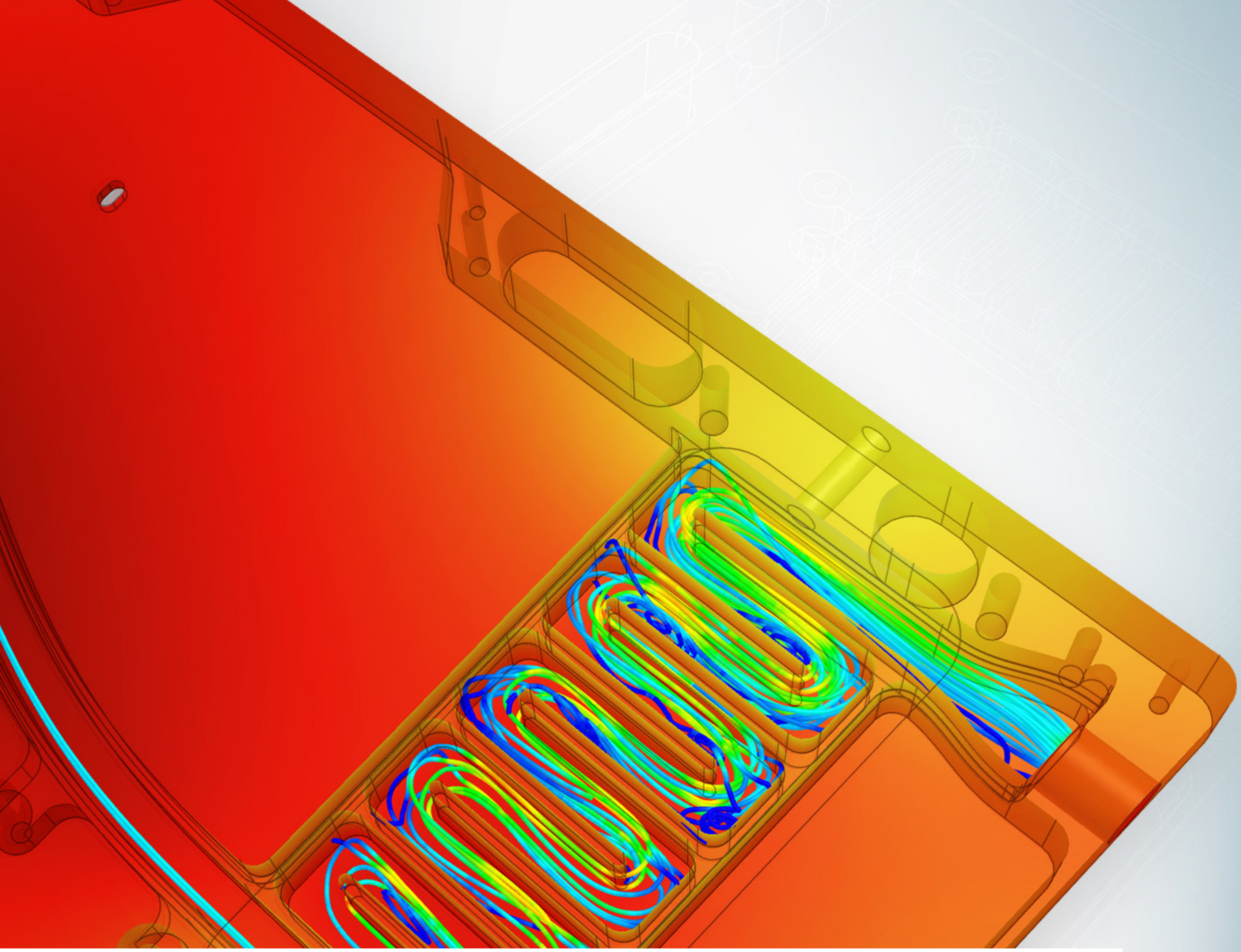
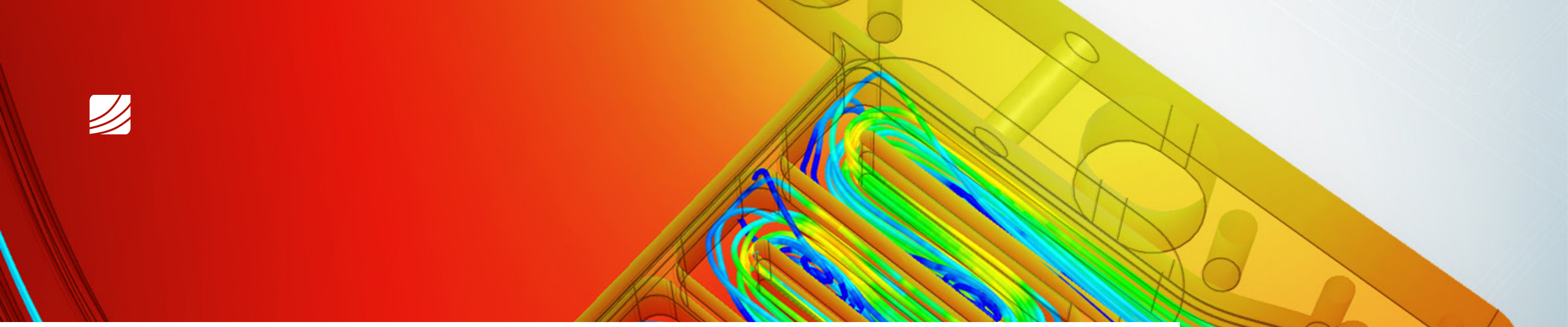


SIMSCALE

WHITEPAPER

Electronics Cooling Multiphysics Simulation

Simulate early, simulate more, simulate now with SimScale



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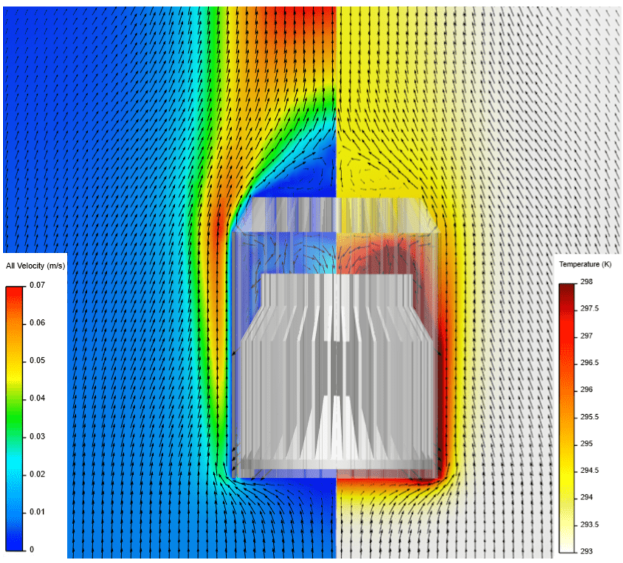
About This White Paper

Engineers who design and test electronics require high-fidelity engineering simulation to investigate heat and fluid flow in order to develop the best thermal management strategies. Access to physics-based solvers in the cloud can enable teams to quickly assess performance and accelerate design iterations by leveraging the power of cloud computing. This whitepaper highlights the benefits of cloud-native engineering simulation using SimScale and describes the fast and accurate analysis types available to engineering teams by simulating early in the design stage, throughout the R&D cycle, and across the entire organization.

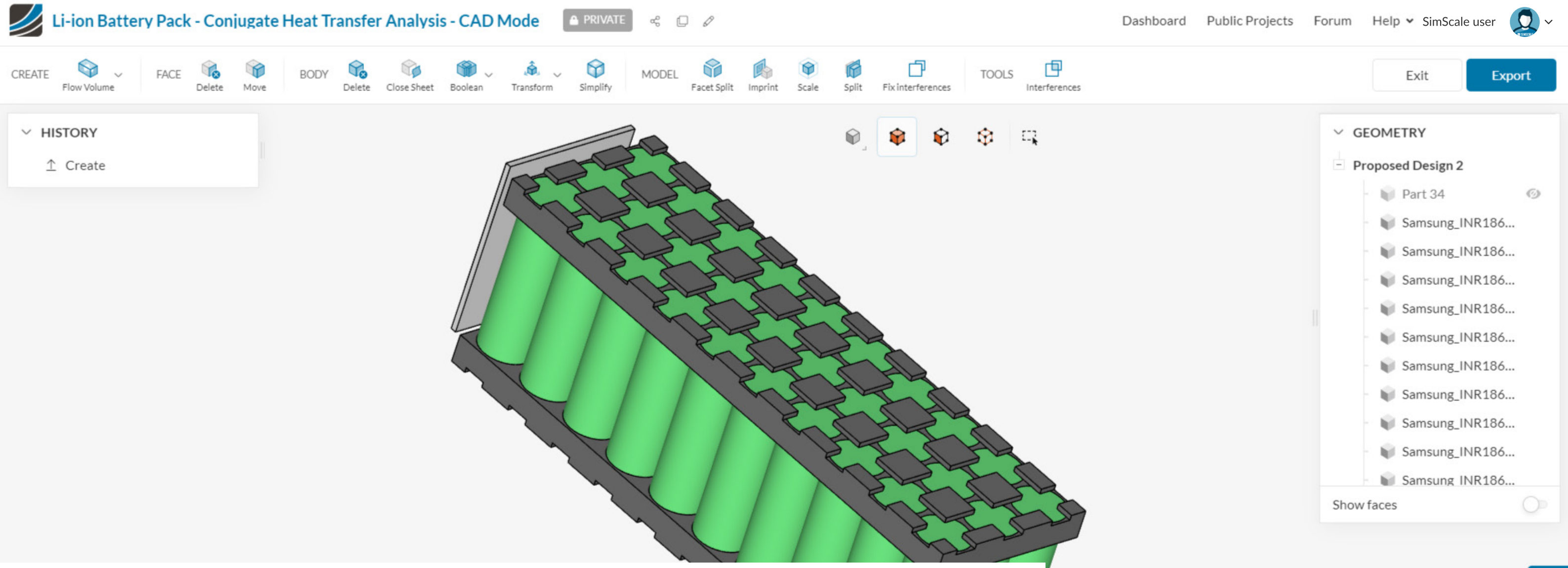
Executive Summary

Engineers and designers have traditionally been constrained by legacy desktop simulation software. Adopting digital prototyping techniques, to explore the full design space and reduce trial-and-error type physical prototyping, has been stifled by limited local computational resources. On-premise computing power does not scale up or down ondemand, nor offer continuously evolving full-spectrum simulation and analysis capabilities. In this whitepaper, we discuss how the availability of cloud-native engineering simulation software mitigates these long-standing bottlenecks.
Understanding electronics cooling is important for a variety of reasons.

A primary objective of good design is to keep every electronic component within operational design limits in order to maintain reliable and safe operation of the product. SimScale enables teams of designers and engineers to efficiently collaborate on projects and predict design performance in the early stages of product development. A fully cloud-native simulation platform allows engineers to simulate and analyze high-fidelity models with complex physics by making High Performance Computing (HPC) accessible, giving unprecedented accuracy in results, efficiency in design collaboration, and versatility in the vast range of electronics cooling applications that can be solved.



LED spotlight generating 9W of thermal dissipation power - airflow pattern, velocity (left) and temperature distribution (right).



Common Challenges in Electronics Design

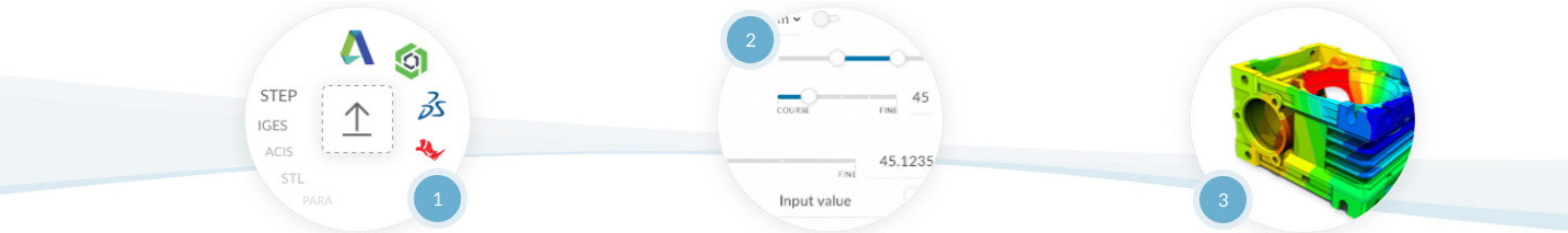
CAD & Geometry

In electronics cooling design, it is not uncommon to spend significant time preparing CAD models for simulation. Detailed production-ready models in their original state are likely to be unsuitable for most simulation tools, burdening simulation engineers with the tedious process of de-featuring geometry, simplifying parts, closing small gaps in the model, and fixing faulty geometry. And, in the case of geometry studies consisting of multiple variants of one base model, all this work often needs to be repeated. Traditional CAD tools in simulation software are, in many cases, inefficient or ill-equipped for such tasks, as they are primarily optimized for designing models from scratch, not simplifying existing models.

The CAD mode feature available in the SimScale platform offers a set of purpose-built CAD editing and simplification tools. For example,the Flow Volume Extraction operation alleviates the engineer from laboriously isolating a flow volume as required in other pre-processing systems. Unlike traditional CAD systems, CAD mode focuses on a core set of simple, intuitive, but also versatile tools that are ideal in making CAD models simulation-ready.

Design Performance

A common challenge in early-stage design is the lack of ability to quickly investigate and simulate design performance. Engineers want the capability to receive design feedback in an iterative manner using fast and accurate thermal and flow analyses applied to their designs. A lack of accessible engineering simulation at the early design stages can significantly reduce product performance. With SimScale's full-stack solution, users can easily go from CAD import and edit to auto-meshing the model and post-processing in a few minutes, all from a web browser.



Import your design

SimScale supports all standard 3D files so you can continue using your favorite CAD system.

Set up your simulation

Choose your simulation type, set your conditions, and away you go!

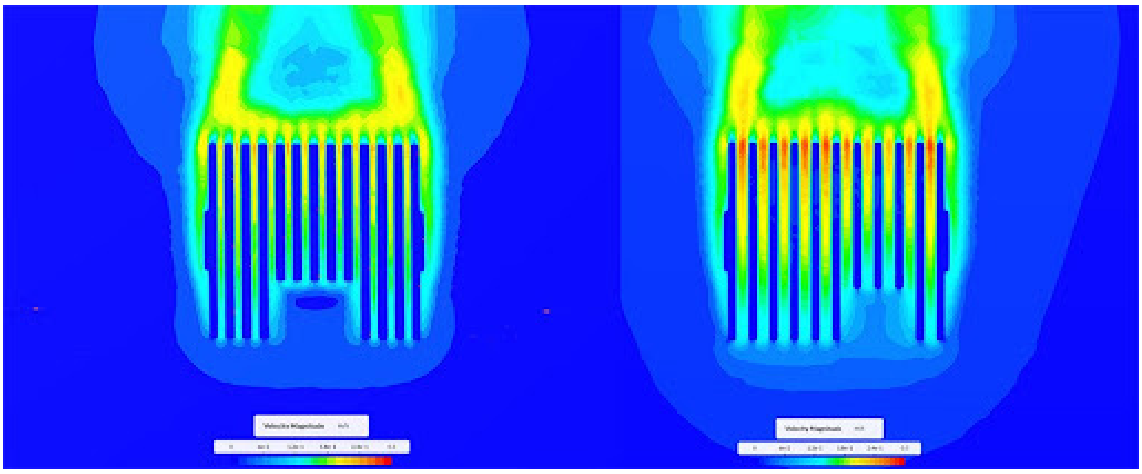
View post-processed results

Analyze your simulation results quickly, with SimScale's integrated online post-processor.

Cost Reduction

Simulation tools that utilize cloud computing eliminate much of the costs associated with traditional simulation. They not only require no hardware installation or space for a workstation on-premise, but are inherently scalable--enabling users to run multiple design iterations in parallel and deploy additional licenses organization-wide. The costs of traditional simulation stacks usually add up to big up-front investments before proving the added value of all the acquired hardware. With that also comes an enormous amount of responsibility in terms of maintaining the systems and a considerable know-how barrier requiring teams to conduct specialized training.

Integrating cloud-native simulation into thermal management design also holds the potential for reducing enormous costs in the product development process. The more quickly a design study converges on its final version, the less costly it is. With simulation tools, designers can identify a problem before money is spent on producing physical prototypes. This is why Raycore Lights uses SimScale to shorten the design and prototype lifecycle of their products. In one example, Raycore ran a design study with eight simulations, each simulation taking five hours to complete. Using legacy software, these would have been completed sequentially over a forty-hour period. With parallel simulation capabilities all eight simulations were run concurrently, yielding a total simulation time of five hours.

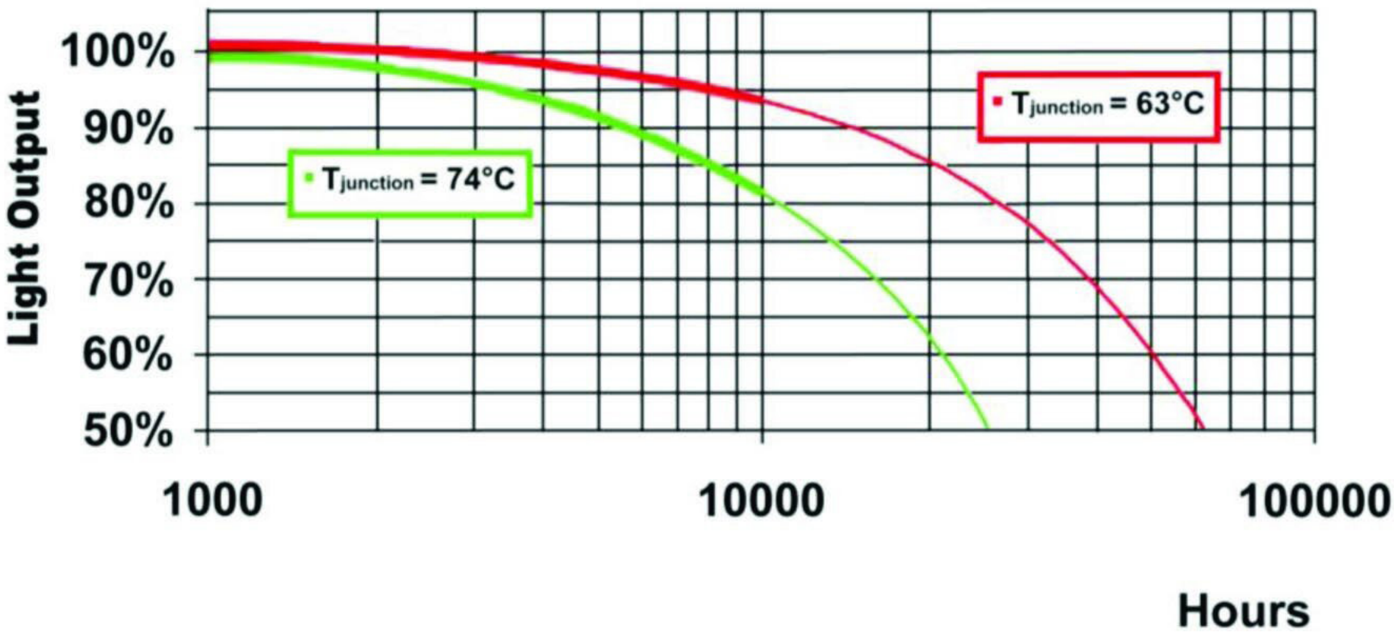


Natural convection velocity around the heat sink fins for the original (left) design vs. new design (right). (Image courtesy of Raycore Lights)

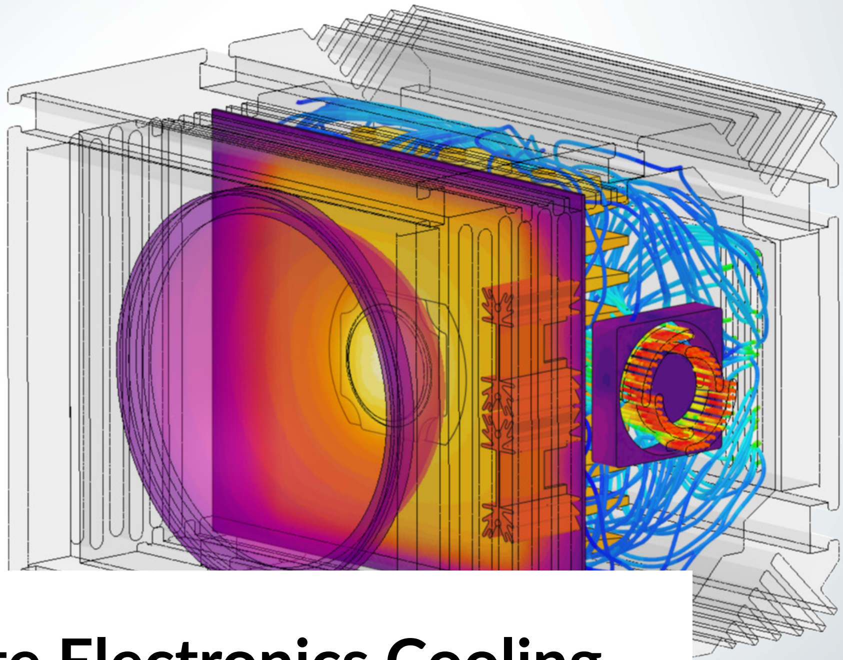
Product Performance and Lifespan

In the absence of the right cooling strategy, the lifespan of components can decrease and the respective electronic device will operate at a suboptimal level. Failure to effectively cool electronics can lead to loss of efficiency and even system malfunction. Therefore, high-performance microchips and electronic devices of all shapes, sizes, and levels of functionality need innovative thermal design techniques to maintain design operating conditions and remain within peak performance range.

The life of LED systems, for example, shortens significantly when exposed to prolonged heat. Following standardized physical testing procedures is expensive, time-consuming, and becomes prohibitive for each LED design. Using thermal simulation means that engineers can quickly evaluate the thermal performance of multiple LED designs at many operating points and use the results to predict component performance and lifespan.



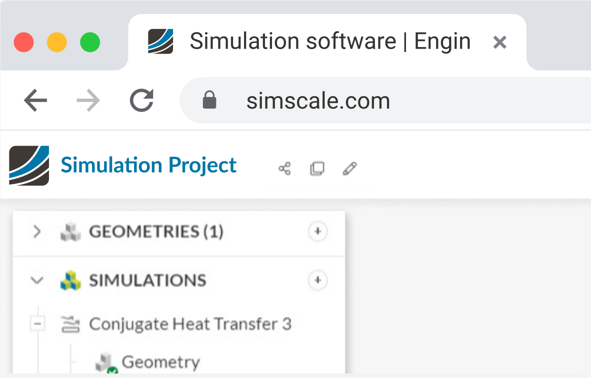
Example of lumen depreciation, over time, based on junction temperature.
A drop of 11°C translates to an extension of 25K hours of working life
Source: Scientific Lights

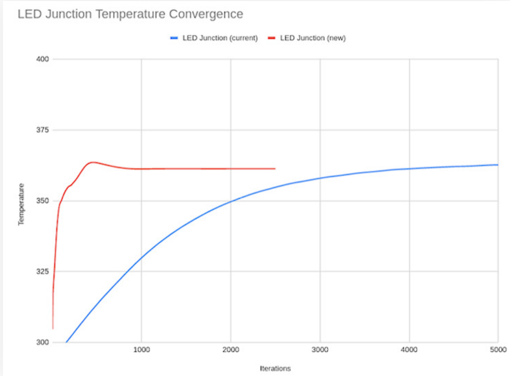


Why Simulate Electronics Cooling on a Cloud-Native Platform?

Visualization of active cooling of a 100W LED device, colored by temperature.

Thermal management is a critical design step for many engineers wanting to design reliable and safe products. Predicting temperature distribution across the product performance range of any device is a significant undertaking to develop fit-for-purpose products. Accurately predicting temperature distribution used to be considered a time-consuming and costly exercise that resulted in poorly understood thermal response in electronics products. Access to simulation at the early design stages is therefore essential to achieving the required design performance, a faster time to market, reduced physical prototyping costs, and confidence in overall quality.



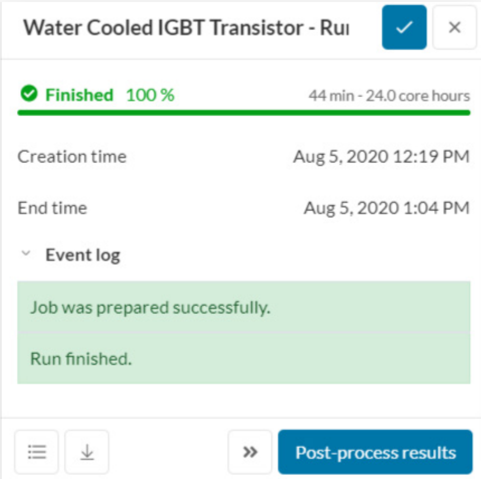


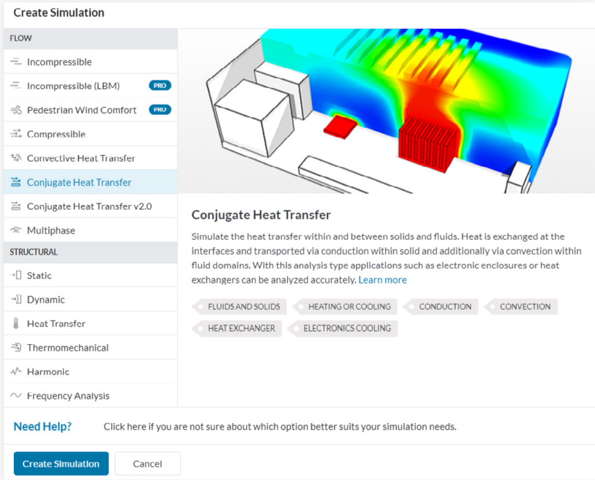
Accessible

SimScale makes engineering simulation economically and technically accessible through an easy-to-use browser-based solution that can be accessed from anywhere, at any time, with a simple login. Users benefit from live technical support and a simple usage-based pricing model that minimizes IT and licensing costs. The SimScale platform easily integrates with your existing workflows and design processes. As an an end-to-end simulation stack users can bring a CAD model to SimScale and leave with robust design decisions.

Accurate

SimScale uses proprietary solver technology specifically designed for electronics cooling applications that has been validated for incompressible and compressible flow. Engineers can harness advanced solvers that account for coupled analyses of conduction, convection, and radiation and deliver accurate results across a variety of problem domains and scales.



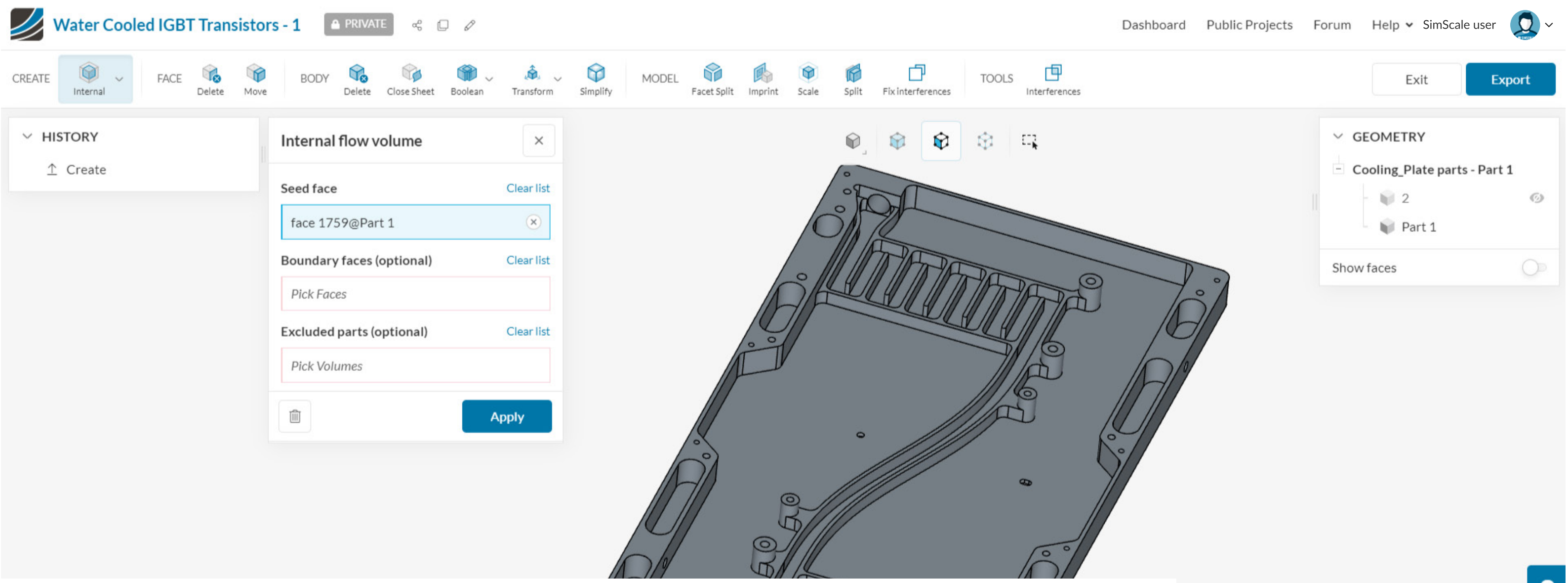


Efficient

SimScale offers a fast electronics cooling simulation solution by harnessing the virtually unlimited HPC power of the cloud. Our electronics cooling solution, with recent improvements in proprietary solvers, has enabled an order of magnitude increase in speed of simulations whilst improving the accuracy and confidence in the results. The ability to run multiple design iterations in parallel means that simulating an entire electronics cooling device from CAD preparation to post-processing can be performed with fast turnaround times.

Versatile

SimScale offers simulation in the analysis of heat exchangers, cooling of electronic equipment, and general-purpose cooling and heating systems. Engineers can solve flow, thermal and structural problems of luminaire design, enclosure cooling, battery packs, microprocessors, and other types of electronic equipment.



How to Simulate Electronics Cooling with SimScale

Fast & simple internal flow volume creation using SimScale's CAD mode.

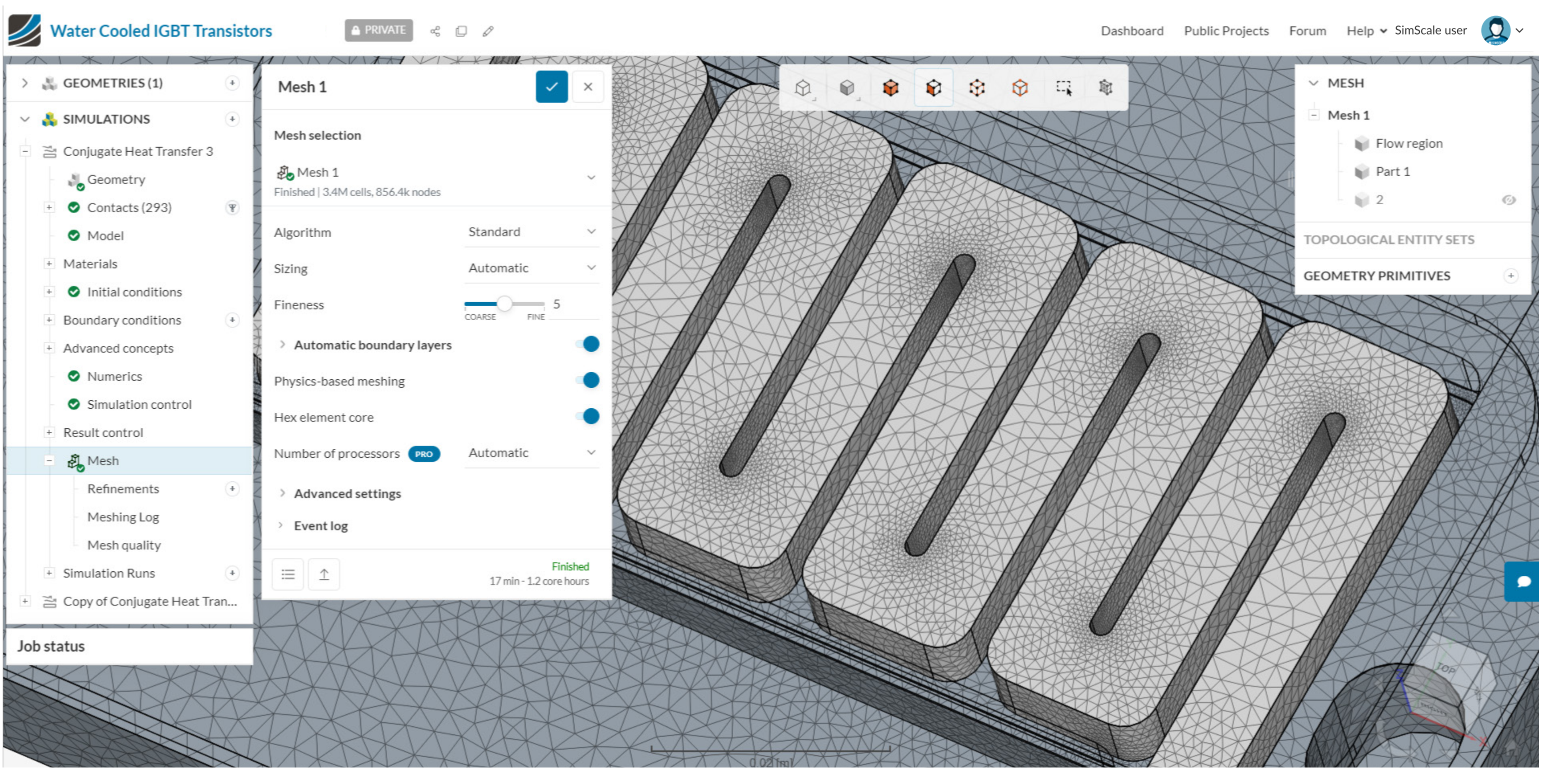
As a cloud-native engineering simulation platform, SimScale facilitates a high degree of collaboration between team members and automates the most common steps of simulation workflow, from CAD import to results analysis.

Import & Edit Your CAD Models with Ease

Preparing, uploading, and adapting your CAD model for analysis is the first step in setting up a simulation. SimScale supports the most common geometry formats for importing electronics cooling CAD including Solidworks, Inventor, STEP, IGES, STL, and Parasolid. Third-party CAD connector apps are available for Onshape and other tools, allowing for more seamless integration. After CAD upload, some additional preparation might be required depending on how the file has been created. SimScale offers a dedicated environment to interact with your model called CAD mode that helps users prepare the model within SimScale without having to switch to external CAD software. Users typically need to create the fluid volume. CAD mode supports operations like scaling, extrude, body and face delete, surface splitting, flow volume extraction, etc. with new features being added continuously.

Quickly Mesh & Solve Complex Designs

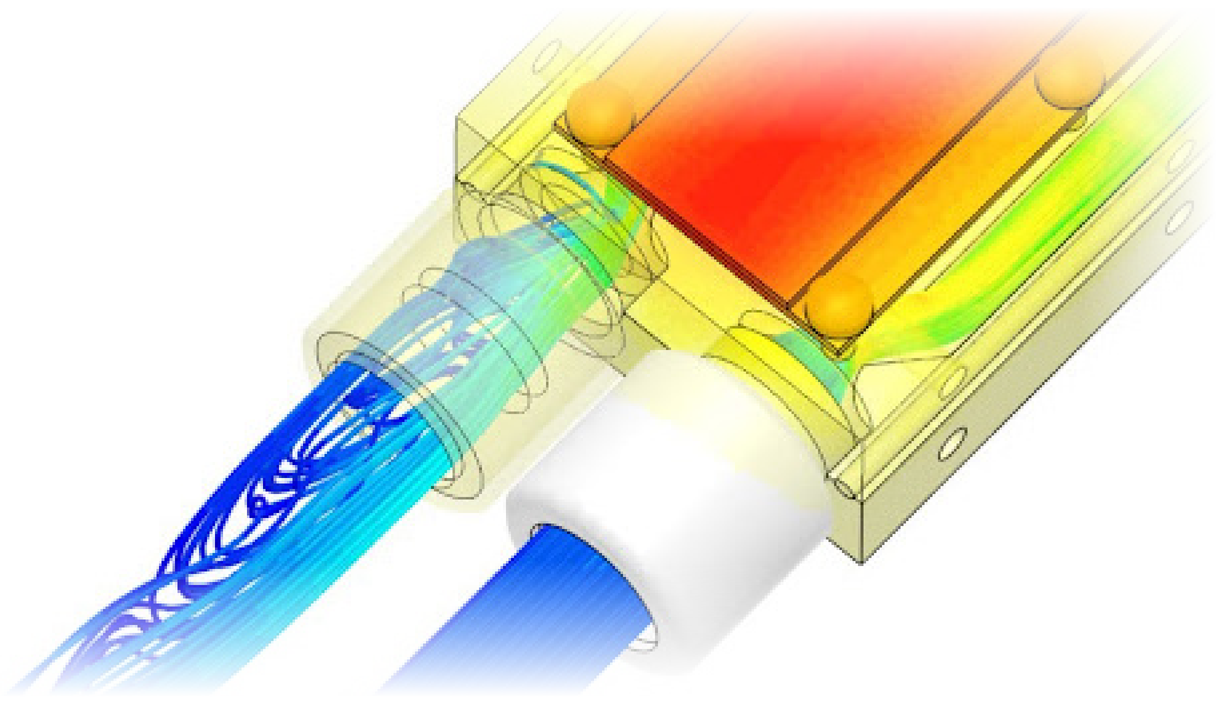
Mesh generation is a labor-intensive and tedious aspect of traditional CFD software. SimScale's platform is based on a special meshing technique that ensures the mesh interfaces are conformal between all parts —and robust enough to apply to many types of CAD models first time around. Our proprietary technology is harnessed specifically for electronics cooling applications and lends itself to meshing complex geometries. In one engineering simulation tool, engineers can mesh and solve their models with an easy-to-use and intuitive workflow.



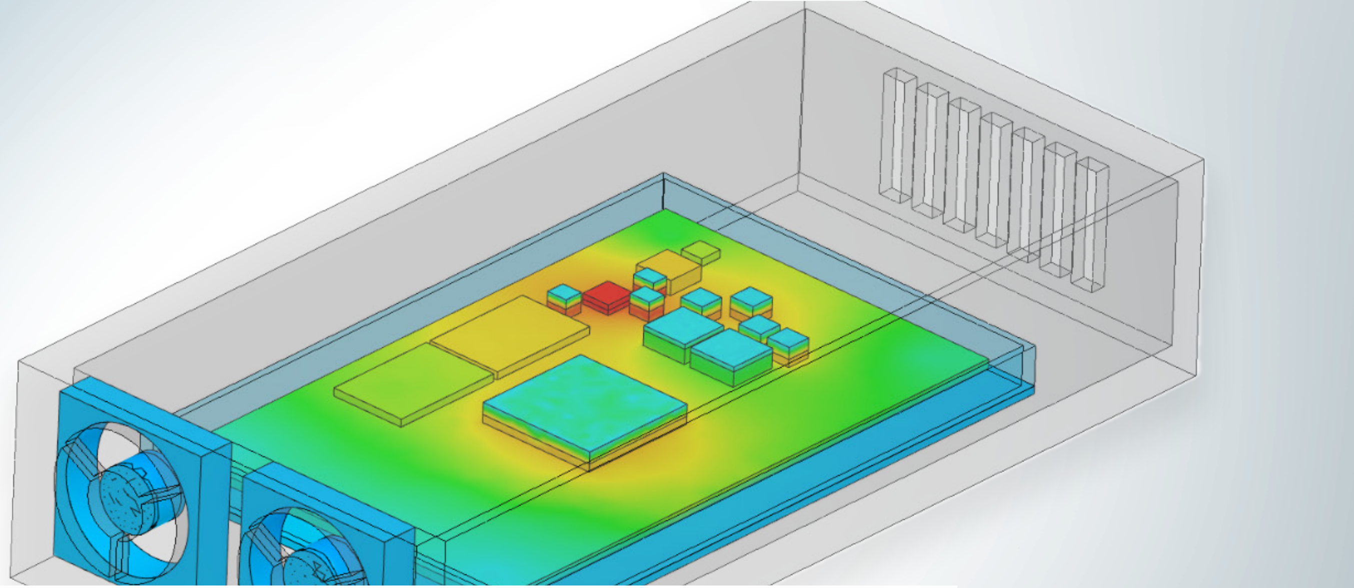
Mesh clip through a liquid cooled EV battery module with 10 million cells.

Visualize Design Insights

Engineers need to identify performance issues early in the product development phase before they manifest in real-world situations and fail to meet customer expectations. CFD simulations calculate, for example, flow and heat phenomena inside enclosure cooling devices and makes them visible. CFD empowers engineers to visualize important quantities, to rapidly gain insight into product performance. SimScale offers a platform to quickly investigate design changes in its own intuitive post-processor which helps users gain a better understanding of flow phenomena in complex devices. Physical variables including flow velocity and temperature, and output quantities such as pressure drop can be calculated and visualized. Additionally, engineers can post-process further quantities including volumetric/mass flow rate on defined faces, velocity and temperature distributions, and much more using the advanced post-processing features in SimScale.



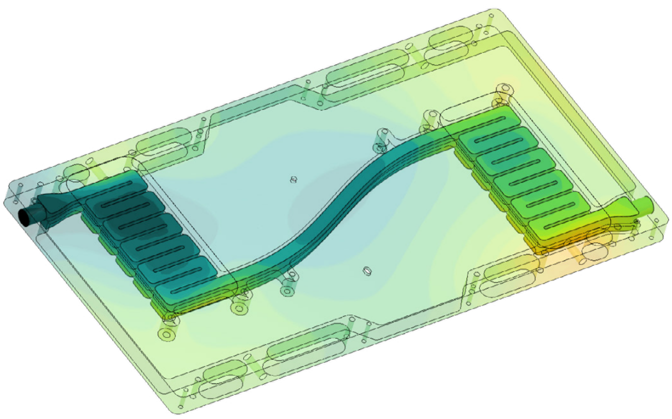
Velocity streamlines highlighting recirculation zones at the outlet of the cooling block of a water cooled 2x160W Chip-on-Board (COB) Series UV LED.



Electronics Cooling Simulation Case Studies

Enclosure

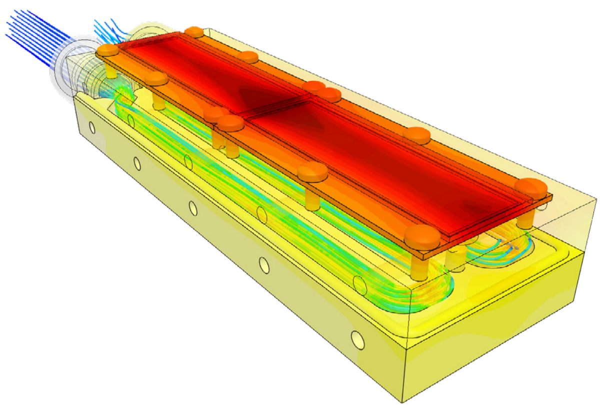
This case study involves the thermal performance of a pair of water-cooled, insulated-gate bipolar transistors (IGBT). Thanks to SimScale's easy and quick workflow, product designers can understand the impact of their design changes on the thermal performance of the system. Many design iterations can be prepared and simulated in the cloud, in less than one hour of elapsed time.



Visualization of the temperature distribution within the cooling fluid and solids of the IGBT transistors.

Lighting

This simulation aims at determining whether the temperature of the board of 2x 160W Chip-on-Board (COB) Series UV LED is below the recommended temperature of 40°C with a water cooling block running with 0.2m/s inlet velocity. CFD Simulation enables the designer to identify unwanted flow recirculation and regions of undesired flow direction, eliminating such phenomenon can improve the efficiency of the cooling block.



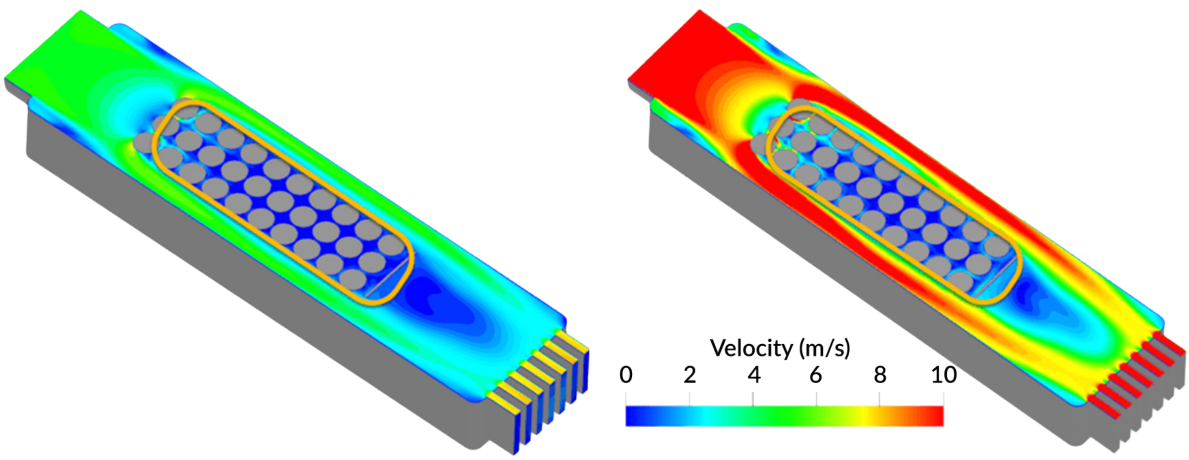
Cooling block and the COB LEDs colored by temperature with streamlines colored by velocity.

Li-ion Battery Pack

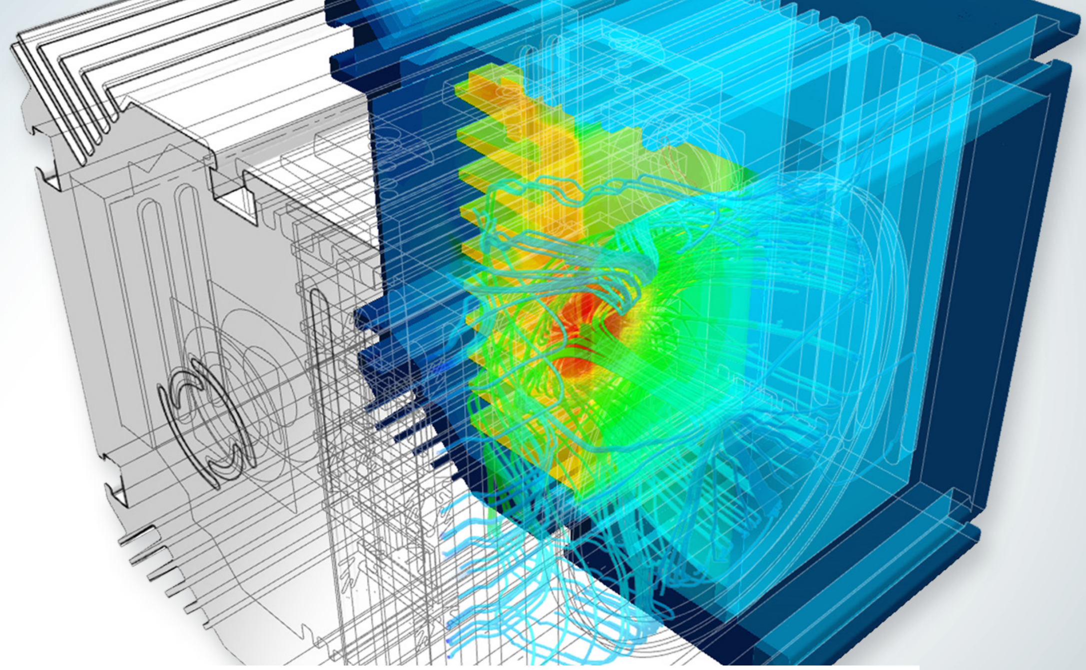
In this case, the temperature of 30 commercial Li-ion 18650 cells under multiple casing designs and inlet flow conditions was predicted. Multiple air velocity values were simulated simultaneously to identify the minimum value required to maintain the cell temperature below 40°C. The cells are simulated under steady state conditions with fully developed turbulent flow (k-omega SST model). The resulting temperature from the original design is compared to two proposed designs. Both solid conduction and convection are modeled. The thermal properties (conductivity, density, and specific heat) of the battery cells, the BMS board, and the battery will significantly impact the temperature distribution within the cells.

With an inlet velocity of 4 m/s and shading the results by temperature, the peak value is 128°C. This means it reached 90°C above the maximum recommended temperature of 40°C causing a faster exponential growth of battery aging, meaning its "health" tends to deteriorate gradually, and even causing irreversible damage to the battery pack. A Parametric study can then be run in the cloud on this simulation with dozens of inlet velocities and geometry variations to identify the optimal design within one hour of elapsed simulation time.

Maintaining battery packs within a specific temperature range is essential for ensuring performance and safety. The cooling effect of forced air at high velocity is reflected in the simulation results.



Velocity contours at the midplane at 5m/s, and 10m/s velocity inlet.

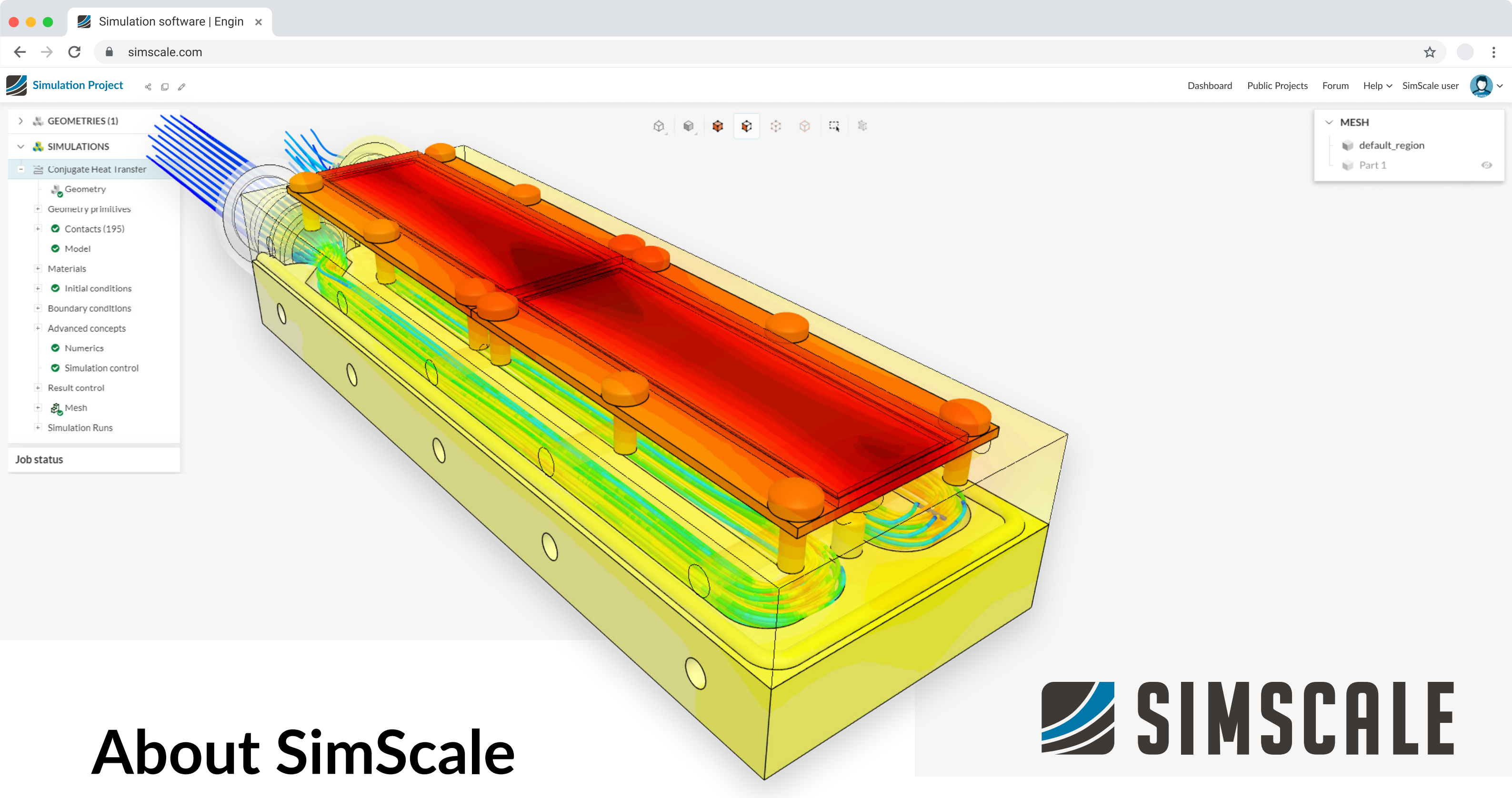


Conclusions and Next Steps

Global engineering organizations recognize the benefits of simulation in the cloud and are rapidly adopting the SimScale platform as part of their product design and digital transformation strategies. R&D leaders and engineering managers rely on the accessibility of cloud-native engineering simulation and trust SimScale to provide their team with immediate access to electronics cooling digital prototyping, early in the design stage, throughout the entire R&D cycle, and across the entire enterprise.

Solve your greatest design challenges with SimScale.

Request a Demo



About SimScale

SimScale is focused on removing the pain of sourcing expensive CAE software licenses, paying for the maintenance and technical support, procuring expensive local HPC hardware, and waiting for IT to deploy and maintain the tools needed to do what matters: designing the best products. With SimScale, engineers and designers have access to fast, accurate, and accessible engineering simulation on the cloud. On the SimScale platform, accessibility translates to a modern usage-based pricing approach and frictionless collaboration between engineers. Learn how leading engineering firms are leveraging the power of SimScale with zero hardware or maintenance investment. Visit [simscale.com](https://www.simscale.com) to learn more.