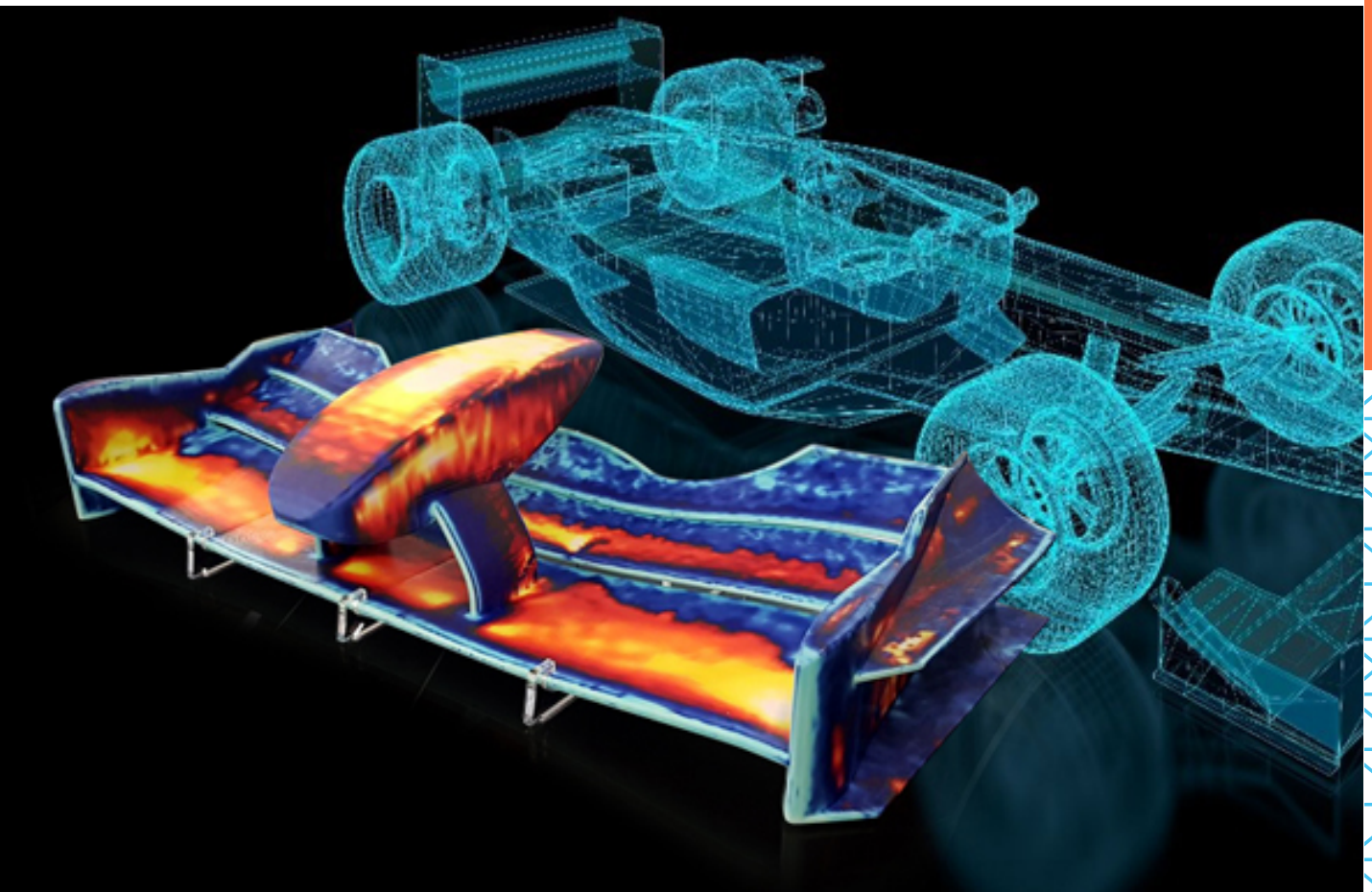
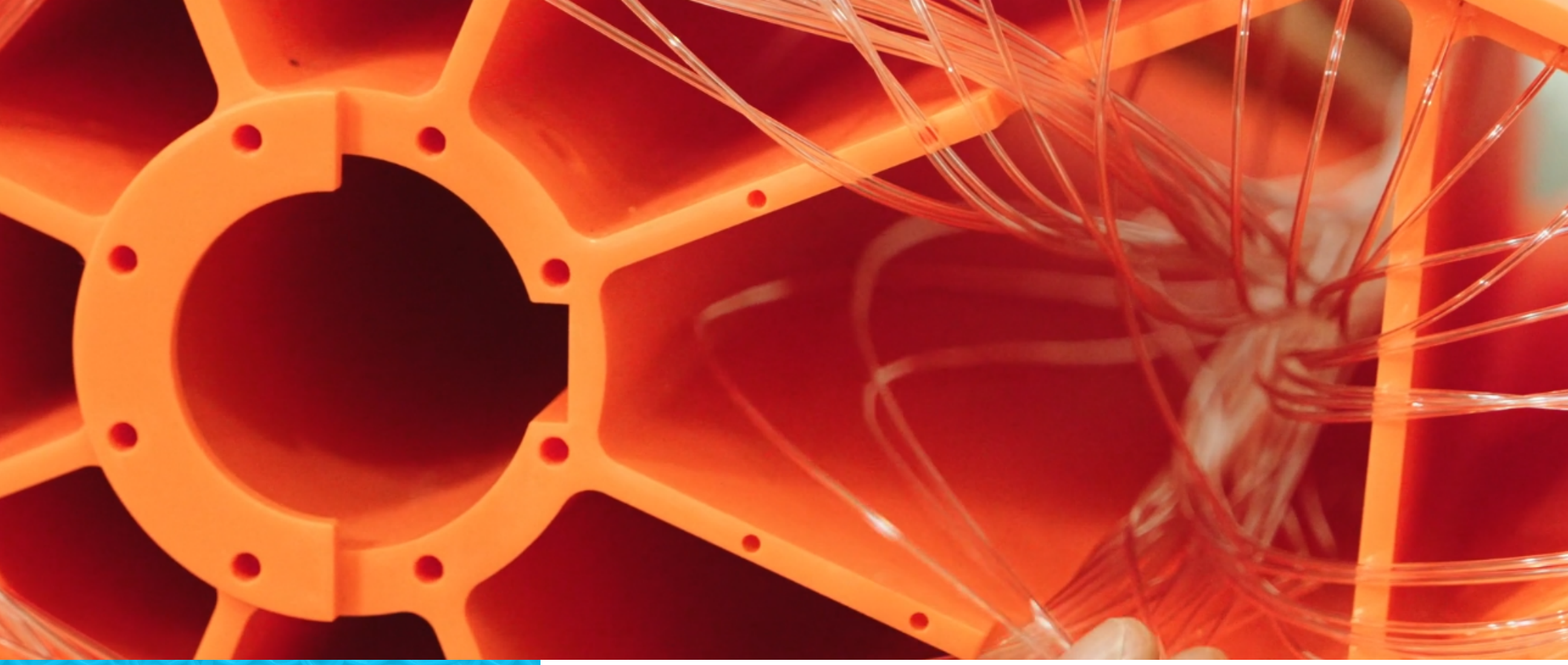
stratasys

eBook
Wind Tunnel Testing

Build Faster, More Accurate Wind Tunnel Models

Discover how stereolithography has improved model production for wind tunnel applications.





Wind tunnel testing is a cornerstone in designing aerodynamically sound and safe products, from vehicles to sports equipment to architectural structures. But traditionally, crafting models for these tests has been a meticulous task - often manual, always time-intensive.

Enter 3D printing. It's streamlined the process, cutting down on both time and costs, without skimping on precision.

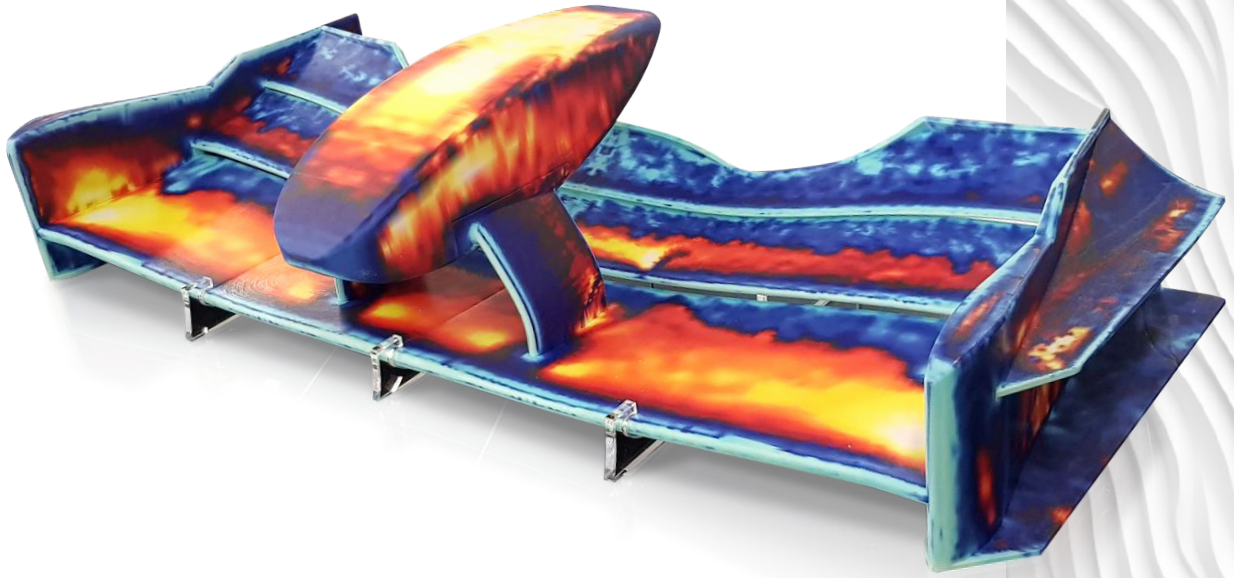
This guide is designed to give you a comprehensive look at how 3D printing can fit into your wind tunnel testing workflow, complete with real-world successes, and tips on technique and best practices.

Choose stereolithography for faster, more accurate wind tunnel models.

Traditional wind tunnel modelling is a true test of patience, stretching over weeks or months for a single model and often resulting in a hefty price tag. The detail you can achieve is limited; intricate designs just aren't feasible with old-school cut-and-carve methods – and you're limited to materials that can handle these tools. When it comes to accuracy, manual methods can vary, and even small inconsistencies could throw your test results off, which is far from ideal in the precise world of aerodynamics.

With Stereolithography (SLA) you can turn complex designs into reality quickly and with incredible precision - meaning less time modeling and more time innovating, testing, and refining.

Think of it as your new best tool in the aerodynamic testing toolbox. See just how SLA can make your models sharper, your data better, and your development process smoother.



In the competitive world of wind tunnel testing, crafting high-fidelity models can be a time-consuming bottleneck. Traditional methods often struggle to keep pace with rapid design iterations and complex geometries. However, Stereolithography (SLA) 3D printing offers a game-changing solution for wind tunnel models. Learn more about how SLA can revolutionize your testing process and unlock the full aerodynamic potential of your designs.

Speed and efficiency - Traditional model-making processes often create bottlenecks due to long concept-to--testing timelines. SLA transforms weeks into days and days into hours. With quicker iteration cycles, you stay on the fast track to innovation and can respond swiftly to changing design requirements.

Precision and accuracy - Conventional methods can struggle to replicate exact design details, leading to a mismatch between your intended design and the physical model. With SLA, each model is always a faithful representation of your original design. This accuracy is critical for reliable results that you can make informed decisions from.

Cost savings - The costs associated with traditional model making, such as materials, labor, and machine operation, are significant and often limit the scope of testing and innovation. SLA technology cuts down on raw material use and reduces the need for expensive labor and machine time. By doing so, it frees up budget that can be redirected into other areas of development, increasing your innovation potential.

Complex geometries - Creating models with complex shapes and detailed features is often challenging - and sometimes impossible - with traditional manufacturing. SLA excels at producing models with complex geometries, no matter how intricate. Parts can be produced with complex pressure tapping channels, allowing for more sophisticated testing and opening the door to exploring more advanced designs that were previously out of reach.

Iterative design adaptability - Having to make quick design changes in response to testing feedback can be a logistical nightmare with traditional model-making. With SLA, engineers can rapidly modify designs and produce new models, allowing for a more agile response to test data.

Data-rich testing - Traditional wind tunnel tests can be limited by your model's fidelity, affecting the quality and depth of data you can collect. SLA produces models with more detail, allowing for nuanced airflow analysis and richer data. With this deeper understanding of aerodynamic behavior, you can make more informed design decisions.

Sustainability - With conventional modeling there is significant waste. But SLA is inherently material-efficient, using only what's necessary to build models layer-by-layer, as opposed to traditional subtractive production technologies such as CNC and machining.

Efficiency and precision in fluid dynamics

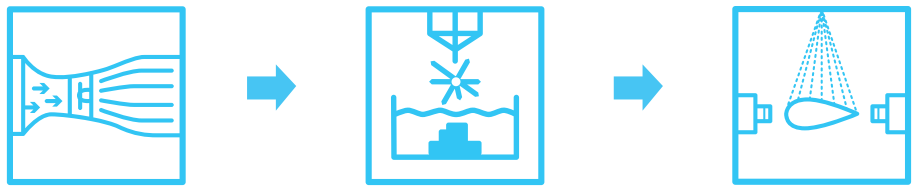
Computational Fluid Dynamics (CFD) and Particle Image Velocimetry (PIV) are software-led processes for analyzing fluid flow dynamics to optimize designs. When you incorporate SLA into these processes you rapidly and accurately refine your models, ensuring precise and efficient advancements in your aerodynamic studies.

Optimize Model Design with CFD: CFD software allows you to simulate models in a virtual Wind Tunnel, testing the aerodynamic aspects of the design. This virtual testing enables you to refine the model design before 3D printing and conducting actual tests in a physical wind tunnel. Validate and refine your simulations by printing exact part replicas, at larger sizes, for use in full-scale testing. This rapid prototyping capability is key for iterative design, making adjustments more affordable and improving accuracy in fluid dynamics analysis.

Enhance Model Testing with PIV: PIV is used for assessing and visualizing flow-regime on complex geometries using a high-energy laser and image acquisition. SLA excels in producing intricate, customized components for PIV setups, enabling detailed and accurate flow measurements. You can make quicker adjustments and more precise replicas of complex real-world fluid dynamics, which is essential for validating your experimental data against theoretical models.

Use CFD, SLA and PIV for faster iterations and more accurate results

Streamline your development cycle, improve the accuracy of your fluid dynamics studies, and reduce both costs and time to complete your projects by integrating all three.



Design and Simulation (CFD) → **Physical Model Creation (3D Printing)** → **Experimental Validation (PIV)**

Industry focus

Motorsport

SLA 3D printing streamlines high-pressure racing design by enabling rapid, on-site iteration of precision aerodynamic models.

SLA 3D printing is changing aerodynamic design optimization in this high-speed, high-pressure sector. When you can iterate designs faster, on a single site, your teams can test and refine to fine-tune the balance between aerodynamic efficiency and the overall performance of the vehicle, ensuring it's optimized for the high pressures of competitive racing.

SLA 3D printing produces detailed scale models with incredible precision - invaluable for gaining deep performance insights and easily simulate extreme conditions. The flexibility of 3D printing means you can customize these models for specific tests, allowing them to explore various aerodynamic concepts and overcome unique challenges specific to each racetrack.

This adaptability is especially critical in Formula 1 and elite racing. Without the delays and costs of traditional machining and molding, hand-modeling, wind tunnel testing becomes a dynamic, iterative process where engineers, aerodynamicists, drivers, and vehicle dynamics experts all collaborate closely for the best outcome.

Industry focus

Architecture

Stand up to the forces of nature

When it comes to preparing for wind tunnel tests, SLA shines. You can quickly create highly detailed and functional scale models that aren't just accurate; they include features like embedded pressure taps that simplify the setup for testing, making the whole process smoother and faster. That's something you can't do with traditional modeling techniques.

See exactly how air moves around a building with transparent materials. This visual insight into your models helps you to make informed decisions to improve a building's aerodynamics.

Customization is easy with SLA and 3D printing, allowing for adjustments so that models accurately reflect the specific wind conditions of where the building will stand - be it a windy hillside or a busy city street - ensuring that new structures are not only beautiful but perfectly adapted to their environments.

SLA is bridging the gap between architects, engineers, clients, and even students. By providing a physical model that illustrates complex concepts, it makes it easier for everyone to understand and appreciate the nuances of your amazing designs.

Industry focus

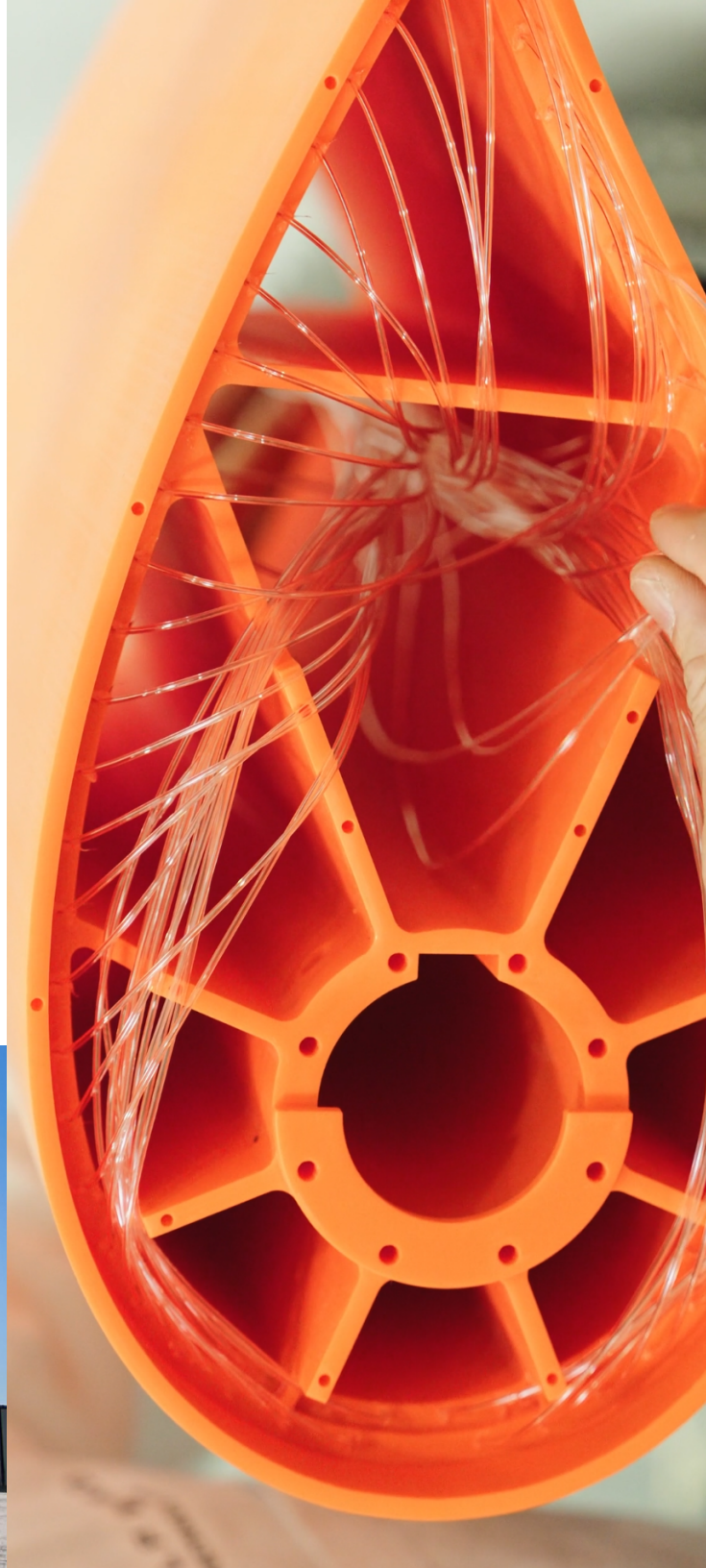
Renewable Energy

Improve energy efficiency and performance

In the energy sector, particularly in the development of wind turbines, SLA 3D printing is making significant strides in how components are prototyped and tested. Produce detailed models faster than with traditional machining - including turbine blades, nacelles, and towers, which can be moved straight into wind tunnel testing.

With the level of customization available with 3D printing, you can tailor designs specifically to the unique environments where your turbines will operate. Whether it's a salty seacoast or a gusty mountain, SLA helps you to optimize each design to perform at its best under real-world conditions.

SLA delivers all-important precision. It makes sure that every curve and contour of the turbine components is reproduced with exactness, which is critical for accurate aerodynamic profiling in wind tunnel tests. This level of detail means that simulations are more reliable, and you get the data you need to refine designs and enhance turbine efficiency.



Case Studies

Motorsport

Toyota Gazoo Racing

TGR-E, at the heart of Toyota's motorsport innovation, has teamed up with Stratasys to integrate the Neo stereolithography 3D printers into their wind tunnel modeling workflow. This partnership is turbocharging the aerodynamic testing for elite competition vehicles, like the GR010 HYBRID, thanks to the Neo's ability to produce detailed, high-precision components rapidly.

In automotive engineering, wind tunnel modeling is the key to boosting car performance, and 3D printing is leading the charge. It's all about speed and precision, and the Neo SLA 3D printer fits the bill perfectly.

It's a standout leader, crafting intricate parts with a smooth finish that nails the aerodynamic testing essentials.

The TGR-E team is making the most of it, quickly iterating designs off real wind tunnel feedback.

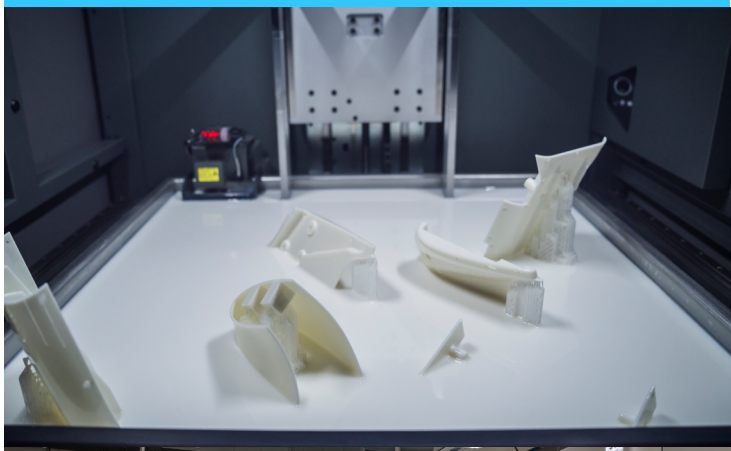
"The smooth surface and dimensional accuracy from the Neo are very good, and parts can be easily reworked. The Neo is the best SLA machine I have had the pleasure of operating in my almost 22-year career in 3D printing."

Manfred Werner - Principal Technician at TGR-E

The team selected the Somos® PerFORM™ material for its strength, stiffness and precise resolution, vital for their rigorous wind tunnel trials. Quick to print and clean, this resin delivers models with crisp details and robust builds, ideal for the thermal demands of aerodynamic testing.

"Having been closely involved in the early development of PerFORM, we knew we wanted to work with it. It's simply the best material for our needs."

Thomas Linke, Composite & Additive Manufacturing Manager at TGR-E



Case Studies

Motorsport

McLaren F1

At McLaren, innovation meets efficiency with the help of Stratasys Neo800 3D printers and Somos® PerFORM Reflect resin.

This powerful combination is revolutionizing how McLaren's Formula One cars are designed, specifically by using 60% scale models that quickly optimize aerodynamics for better balance and grip. PerFORM Reflect produces robust parts that, when paired with the Neo800's superior finish, cut down the need for extensive post-processing by more than 30%.

The Neo800's large printing bed can handle big single pieces or numerous smaller ones, ensuring every detail is captured precisely. This is critical as about 50 to 60 pressure taps integrated into the car gather vital airflow data, helping engineers make informed improvements continuously.

Cost-efficiency is another hallmark of McLaren's use of 3D printing. The ability to produce all wind tunnel models at a single site has become invaluable. It not only saves money by reducing the need for subcontractors but also speeds up the design and iteration process. The team can now quickly produce new parts and make adjustments throughout the season, all without the traditional costs and delays associated with re-machining tool blocks or creating new carbon fiber molds.

With the Neo, McLaren can maintain a nimble and responsive design cycle that keeps them competitive on the track

"Our new Neo series of 3D printers have dramatically helped to reduce the lead times of our aerodynamic wind tunnel components and projects. The large bed size of the Neo800 allows very large parts to be built quickly and to a very high level of detail, definition, and repeatability. We find the high-definition components from our Neo machines require minimal hand finishing, which allows much faster throughput to the wind tunnel."

Tim Chapman, Head of Additive Manufacturing, McLaren Racing

Case Studies

Energy

Gulf Wind Technology

In their quest for greener energy, Gulf Wind Technology harnessed the power of SLA to overcome the challenges of rotor design for wind turbines. With the Neo800 SLA printer, they're creating scale models with innovative designs that stand up to the unpredictable winds of the US Gulf Coast, delivering on both speed and precision.

Not only does 3D printing significantly streamline the design and fabrication cycle, it uniquely allows for the direct integration of pressure taps into the wind tunnel models - something that is notably challenging with conventional machining or molding. This approach directly shapes the design and manufacturing of the final, larger wind turbine blades.

The Neo's size meant large, complex parts could be printed as a single entity - along with the range of materials. The Somos® PerFORM Reflect™ material is ideal for wind tunnel testing primarily because of its strength, stiffness and temperature resistance. As well as its resilient and smooth aerodynamic surface, PerFORM Reflect reduces the cycle time to produce a test-ready model, bypassing additional finishing steps, and ensuring precise aerodynamic assessments with PIV testing.

Despite their small size, the small air channels used for the airfoil's pressure taps were also printed with integral threaded connections. "The fact that we can put a decent amount of torque on them without stripping, I think that's something that is unique with this material," Locuato added. The ability to print these ports right in the model also speeds up the process.

This technological edge isn't just about speed; it's setting Gulf Wind Technology apart in the wind energy sector. Like many who dive into 3D printing, they've found it opens doors to even more innovation, expanding what's possible.

> "Using the Neo to make the same exact airfoil, same geometry and size, was on the order of 2.5 to 5 times faster to print versus composite lay-up or CNC machining."
>
> **Joe Lotuaco**, Senior Product Developer, Gulf Wind Technology

Your blueprint for better wind tunnel testing starts with Neo SLA 3D printing

Our engineers built the Neo stereolithography printer to overcome the frustrations other engineers face using legacy SLA 3D printers in creating reliable prototypes and models for testing.

The Neo's speed, precision, and versatility continues to redefine the boundaries of aerodynamic analysis in performance manufacturing.

Maximized scale and detail

With the Neo, select the optimal scale for your wind tunnel models, striking the perfect balance between the size constraints of your testing facility and the intricacy of detail required. The Neo's expansive build volume caters to various scales, ensuring every nuance of your design is captured without compromising on fidelity.

Accuracy at all sizes

Design with confidence, knowing the Neo's fine-tuned laser system accurately reproduces complex geometries and sophisticated aerodynamic profiles. It caters to your material specifications with unparalleled accuracy, maintaining structural integrity even at minimal feature sizes - critical for capturing true-to-life aerodynamic behavior.

Strategically integrated pressure taps

Get reliable data to assess surface pressure distribution and flow dynamics by integrating pressure taps directly into your 3D models. The Neo's detailed printing allows for the precise placement with minimal post-print work of those complex channels that would be impossible with traditional methods.

Custom material selection for specialized testing

Choose from a range of SLA resins, each engineered to meet your specific testing needs - from high-temperature resistance for motorsport applications to enhanced durability for large-scale architectural models. The Neo supports a variety of resins, each providing the properties you need to accurately simulate real-world conditions.

Superior surface finish

Renowned for exceptionally smooth sidewall quality, the Neo significantly reduces the time spent on post-processing. Its high-definition capabilities ensure that the smallest aerodynamic features are printed with clarity, allowing for more accurate data capture in wind tunnel tests.

Simulate before you print

Validate your designs by coupling Computational Fluid Dynamics (CFD) with the Neo's printing capabilities. This combined approach means you can simulate, adjust, and then print models that have already been virtually tested, fast-tracking your design process.

Optimal structure orientation

Determine the best orientation for your print, factoring in structural demands and aesthetic qualities. Titanium, the Neo's versatile software, allows for meticulous configuration, ensuring that even the most complex models with integrated pressure taps or hollow sections maintain their integrity and function after printing.

Finishing models to perfection

The Neo's superior surface quality reduces and, in some cases, eliminates the need for sanding, allowing for a quicker transition from design to wind tunnel testing.

Inspect and test to rigorous standards

Before heading to the wind tunnel, perform comprehensive inspections of your printed models. The Neo produces parts with such accuracy that any defects are minimized, but meticulous checks ensure your models are aerodynamically sound and ready for rigorous testing.

With the Neo, you're ready to push the boundaries of wind tunnel modeling, driving innovation with every iteration.

Performance materials for wind tunnel modeling

Somos PerFORM and Somos PerFORM Reflect are specialized SLA resins, each offering unique properties that make them perfectly suited wind tunnel modeling. Let's take a closer look:

Somos® PerFORM™

Known for its exceptional strength and stiffness, it's an excellent choice for applications where high-detail and high-stiffness are crucial.

- **High Strength and Stiffness:** Somos PerFORM parts are incredibly strong and stiff, essential for wind tunnel models that must withstand the physical stresses of testing without deforming.
- **High Thermal Resistance:** This resin can withstand high temperatures, which can occur due to friction and air resistance in wind tunnel tests.
- **Dimensional Stability:** It offers excellent dimensional stability, so parts won't warp or change shape under varying temperatures - crucial for accurate testing.
- **Detailed Resolution:** Used with the Neo SLA printer, it's capable of producing parts with exceptional detail and accuracy - ideal for the complex geometries commonly found in automotive, aerospace, and motorsports applications.

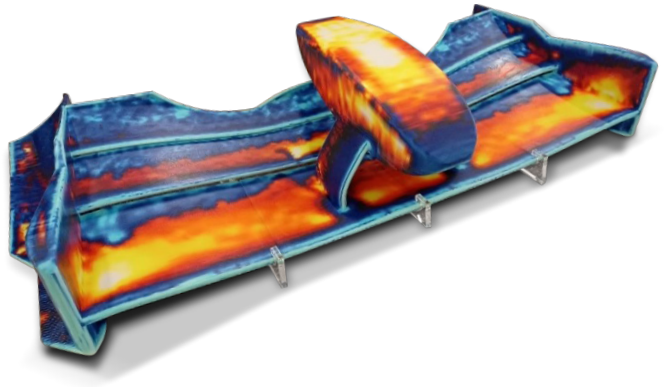
Somos® PerFORM Reflect™

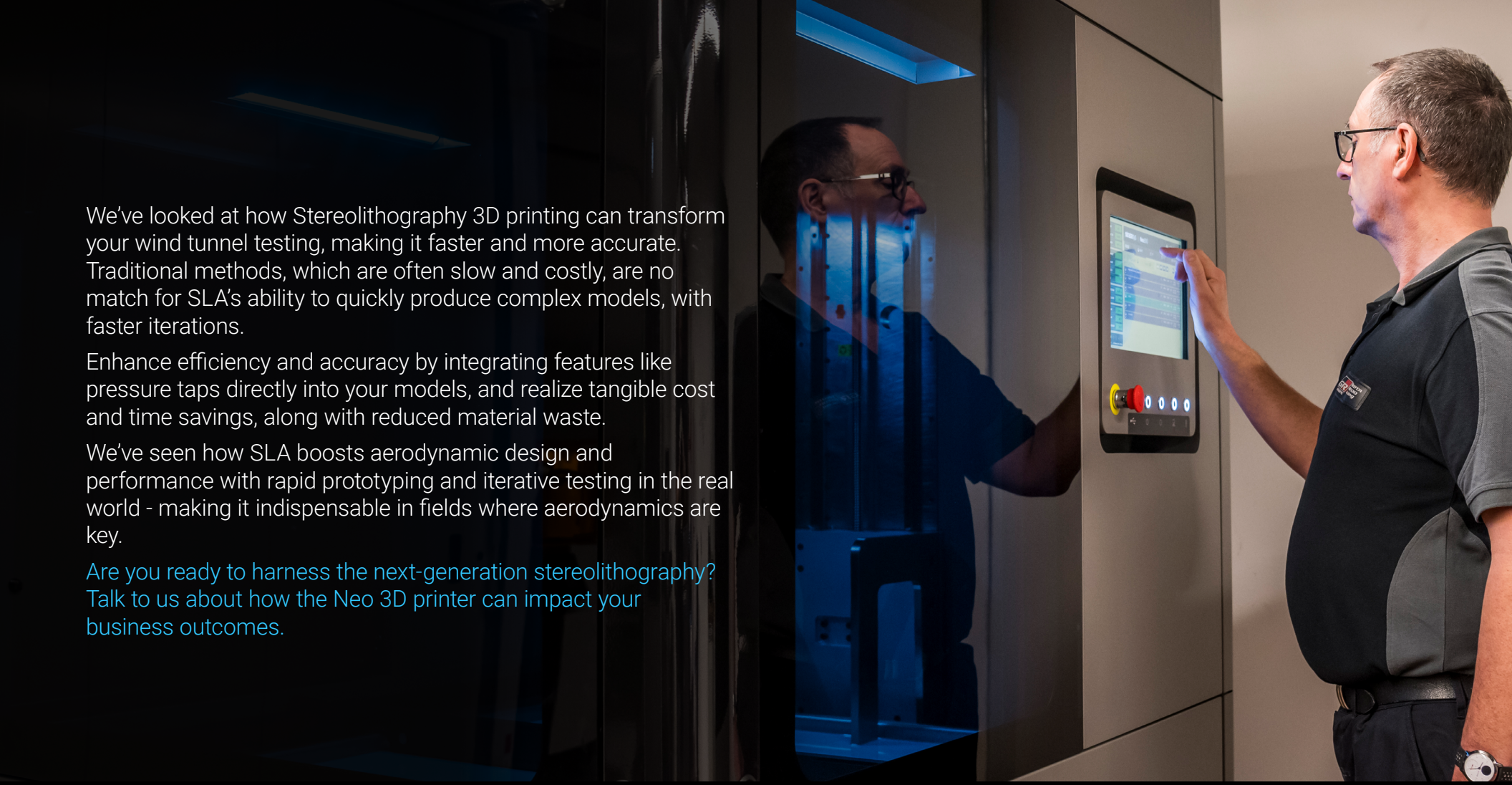
Building on the qualities of Somos PerFORM, but with extra features tailored specifically for PIV testing:

- **Minimal Post-Processing:** Designed to reduce the need for post-processing, parts printed with Somos PerFORM Reflect have a surface quality that scatters light, minimizing the glare often encountered during PIV (Particle Image Velocimetry) testing, which uses lasers to measure flow.
- **Reflective Properties:** It naturally reflects light, which is beneficial in reducing the setup time and complexity involved in applying reflective coatings to models used in laser-based aerodynamic testing.
- **Durability and Stability:** Like Somos PerFORM, Reflect offers high durability and stability, essential for maintaining the integrity of fine, detailed features under test conditions.
- **Precision in Detail:** Ensures precise replication of complex details and surfaces, crucial for accurate aerodynamic assessment.

Great materials lead to more reliable, more accurate testing

Where wind resistance and aerodynamics are critical factors, Somos PerFORM and Somos PerFORM Reflect are popular for their ability to produce accurate, robust models. Their high resolution and stability ensure that the airflow data collected is reliable and reflective of real-world scenarios, so engineers can collect highly accurate data from their tests.





We've looked at how Stereolithography 3D printing can transform your wind tunnel testing, making it faster and more accurate. Traditional methods, which are often slow and costly, are no match for SLA's ability to quickly produce complex models, with faster iterations.

Enhance efficiency and accuracy by integrating features like pressure taps directly into your models, and realize tangible cost and time savings, along with reduced material waste.

We've seen how SLA boosts aerodynamic design and performance with rapid prototyping and iterative testing in the real world - making it indispensable in fields where aerodynamics are key.

Are you ready to harness the next-generation stereolithography? Talk to us about how the Neo 3D printer can impact your business outcomes.

stratasys

Stratasys Headquarters

7665 Commerce Way,
Eden Prairie, MN 55344
+1 800 801 6491 (US Toll Free)
+1 952 937-3000 (Intl)
+1 952 937-0070 (Fax)

1 Holtzman St., Science Park,
PO Box 2496
Rehovot 76124, Israel
+972 74 745 4000
+972 74 745 5000 (Fax)

stratasys.com
ISO 9001:2015
Certified

eBook
Wind Tunel Testing