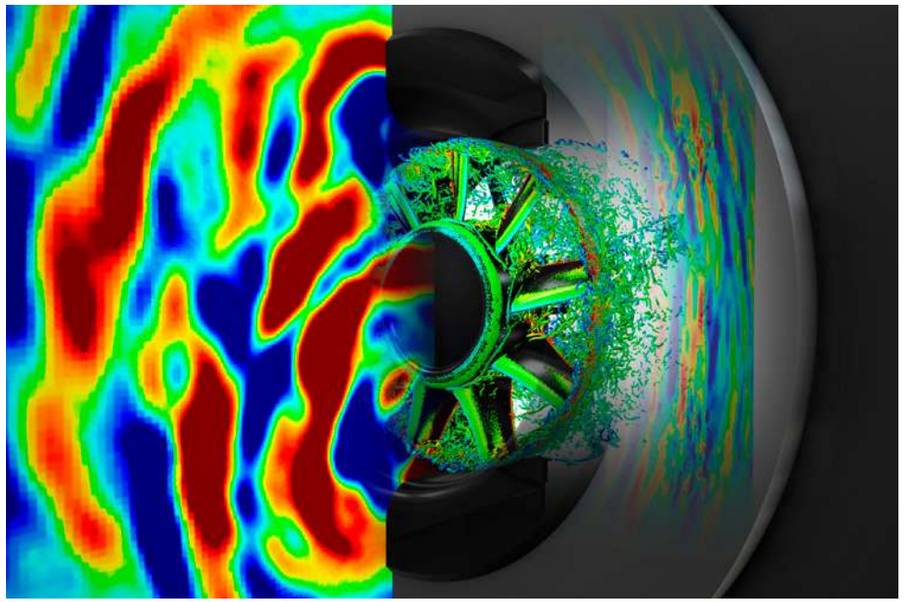
QUIET AND EFFICIENT THERMAL SYSTEMS

Optimize Heavy Machinery Design with Simulation

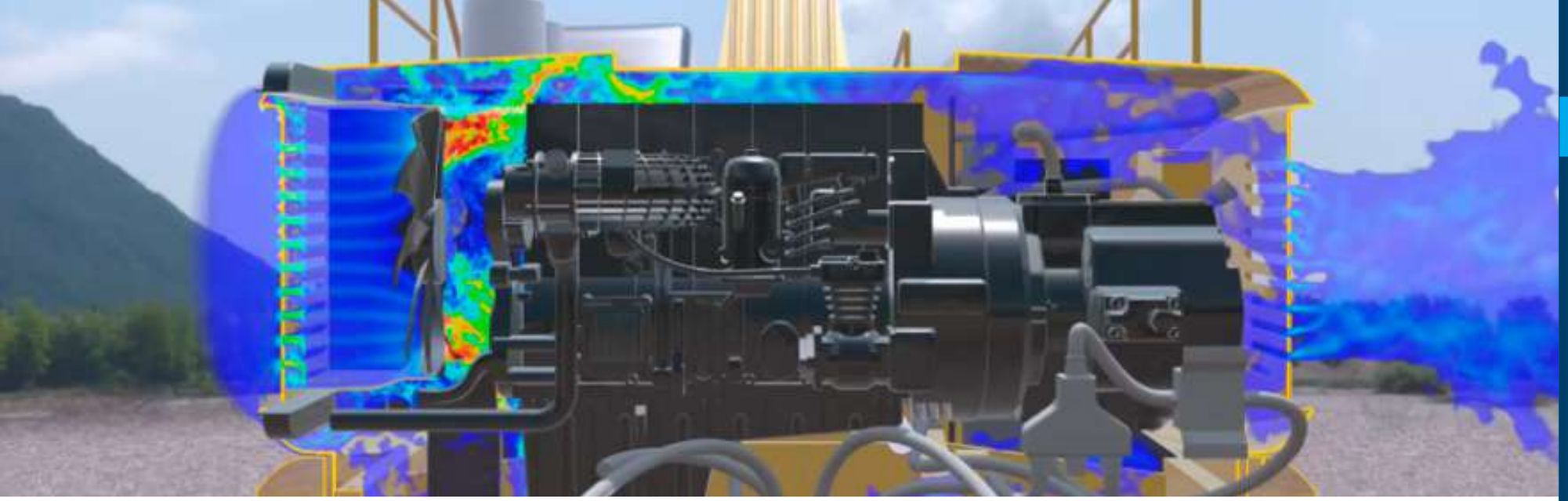
EFFICIENT THERMAL SYSTEMS SIMULATION WITH A VIRTUAL TWIN

With growing pressure on Industrial Machinery OEMs to manufacture comfortable and durable machines, engineering and design departments are leveraging new solutions to ensure that products meet requirements before a prototype is built. Creating a Virtual Twin to simulate and optimize durability can avoid warranty costs which are currently decreasing OEMs profitability by 1–2%, while retaining the fast development pace needed to compete in the global market. For thermal systems and their design in the context of Tier 3 & Tier 4 certification*, modeling and simulation of the virtual twin can help balance comfort and durability while meeting homologation requirements in early design stages.

This e-book covers the fundamentals of thermal system simulation using computational fluid dynamics and demonstrates how our solutions can help companies address the challenges of optimizing performance, thermal management and acoustic noise.



*https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-air-pollution-nonroad



CERTIFICATION—TIER 3, TIER 4 & TIER 5

Emissions regulations in the Heavy Machinery Industry aim to reduce the two primary exhaust pollutants: Nitrogen Oxides (NOx, including both Nitric Oxide and Nitrogen Dioxide) and Particulate Matter (PM). The Tier 4 emissions standards were phased in from 2008–2015, and limited maximum NOx emissions to be about 10% of those in Tier 3 and PM emissions to be less than 5% of those in Tier 2. The Tier 5 Californian standards are currently being defined, and aim to reduce emissions by a further 50–90% by 2030, but have not yet been adopted by the Environmental Protection Agency[1]. Conforming to the highest level certifications is often necessary to secure construction contracts and is therefore a main OEM concern.

Typical approaches to reduce NOx emissions involve the recirculation of air from the exhaust into the engine intake, leveraging Exhaust Gas Recirculation (EGR)[2] devices, or implementing Selective Catalytic Reduction (SCR) devices. EGRs can increase the temperature of the engine, and so it is common for OEMs to alter cooling designs, or increase the size of engine cooling packages, in order to meet Tier 4 standards.

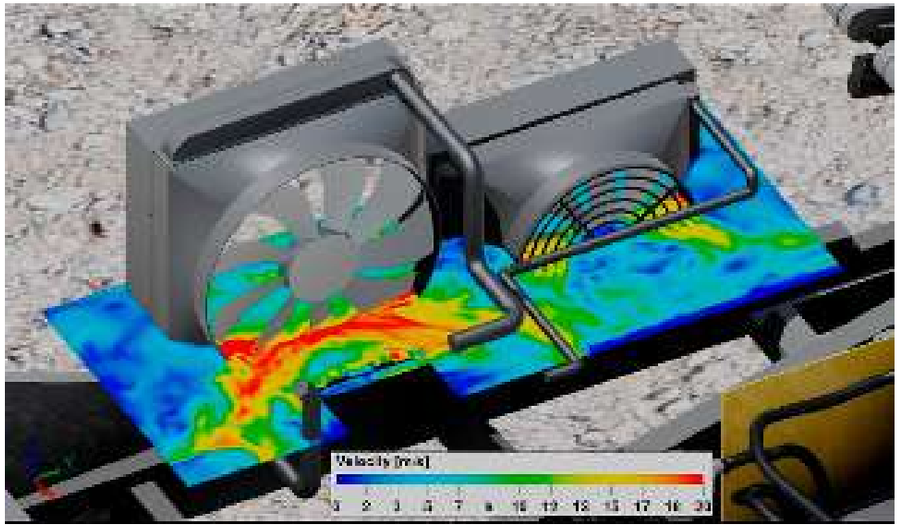
1 https://dieselnet.com/standards/us/nonroad.php#tier4,
1 https://woodstockpower.com/blog/epa-tier-5-what-we-know-so-far/

2 https://www.equipmentworld.com/equipment/article/14952553/everything-you-need-to-know-about-tier-4-final

OPTIMIZE YOUR COOLING PACKAGE

Leveraging simulation to design your cooling package can help minimize downtime, reduce development cost by avoiding expensive thermal management prototypes, and potentially reduce warranty recalls, at the same time meeting legislation requirements.

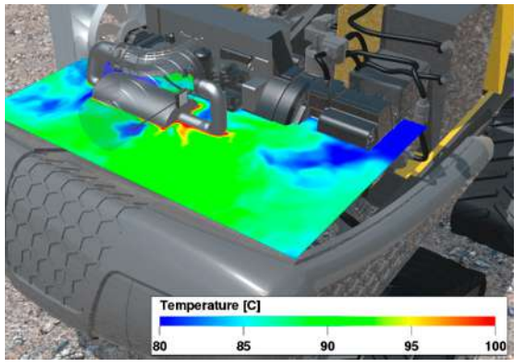
Simulation from Dassault Systemès SIMULIA enables you to assess the airflow around your drivetrain accurately, without needing to simplify any of the geometry, and starting directly from your design CAD tree. Our highly parallelized Lattice Boltzmann based solvers provide native transient results, with VLES turbulence modeling, and real rotating geometry, to **provide accurate flow behavior** even in complex environments, at low simulation cost. This allows OEMs to select appropriate fans, or redesign elements around the cooling systems, **to optimize airflow and performance**.



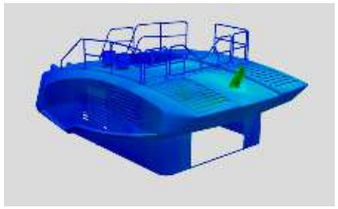
Velocity field around a fan

IMPROVE THERMAL PROTECTION

Simulation results can be leveraged for thermal protection, providing a typical accuracy within 4°C* and ensuring that **all components within the engine bay remain at optimum operating temperature**. With the increase in the number of electronics or temperature sensitive devices, the information from simulation helps test out heat shields or component layout changes to improve durability.



Temperature field

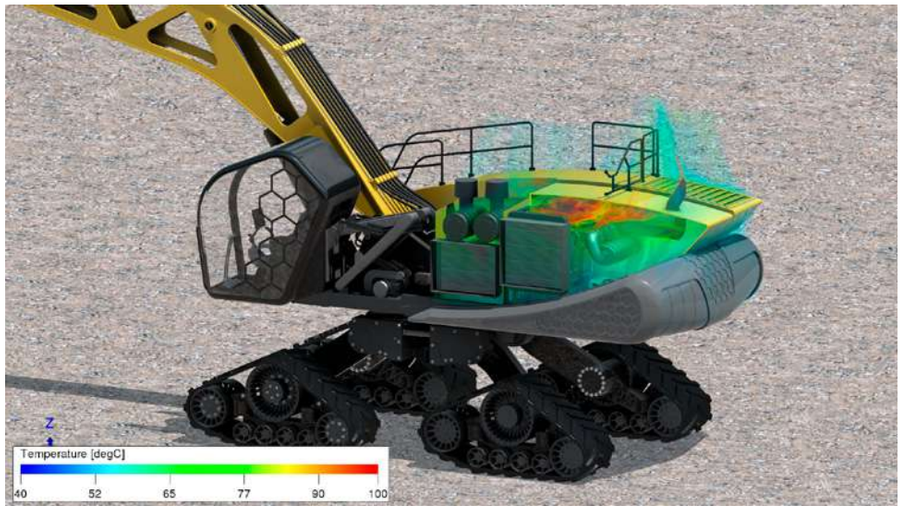


Prediction of surface and component temperatures with Computational Fluid Dynamics

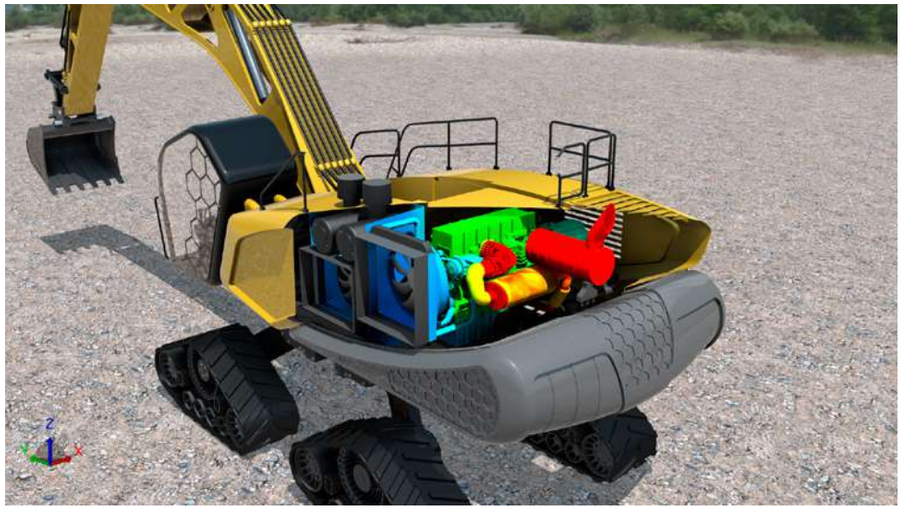
*Observed with our customers

CAPTURE REAL OPERATING CONDITIONS

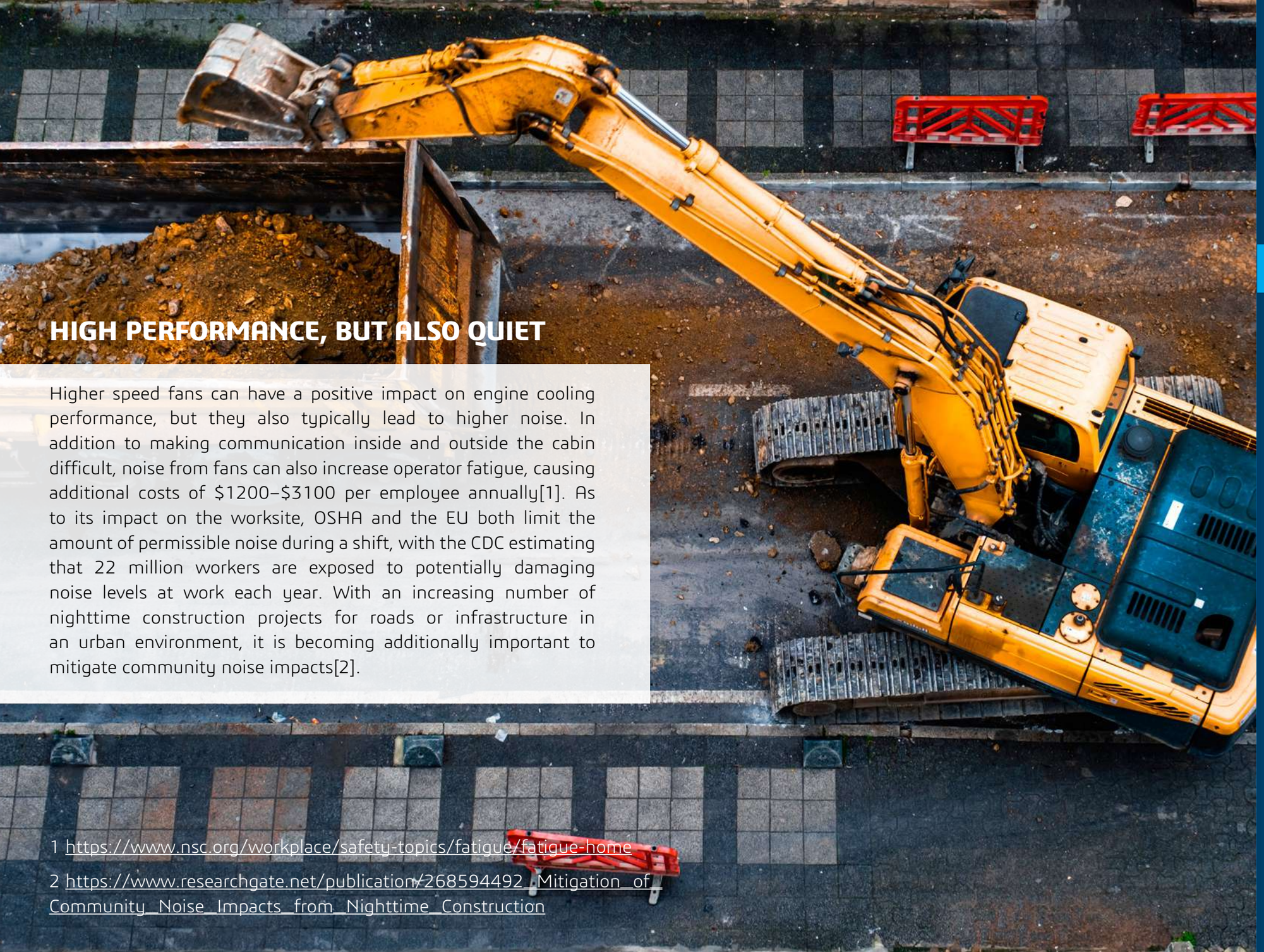
Operating conditions on a real worksite can be very different from those of a climatic wind tunnel: machinery can be used for hours on end, in extreme weather, before being switched off for a lunch break. During that break, the cooling system deactivates, and it's common for temperature spikes to occur in the engine bay. Simulation can capture those effects, and typically provide the engine bay temperature within 5°C* in extreme operating conditions, under long duty cycles. These simulation results can be provided in under a week, and help designers produce products that are built for the real world. **Simulation allows different operating condition scenarios to be investigated**, facilitating the design of a product that meets performance criteria, and reducing the risk of prototype failure during testing.



Key-off underhood simulation, ensuring robustness of design



*Observed with our customers



HIGH PERFORMANCE, BUT ALSO QUIET

Higher speed fans can have a positive impact on engine cooling performance, but they also typically lead to higher noise. In addition to making communication inside and outside the cabin difficult, noise from fans can also increase operator fatigue, causing additional costs of $1200–$3100 per employee annually[1]. As to its impact on the worksite, OSHA and the EU both limit the amount of permissible noise during a shift, with the CDC estimating that 22 million workers are exposed to potentially damaging noise levels at work each year. With an increasing number of nighttime construction projects for roads or infrastructure in an urban environment, it is becoming additionally important to mitigate community noise impacts[2].

1 https://www.nsc.org/workplace/safety-topics/fatigue/fatigue-home

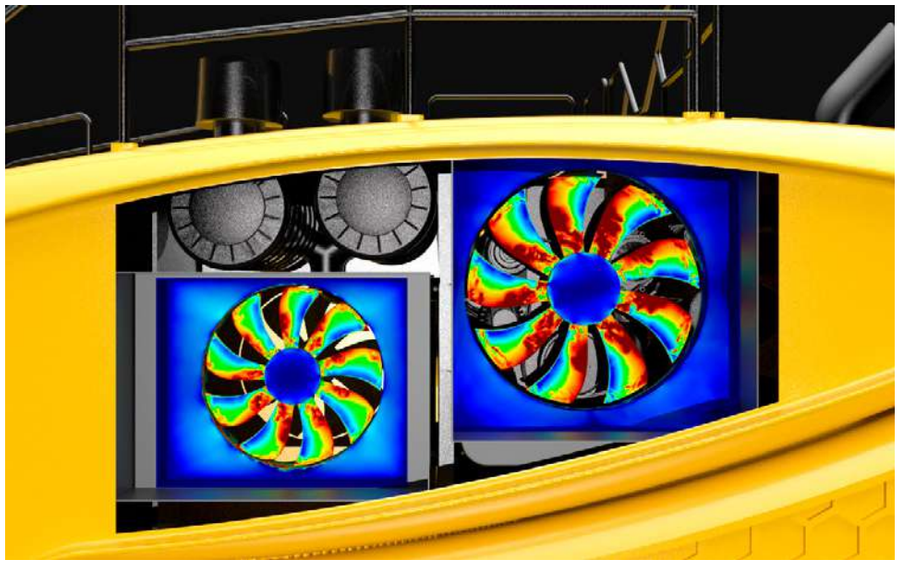
2 https://www.researchgate.net/publication/268594492_Mitigation_of_Community_Noise_Impacts_from_Nighttime_Construction

OPTIMIZE FAN & ITS SURROUNDINGS

Our Lattice Boltzmann approaches leverage their weakly dissipative formulation to capture acoustic pressure fluctuations directly in the CFD solution pressure field. This removes the need for employing more restrictive models such as Lighthill or Powell analogies, and provides cost effective solutions typically accurate within 2dB* of the Overall Sound Pressure Level (OSPL).

These simulation results can be leveraged to optimize the design of a fan, or of its surroundings, including acoustic damping packages. Leveraging advanced postprocessing approaches, we can typically reduce OSPL from early design by 4dB*, or more.

In addition to simulations, the available postprocessing methodology includes realistic rendering which provides clear images of the simulation results enabling effective communication within teams.



Double underhood fan noise simulation

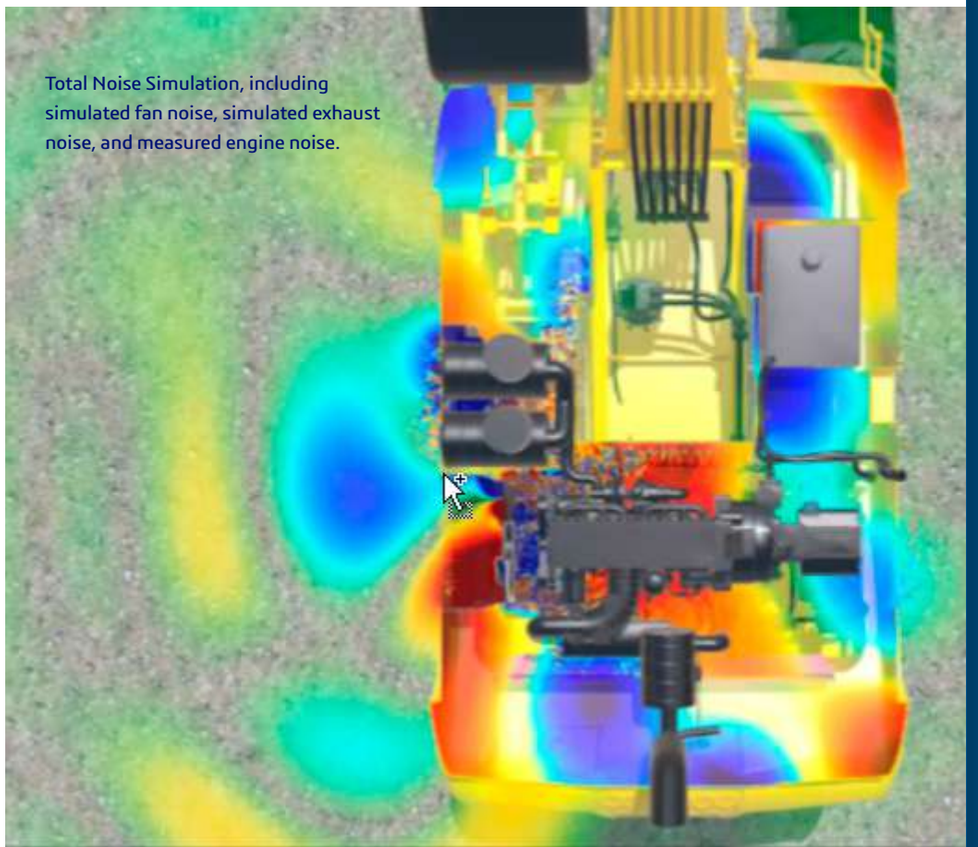
*Observed with our customers

OPTIMIZE TOTAL NOISE

Combining fan simulation with simulations for exhaust noise, and including measurements from additional noise sources from the machinery, such as engine noise, enables analysis of the overall acoustic packaging of the machinery. Adjusting the arrangements of louver and slats, or acoustic damping material can have a notable impact on community noise, and help reduce Overall Sound Pressure Level (OSPL) typically by 3dB*. An overall achievable accuracy of 1dB also means this methodology can be leveraged for digital precertification, to **ensure machinery will pass community noise requirements without the need for a full prototype**.

*Observed with our customers

Exhaust noise simulation.



Total Noise Simulation, including simulated fan noise, simulated exhaust noise, and measured engine noise.

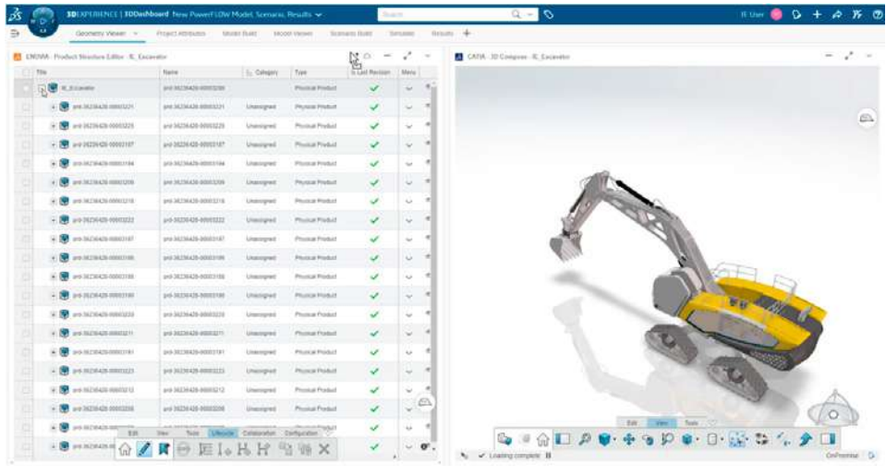
FULLY AUTOMATED WORKFLOWS TO DEMOCRATIZE SIMULATION

Designers, when initiating new designs or design changes, must ensure the first step goes in the right direction.With simulation templating, and simulation automation, expert simulation analysts can help designers verify the impact of design changes, as they implement them. Virtual testing can not only assist in reducing the cost associated with manufacturing prototypes but it also allows potential problems to be identified and addressed earlier in the design process.

Both our **underhood cooling**, and **underhood fan noise workflows** are available in our cloud **fully automated workflows**, providing easy to read results from a simple geometry drop.

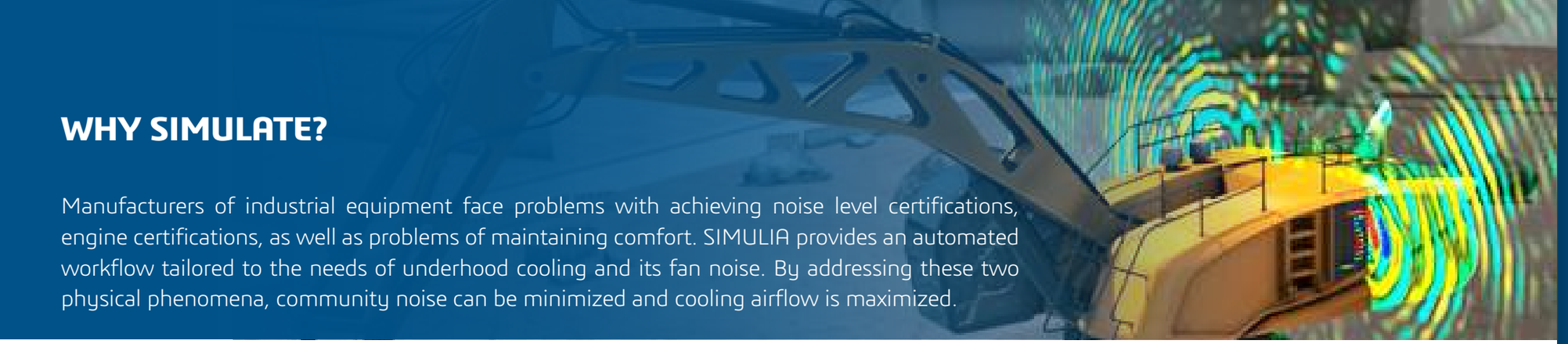
Users familiar with the **3DEXPERIENCE®** platform will also find the underhood fan noise automated process there, allowing designers to leverage geometry sorting capabilities to initiate simulations directly from their CAD geometry tree.

SIMULIA-Cloud Underhood Cooling Automated Process.



Semi-automated CAD sorting on the **3DEXPERIENCE** platform.

Auto postprocessing on the **3DEXPERIENCE** platform.



WHY SIMULATE?

Manufacturers of industrial equipment face problems with achieving noise level certifications, engine certifications, as well as problems of maintaining comfort. SIMULIA provides an automated workflow tailored to the needs of underhood cooling and its fan noise. By addressing these two physical phenomena, community noise can be minimized and cooling airflow is maximized.

Virtual Testing

Virtual twin experiences let you visualize, model and simulate in multiple real-world enviroments.

Optimize Products

Optimize products to meet performance criteria under different real-world operating scenarios.

Collaboration

Ensure all stakeholders collaborate with up-to-date data for continuity from design to simulation to manufacturing.

$€¥ Cost Savings

Accelerate product development cost effectively using virtual twins.

Avoid Risk

Reduce the risk of failure during testing before a prototype is built.

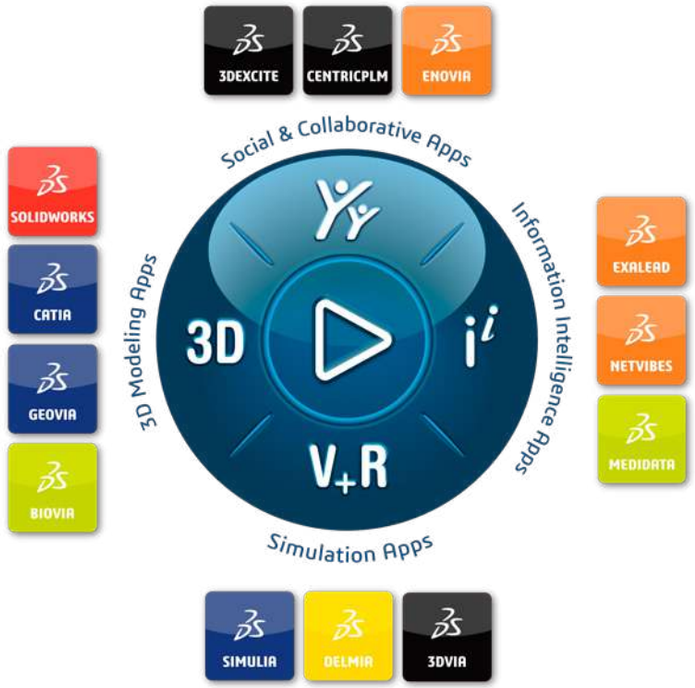
Certification

Ensure certification—Tier 3, Tier 4, Tier 5—requirements are met, early in the design process.

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

Dassault Systèmes, the **3DEXPERIENCE** 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 **3DEXPERIENCE** 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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