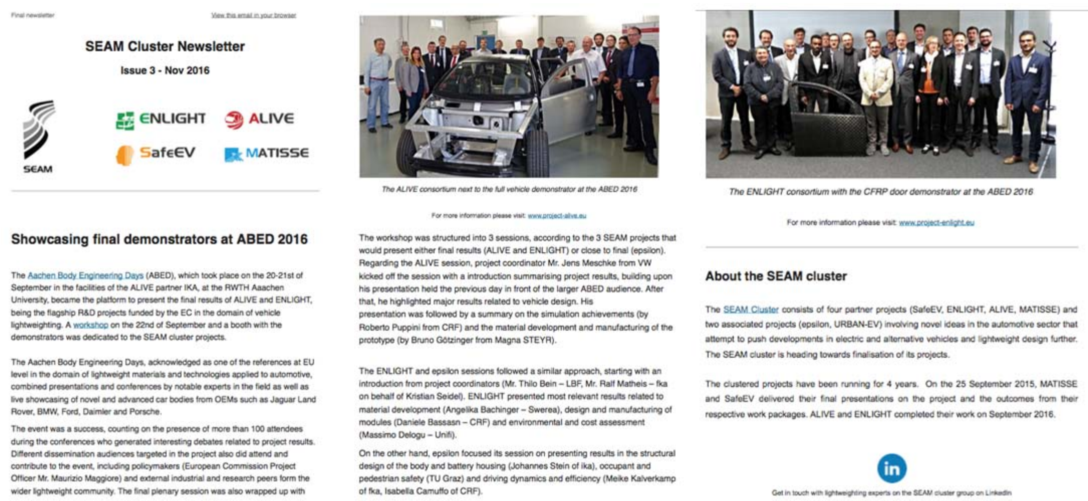
To arrive there, the vehicle modules went through regular iterations during the past year to optimise their design according to the needs of the materials and manufacturing technologies targeted throughout the project, whilst ensuring top safety standards and manufacturability at high volumes.

A significant 35% weight reduction was achieved for the Body in White (BiW) component, while for certain components reductions reached a staggering 50% comparing with reference modules.

ALIVE will fabricate, test and finally showcase a full vehicle demonstrator model including the developed light-weighting technologies at Aachen Body Engineering Days in September 2016, side by side with the ENLIGHT demonstrator modules.

SEAM Cluster newsletter #3, November 2016

Issued after the organisation of the SEAM final event in Aachen, during the AEBD16. The event was a success, counting on the presence of more than 100 attendees during the conferences who generated interesting debates related to project results. Different dissemination audiences targeted in the project also did attend and contribute to the event, including policymakers (European Commission Project Officer Mr. Maurizio Maggiore) and external industrial and research peers form the wider lightweight community. The final plenary session was also wrapped up with a discussion of the importance of lightweight materials in the future of EU automotive sustainability, sharing the vision of the SEAM partners for the short-term future.


Final newsletter

View this email in your browser

SEAM Cluster Newsletter

Issue 3 - Nov 2016

SEAM

ENLIGHT ALIVE SafeEV MATISSE

Showcasing final demonstrators at ABED 2016

The Aachen Body Engineering Days (ABED), which took place on the 20-21st of September in the facilities of the ALIVE partner IKA, at the RWTH Aaachen University, became the platform to present the final results of ALIVE and ENLIGHT, being the flagship R&D projects funded by the EC in the domain of vehicle lightweighting. A workshop on the 22nd of September and a booth with the demonstrators was dedicated to the SEAM cluster projects.

The Aachen Body Engineering Days, acknowledged as one of the references at EU level in the domain of lightweight materials and technologies applied to automotive, combined presentations and conferences by notable experts in the field as well as live showcasing of novel and advanced car bodies from OEMs such as Jaguar Land Rover, BMW, Ford, Daimler and Porsche.

The event was a success, counting on the presence of more than 100 attendees during the conferences who generated interesting debates related to project results. Different dissemination audiences targeted in the project also did attend and contribute to the event, including policymakers (European Commission Project Officer Mr. Maurizio Maggiore) and external industrial and research peers form the wider lightweight community. The final plenary session was also wrapped up with

The ALIVE consortium next to the full vehicle demonstrator at the ABED 2016

For more information please visit: www.project-alive.eu

The workshop was structured into 3 sessions, according to the 3 SEAM projects that would present either final results (ALIVE and ENLIGHT) or close to final (epsilon). Regarding the ALIVE session, project coordinator Mr. Jens Meschke from VW kicked off the session with a introduction summarising project results, building upon his presentation held the previous day in front of the larger ABED audience. After that, he highlighted major results related to vehicle design. His presentation was followed by a summary on the simulation achievements (by Roberto Puppini from CRF) and the material development and manufacturing of the prototype (by Bruno Götzinger from Magna STEYR).

The ENLIGHT and epsilon sessions followed a similar approach, starting with an introduction from project coordinators (Mr. Thilo Bein – LBF, Mr. Ralf Matheis – fka on behalf of Kristian Seidel). ENLIGHT presented most relevant results related to material development (Angelika Bachinger – Swerea), design and manufacturing of modules (Daniele Bassasn – CRF) and environmental and cost assessment (Massimo Delogu – Unifi).

On the other hand, epsilon focused its session on presenting results in the structural design of the body and battery housing (Johannes Stein of ika), occupant and pedestrian safety (TU Graz) and driving dynamics and efficiency (Meike Kalverkamp of fka, Isabella Camuffo of CRF).

The ENLIGHT consortium with the CFRP door demonstrator at the ABED 2016

For more information please visit: www.project-enlight.eu

About the SEAM cluster

The SEAM Cluster consists of four partner projects (SafeEV, ENLIGHT, ALIVE, MATISSE) and two associated projects (epsilon, URBAN-EV) involving novel ideas in the automotive sector that attempt to push developments in electric and alternative vehicles and lightweight design further. The SEAM cluster is heading towards finalisation of its projects.

The clustered projects have been running for 4 years. On the 25 September 2015, MATISSE and SafeEV delivered their final presentations on the project and the outcomes from their respective work packages. ALIVE and ENLIGHT completed their work on September 2016.

Get in touch with lightweighting experts on the SEAM cluster group on Linkedin

More than 200 people were engaged in the joint SEAM mailing list, a critical mass of expert community in Europe on lightweight design of electric vehicles. The engagement statistics can be seen below. They are considered very positive, in comparison with standard expected “conversion rates” for typical newsletters: from 2x to 4x higher engagement.

SEAM Cluster discussion network

In order to strengthen the networking and connections between all SEAM partners, a SEAM discussion group was set up and maintained in the LinkedIn website. It has also served as a platform to discuss developments in the different SEAM projects as well as a framework to share international news outside SEAM, which were relevant to the lightweight community. Some screenshots of the SEAM discussion group in LinkedIn are attached below.

SEAM cluster discussion network

52 miembros Miembro

Debates Acerca de Buscar Gestionar

Perfil del grupo

Safe Efficient Advanced Materials (SEAM) is the largest European RTD cluster on lightweight automotive design. This group is for members of the SEAM cluster members.

This group has been created to facilitate fast and informal internal communication within the SEAM cluster. It is hoped that this will serve as both a networking tool and a source of information and announcements from and about the SEAM cluster and related topics.

This group is private and strictly moderated, but it should be noted that it is not intended to serve as a venue for confidential or sensitive matters relating to the activities of the SEAM cluster projects.

Your group administrators are Ignacio Magallón, Harilaos Vasiliadis and Sam Taylor of Bax & Willems. For all enquiries or requests related to the group, please contact one of the administrators or email communication@seam-cluster.eu

Acerca de este grupo

Creado: 17 de septiembre de 2014
Miembros: 52
Propietario: Sam Taylor
Administradores: Ignacio Magallón Hernández y Harilaos Vasiliadis,
Sitio web: http://www.seam-cluster.eu

Reglas del grupo

Angelika Bachinger
Research Engineer bei Swerea SICOMP

1año

An article about Swerea's work in ENLIGHT was published in the popular Swedish newspaper NyTeknik

http://www.nyteknik.se/nyheter/innovation/forskning_utveckling/article3901431.ece

Strömpuls gör motorhuven mjuk

En bil kör på en fotgängare. Men personens huvud slår i en huv som hunnit bli mjuk.

Recomendar Comentar 1

Potential impact, main dissemination activities and exploitation of results (not exceeding 10 pages)

Publications and dissemination

ALIVE has published 7 scientific papers (3 expected in 2017) in high-level specialised journals, e.g. ASME Journal of Vibration and Acoustics, as well as in relevant high impact industry magazines and conferences, such as SAE. At the same time, the ALIVE partners has carried out 43 dissemination activities, including both internal dissemination at partners premises, and external actions, presenting the project in the most relevant dedicated conferences in the lightweight and electromobility field: EUCAR, Aachen Engineering Body Days, Transport Research Arena, EEVC Conference or the EV Symposium.

A detailed list including all dissemination actions is annexed below in Section A.

Exploitable results

The ALIVE partners have produced a number of valuable and exploitable results, including:

- Magnesium sand casting technology, by using an electromagnetic pump and an advanced electronic control system.
- Methods to accelerate the fatigue testing of materials and components.
- Numerical fatigue calculations of components and complete BiW by using sophisticated modelling techniques of joints
- Cyclic material characteristics
- New thermoplastic composite roof concept design based on a sandwich structure made of two thin plies of GFRP with a pressure stable polyester nonwoven core

Partner Faurecia has also registered an utility model in Germany related to the developments of ALIVE (adjustment element for an adjustment device of a vehicle seat). More details are annexed in section B below.

Impact

The implementation of ALIVE results into real vehicle developments will contribute to achieve several impacts including:

- Environmental impact – CO_2 reduction in Europe due to EV lightwieghting (422.0000 tons of CO_2/year) and 9,6 millions tons of CO_2/year due to ICE lightweighting. Additionally, reduction of some 2 million tons of CO_2/year (rest of the world).
- Impact on urban quality of life and health, including urban quality of life improved, substantial amounts of healthy life years saved.
- Economic impact on EU competitiveness: ALIVE will contribute creating a European competitive advantage in EV vehicle architecture and concept.
- Economic impact supporting to anchor and create jobs in Europe, estimated in total 370.588 jobs (both direct and indirectly related to automotive manufacturing)
- Economic market impact for ALIVE partners, assessed in a business worth €7,5 billions which will supporting them strengthening their position in the global market.

Project website and contacts

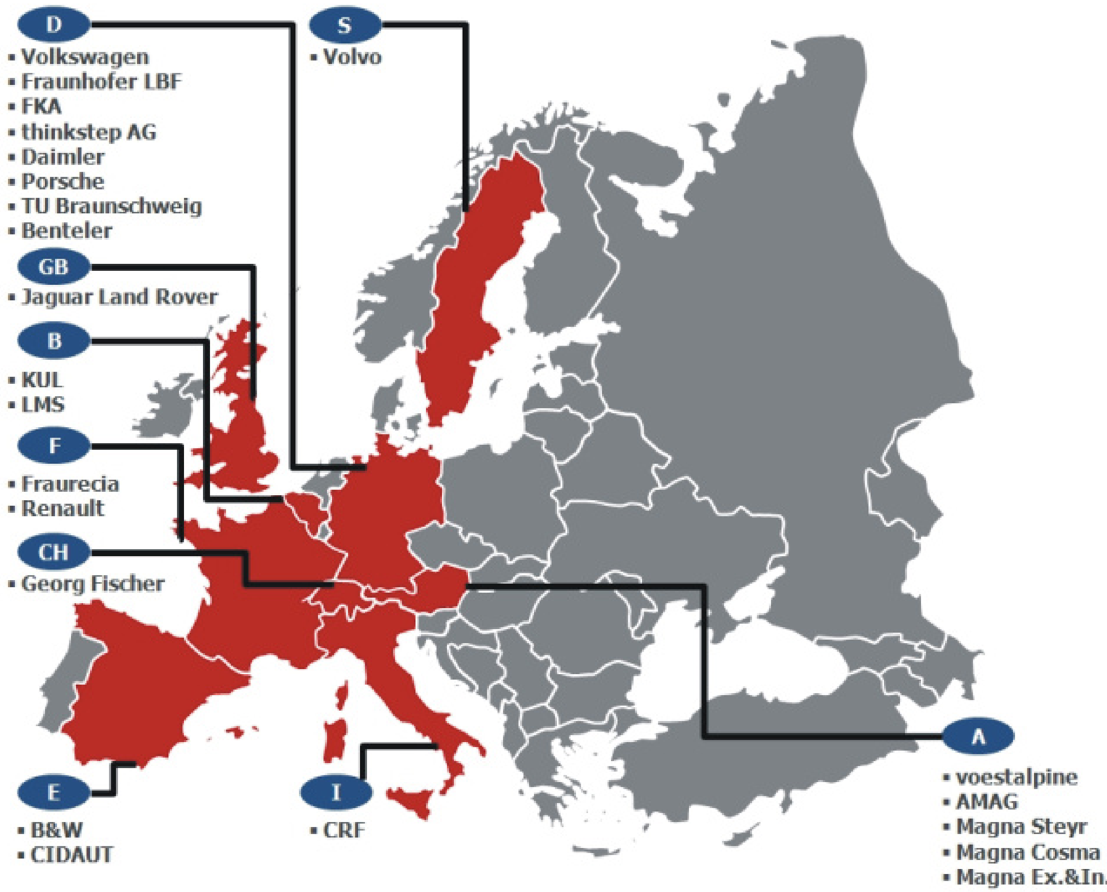
Website: *www.project-alive.eu*

Contacts:

Dr. Jens Meschke
Coordinator
VW AG
jens.meschke@volkswagen.de

Annex

ALIVE Consortium



The ALIVE consortium was composed by a core team of 4 carmakers, 2 tier one suppliers and 2 leading research organisations on the basis of detailed proposals for RTD work received from some fifty-five organizations throughout Europe. In order to keep the consortium compact, highly focussed and strongly industry-driven, only the most innovative and high-impact contributions were selected and integrated into a synergetic RTD program. The ALIVE consortium covers all areas from materials, engineering, design, manufacturing, joining as well as experimental and virtual performance assessment.

The ALIVE consortium consists of best-in-class leading RTD organisations, which have been selected to assure both the achievement of project results as well as the widest possible impact on society. Partners are some of the most relevant European organisations involved in Electric Vehicle development with a commitment to achieve this objective that goes far beyond this project.

The ALIVE project unites members of the following three major associations to ensure the consortium is a well-balanced mix of key players within the European automotive industry:

- EUCAR: The European Council for Automotive RTD is the European body for collaborative automotive and road transport RTD whose mission is to "Strengthen the Competitiveness of the European Automotive Manufacturers through Strategic Collaborative R&D.”43 Its members, the major European manufacturers of cars, trucks and buses, share goals align with those of ALIVE as it looks to devise strategies and solutions to future challenges that the car industry encounters. Seven of its members are represented in ALIVE. (Volvo, Renault, Jaguar, Daimler, VW, CRF, Porsche)

- CLEPA: The European Association of Automotive Suppliers promotes the interests of the European Automotive Industry and promotes competitiveness through investment in “innovation, safety, environmental protection, social responsibility, sustainable development and sound economic growth”44. Three of its members are represented in ALIVE. (Magna Steyr, Faurecia, and FKA)

- EARPA: The European Automotive Research Partners Association “aims at actively contributing to the European Research Area and the future EU Framework Programmes45”. Three of its members are represented in ALIVE. (Foundation CIDAUT, Fraunhofer LBF, KULeuven) The project includes the involvement of seven major European vehicle manufacturers – Daimler, FCA, Jaguar, Porsche, Renault, Volkswagen, and Volvo. Representing about 48% of the European car market, these OEMs have already dedicated significant resources to the development of EV technology and its application in mass volume produced EV (as part of their RTD activities to reduce CO2 emissions). This has resulted in various first generation EV concepts that are in the process of being commercialised. The automotive supply chain is also well represented within the consortium, consisting of seven nine different companies, Faurecia, Magna Styer, Cosma International, Magna Exteriors & Interiors, LMS, AMAG, Georg Fischer, Voestalpine, and Benteler. They bring to ALIVE experience in manufacturing a wide range of vehicle components from materials and parts to an entire automobile. Academic excellence is ensured in the consortium through the involvement of two high ranking European universities – Katholieke Universiteit Leuven (KULeuven) and Technische Universität Braunschweig (TUBraunschweig) and three well-regarded technology centers – CIDAUT Foundation, FKA Forschungsgesellschaft Kraftfahrwesen mbH Aachen, and Fraunhofer Institute for Structural Durability and System Reliability (LBF), with long-time experience supporting car manufacturers in vehicle component research and development. Additionally the consortium incorporates an SME specialised in life cycle analysis in the automotive sector – PE International, which brings to the project long time experience in automotive industry, and another SME (Bax&Willems) specialized in supporting industries and spin-offs in the development and execution of their technology-to-market strategies, and with a long-standing track record of supporting business-oriented RTD collaborations for leading industries.

Relevant publishable images

Final SEAM cluster meeting Aachen