

# Altair Inspire Adds an “Implicit” Edge

## Simulation-driven design boosted with implicit geometry modeling

### Key Takeaways

Simulation-driven design, the process of using performance simulations early in the design cycle, particularly on the left side of the traditional product development “V,” is crucial for organizations to achieve the best return on product development investments.

Implicit modeling treats 3D solid geometries as a continuous field and offers several benefits. It excels in handling complex and intricate topologies, enabling the creation of highly detailed objects. Implicit modeling finds significant applications in diverse industries. It enables the creation of intricate and lightweight designs across tooling and fixtures, fluid power systems, complex structural components, medical and dental implants, high-performance sporting equipment, and more.

Altair® Sulis™ (previously Gen3D Sulis) is a design software enabling fast geometry creation for additive manufacturing (AM). With both lattice and fluid flow modules, one can rapidly create AM-appropriate geometry. Now capabilities of Altair Sulis are being integrated in Altair Inspire™ expanding its design capabilities. With existing computational physics and generative design functionality, Inspire also supports simulation of a large range of manufacturing processes. This expands Inspire’s capabilities from geometry to manufacturing making it a truly simulation-driven design platform.

Combining AI with implicit modeling holds promise for unlocking unique design possibilities and creating intricate and complex geometries. The computational efficiency of implicit modeling allows for real-time interaction and analysis, opening new frontiers for generative design.

## Simulation-Driven Design and Implicit Geometry Modeling

Simulation-driven design is a modern engineering approach where simulation is used as a primary tool to inform and guide the design process from the earliest stages. It integrates simulation, optimization, and visualization tools directly into the design workflow, allowing designers and engineers to evaluate the performance, reliability, and manufacturability of their products under various conditions without the need for physical prototypes. This method helps in identifying potential design flaws, optimizing design for better performance, and ensuring product durability and efficiency. It encourages innovation, as it allows for rapid exploration of a broader design space with immediate feedback on how changes impact

the product's behavior. Numerous industry studies have underlined the importance of performing simulations as early in the design cycle; as possible. Organizations can derive the best return on investment when simulation is performed during the left side of the traditional product development “V.” Adoption of simulation-driven design systems allows organizations to achieve just that.<sup>1</sup>

Implicit geometry modeling is a mathematical approach to create and represent complex geometry in a computational environment. Unlike traditional boundary representation (B-rep) that uses vertices, edges, and faces to define shapes, implicit modeling uses mathematical functions to describe objects. These functions define a volume in space with points inside the shape yielding negative values, points outside giving positive values, and points on the surface equating to zero. This allows for a more efficient and flexible way to handle intricate and organic shapes that can be difficult to model with conventional CAD software. It's particularly useful in fields like additive manufacturing and simulation-driven design, enabling rapid iteration and precise control over complex geometries.

Simulation-driven design and implicit geometry modeling are a natural fit as simulation-driven design can benefit from the ability of implicit modeling to make changes to shapes rapidly in response to optimization goals. Implicit modeling expands the possibilities of complex shapes by allowing multiple performance considerations to be implemented as “field” operators. Such shapes are naturally suitable for anisotropic properties variations leading to the possibility of spatial performance variation to achieve specific design optimization goals.

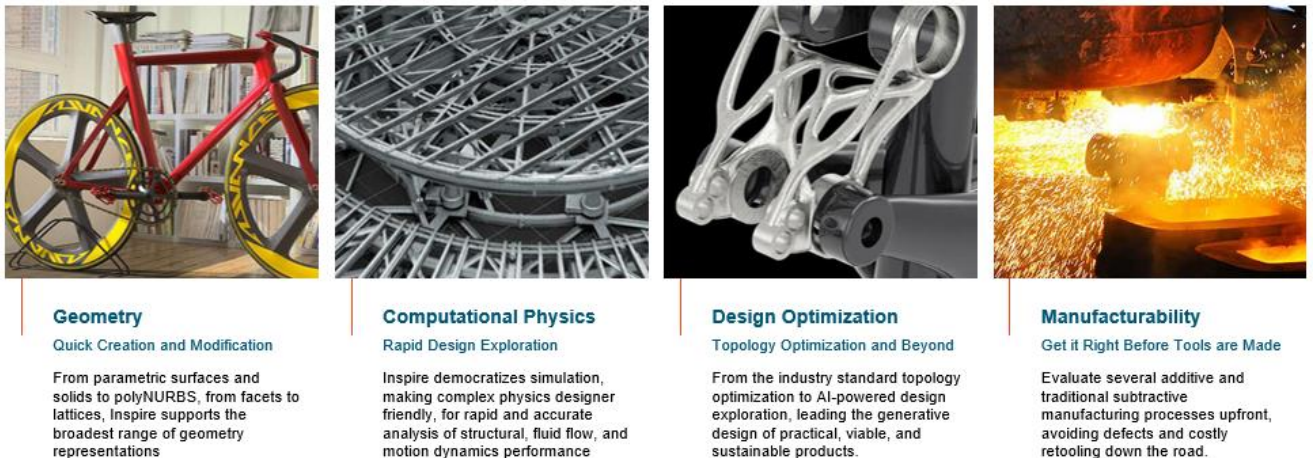


Figure 1—Simulation-Driven Design with Altair Inspire  
(Courtesy Altair)

## New Design Possibilities with Implicit Modeling

Implicit geometry modeling, particularly within the context of 3D printing and complex engineering tasks, stands out as a robust alternative to traditional CAD methods. Its approach, which defines geometries through mathematical functions rather than explicit shapes, offers a new level of efficiency and flexibility. Firstly, implicit modeling thrives on complex topologies that traditional CAD systems often find challenging. Branching structures, intricate lattices, and organic forms are handled with a level of simplicity and robustness that boundary representation methods cannot match. Designers gain the freedom to push creative boundaries without the software's limitations, crafting highly detailed and complex objects with ease.

<sup>1</sup> Research for this paper was partially sponsored by Altair.

Secondly, the inherent robustness of implicit modeling comes to the fore in operations that involve the combination or alteration of complex shapes. Whether merging multiple geometries or creating cutouts, the results are reliable and free of the errors that often plague traditional CAD processes. This reliability is a boon for designers, allowing them to iterate and explore design variations without the risk of generating invalid geometries. The GPU-centric nature of implicit modeling significantly enhances computational efficiency. By leveraging the parallel processing capabilities of modern GPUs, implicit modeling also allows real-time interaction with computationally intensive complex models, a stark contrast to the CPU-bound operations of traditional 3D CAD tools.

In summary, implicit geometry modeling is not just an incremental improvement over existing design methods; it represents a paradigm shift. The ability to handle intricate designs with high computational efficiency and to integrate with AI for generative design is shaping a new frontier in engineering and manufacturing, offering a glimpse into the future where the design is only limited by the imagination.

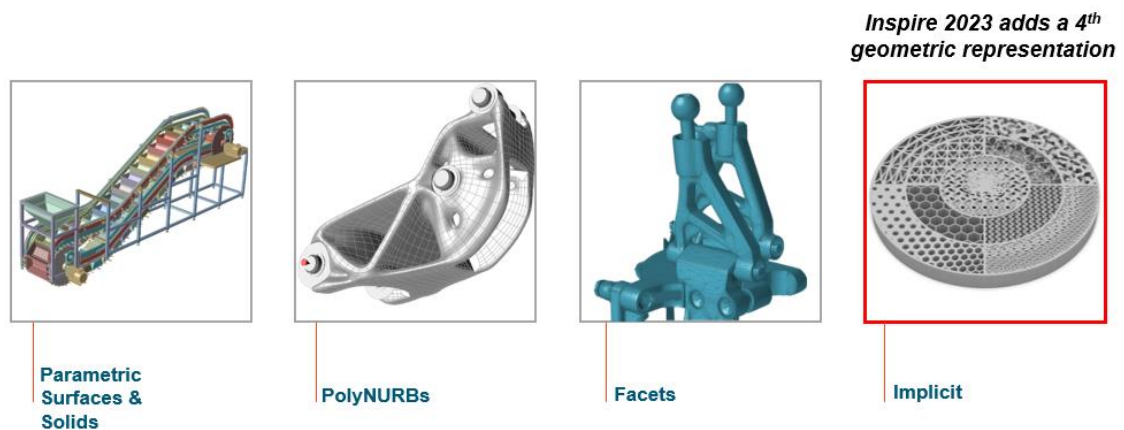


Figure 2—Addition of Implicit Modeling to Altair Inspire Geometry Modeling  
(Courtesy Altair)

## Implicit Modeling Integrated in Altair Inspire

In June 2022, Altair expanded its additive manufacturing portfolio by acquiring Gen3D, a startup from the University of Bath, U.K., renowned for its expertise in using implicit geometry to develop complex geometries in additive manufacturing. Gen3D's flagship software, Gen3D Sulis, was rebranded as Altair Sulis, and its capabilities are now being integrated into the Inspire environment.

Altair Inspire is a software framework that offers CAD-like features for conceptual design geometry creation and analysis, despite not being a traditional CAD system. Inspire combines geometry and rendering capabilities with computational physics and generative design functionalities, supporting parametric surfaces, solids, and introducing Polynurbs for organic shapes. The software includes generative design features like topology optimization, design space exploration, and manufacturing simulation, allowing extensive design optimization and exploration. Inspire's strength lies in its integrated simulation capabilities, including OptiStruct for structural optimization, SimSolid for solid simulations, and a new CFD solver for fluid dynamics simulations.

The software extends to manufacturing simulations, supporting multiple processes, and facilitating rapid analysis for techniques like injection molding. Inspire integrates topology optimization and design exploration in a user-friendly manner, enhancing the design refinement process based on specific criteria.

A fully documented Python-based API in Inspire supports both batch and interactive workflows, increasing the software's adaptability and integration into various workflows. The integration of Gen3D's technology into Inspire has broad industry implications, enabling more efficient and optimized design in

fields like automotive, aerospace, healthcare, consumer goods, sports equipment, architecture, and energy.

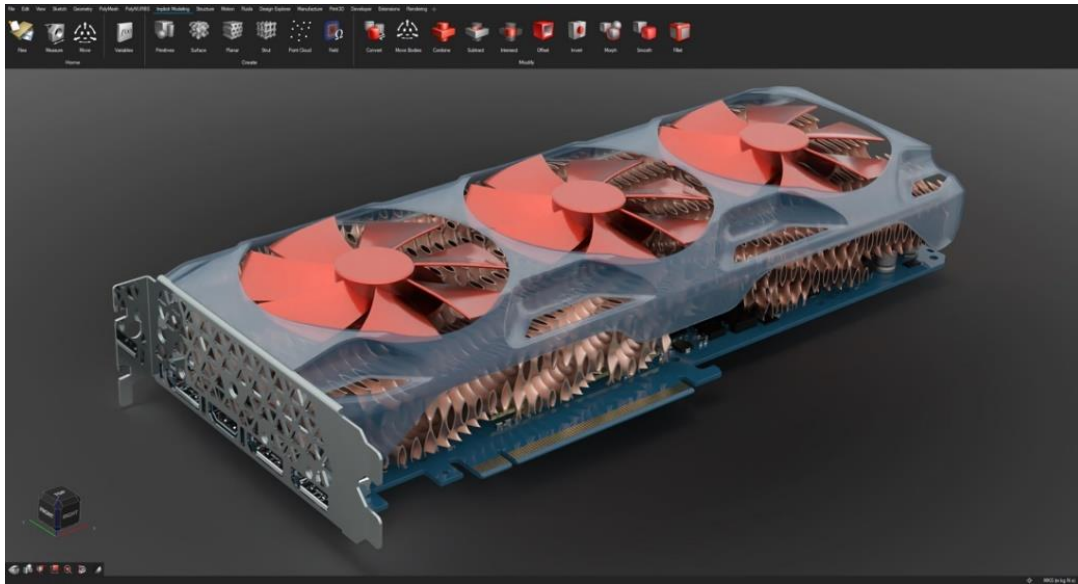


Figure 3—Implicit Modeling Integrated in Altair Inspire  
(Courtesy Altair)

## Case Study: Exergy Solutions

Exergy Solutions is a highly innovative Canadian product development organization which is focused on the energy industry. The company enables its customers to take technology to market quickly, safely, and cost-efficiently with advanced design-build solutions. Equipped with best-in-class 3D printing technology and one of Canada's largest additive manufacturing facilities, it helps clients get prototypes to market faster.

In the case study being described here, Exergy's team were able to design a heat exchanger using the lattices within Altair Sulis now part of Altair Inspire. The team was able to create a lattice that naturally divides into two separate fluid domains, in this case a blue cold zone, and a red hot zone. By plugging the red zone at the entry of the blue port (and vice versa) there is no cross contamination between the two fluids. This design was able to not only make the overall envelope smaller by placing the inlet and outlet ports in line with the fluid flow through the exchanger, but it also nearly doubled the internal heat transfer area. As this is manufactured all in one piece, there are no areas for brazed welds to fail. In testing of this design, it was found to greatly outperformed the traditional one for low flow applications. For higher flows, it performed slightly poorer due to the larger pressure drop across this type of lattice. However, future designs can be easily tailored to the specific flow requirements of the application.

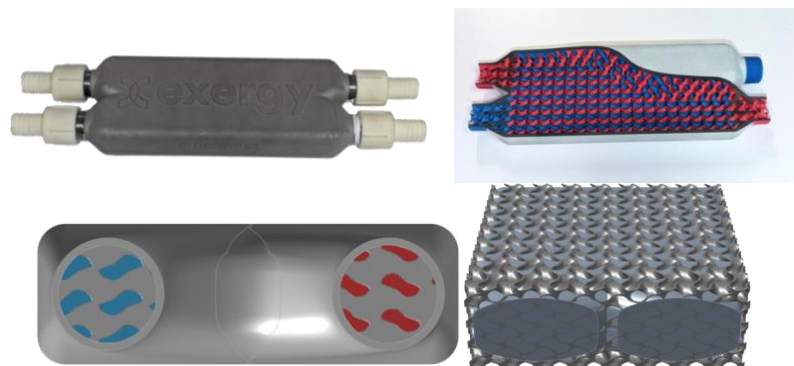


Figure 4—A Two-Fluid Counter-Flow Heat Exchanger Designed with Implicit Modeling Approach  
(Courtesy Altair and Exergy)

## Concluding Remarks

An exciting aspect of implicit modeling is its ability to layer various field effects, based on lattice configurations, density, size, or even simulation data like stress analysis. These field effects can be adjusted iteratively, enabling designers to fine-tune their designs to meet exact specifications and performance requirements. The intersection of AI and implicit modeling holds vast potential. AI can assist in navigating the large design space implicit modeling opens, suggesting optimizations and novel design pathways that might not be immediately obvious to designers. This is leading to an era of design where human creativity is augmented by AI, pushing the limits of what can be imagined and manufactured.

The addition of implicit geometry modeling in Inspire can have a significant impact across multiple industries. It can change the design and manufacturing processes paradigm by enabling the creation of complex geometries that were previously challenging to achieve. The tooling and fixtures industry benefits from lightweight yet structurally sound designs, improving productivity and performance. In fluid power systems, implicit modeling optimizes fluid flow characteristics, enhancing efficiency. The aerospace industry can leverage implicit modeling to design lightweight, yet robust structural components, leading to fuel efficiency and innovative designs. Implicit modeling in the medical and dental field facilitates the development of customized implants with engineered textures, improving patient outcomes. Heat transfer applications, like heat exchangers, benefit from optimized and intricate geometries, enhancing thermal performance. High-performance sporting equipment industry benefits from implicit modeling to create innovative designs that optimize performance and structural integrity.

The implicit modeling capability is an “addition” to already powerful geometry modeling capabilities in Inspire and it allows a combination of traditional and new design and manufacturing processes under one roof. This positions Altair Inspire platform as a robust simulation-driven design software solution which has excellent value proposition for wider adoption in the industry.

## About CIMdata

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