Development of materials and process technologies for the lightweight vehicles of tomorrow

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Abstract

Europe has done significant steps in the area of vehicle lightweighting over the past two decades. Several pan-European initiatives have contributed to the development of material and process technologies that enable reduction of vehicle weight by up to 35%. Despite their high lightweighting potential, it has been proven difficult to implement these technologies in medium to high volume vehicles, mainly due to their high production and material costs.

The AffordabLe LIghtweight Automobiles AlliaNCE (ALLIANCE) has the ambition to develop novel advanced materials (steel, aluminium, hybrid) and production technologies, aiming at an average 25% weight reduction over 100k units/year, at costs of <3 €/kg. Additionally, ALLIANCE will develop a mass-optimizer software tool and a multi-parameter design optimisation methodology and process, aiming at an accelerated pre-assessment of technologies over existing designs in a holistic framework.

ALLIANCE will work on 8 different demonstrators of real vehicle models, aiming at market application by OEMs by 2025. A transferability and scalability methodology will also be developed accelerate the replication of results across vehicle components and models in other segments.

The paper looks into the process followed to develop the novel material and process technologies within the requirements set by the OEMs, as well as the necessary tools that are used to support, monitor and evaluate the developments. Additionally, the paper presents the up-to-now results from the project, as well as key learning points for the OEMs, suppliers, and knowledge partners.

Introduction

Since it's invention by Carl Benz in 1879, and the transformation it underwent in the following years, the automobile has had a great influence on the way we live. It has enabled more people to travel longer distances more easily, affecting our decisions about where we live and work. The success of the automobile has been apparent in the growth of cars in circulation. In Europe, total number of vehicles peaked 324 million by the end of 2015, out of which 252 million were passenger vehicles, a 4.5% increase from 2011 [1].

Together with the increase of number of cars in circulation, the average weight of vehicles has also been growing. Since 2001, average weight of new cars in the EU increased by 10% [2], mainly driven by improved safety requirements.

Apart from increased safety though, higher vehicle weight also translates to higher energy consumption, which means increased energy bill for the driver, but more importantly increased greenhouse gas emissions. Transportation is the only sector in Europe of which greenhouse gas emissions have increased since 1990, while for all other sectors emissions have since decreased [3]. One way to address this issue is to decrease vehicle weight, without compromising safety.

Over the last few years several lightweighting efforts have taken place, suggesting a range of innovative solutions. Nevertheless, not all solutions have been adopted, as the combination of high cost and high cycle times makes them prohibitive for the high volume vehicle sector – the majority of cars on the roads.

Acknowledging the importance of the issue, the European automotive R&D community – with the lead of EUCAR, the European Council for Automotive R&D – has joined forces forming the ALLIANCE collaborative project, bringing together six leading OEMs (Daimler, FCA – represented by CRF, Toyota, Volvo, Opel, Volkswagen), four suppliers (ThyssenKrupp, Benteler, Novelis, Batz) and eight knowledge partners (Fraunhofer LBF, ika, Swerea, University of Florence, KIT, Bax & Company, Ricardo, inspire). The project aims at a weight reduction of 21-33% for production volumes of 100,000 vehicles a year, which will enable fuel savings of 10%, and reduce GWP (Global Warming Potential) by 6%. In order to ensure that the innovations will find their way to the market sooner than later, project partners are aiming to keep the cost of their lightweighting innovations at under €3/kg saved.

Methodology

In order to achieve the project objectives, partners are targeting a range of innovations. Development and adaptation of innovative materials that enable weight reduction in a cost-efficient way without compromising structural integrity and vehicle safety; new manufacturing technologies – for the respective and other materials – with lower energy consumption and increased automation (hence decreased cycle times), as well as tools that will support the development and implementation of these new technologies. Additionally, aiming to involve organisations outside the consortium in the process, the project has set up an inclusive framework to attract innovations from partners outside the consortium.

The innovations developed in the project will then be combined in 8 existing demonstrators (6 physical and 2 virtual) and tested to evaluate their performance.

The innovations in the different domains are described below.

Materials
In order to achieve the overall lightweighting, cost, and manufacturability targets, the project focuses on three material families:

- **High strength Quenching & Partitioning steel**
  Steel alloys exhibit good elasticity and strength, making them a good candidate for parts that have

safety as well as high volume production requirements. Currently, steel accounts for some 65% of material usage in passenger cars [4],as the recyclability of steel makes it a cheap and viable option. In ALLIANCE, partners target further development of a 3rd generation Q&P (Quenching & Partitioning) AHSS (Advanced High Strength Steel) with approximate tensile strengths of 750-1600 MPa and elongation A_{80} range of 9-45%. This will allow reaching lower thicknesses while maintaining structural properties.

- **High strength and highly formable 6000 and 7000 series aluminium alloys**
  Although aluminium has a high lightweighting potential, it is not used in high volume, lower price car segments due to the high cost of material, manufacturing and assembly, as well as the relatively lower strength compared to steel alloys, limiting its usage in crash-critical parts. Developments in ALLIANCE focus on increasing tensile strength of 6000 series up to 350-400 MPa while improving crash behaviour; and improving strain resistance and sensitivity to stress corrosion cracking for 7000 series. Additionally, activities aim to achieve more predictable forming behaviour, and allow cold and hot forming for the 6000 series, and hot forming for the 7000 series.
  To reduce assembly costs, ALLIANCE is also working on a family of fusion technology alloys, where the surface alloy is the welding wire for the core alloy. This would enable welding of final packages without the usage of filler material and works well with remote laser welding technology.

- **Composite materials**
  Composites have a very high lightweighting potential, but so far, application has been limited to high-end sports cars, with very limited parts in medium to high volume vehicles (mainly semi- or non-structural). ALLIANCE focuses on GF (Glass Fibre) reinforced plastics – Carbon Fibre has been excluded due to the high cost – as well as steel sandwich materials. Innovations mainly target manufacturing processes.

Next to the technological developments, testing and characterisation will be carried out for all materials.

Manufacturing Technologies
Aiming at reducing energy consumption, cycle times, and enabling the manufacturing of complex tailored parts in an efficient way, the following technologies will be developed within the project:

- **Metal forming**
  Aluminium alloys already have a high extrudability index, enabling a diversity of shapes, while reducing a number of machining and joining operations, and maintaining modest tooling costs in comparison to other processes. The focus of ALLIANCE is to develop an innovative forming technology (TEB – Tailored Extruded Blanks) tailored for light alloys. This would enable the creation of variable thickness within a specific component, allowing for higher customisation and better management of the load bearing capacity, with a high weight reduction possibility, as well as a shorter process chain with potentially reduced costs. Furthermore, TEB counters specific disadvantages such as warpage, weld spatters and a dramatically reduced strength in the weld seam.

- **Thermoplastic composites manufacturing processes**
  Injection moulding is among the most advanced manufacturing technologies for plastics. Nevertheless, it cannot offer continuous fibre reinforcement. The focus of ALLIANCE is to combine existing technologies IMC (Injection Moulding Compounder) and WIT (Water Injection Moulding) to allow for the manufacturing of parts with local continuous fibres with hollow design. The ability to produce parts with this combined approach will avoid secondary operations allowing a cost-effective production cycle time.

- **Joining technologies**
  As joining can greatly contribute to manufacturing cycle times and cost – especially when considering innovative materials – ALLIANCE targets developments in the following joining technologies:

- Remote Laser Welding
  Welding of aluminium is more demanding than that of steel. It has an inherent lack of fusion, lack of penetration and porosity. Many aluminium alloys are prone to solidification cracking and have an increased susceptibility to stress corrosion cracking. ALLIANCE is developing a remote laser welding technology to make use of the fusion technology alloys developed in the project, which do not use filler wire, but instead incorporate the wire in the surface alloy on one side (typically lower series) while the other side does not include wire. This would allow reduction in the use of adhesive bonding (passenger cars typically have a total of 160 meters of adhesive bonding) which significantly contributes to total costs.

- Multi-material joining
  With the ever-increasing diversity of materials used in vehicle manufacturing, multi-material joining is becoming more important. Currently, most of such technologies require the use of mechanical fasteners such as rivets and bolts and involve drilling holes, adding an extra step to the process, generating higher costs. Additionally, material thickness needs to be increased at the joint area to increase the load bearing capacity, at the added risk of rust and corrosion. To address these issues, ALLIANCE is targeting a combination of FEW (Friction Element Welding), fast-curing adhesives and improved SPR (Self Piercing Rivets).

Support Tools
Many of the decisions when it comes to materials, manufacturing processes, and design optimisation are typically taken in the early design stage of a vehicle’s components. To make such informed decisions, many parameters need to be taken into account at the same time and trade-offs need to be made between performance, cost, environmental impact and processability, at a phase in the design process when detailed geometries and materials specifications are not yet available. For that reason, appropriate and comprehensive methods and tools enabling “design for lightweighting” need to be developed to be used by designers and engineers working on these stages of vehicle and component development. Within ALLIANCE, partners are developing a range of tools that can support decision making at the early stages of part development.

- **Lifecycle cost and environmental analysis**
  Lightweighting innovations that have been proposed in the past manage to reduce energy bill and emissions during the use phase, but many of them transfer the related costs and environmental impact to the manufacturing and/or EoL (End-of-Life) phases by increased cost of raw materials and manufacturing energy consumption – in the manufacturing phase – and increased cost of dismantling or materials that have limited recyclability – in the EoL phase. Aiming to address this issue, ALLIANCE will provide a wholistic (i.e. including all lifecycle phases – production, use, end-of-life) cost and environmental assessment of the 8 demonstrators developed within the project, and extrapolate the results for full vehicles of various segments to validate their viability. In addition to providing a final assessment, the tools will support the engineers and designers throughout the project, aiding them in selecting the right combination of materials and manufacturing technologies, and making sure that the developments are in-line with the project cost and environmental targets.

  In order to extend the analysis to other vehicle parts (to provide a full vehicle analysis) as well as vehicles of other classes, a “scalability and transferability” methodology is developed, allowing for the estimating the lifecycle performance of multiple parts and vehicle classes.

- **Extended Target Weighing Approach**
  As historical data show [2], lightweighting has not been the priority in vehicle development in the past few decades. Instead, main concerns – at least for the wholistic performance – so far have been safety and cost. Pressed by the need for increased sustainability and functionality among others, additional parameters are coming into consideration, such as lightweighting and emissions. To find a way to satisfy all selected parameters in the best way, a multi-parameter optimization methodology has been developed – the ETWA (Extended Target Weighing Approach). The ETWA is based on Value Engineering and Target Costing, and the core of the methodology is the “Function-Effort-Matrix”. Based on the results of the ETWA, new concepts are generated that fulfill the various criteria

on a different level. The tool aims to support designers in the early stage of development of the demonstrators throughout the project.

- **Lightweight Open Innovation Competition**
  Acknowledging that the project consortium does not necessarily possess all the knowledge and expertise to develop the optimal lightweighting solution for each vehicle part, project partners have decided to set up an open inclusive framework for organisations outside the consortium to propose their material and manufacturing innovations, and give the chance to the most promising ones to co-develop their solutions together with ALLIANCE's OEMs and suppliers on real-life demonstrators. To achieve this, the LOIC (Lightweight Open Innovation Competition) is split in three phases: the submission phase, when organisations can submit their innovations which are evaluated by a jury, the demonstration/validation phase, where the most promising solutions (winners) from the previous step work with project partners to tailor their technologies, apply them (virtually) to one of the demonstrators, and validate them; and final presentation phase, where the winners present their results at the LOIC final event, in front of an audience of OEMs, suppliers and researchers.
  Apart from sourcing innovative ideas, the LOIC serves as means to lower the initial barriers for organisations that are interested in entering the European automotive value chain – by bringing them in contact and allowing them to collaborate with leading OEMs and suppliers – as well as generating a map of European innovators in the field of lightweighting.

Work Performed and Results

The project was initiated in October 2016. The activities up to now have mainly focused on the conceptual design of the demonstrators, the development/adaptation of high performing materials, as well as information gathering and development of the necessary tools to support and evaluate the project developments [5]. A brief description of the work performed so far, and up-to-now results is provided per domain below.

Materials

- **High strength Q&P steel**
  Initial Q&P steel casts have been produced and processed into annealed galvanized strip. The coupons produced by the material have undergone a variety of coupon level tests as agreed by the project partners. The tests evaluated basic and advanced mechanical properties, formability, weldability, as well as in-service aspects such as corrosion, fatigue, and crash properties according to the requirements for the multiple possible applications. The material was tested under two conditions, described as paint-baked (PB), simulating the heat treatment experienced by the body-in-white for the paint-baking process and involves heating the sample up to 170°C for a holding time for 20 minutes before cooling in air, and as-delivered (AD) which it the initial material without any treatment. All tests were performed according to existing standards (whenever available).

  In regards with forming behaviour, tensile properties were characterised with the quasi-static ($\dot{\varphi}$=0.004 1/s) tensile test according to DIN EN ISO 6892-1 with sample form 2. The material could satisfy the requirements of YS>850MPa and UTS>1180MPa in both longitudinal and transverse directions. The bending ability of the material was tested by the standardized three point bending test after VDA238-100. The bending angle exceeds in average 90° which is of typical amount for this material class. Paint baking leads to a slight increase not only of the bending angle but also of the scatter. The edge crack sensitivity was determined by the hole-expansion test according to ISO 16630. The measure is the hole expansion ratio (HER) which is defined by the increase of the hole diameter related to the original diameter. Due to the visual judgement of the operator the determined values can suffer from noticeable scatter. The measured HER values range from 25 to 33%.

  In terms of corrosion behaviour, the material underwent testing for internal hydrogen embrittlement according to SEP1970, for which the material showed no signs of embrittlement after 96 hours. Testing for external hydrogen embrittlement, which represents the hydrogen uptake and material response during in-service conditions was characterised with a stepped loading test. After 24 hours of tensile loading (at 50% of the maximum load) while being immersed in a charging solution, the tensile load was increased by 5% every hour in a stepwise manner. The tested samples withheld loading up to 65% loading, which is a good result for materials of this strength class.

Regarding weldability testing, the resistance spot welding of the DP-K® 850Y1180T-DH was characterised according to SEP-1220 part 2. In metallographic inspection, the standard weld nuggets are defect-free and the contact surfaces with the electrodes show no signs of liquid metal embrittlement. The MAG welding was subjected to MAG tests according to SEP-1220, parts 4 and 5. Welding was carried out with Union K56 filler wire under a 82%-Ar / 18%- CO_2 atmosphere at a welding speed of approximately 45 cm/min. The welding process was stable with only very limited splashing. Radiography indicated single pores and hardness profiles show a slight weakening in the heat-affected-zone before hardening next to the weld seam. The bond showed a good transfer of strength with weld failure (1.0mm sheet thickness, 25mm wide samples) after tensile shear testing at 26.7kN

- **Aluminium**
  Several aluminium grades were developed to satisfy requirements for high formability, high strength, and simplification of assembly process (grades weldable without filler wires). The seven grades developed and tested in the project belong to the 6xxx and 7xxx families. All grades developed were characterised for their mechanical and forming behaviour.

  Higher elongation, higher FLC (Forming Limit Curve), (also better bendability for FusionTM© variant) were observed for the studied grades compared to regular grades used today. This gives the possibility to manufacture parts with complex geometries, opening the door to applications which are only possible with steel today. This also enables manufacturing more complicated parts out of a single metal piece, reducing component part number, and thus decreasing costs and energy consumption. High strength materials also offer the potential for downgauging.

  Weldability tests for MIG and friction stir welding are currently being conducted, while further joining tests (riveting, adhesive bonding, hemming, laser welding) are planned to be performed with the new material grades, and full characterization of the joints will be carried out.

  To describe the crash performance of the aluminium grades, quasi-static, dynamic tensile, quasi-static notched tensile as well as quasi-static shear and bulge tests are performed, the data of which will then be implemented in a CAE crash simulator.

  Additionally, a concept for joining an aluminium extruded alloy together with a TP composite was evaluated. Tests evaluated the joining concept before and after corrosion aging. Results show that before aging all aluminium joints feature completely cohesive fracture patterns, while all joining strength values decrease by some 30% after aging most probably due to water uptake effects in the epoxy adhesive which did not reverse during reconditioning at room temperature. Failure is improved by mechanical or chemical deoxidizing of the extruded aluminium alloy.

Manufacturing
In order to address the manufacturability of the demonstrator designs with the materials developed in the project, for the target production volumes (100k vehicles/year), the relevant manufacturing technologies have been developed and/or adapted.

- **Metal forming**
  In regards with steel, complex yield locus model Barlat 2000 was calibrated and can be used in material cards for forming simulations, i.e. for LS-Dyna. For forming simulations with AutoForm corresponding standard material cards but with the yield lodel Hill 90 have been provided too. Improved material modelling using HAH and Yoshida models for spring back prediction in numerical simulations of Advanced high strength steel have been accomplished.

With respect to aluminium, an enhanced formability of new 6xxx grades has been developed, allowing complex design through conventional cold forming and without using expensive process like warm forming.

Specific solutions have been investigated to develop a concept (CMS, crash management system) to tailor mechanical properties of aluminium products by wall thickness variation and softening.

- **Hybrids, metals with plastic reinforcement**
  Following definition of potential applications for hybrid materials, the development of technologies has focused on the manufacturing of structural beams, as well as a hybrid sheet forming process for TP (thermoplastic) composites in combination with aluminium

- **TP composites manufacturing processes**
  Several trials with different combinations of TP and GF have been performed, in order to select the proper material taking into account the processability of hybrid process, including the analysis of different water feed systems for combining the IMC and WIT technologies, and relevant factors associated to the process for an accurate verification of TP hybrid processes. The research performed sought to satisfy three main goals: weight optimization through a material hybrid approach (injection compound in combination of hollow structures and continuous fibre); feasibility of manufacturing considering a range of raw materials; and improvement of the simulation software and accuracy. In regards with the first, analysis of flow, GF orientation and raw material feeder system have been analysed in order to set the best location and geometry of injection gates for hollow structures. In regards with the raw materials, the processability of various materials has been assessed to ensure that they satisfy requirements on flow rates, fibre content, fibre length, etc. Namely the MFI (Melt Flow Index), HDT (Impact & Head Deflection Test), GF content, GF length, etc.) are being assessed.

  In terms of improvement of simulation models, a characterisation methodology has been adapted bearing in mind the hybrid process. Tensile curves for non-linear structure modelling have been created taking into account manufacturing process criteria such us injection speed or GF orientation. These curves help to capture realistic anisotropic properties of the plastic material in the structural analysis resulting from both the injection moulding and water injection processes. In order to analyse the level of prediction in terms of GF orientation, different tomographies of raw material injected with different process parameters have been made. Finally, different modifications in the logarithmic of the software have been adapting in order to have a more accurate prediction of the fibre orientation.

- **Joining technologies**
  Innovative joining trials have been performed with different joining processes in loops to investigate and develop joining solutions for new material combinations. Different test joints have been produced, currently under evaluation from the performance (corrosion, strength, etc...) point of view. Joining fact sheets have been generated and shared with partners working on material developments. The joining fact sheets include all relevant aspects such as equipment cost, consumables, energy consumption, footprint, cycle times, capacity, maintenance, personnel required, etc., and are being used by the partners developing the LC assessment.

  In regards with specific joining technologies, a methodology for simulation of the SPR process has been developed, and simulation of SPR joints has been generated and verified by comparison with coupon tests. A design concept for adhesives to be used in the rear floor demonstrator has been developed, and CAE prediction for adhesive strength and creep load was finalized. Materials testing of test samples has also been completed (shear, peel, fatigue, creep, after ageing and chemical) and safety margins determined. On-going innovative joining trials have so far reached results with FEW – both “conventional” and “stationary shoulder” (which creates colder welding than conventional FEW), and new MIG (current wave form control). These tests have been carried out with different material combinations.

Finally, aiming to evaluate the feasibility of the developed manufacturing technologies with the range of materials, a process compatibility for new materials and manufacturing technologies has been investigated for some demo components (door and floor concept assembly).

Support Tools

- **LC cost and environmental analysis**
  To generate the assessment, a "reference" vehicle with two different powertrain configurations was defined – to be used as a benchmark – as well as the boundary conditions (LC distance of 150,000km for ICE and 230,000km for BEV, both NEDC and WLTC driving cycles). Components of the reference vehicle were broken down to their mono-material parts, and detailed information (geometry, materials and manufacturing technologies used, weight, etc.) were obtained from project partners and literature whenever available. In parallel, information was gathered regarding the manufacturing processes (machinery involved, machinery cost, energy consumption, energy flows, cycle times) employed for the reference and lightweight vehicle. The collected data were entered into the "lifecycle inventory", a database that contains data used to develop LC assessments. In order to perform the assessment on the full vehicle, the different domains of a vehicle were analysed independently. The full vehicle was therefore broken down into the major domains drivetrain, electric/electronics (E/E), chassis and Body-in-White (BiW) including closures. The lightweighting efforts within ALLIANCE focus on the chassis and body domain, therefore these domains were analysed in detail. Lightweight measures in the E/E do not contribute to significant weight reduction. The material composition of the drivetrain and E/E was analysed in detail to evaluate the environmental impact. Cost of the drivetrain was derived from an empirical, performance-related analysis, while cost of E/E was estimated on the basis of market relevant prices. Using the data collected, a full LC assessment was carried out for the ICE and BEV configurations of the reference vehicle for both WLTC and NEDC driving cycles. The EoL phase was omitted from the cost assessment due to lack of data, that would result in inaccuracies. Calculations of the manufacturing phase were performed using part and manufacturing data; of the use phase using vehicle energy consumption and driving emissions; and EoL phase considering two different scenarios in which the recyclability (R_{cyc}) and recoverability (R_{cov}) rate was varied.

  Results show that from the five domains, the drivetrain is by far the one with the highest cost, and in the case of BEV it is almost 2.5 higher of that with the ICE configuration. Similarly, for the environmental analysis, the drivetrain contributes the most to the GWP of the vehicle, with the BEV version having a much higher impact than the ICE. This is explained by the higher costs and GWP associated with the materials and manufacturing of the battery and electric motor elements. As expected, the BEV version has a higher cost and GWP values in the manufacturing phase compared to the ICE version. This is compensated with lower emissions and energy consumption in the use phase. A comparison between the two configurations shows a break-even point (when the increased GWP and cost of the manufacturing phase compensates in the use phase) of 42,000km when it comes to GWP, and just above 200,000km when it comes to cost [6].

  Initial assessment of the demonstrators developed in the project has already been carried out, and partners are working together to validate the results and calibrate further the LCC and LCA models.

  To be able to replicate the assessment of the lightweight demonstrators to other vehicle parts and vehicle segments, a tool is being developed, building on a commercial package (mass manager). For the expansion of functionalities, the existing tool was updated to include BiW sub-assemblies. The component database was expanded to include component requirements (e.g. material specifications, manufacturing processes) next to mass and geometry. To allow scaling results from the detailed LCC and LCA assessment of the demonstrators to other vehicle components, a regression formula has been employed to compare part mass and dimensional data from an external database (a2mac1) and develop mass-dimensional relationships. Finally, an additional transferability functionality has been added to the tool to estimate the impact of transferring a lightweight component's design and technology from a "source" to a "candidate" part. Preliminary results show unrealistic lightweighting potential. This is due to the additional requirements that need to be defined (e.g. an interior cup holder and a crash-box have very different requirements), and partners are currently working in defining these requirements, which will be implemented in the software tool.

- **Extended Target Weighing Approach**
  The existing Target Weighing Approach has been extended in order to balance mass, costs, and CO_2 emissions, depending on the vehicle segment under consideration. To perform the analysis, the first step is to identify the functions and efforts of the system under investigation which is done with the aid of the Contact and Channel Approach (C&C2-A) or with expert knowledge. Both approaches were tested, and results show that C&C2-A is crucial for the function analysis if the product developer does not know the functionality of the system under investigation [7]. Next to the development of the approach, a training program (including workshops and handouts) was carried out, to educate ALLIANCE partners and external interested organisations on the approach.

- **Lightweight Open Innovation Competition**
  The details of the competition such as evaluation criteria, timing and jury were defined in the early stages of the project, and the competition was launched in October 2017. The first – submission – phase took in total five months, during which a dedicated microsite was set up. Promotion of the LOIC took place through participation at relevant industry and academic events, as well as through press releases via relevant and more general communication channels. Additionally, a webinar was held by ALLIANCE partners, to inform, and answer questions from interested parties. By the end of the first phase partners received 22 applications in total. Nine applications targeted manufacturing innovations, while 13 materials innovations. In terms of type of organisations, half of the applications came from large enterprises, seven from SMEs, two from academia/RTOs, and two from individuals. In terms of geographical focus, submissions from Europe, Asia and South America were received, the majority of which was from Europe. After input from the relevant partners, the jury selected four applications to proceed to the next phase (F.tech, Imperial College London, Vestaro, Outokumpu) [8]. At the moment the LOIC is in the second – demonstration/validation – phase in which the selected applicants are working together with the relevant partners to further develop their solutions, and apply them to the virtual demonstrators for validation and testing.

Next Steps

The project is now entering its final year, out of a total duration of 36 months. The main focus from now until the finalisation of the project is the fabrication of the physical demonstrators and their testing, as well as the finalisation of the supporting tools, and the environmental and cost assessment of the lightweight vehicle.

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