DS DASSAULT SYSTEMES

PERFORMANCE DRIVEN GENERATIVE DESIGN ON THE CLOUD

Automatically generate optimized conceptual parts
from a functional specification at the push of a button

INTRODUCTION

In today's increasingly competitive market, it is no longer sustainable to approach design slowly and methodically. Designers are faced with faster design cycles and more demanding design requirements. Their compositions have to be **lighter, cheaper, more aesthetic** and more streamlined than the competition's. They need to push past conventional ways of working to think innovatively - and quickly.

Until recently both traditional design tools and partiality impeded professionals. The traditional approach had mechanical engineers and designers think of a shape, or several shapes, that fit the design criteria, perhaps sketch them on paper and then detail the best shape with their CAD program. **Were all possible shapes considered? Could the optimal shape, in terms of weight, cost and other target goals be identified using this traditional method?**
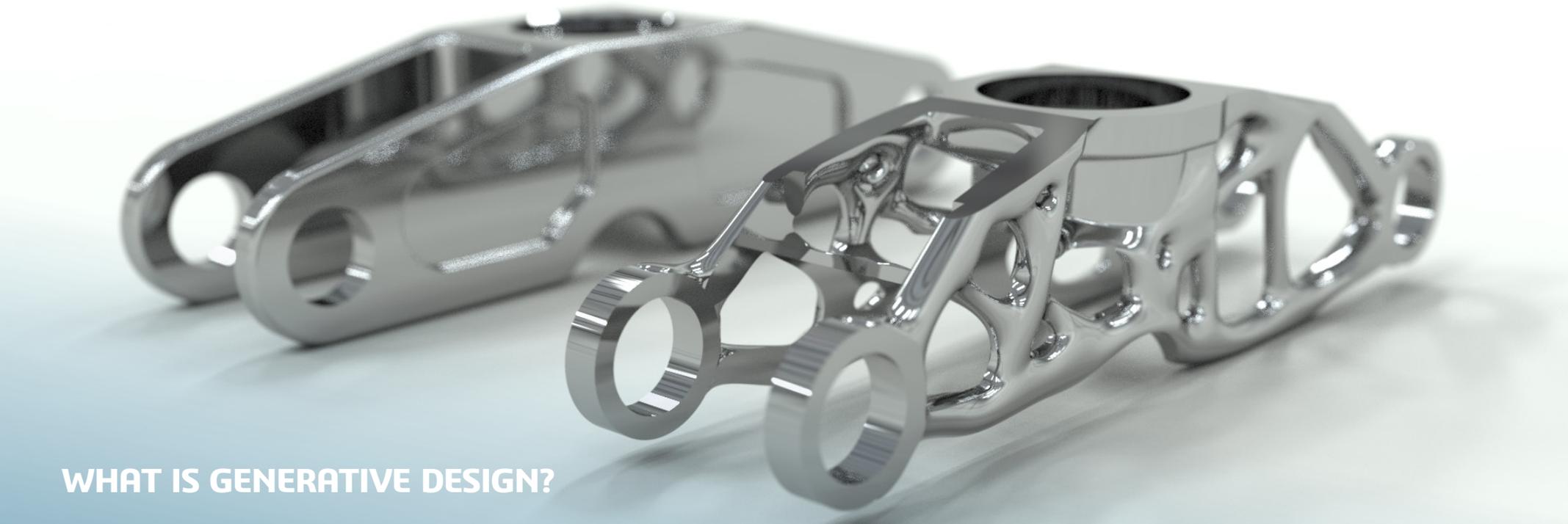
WHAT IS GENERATIVE DESIGN?

Generative design is often viewed as a generic term for using computation to assist in the design process. Conceptually, it represents the use of algorithmic methods to quickly and automatically transform requirements, constraints, uncertainties, and design space to create viable shapes.

Instead of starting from a blank sheet of paper and sketch, the idea here is to start from specifications: You have a given space, you know the forces and loads, the material required (steel, aluminum, polymer…) and the boundary conditions applied to the presumed design space. Generating a design concept started from these specifications has now been drastically simplified.

Furthermore, depending on the parts manufacturing process you select (casting, forging, milling, additive manufacturing), generative design methods allow you to adapt the shape of the concept to match the constraints coming from the selected manufacturing process.

Topology optimization is a methodology to derive an optimal material distribution for a design under given usage conditions: it gives the optimal shape of a part or system constrained only by the available design space. The goal of this process is to both meet the structural strength of the model while minimizing its mass, thereby reducing its weight and saving on material.

Topology optimization has been a subject of academic research for decades, and has been utilized in specialized commercial products for about that long. As such, topology optimization can be a key enabler of generative design.

Nevertheless, generative design differs from topology optimization in that it does not refer to a specific algorithmic process per se.

Performance Driven Generative Design adds a powerful layer to this already staggering technology by offering a wide range of techniques and science domains to produce concepts, solutions and efficient production models.

FROM COMPUTER AIDED DESIGN TO COGNITIVE AUGMENTED DESIGN: FIT FOR PURPOSE

> " Simply, science (cognition) augments the ability of the human being to create innovative design."

Daniel PYZAK,
Worldwide Mechanical Industry Process Consultant
Senior Director at Dassault Systèmes

When it came to market, Computer Aided Design was both feature-based and parametric. It has allowed designers to create, modify, analyze and optimize a design in record time and has revolutionized the design process.

When CATIA's Cognitive Augmented Design entered the game, it brought along a new, science-based generative approach.
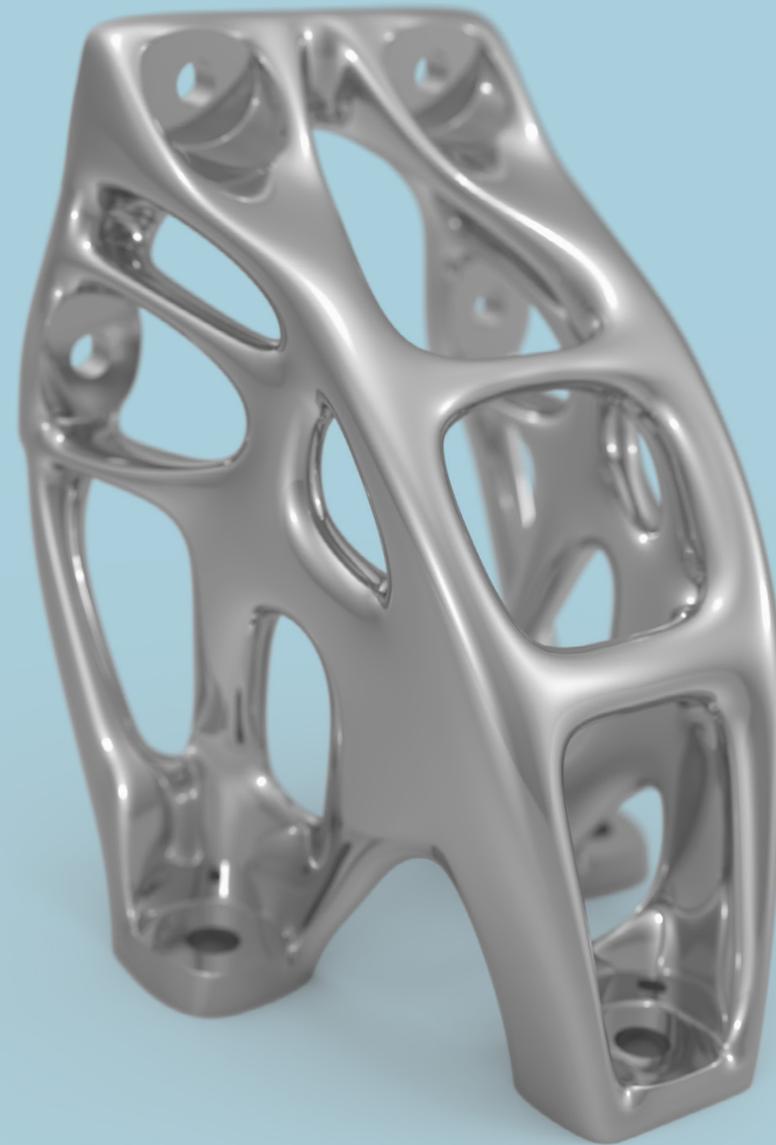
INTRODUCTION

WHAT IS GENERATIVE
DESIGN?

FROM COMPUTER AIDED
DESIGN TO COGNITIVE
AUGMENTED DESIGN

PERFORMANCE DRIVEN
GENERATIVE DESIGN

Structural Generative Designer
Flow Driven Generative Designer

"LIGHT IS RIGHT"

GENERATIVE DESIGN
AND THE FUTURE
OF PRODUCTION

SUSTAINABILITY BY DESIGN

GO TO MARKET FASTER WITH
THE POWER OF THE CLOUD

CONCLUSION
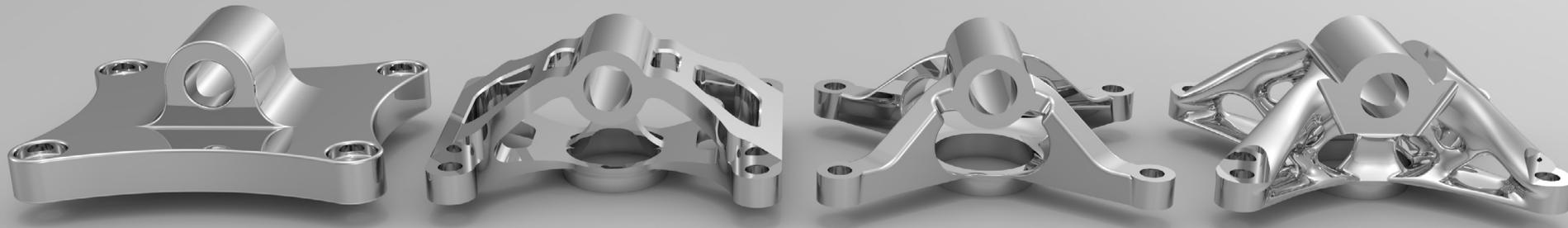
" The creator simply provides the design space and specifications and new concepts are generated. Then depending on the manufacturing process you selected to actually manufacture the part you can now adapt the shape of the part to comply with the constraints coming from the selected manufacturing process."

Daniel PYZAK

This immersive design process uses a new generation of design tools that provides a fully collaborative, virtual product environment for creators. Imagine selecting the shapes you want for faster and better design based on the know-how of past designs, planning the ideal manufacturing process and seeing how this design will function in the real world. **Cognitive Augmented Design** brings three new design approaches:

1. Replace current feature-based design
   with a new cognitive augmented design approach.

2. Reuse current design to start to redesign
   with a new cognitive augmented design approach.

3. Initiate assembly designs to start to optimize
   with a new cognitive augmented design approach.

Design for Manufacturing

On top of the definition of the specifications of the part, the tool is optimizing the shape to take into account the constraints of the selected manufacturing process: Casting, Milling or Additive Manufacturing (a cast part or a milled part is much more constrained than one to be produced with additive manufacturing). It can certainly create a shape without any manufacturing constraints. If the user selects Milling or Additive Manufacturing, CATIA will furthermore provide specialized assistants to do the detailed design of the part   quickly. As a result not only have you optimized the concept for a given manufacturing process but you have also drastically reduced   the lead time of the detailed modeling step.

Finally, thanks to the suite of Apps available on the **3D**EXPERIENCE® platform, if the parts are 3D printed, one can directly prepare the part for printing predict the distortion occurring during the printing through inherent deformation methods, for a quick evaluation and/or a more precise thermo-mechanical simulation. If needed it can even compensate for the predicted deformation by morphing the part 3D solid model.

The entire Additive Manufacturing process is performed smoothly and without the need for file exchange, on one single point of truth, the **3D**EXPERIENCE platform.

5
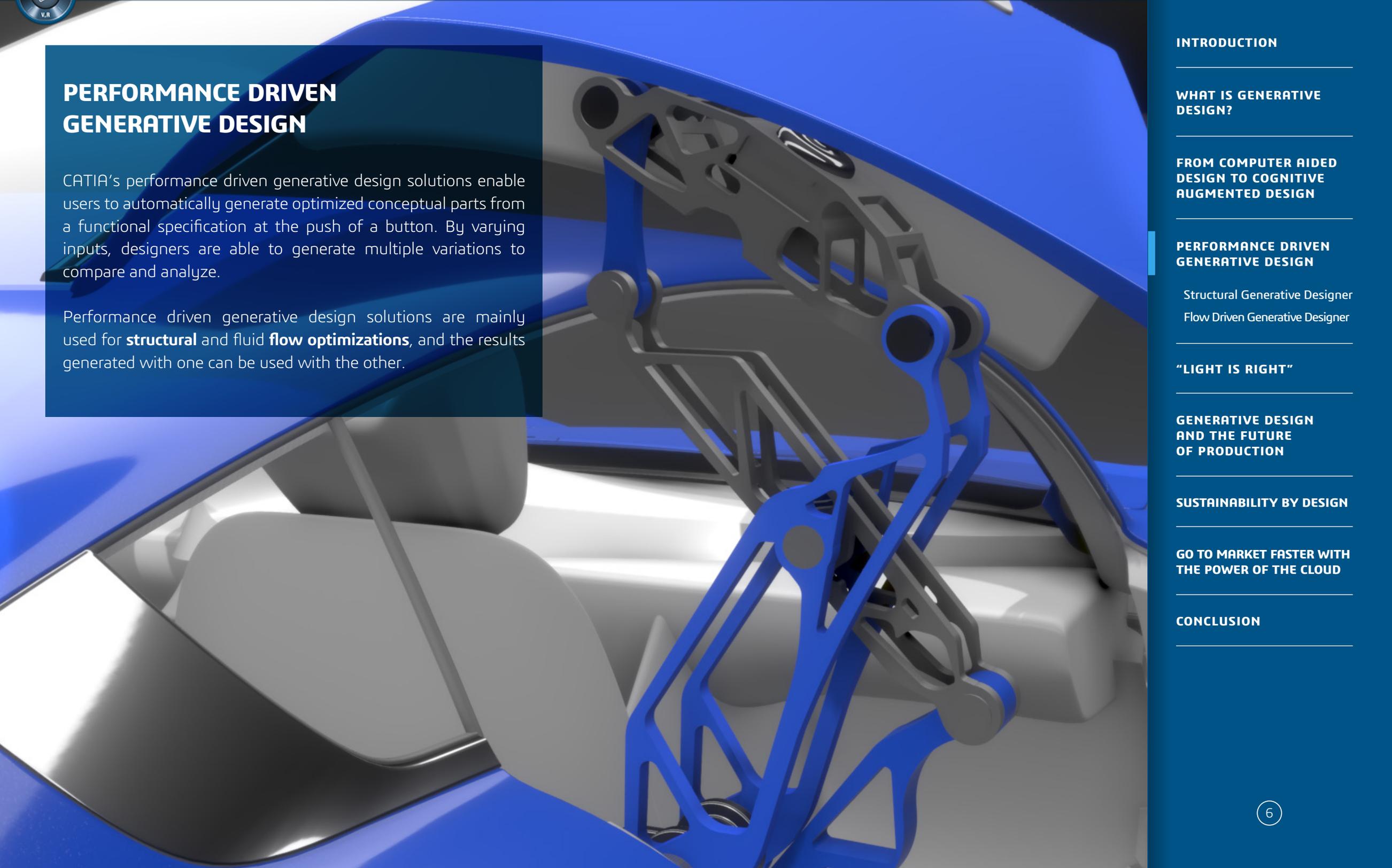
PERFORMANCE DRIVEN GENERATIVE DESIGN

CATIA's performance driven generative design solutions enable users to automatically generate optimized conceptual parts from a functional specification at the push of a button. By varying inputs, designers are able to generate multiple variations to compare and analyze.

Performance driven generative design solutions are mainly used for **structural** and fluid **flow optimizations**, and the results generated with one can be used with the other.
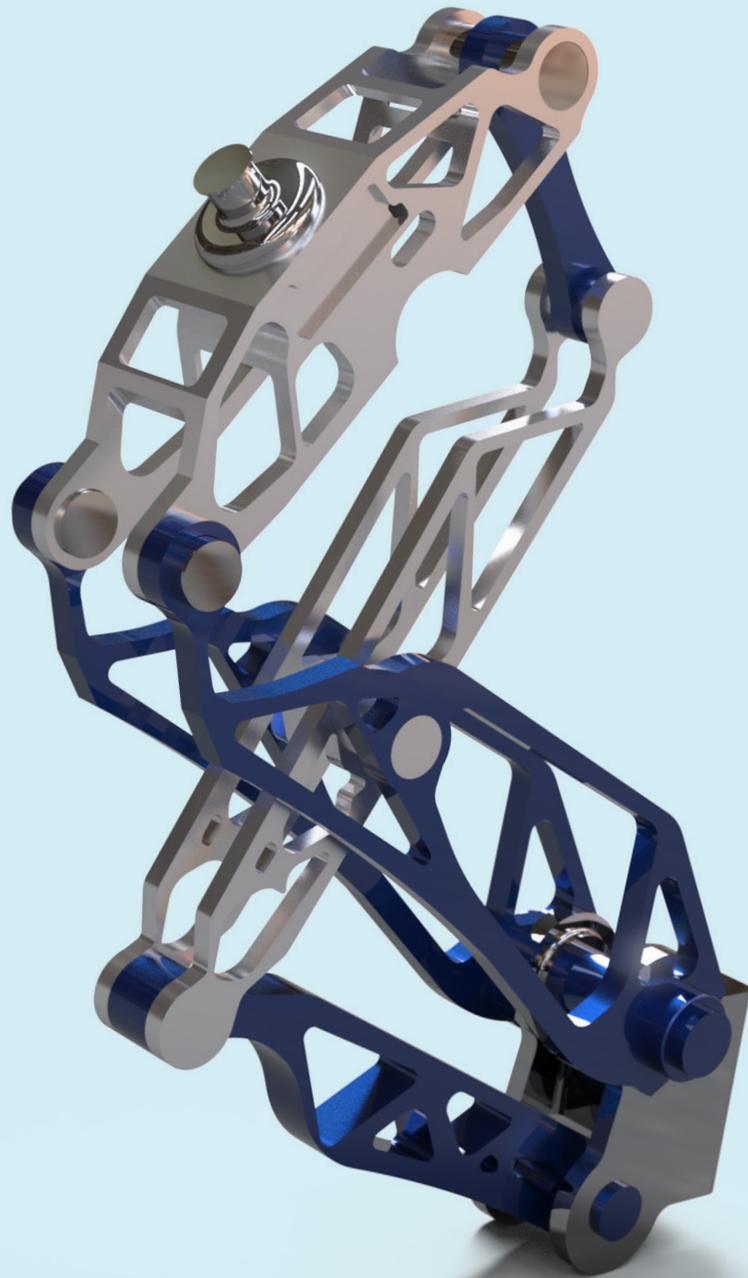
STRUCTURAL GENERATIVE DESIGNER

Structural Generative Design allows users to perform rich weight reduction trade-off studies of generated design alternatives, with high quality shapes respecting structural KPI targets. Creators can compare and assess different configurations against KPIs to select the best lightweight concept.

At the same time, they can reduce local stresses and further reduce mass through parametric and shape optimization. **3D**EXPERIENCE brings these capabilities together with an intuitive Workflow Assistant to guide the user at every step of the design process. Furthermore, it provides automatic generation of functional concept CAD and can easily validate the structural behavior of the lightweight design with comprehensive sets of loading and boundary conditions.

Main Benefits of Functional Generative Design

- Explore new lightweight shape ideations that fit design functions

- Perform trade-off based on manufacturing processes and material variants

- Automatically reuse optimization setup to validate design proposal, at any stage of the design process

FLOW DRIVEN GENERATIVE DESIGNER

Fluid Flow engineers face the challenge of finding feasible flow paths that can form complex networks throughout a product, while ensuring consistent maximum flow rates, minimizing pressure drops and recirculation. This traditionally leads to the need for multiple siloed software solutions to design, simulate, optimize and validate these complex products. CATIA's Flow Driven Generative Designer offers a unique experience where a new duct concept would be automatically designed and validated from the specifications of the fluid performances expected.

Main Benefits of Flow Driven Generative Design

• Find the optimal duct shape that will reduce pressure drop

• Find and explore design proposals within a principal design space

• Improve an existing design that still contains recirculation

• Re-use optimization setup to validate design proposals

For complex designs, leveraging multiple generative solutions in a sequential manner is a door opener to a new design conception. When removing limitations due to traditional manufacturing constraints, it truly unleashes performance-driven design solutions.

The hydraulic manifold block is a very representative example, as it is currently limited in terms of performance due to the milling manufacturing process. By removing this constraint and combining Fluid and Structure Generative Design, a disruptive outcome can be achieved, **minimizing pressure drop down to 37% and achieving a weight saving of 80% to fit both fluid and structure functions.**
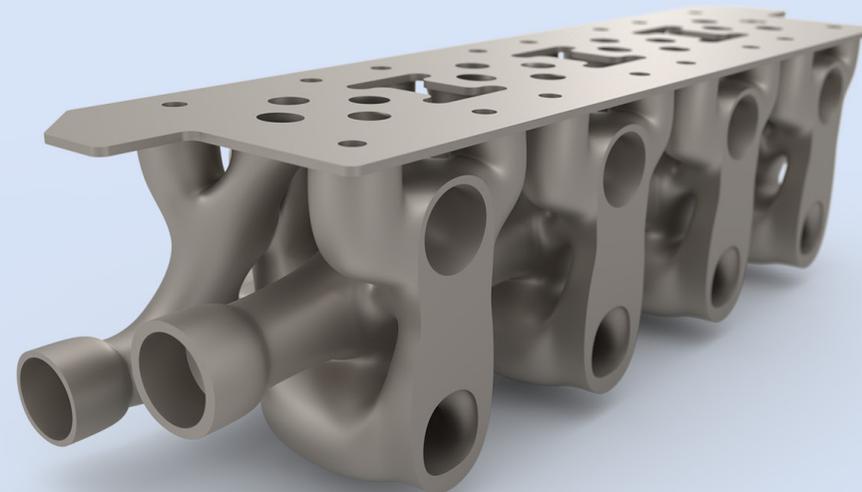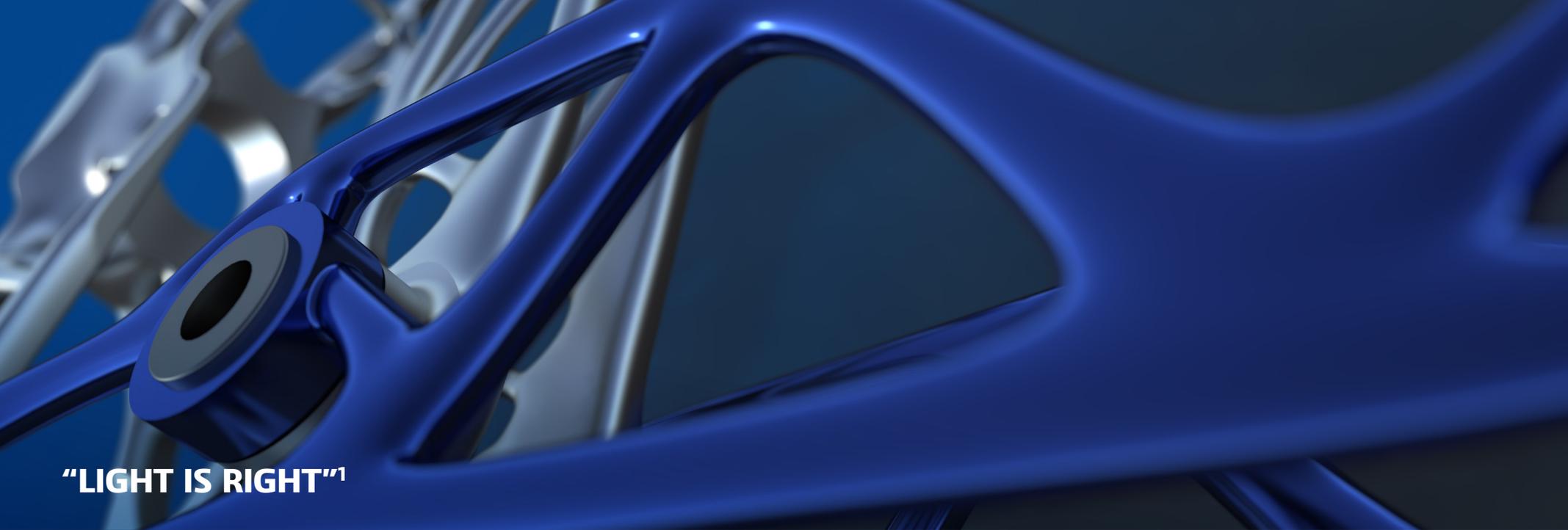
"LIGHT IS RIGHT"[1]

In mechanics, a light part requires less energy to put in motion, less material and energy to produce. With the increased pressure for organizations to lower carbon emissions, there is an increased need for lighter products, as well as a demand for alternatives to conventional materials that will reduce the impact on the environment. Engineers need to design products that meet these demands, reducing weight, cost and material usage while maintaining strength, stability and safety.

Performance Driven Generative Design, with its unique ability to come up with the right shapes under user-set constraints, is a natural-born enabler for the engineering of lightweight products.

The **Structural Generative Design** puts just the amount of material required to withstand structural charges. With **Flow Driven Generative Design**, you reduce the pressure drop and the energy loss in your ducts, thus leading to a reduction of the venting systems capacity, which usually means lighter systems requiring less energy!

With **3DEXPERIENCE** you have an integrated weight optimization platform to allow you to increase productivity by leveraging the extensive portfolio of apps for the creation and management of sophisticated lightweight products.

Colin Chapman, founder of Lotus cars, aptly coined the expression "light is right". But he also said that:

> " Adding power makes you faster on the straights. Subtracting weight makes you faster everywhere."

It truly emphasizes the importance of light products when trying to reach the balance between frugality and performance.

[1]"Light is Right" (Colin Chapman, Lotus cars founder)

"We tested the Generative Design app on several parts. Then we also **produced** these parts. And **put them on a test bench**. And it confirmed an **uncompromised mechanical behavior**, as well as **endurance**, and it **also confirmed a weight saving of around 30%**."

Jean-Denis LENOIR
Renault Sport Cars
Powertrain Integration Engineering
Deputy General Manager

GENERATIVE DESIGN AND THE FUTURE OF PRODUCTION

In order to be competitive in today's market, designers and engineers are being required to minimize part weight, **maximize stiffness, reduce cost and optimize material usage**. Additionally, there is a need to provide high-level aesthetics customers are now demanding. Because of this, the design world has been rapidly changing and so is the process involved. In parallel, Technology produces new materials and new machines to make the once impossible - possible.

However, it is often cost-prohibitive to explore the possible iterations of optimized parts due to the challenges of collaborating across disciplines while using the various systems and tools required. This individual silo approach creates huge delays and errors of data translation.

As well, optimization has traditionally required experts and was not accessible to designers. Furthermore, with niche optimization tools to generate real geometry that can be reused and matured, the process is long and drawn-out and error-prone. For most engineers it is too time-consuming to create and validate multiple concepts to select from. The result can be uncompetitive, sub-optimal products.

Generative design methods facilitate faster decision-making. Once initialized, generative design processes run without human intervention. With a given set of conditions, designers are able to conduct more experiments in much less time.

> " The parts you get with Performance-Driven Generative Design are fit for purpose. Firstly, because their intended purpose drives their shape, and this driver is being verified all along the design process. And because the designs you get are fit: nothing superfluous."

Nicolas GUERIN,
CATIA Generative & Composites Portfolio Management Director,
Dassault Systèmes

Most current approaches (best of breed disintegrated apps and disciplines) are incapable of delivering the performance required for tomorrow's products.

SUSTAINABILITY BY DESIGN

Generative Design is a formidable catalyst for designers.
Data-driven computational design enhances research into aesthetical shape, without compromising on functionality.

The TAMU chair developed by celebrated French designer Patrick JOUIN in collaboration with Dassault Systèmes is a perfect illustration.

For the past 15 years, Patrick Jouin has explored the creative power of 3D technology. In 2004, his «SOLID» collection — the first series of scale 1 furniture made with 3D printing — entered history and the permanent collections of major museums.

In 2019 Jouin, in collaboration with Dassault Systèmes' Design Studio launched the TAMU PROJECT. The TAMU prototype is a foldable chair which uses as little space and the least amount of material possible revealing a new approach to design, revisiting the traditional design process, proposing brand new aesthetics through integration of scientific features into the creative thinking.

The result of the inspired dialogue between designer and machine:

> **"** Previously designers were inspired by 'organic' as a style, but what is completely new is that designers are now inspired by the organic process itself, and how to emulate it."
>
> **Patrick JOUIN,**

Dassault Systèmes' support of Patrick Jouin creative, sustainable approach is part of "Design for Life", a collaborative program on the **3D**EXPERIENCE platform. The TAMU chair was revealed as part of "Design in the Age of Experience", Dassault Systèmes' annual conference for sustainable design innovation held during Milan Design Week in 2019 and displayed in the "Designers du Design" featuring the best of French design at Lille World Design Capital 2020.
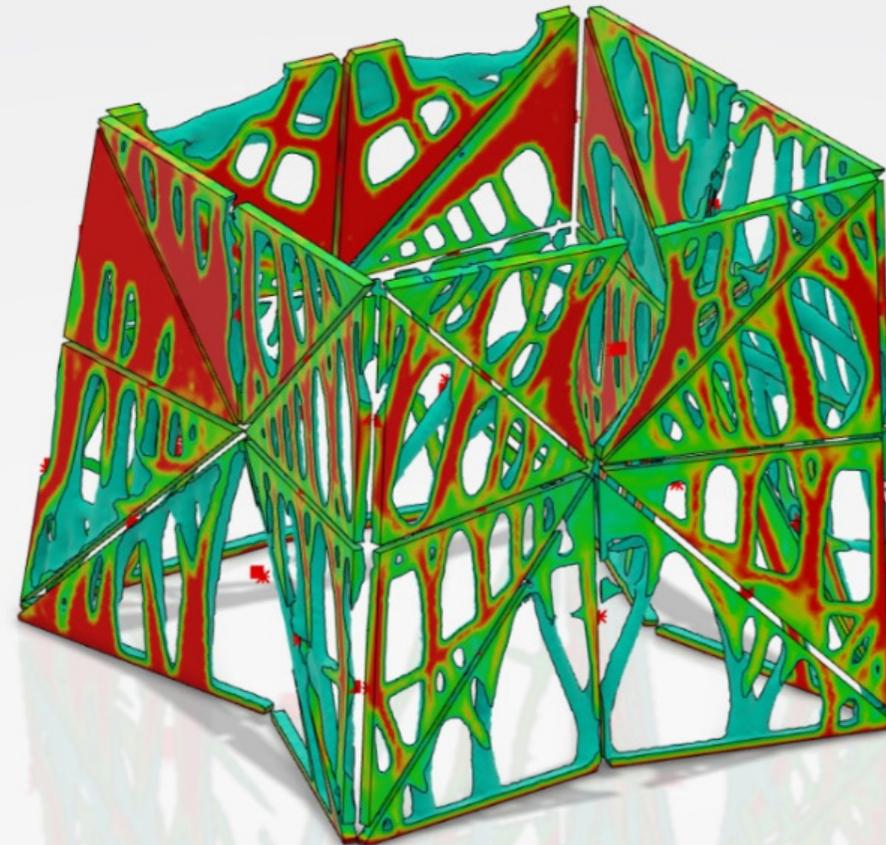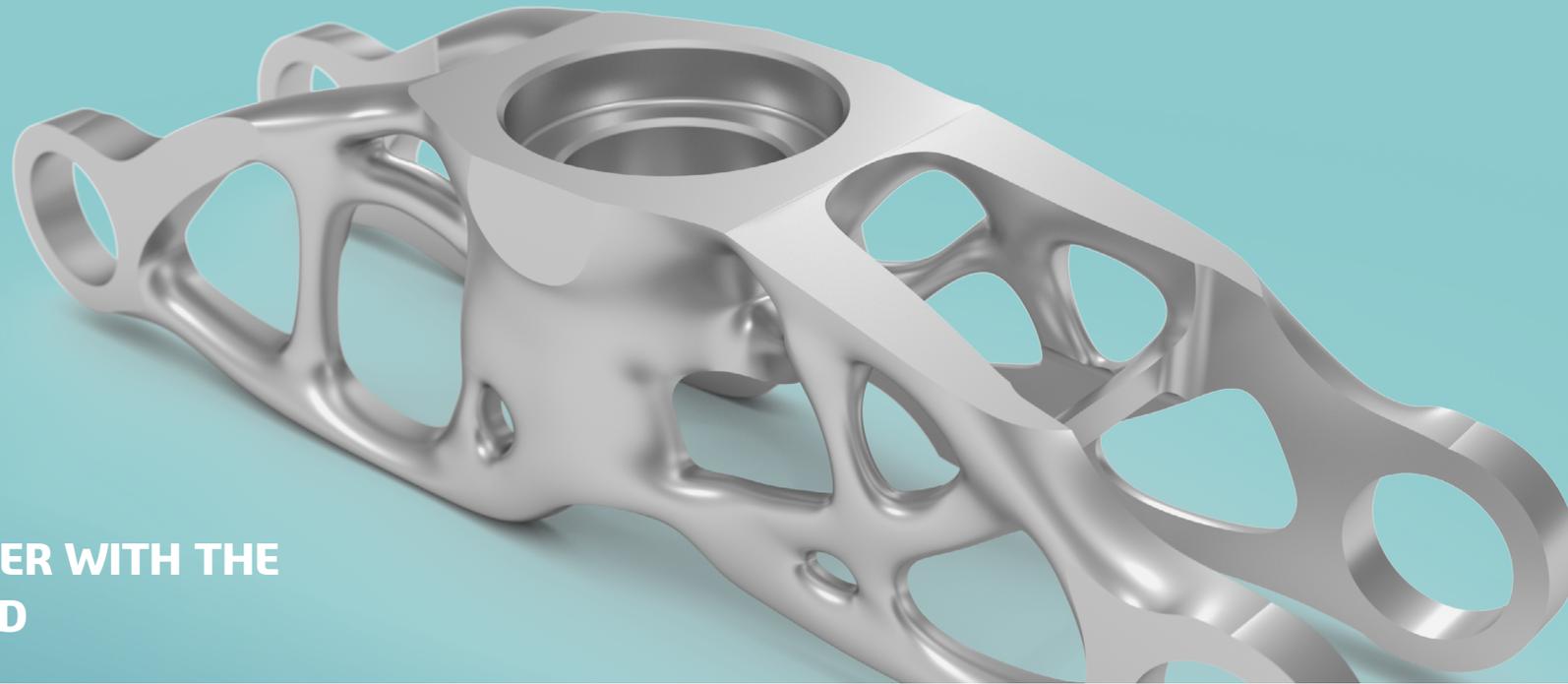
GO TO MARKET FASTER WITH THE POWER OF THE CLOUD

Global industry giants as well as Small and Medium businesses have embraced Performance Driven Generative Design because it directly impacts time to market while reducing expenses, amongst other benefits. Aerospace and Defense, Transportation and Mobility, High Tech, Industrial Equipment, Marine and Offshore, Life Sciences as well as dozens of players in other industries are reaping the benefits of performance driven generative design.

On a simple level, a company that can optimize a product part is going to save on manufacturing costs by using less material.

On an advanced level, generative design has become integral to technology shifts known as the Factory of the Future and Industry 4.0. This operational flexibility allows organizations to **experiment rapidly and cost effectively**.

> " More and more companies are seeing the benefits associated with automation and data exchange in manufacturing technologies, and subsequently seeing the same benefits and principles for design and simulation in generative design. Companies in the automotive, aerospace, healthcare and consumer goods industries are taking advantage of what generative design has to offer."
>
> **Daniel PYZAK**

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GENERATIVE DESIGN

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CONCLUSION

Performance Driven Generative Design on **3D**EXPERIENCE is available through Dassault Systèmes cloud offering. Through this offering, the code is always up to date; benefiting from the latest innovations Dassault Systèmes' Research and Development has to offer.

Performance Driven Generative Design requires computing power. On this too, the cloud offers attractive features: the ability to **run simulations and optimizations on the cloud IT, freeing the customer's device and allowing the user to parallelize the computation over many cores, going beyond commonly found devices for CAD designers.**

Main Cloud Benefits

- Simplified IT overhead, including the computation capacities.

- Unmatched speed of access to the newest enhancements brought to the product in a production environment.

- Simplified code upgrade.

16
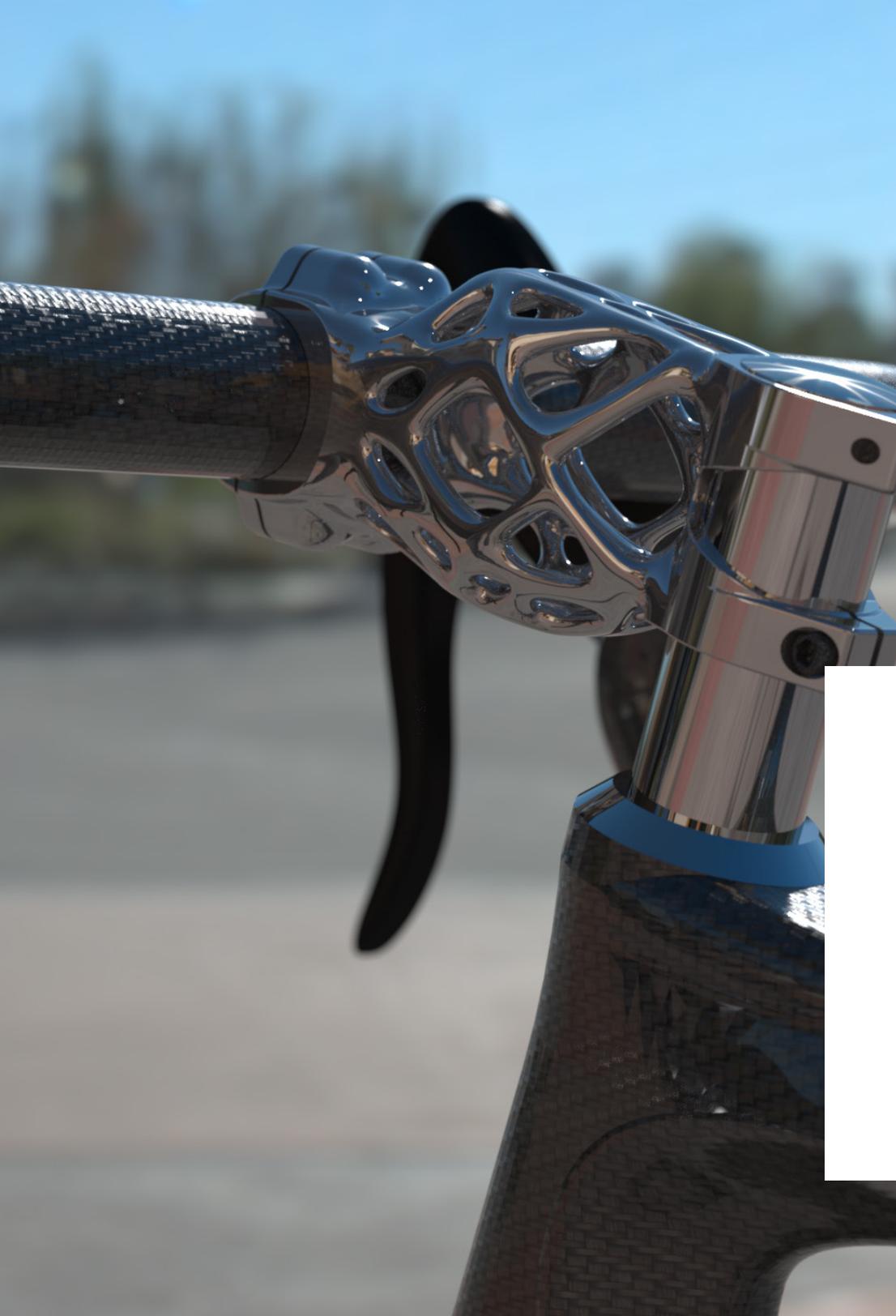
CONCLUSION
BETTER PRODUCTS FASTER

Performance Driven Generative Design allows designers to explore and validate through simulation, make informed decisions on weight reduction and performance gain. Optimized shapes that could not have been imagined using conventional design methods are now at the designer's fingertips.

Designers have a newfound freedom to take advantage of flexible processes while benefiting from the seamless collaboration between design, simulation and manufacturing. No data is lost in translation and fast design optimization and evaluation is only increased - allowing users to **create better products faster**.

With 3DEXPERIENCE CATIA

· Optimize product weight and stiffness with lightweight engineering.

· Reduce time and cost by evaluating concepts faster.

· Evaluate more concepts while maintaining design specifications.

· Leverage real editable geometry for both conventional and additive manufacturing.

· Generate and simulate optimized concept shapes easily.

· Manage collaboration between design, simulation and Manufacturing seamlessly.

**Our 3D**EXPERIENCE® platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3D**EXPERIENCE Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating 'virtual experience twins' of the real world with our **3D**EXPERIENCE platform and applications, our customers push the boundaries of innovation, learning and production.

Dassault Systèmes' 20,000 employees are bringing value to more than 270,000 customers of all sizes, in all industries, in more than 140 countries. For more information, visit **www.3ds.com**.
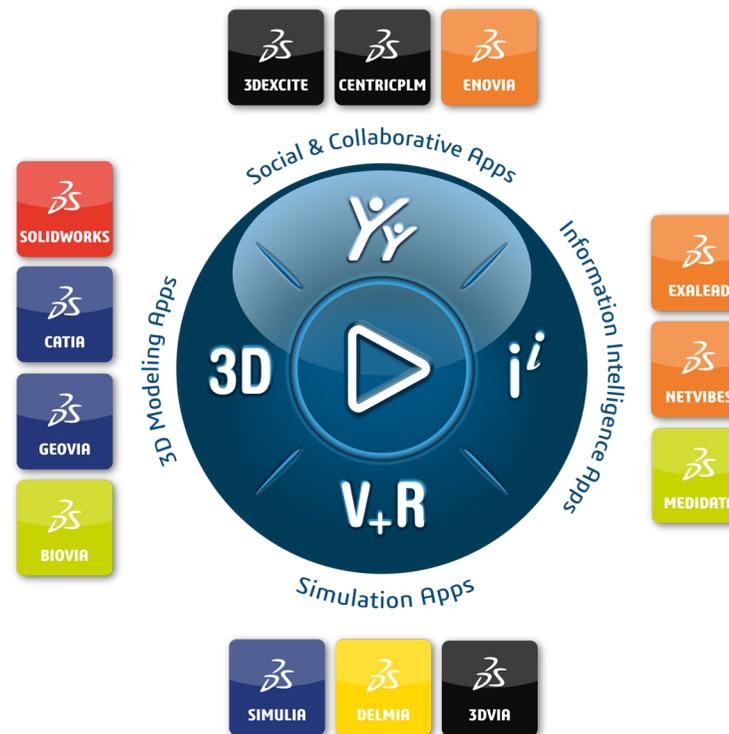
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