Altair

3i-PRINT – individualize, integrate, innovate

CSI ALU CAR

APWORKS

EOS

Heraeus

GERG Group

Key Highlights

Industry
Automotive

Challenge
High demand for light components with increased function integration

Altair Solution
Simulation-driven design process including structure and multi-domain optimization in combination with the design freedom offered by additive manufacturing

Benefits
- weight savings due to load specific design
- less components thanks to function integration
- new development and manufacturing method applicable to all industries

VW Caddy Youngtimer with new functional integrated 3D printed front-end

As a relatively young manufacturing method with great potential, 3D printing, or additive manufacturing, is quickly gaining popularity in a variety of industries where the aim is to build components that are better, lighter, and more cost-efficient. The technology proves its strength particularly in areas where conventional manufacturing reaches its limits. Industrial 3D printing allows for small-batch production at reasonable cost and component customization even in serial production. Compared to traditional methods, 3D printing offers numerous advantages – tool-free manufacturing, highly flexible production, new aesthetic design freedom, and the ability to integrate multiple features in one component.

The aerospace industry has been the leading adopter of 3D printing in its quest to design ever more fuel-efficient and lightweight components and aircrafts. Now, other industries are finding ways to implement 3D printing, particularly in the automotive and medical equipment sectors. The need for lighter components in combination with a high degree of functional integration makes 3D printing particularly interesting for the automotive industry.

A recent research project into the potential of 3D printing called 3i-PRINT brought six top technology and manufacturing companies together and resulted in not only a new additively manufactured front-end structure for a VW Caddy Youngtimer, but also an agile, collaborative engineering platform for research and development enabling innovative prototype concepts

Keywords: Additive manufacturing, optimization, function integration, lightweight design, multi-domain optimization

3i-PRINT Success Story

"We are proud to present the classic Caddy with an innovative new front end structure. This impressively demonstrates the potential that industrial 3D printing with its enormous opportunities for functional integration offers, particularly for the automotive industry."

Stefan Herrmann
csi entwicklungstechnik

using 3D printing. From the concept to the final rebuilt vehicle, the project was completed in only nine months. The new front-end component is lighter, stable, and features a high degree of functional integration.

3i-PRINT – From Idea to Prototype in 9 Months

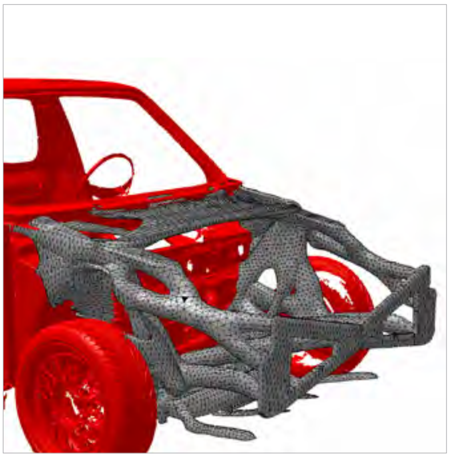
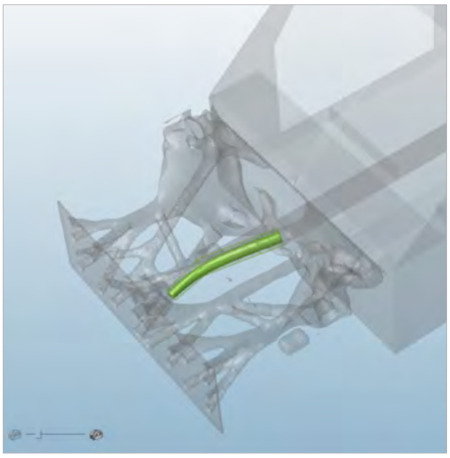
The initiator of the project, csi entwicklungstechnik, is an engineering service company with a focus on the automotive industry. Stefan Herrmann, lightweight design engineer in the company's body-in-white team, explains, "We had the idea to combine additive manufacturing with our body-in-white competence. We did not want to just replace cast nodes with 3D printed nodes, which is the usual procedure today. The aim was, to demonstrate how to design and develop a complete front-end structure to fully benefit from the many advantages additive manufacturing offers." csi entwicklungstechnik presented the idea to companies with experience in 3D printing. The participating companies covered every development step of the process chain, from design, simulation, optimization and manufacturing to post-production of the part.

csi Entwicklungstechnik designed, developed and built the Caddy front-end structure with support from APWORKS, an Airbus subsidiary specializing in metal 3D printing from design and material to qualified serial production. Several tools of Altair Engineering's HyperWorks software suite were used to design, optimize, simulate, and develop the structure, including RADIOSS for crash analysis, OptiStruct and solidThinking Inspire for optimization, and others. All components were printed on the system EOS M 400, using the high-strength aluminum alloy Scalmalloy®, developed by APWORKS and supplied and qualified by Heraeus. GERG, a leading supplier of innovative solutions in the area of prototyping and small-scale series for the automotive and aerospace industries, was responsible for joining the additively manufactured components to finalize the full front-end frame.

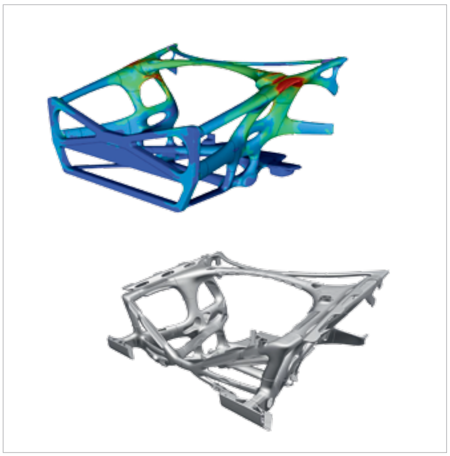
Design considerations and optimization

In view of the growing trend toward electrification in the automotive sector, for example in the drive train and actuators, heat management as well as the reduction of design space and overall weight were crucial considerations when designing the front-end section. Moreover, structural requirements relating to vehicle safety, performance, and comfort needed to be addressed.

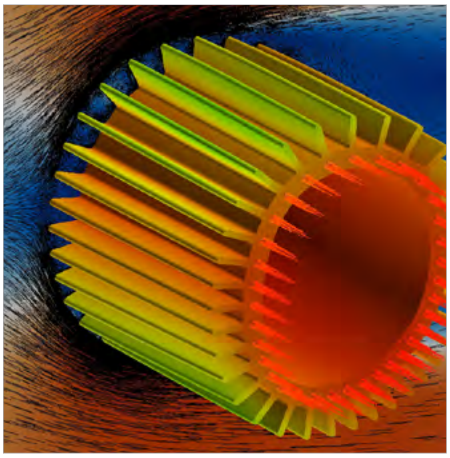
The simulation-driven design process was conducted by csi with the Altair tools, which are standard tools at csi for the methodical design and optimization of lightweight structures with various parameters. As a CAE software and engineering services company, Altair also brought comprehensive knowledge of the design of load-specific and material-efficient components to the project. For bionic inspiration and to meet all load cases and demands regarding stiffness and crash safety, and in order to fully exploit the potential of 3D printing with regard to weight reduction, a topology


Bionic optimized design based on topology optimization results. Function integration enables to cut down the overall number of parts.



The refined final geometry is subsequently evaluated in an FE analysis.



AcuSolve enables the integration of active and passive cooling.

optimization was carried out in OptiStruct, and a FE analysis was performed for the proposed design. The 3D printing of the front-end structure was based on the results of the topology optimizations, which considered static requirements as well as crash load cases.

In addition, Altair's CFD analysis tool AcuSolve was used to achieve the structure's maximum functional integration. In this way, heat management by load-bearing structures with details for active and passive cooling could be considered (for example, a channeled airflow to cool batteries and brake systems.)

Designing specifically for 3D printing

Following the successful simulation and optimization of the frame geometry, APWORKS took over the final dimensioning of the components for the 3D printing. As a subsidiary of Airbus, the company is very familiar with state-of-the-art manufacturing processes, and helps various industries implement best-practice concepts from the aerospace sector.

"csi entwicklungstechnik was familiar with our Light Rider project, where we designed and produced the first 3D printed motorcycle prototype," explains Sven Lauxmann, director of marketing and sales at APWORKS. "They were very interested in the experiences we have had regarding material, design and printing. The focus was on bionic-inspired design and on the experience of printing a component whose dimensions go far beyond the design spaces that are possible today."

APWORKS installed a project engineer, who was the main contact person for the engineers from csi entwicklungstechnik. The project benefitted from the know-how of both companies – the csi engineers have deep experience in optimization, and the APWORKS engineers contributed their knowledge about designing specifically for 3D printing.

Although additive manufacturing offers significant freedom, some design constraints still have to be considered. Among these are details such as the modeling of multiple features in a component, wall thicknesses, or the printing orientation of the component for optimal print space usage. Another question that had to be answered was how the support structures which are necessary for the printing could be reduced or later used in the component for other features. Through close collaboration and the continuous, iterative exchange between the engineers of csi and APWORKS, the final, technically effective and cost-efficient design was developed and printed out of Scalmalloy®.

Manufacturing and material

To manufacture the front-end structure, APWORKS relied on the EOS M 400 system by EOS, a leading technology provider for industrial 3D printing of metals and polymers. Nikolai Zaepernick, EOS senior vice president, Central Europe, said of his company's contribution, "The project 3i-PRINT impressively shows what is possible with the 3D printing manufacturing technology. With a large building volume and 1,000 watts of laser power, the EOS M 400 reliably fulfilled the project's demands: producing very complex, high-quality metal components in small batches within a very short time."

For the material choice, APWORKS cooperated with the metal powder specialist Heraeus, supplier of the high-strength aluminum alloy Scalmalloy®, developed by APWORKS.

In additive manufacturing currently, existing materials such as stainless steel, which has been optimized for conventional manufacturing methods such as casting and molding over decades, are being used. While these materials are perfectly adequate, the question arises whether it makes sense to use an existing material in a new production technology such as 3D printing – or if here too optimization is possible. The project's answer to this question was Scalmalloy® – the first material developed as an alloy system specifically for additive manufacturing, with high cooling rates and rapid solidification.

As the marketer of Scalmalloy®, Heraeus saw the 3i-PRINT project as an opportunity to further the commercialization of the material, to find new fields of application, and to inspire industries such as automotive with the possibilities of Scalmalloy® in particular and 3D printing in general. (Scalmalloy® contains rare earth substances, and Heraeus is working on a recycling process for this valuable material.)

Tobias Caspari, head of additive manufacturing at Heraeus, said, “To market the powder, Heraeus focuses above all on the aerospace and medical industry and also covers what we call industrial applications. I am convinced that for many areas, 3D printing will be the technology of choice in the future. As in aerospace, the reasons for this are, for example, environmental requirements. 3D printing offers possibilities for weight reduction that cannot be reached with a classical casting form.”

Assembling the final component
In the next step of the project, the single components had to be connected. The company GERG, also a participant in APWORKS’ Light Rider project, provided the design and construction of the welding device, the assembly process, and the mechanical post-processing.
he components 3D printed by the EOS system are about the size of a shoe box. The 31 parts for the Caddy’s front-end structure were assembled like a 3D puzzle and joined in a TIG welding process.
The requirements for the complex assembly process had been taken into account from the start of the design process. Accessibility and deformation due to heat input was considered. Joint locations were developed with the welding seam in mind, so that manual assembly steps could be reduced to a minimum. To ensure reliable connections between the individually printed parts, GERG engineers carried out welding parameter tests for Scalmalloy®.

When asked about GERG’s contribution to the project, Benjamin Scheffler, head of production engineering, responded, “In the 3i-PRINT project, we could contribute our know-how from development to manufacturing cross-process and provide substantial contribution to its ‘materialization.’ The amazing variety of manufacturing possibilities under one roof enables us to implement complex and innovative projects within a short time frame. As a manufacturer for prototypes and small series in the automotive, aerospace, and medical engineering fields, we are always confronted with new challenges. Here, we can count on experienced and creative specialists. As our slogan says: 'We materialize ideas'.”

Project 3i-PRINT – a platform for innovative prototyping concepts

Initiated by csi entwicklungstechnik, the 3i-PRINT project acts as an agile engineering platform for research and development enabling innovative prototype concepts. The idea is based on the use of new development tools and methods, including industrial 3D printing. The project's main goal was to demonstrate and fully exploit the potential of state-of-the-art manufacturing methods. The 3i-PRINT project is an open platform for collaboration that quickly enables the implementation of new ideas.
"We are proud to present the classic Caddy with an innovative new front end structure,” said Stefan Herrmann of csi. “This impressively demonstrates the potential that industrial 3D printing with its enormous opportunities for functional integration offers, particularly for the automotive industry.”

About Altair

Founded in 1985, Altair is focused on the development and application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held with more than 2,600 employees, Altair is headquartered in Troy, Michigan, USA with more than 45 offices throughout 20 countries, and serves more than 5,000 corporate clients across broad industry segments. Our passion is developing and applying technology in new and inventive ways to help our clients succeed through increased innovation intelligence. We innovate constantly in the way we design, the products we create and the business models we experiment with. We aggressively employ our software tools and product development methods, leveraging high-performance computing and data analytics, so that we can play an enabling role in the great things our clients are accomplishing. We strongly believe that bringing simulation software and rapid manufacturing technology forward in the design process can be a source of inspiration along with a winning response to accelerated product lifecycles. Learn more at **www.altair.com**

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