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Thick TPC wing rib: STAMPED, WELDED RIB DESIGN FOR NEXT-GEN WINGS



OCTOBER 2026

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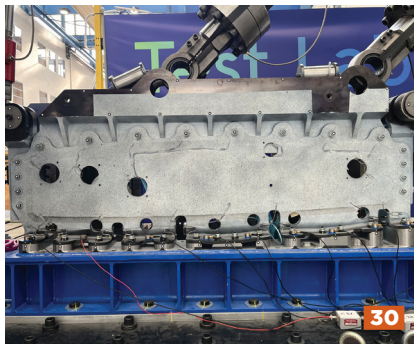
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By Stewart Mitchell



» ON THE COVER

The cover depicts Daher's Highly Loaded Thermoplastic Wing Rib and the part's evolved design, which consists of a wave shape in the lower L-section and a contoured top edge in the larger L-section that follows systems-installation holes, reducing excess material and weight. Launched in 2021, the project targets thick thermoplastic composite (TPC) ribs for next-generation single-aisle (NGSA) aircraft. Built from up to 64 plies (12 millimeters) of UD carbon fiber/LMPAEEK, the rib combines Daher's patented Direct Stamping process with LIST's patented infrared welding. Compared to machined aluminum, the rib cuts weight by 22% and compared to a TPC bolted rib, reduces the production cycle and cost by 25% and 15%, respectively, while meeting the high rates (75-100 aircraft/month) targeted for NGSA and other future aircraft.

See p. 30. Source | Daher

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SCOTT FRANCIS

EDITOR-IN-CHIEF
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Curating Your Composites Content

» I grew up in the 80s and 90s — the era of the mixtape. So naturally, I think a good mixtape or playlist can be a work of art. It takes time to sort through a collection of music, picking just the right songs and organizing them into the perfect order. It's a lot of work.

Now that I'm older and much busier, I do what many of us do — I let algorithms do the work for me. Spotify, Apple Music, Netflix and similar services have become so good at picking new music or movies based on individual interests. Busy work schedules, business travel, responsibilities and commitments have made these kinds of tools almost essential for staying in step with the world around you. Membership services have become more than just a subscription, more access, discounts or add-ons. What you're actually paying for is a service that knows you well enough to make that library feel smaller and more personalized by directing you straight to the things that really matter to you.



Source | Getty Images

CompositesWorld (CW) editors are constantly thinking about the brand's own curated membership model and the ways we serve the composites community. The way we all consume information has changed, and it keeps changing. The old publishing model of putting information out into the world and letting your audience find it is no longer viable. Readers today are pulled in more directions and have less time than ever to sort through it all.

Over the past few years, we have been working to refine our platform to offer you a more tailored experience and help you find what you care about and get there faster, whether you're exploring material systems, processes or trying to understand markets or gain insights from new applications.

Part of that means broadening what we cover and how we organize it. You may have already seen this via the growth and evolution in our column and content types, covering topics like:

- Design, testing and simulation.
- AI and machine learning.
- Finishing and fastening processes, including machining, coatings, bonding and welding.
- Troubleshooting composites materials and processes.
- Insights into global material markets.
- Startups, investors and the ecosystem of innovation.

Expect to see others take shape, each one built around a particular slice of this industry.

Notably, many of these new columns and insights are being shaped by contributed content from the engineers, designers, technicians, researchers and experts performing this work in the field. We believe original reporting from our editors, paired with focused columns and expert voices from across the composites industry, is one of the best ways to inform you and enrich CW's digital and print pages.

However, none of this works without you. Our membership model — a free website account that tailors what CW sends your way instead of treating every reader identically — exists to make that curation possible. If you haven't set one up yet, make sure to visit the www.compositesworld.com homepage and start an account by clicking the top right-hand corner. It only takes a few minutes, and it is the clearest way to tell us what you want more of.

CW is proud of its history serving the composites community and we're excited about where we're going. Media will keep changing, and so will we, but the goal stays the same — to help you find what you need quickly and keep you informed of the latest news, trends and innovations, and to give you insight into where the composites industry is headed next. Consider this an open invitation to continue that journey with us. **CW**



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Joining the CW Community: Contributions and Membership

By Grace Stubbins / Senior Managing Editor

» The composites industry is dynamic and continuously changing. The *CompositesWorld* (CW) editorial team understands this and constantly looks at how to better present the latest developments to our global audience using a range of media channels: online, print, social media, video, podcasts and more.

As the pace of development has continued to increase, CW has also increased its use of contributed content from our readers and industry members. We still maintain editorial oversight, but we value these interactions and your collaboration in helping CW to cover the industry's topics, tell its stories and build its foundational knowledge. The different perspectives and technical expertise that your contributions bring to our platform are important to share and improve us as an industry.

Joining the CW community is a two-way exchange

So, how can you interact with us, and continue bringing value to our wide range of content? The first step — if you aren't already — is to consider subscribing for free to CW, which includes our CWToday and CWSpotlight newsletters and monthly digital magazine. A next step would be to become a CW member. Make a free account login to our website homepage, which will enable you to access all original and contributed article content at any time, save items for later, maintain your search history and more.

Another step is to consider contributing content, which is also free. This goes beyond new product announcements and press releases, giving you the chance to share your expertise, your company's latest developments and perspectives on real-world applications and technologies impacting composites. CW offers a variety of ways to do this and works closely with authors to ensure the final product meets our established bar for high quality and technical content. It should be noted that as part of this process, all contributed content is vetted by CW editors to determine its suitability for CW readers.

CW has received and published a variety of guest-authored content over the last few months. Each addresses a different aspect of our industry, but with the quality and detail that we prize:

AI Control Enables Faster, More Even Infrared Heating for Complex TPC Parts

KraussMaffei develops high-resolution, smart heating for load-optimized tailored organosheets and blanks, enabling consistent, high-rate production of complex thermoplastic composite and overmolded parts.

WHY IT WORKS:

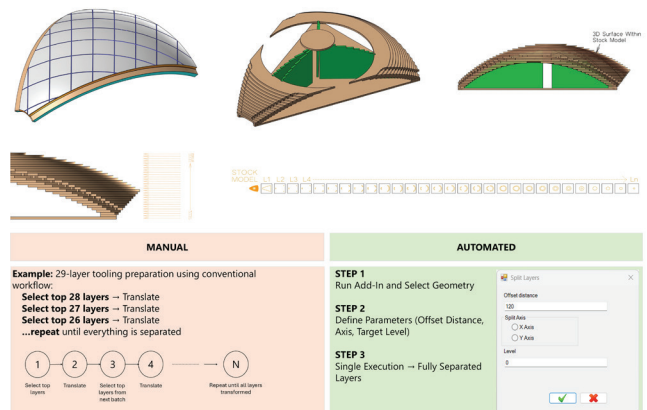
- This article gives a new angle to the AI conversation, explaining how it is being used to achieve new efficiency gains in complex composites manufacturing.
- How the company's technology works, and how and why AI tools were considered and implemented are clearly described.
- Specific projects or examples within industry are provided to further contextualize the technology and demonstrate how it is advancing work with composites.

Automating Layer Preparation in Composite Tooling Workflows

Rule-based add-in for CAM workflow automates sliced layer preparation for CNC-machined molds, cutting 10 seconds per layer to 10 seconds per mold for scalable, high-volume custom tooling production.

WHY IT WORKS:

- This article deals with a digital workflow that can speed tooling for architectural applications, but it could also be applied to boats or other large composites.
- The author's discussion provides almost a 101 on how these large molds can be designed and built, explaining the layer preparation process in a clear and transparent way with real-world project examples.
- Although many people might not have heard about this custom CAM software utility for CNC operations, it has been implemented and validated across more than 1,000 molds and could be a helpful solution.



Source | Saumil Patel

From Aerospace to Infrastructure: Mapping FRP's Adoption in Mainstream Markets

Scott Reeve, founder of Composite Advantage, shares insights from more than two decades of ventures that helped prove the viability of FRP composites in infrastructure, waterfront and rail. A new chapter with Creative Composites Group signals the next phase of growth for established technologies and new FRP products.

WHY IT WORKS:

- The piece is contributed by a true industry veteran who provides a valuable perspective on both history and next steps for his end market.
- It strikes a balance between celebrating the company's own achievements and offering advice relatable to a larger industry audience.
- The article takes an honest approach to walking through what technologies and applications worked, and which didn't and ultimately evolved into something else.

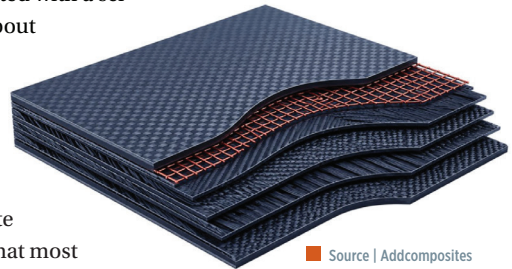


Beyond LSP to an Architected AFP Multifunctional Conductive Layer

Lightning strike protection has traditionally been achieved via single sheets of metallic materials potentially compromised by paint while AFP provides a path toward tailored conductivity and connectivity plus multifunctionality.

WHY IT WORKS:

- This topic continues to be of interest to many CW readers, and the author is putting forward a novel approach.
- The author started with a scientific paper about paint's effect on lightning damage and how it manifests in a CFRP laminate — something that most of us probably hadn't read — and then envisioned a way to tailor not only LSP but also multifunctionality.
- CW appreciates discussions about new developments that could possibly lead to further improvements for the industry.



Submit your ideas

If you have expertise, a lesson learned, a perspective worth sharing or a deep dive into a process, consider pitching your idea to CW editors. We have columns that focus on AI, design, testing, simulation, processes like machining, fastening and coatings, 101 content, global markets and more, but our articles truly span practically every aspect of the composites industry. Outside of contributed content, companies and individuals are also still welcome to continue pitching stories, podcast ideas, etc. that are authored by CW editorial staff.

- Visit our online submissions page for topic guidelines and expectations on images and use of AI: www.compositesworld.com/articles/compositesworld-editorial-submission-guidelines
- Pitch your story to press@compositesworld.com with a clear topic outline.

Thank you for being a CW reader. We look forward to hearing from you! **CW**



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THE COMPOSITES PODCAST

EPISODE 58: Jason Gibson, IACMI

» This episode of *CW Talks* features host Scott Francis, editor-in-chief of *CompositesWorld*, in conversation with Jason Gibson, chief commercialization officer at IACMI – The Composites Institute. Gibson discusses National Composites Week, IACMI's role within the Manufacturing USA network, the scale-up hurdles that stand between a promising composites technology and full production, and an open house at IACMI's Scale-Up Research Facility (SURF) in Detroit.

CompositesWorld (CW): You stepped into the chief commercialization officer role at IACMI a little over a year ago. How does your background moving composites technology out of the lab and into the market shape the way you think about commercialization at an institute like IACMI?



■ Jason Gibson, chief commercialization officer, IACMI. Source (All Images) | IACMI

Jason Gibson (JG): I've been fortunate to spend my career at the crossroads between technology and market adoption — whether it was thermoplastic composites [TPC], graphene-enhanced resin systems, advanced defense materials or other emerging technologies. The common challenge has always been the same: How do you bridge the gap between a promising innovation and a commercially viable product? One of the biggest lessons I've learned is that technology alone doesn't create markets. Successful commercialization requires alignment

among material suppliers, equipment manufacturers, OEMs, workforce capabilities and end-user demand.

That experience translates well to IACMI, because our role is fundamentally about accelerating adoption. We help reduce risk for companies by providing access to technical expertise, large-scale manufacturing assets, demonstration projects and industry partnerships. I approach commercialization through the lens of solving real manufacturing and business challenges, not just proving technical feasibility. Ultimately, success is measured when a technology creates jobs, strengthens supply chains and becomes part of everyday manufacturing.

CW: Can you talk about IACMI's mission and its role in the Manufacturing USA network?

JG: IACMI's mission is to improve products, processes and people's lives through composites innovation and workforce solutions that secure America's position as a global leader in advanced manufacturing. We focus on two basic principles: products and people. On the product side, we do R&D in advanced manufacturing processes and materials; on the people side, we develop the workforce needed to deploy them. While we're known as a composites institute, our impact extends well beyond composites through workforce programs and partnerships that support the broader advanced manufacturing ecosystem.

As part of the Manufacturing USA network, we bring together industry, academia, government and national labs to accelerate innovation, commercialization and talent development. We believe technical innovation plus workforce development equals economic impact — and we've seen that equation play out again and again across our facilities.

CW: Can you talk about some of IACMI's partnerships and how those organizations work together?

JG: IACMI was founded by six institutes that we work through to do our research: Oak Ridge National Laboratory, the University of Tennessee, Purdue University, the University of Dayton Research Institute, our CoMET facility in Colorado and our Scale-Up Research Facility [SURF] in Detroit. Together, that's more than \$400 million in equipment assets available for research and testing, an incredible capability we offer to our membership.

It's a great proving ground for taking new technologies, getting them validated and then presenting them to the rest of our membership [who are] the OEMs and other companies that might be interested in bringing them forward to commercialization.

CW: National Composites Week ran Aug. 24-28 this year under the theme "Composites Built to Scale." What does that theme mean with respect to what you're seeing across IACMI's membership right now?

JG: The theme is especially timely. For years, the conversation around composites focused on what was possible — how do you

make things with composites? Today, that conversation is increasingly about how quickly and efficiently we can produce these materials and products at industrial scale. Across our membership, we're seeing strong interest in high-volume manufacturing, automation, supply chain resilience and cost-effective processing technologies, in industries ranging from automotive and energy to infrastructure and defense. The question is no longer whether composites can deliver the required performance; it's how to manufacture those solutions at the speed, consistency and cost the market demands.

That's exactly where IACMI operates. We help members bridge the gap between innovation and production by validating processes, demonstrating manufacturability and reducing commercialization risk. You'll hear people in the industry talk about the "valley of death" — the gap between technology readiness level [TRL] 4 and 7 — where good technologies die before they're commercialized because companies can't test and validate them at scale. If a member has an innovative material or process but doesn't want to spend \$20 million on a 4,000-ton press or build a large injection molding line, we give them access to that equipment so they can validate at scale. That's of real interest to our larger members, like Boeing, Ford and Airbus.

CW: IACMI had an open house for the SuRF facility in Detroit in early September. What did visitors see, and why was now the right time?

JG: We were excited to offer companies attending the SPE ACCE [2026] show in Detroit the opportunity to visit SuRF and get a firsthand look at what we're doing there. Visitors met our director, Dr. Ray Bowman, along with key team members including Dave Okonski and Doug Bradley, who bring decades of industry experience. It's one thing to talk about advanced manufacturing and composites scale-up — it's another to see the equipment, the footprint and the production capabilities in person. The facility is designed to help companies bridge the gap between innovation and commercialization, and with so much industry interest

in advanced manufacturing right now, it's an ideal time to open our doors and show how SuRF can help companies accelerate their next-generation programs.

Our communications team also highlighted "Composites Built to Scale" examples throughout National Composites Week across our social media channels, showing real examples of companies we've worked with to take technologies from development to scale.

CW: Tell us about SuRF itself — the capabilities and the kinds of projects it's designed for.

JG: SuRF is approximately 80,000 square feet of advanced manufacturing capability focused on composites innovation. We have large-scale compression molding, including a 4,000-ton Schuler press modified for fast closing speeds so we can run thermoplastics as well as BMC and SMC compression molding. We also have high-pressure resin transfer molding [HP-RTM] equipment from Cannon, three injection molding machines up to 3,000 tons, prepreg manufacturing, automated layup technology and product validation capabilities.

What makes the facility special isn't any single piece of equipment, but the ability to integrate these technologies into an end-to-end manufacturing solution. Projects range from lightweight automotive structures and battery enclosures to next-generation material systems, process qualification and manufacturing validation programs. Companies can test new materials, optimize production processes and evaluate economics before committing to full-scale deployment.

CW: IACMI is involved in several workforce development campaigns. What would you like people to know?

JG: Workforce development remains one of our highest priorities. The composites industry has tremendous growth opportunities, but long-term success requires a strong talent pipeline. Through initiatives like America's Cutting Edge, our K-12 outreach, industry training programs and educator engagement, we're working to expand awareness of advanced manufacturing careers and create more accessible pathways into the industry. National Composites Week is a great platform to showcase not just the technology, but the people behind it. We want students, educators, veterans and experienced professionals to recognize that advanced manufacturing offers exciting, high-impact career opportunities. **CW**

+ LEARN MORE

Scan the QR code to listen to the complete interview online.



■ Shown here is a Proxima Autocell in operation at IACMI's SuRF facility.



AI Control Enables Faster, More Even Infrared Heating for Complex TPC Parts

By **Eugen Schubert** / Sales & Applications Manager IMM, Automation, KraussMaffei Corp.

» For nearly two centuries, KraussMaffei has been helping manufacturers push the boundaries of industrial production. Founded in Munich, Germany, the company has established itself as a global technology leader in injection molding, automation and plastics processing. Over the years, however, the demand for lighter, stronger and more sustainable products encouraged it to look beyond conventional plastics and explore the possibilities of advanced composites.

As automotive manufacturers sought alternatives to steel and aluminum, aerospace companies pursued higher levels of lightweighting and industrial manufacturers searched for stronger and more efficient structures. As a result, over time, continuous fiber-reinforced thermoplastic composites (continuous fiber TPC) have emerged as one of the most promising material platforms. Unlike thermoset composites, thermoplastic composites (TPC) offer short processing times, excellent impact resistance, weldability and the potential for recycling. These characteristics make them especially attractive for high-volume production environments where manufacturing speed is often as important as structural performance.

Recognizing this opportunity early, KraussMaffei developed FiberForm, an integrated manufacturing technology that combines TPC forming and injection molding within a single automated production cell. What began as a novel approach to hybrid lightweight structures has evolved into a proven industrial manufacturing platform used in automotive, sporting goods and aerospace applications.

FiberForm: Combining composites and injection molding

The FiberForm process was developed around a simple but powerful concept: Combine the strength and stiffness of continuous fiber TPC laminates with the design flexibility and functional integration capabilities of injection molding.

The process consists of six automated manufacturing stages:

- Organosheet pickup
- Infrared heating
- Transfer into the mold
- Thermoforming
- Injection overmolding
- Part removal



■ An IR oven with mixed IR-transmitters is installed here on a KraussMaffei injection molding machine. Source (All Images) | KraussMaffei

Integrating these operations into a single manufacturing workflow, FiberForm enables highly efficient production of hybrid structures that combine continuous fiber reinforcement with molded ribs, bosses, attachment points and other functional features.

Unlike many composites manufacturing technologies that require dedicated equipment and lengthy processing cycles, FiberForm can be integrated into standard KraussMaffei injection molding platforms. This compatibility has helped accelerate adoption because manufacturers have the opportunity to leverage existing automation and molding expertise while gaining the structural benefits of TPC.

Demonstrating industrial scalability

The maturation of FiberForm can be measured through the progression of its applications. Early programs focused on validating the manufacturing concept and demonstrating that continuous fiber TPC structures could be integrated into production environments. These applications typically involved specialty products with relatively modest production volumes.

One example was the Marker Kingpin ski binding (at right), a demanding sporting goods application that required high stiffness, durability and low weight. FiberForm enabled the integration of continuous fiber reinforcement with highly engineered overmolded features, demonstrating that hybrid composite structures could be manufactured economically at annual volumes approaching 100,000 units.

The technology subsequently advanced into automotive production programs. A major milestone was the Mercedes-AMG GT

seat shell (p. 12), manufactured using a FiberForm production cell combining a TPC organosheet with glass fiber-reinforced over-molded features. The resulting design achieved more than 36% weight savings while meeting demanding structural performance requirements and integrating metallic inserts directly into the manufacturing process.

Another significant program was the Ford *Focus* door module carrier (p. 12), developed through collaboration with mechatronic supplier Brose (Coburg), auto company ElringKlinger (Dettingen an der Erms, Germany) and KraussMaffei. This application demonstrated that TPC technology could meet automotive requirements for productivity, quality and consistency while delivering meaningful lightweighting benefits. This project also illustrated FiberForm's ability to transition from development concepts into true industrial-scale manufacturing.

Today, FiberForm applications range from low-volume specialty products to manufacturing programs producing more than 1 million parts annually. This progression reflects not only increasing confidence in TPC but also the robustness of the manufacturing platform.

The emergence of tailored organosheets

As FiberForm matured, designers began pursuing increasingly sophisticated composite architectures.

Rather than using uniform laminates with consistent thickness across an entire component, engineers started applying load-path optimization methodologies inspired by nature and enabled by advanced simulation tools. Material could be placed only where structural loads demanded reinforcement, reducing weight while maintaining performance.

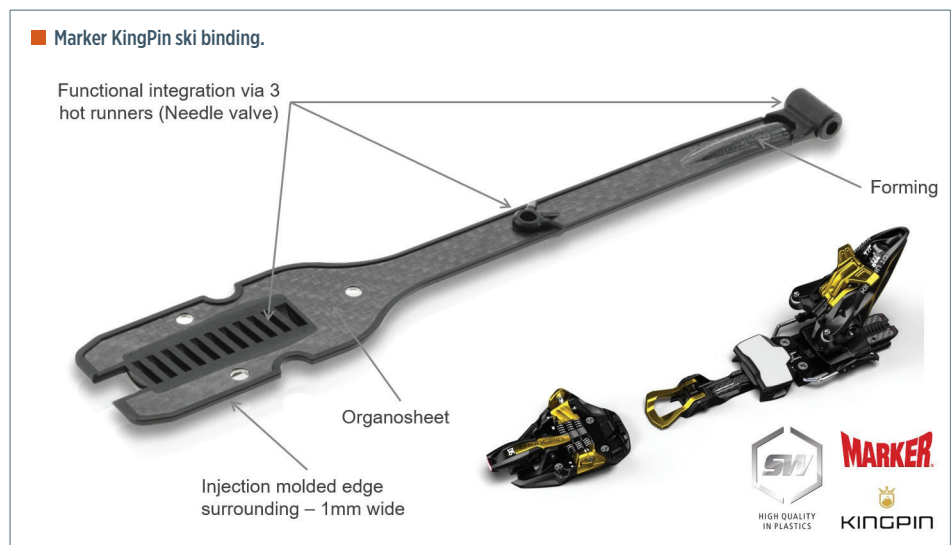
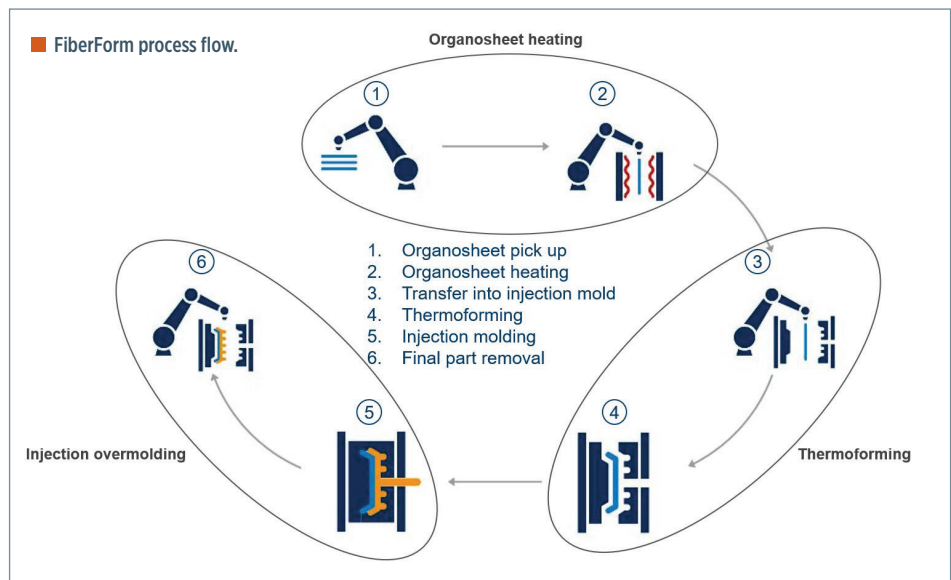
The result was the emergence of tailored organosheets incorporating:

- Variable wall thicknesses
- Local reinforcement patches
- Hybrid material combinations
- Recycled carbon fiber reinforcements
- Loadpath-optimized laminate configurations.

These engineered semi-finished products create tremendous opportunities for improving stiffness-to-weight ratios and reducing material use. They also support sustainability objectives through optimized material utilization and the incorporation of recycled materials. However, these benefits come at a cost: thermal complexity.

Why heating suddenly became difficult

For many years, heating was viewed as a relatively straightforward stage of TPC processing. Conventional infrared ovens were developed around homogeneous laminates where material properties and thickness remain relatively constant across the blank. Under those conditions, uniform energy input produces acceptable temperature distributions and consistent forming results. Tailored organosheets fundamentally change this situation. »



■ Mercedes AMG-GT seat shell (top) and Ford door module carrier (bottom) are key illustrations of FiberForm's ability to meet automotive rate, quality and performance prerequisites.



the thickest regions while avoiding overheating thinner sections. The challenge is compounded by the chimney effect that occurs in vertical ovens. Because hot air naturally rises, portions of the organosheet located near the top of the oven tend to heat more quickly than those positioned lower in the system. While manageable for simple laminates, this behavior becomes increasingly problematic as part complexity increases and process windows narrow.

Historically, manufacturers have addressed these challenges through longer cycles, conservative temperature settings and wider process tolerances. But these approaches reduce productivity and limit design freedom.

Developing OsTOS

Recognizing that tailored organosheets required a new approach, KraussMaffei and ITA Augsburg (technical university in Augsburg, Germany) began developing the Oven System for Tailored Organo Sheets, known as OsTOS.

Rather than treating every square inch of a composite blank identically, OsTOS approaches heating as a highly localized and dynamically controlled process. The objective is not merely to heat the part but to bring every region to the correct processing temperature at precisely the right time.

To achieve this goal, OsTOS combines three key technologies:

- High-resolution infrared heating
- Thermographic process monitoring
- AI-supported process control.

Together, these technologies create a smarter, more adaptive heating environment capable of handling increasingly sophisticated organosheet designs.

A central innovation within OsTOS is the transition from traditional infrared emitters to a high-resolution spot-heating architecture. Conventional ovens typically employ relatively large heating zones. While effective for many applications, these systems offer limited ability to tailor heating profiles to local material conditions.

The KraussMaffei approach uses individually controllable spot emitters that provide approximately 25X greater control resolution than traditional systems. This enables localized energy input precisely where it is needed. Reinforcement patches receive additional

A locally reinforced region possesses significantly more thermal mass than a surrounding thin section. Multiple laminate architectures may exist within the same component. Different materials absorb and retain heat differently. As a result, different regions of the part demand different amounts of energy to reach the desired processing temperature.

Manufacturers using conventional heating systems often encounter a familiar dilemma: How to apply enough energy to fully heat

■ Nature is often used as a role model for design complexity. The leaf at left, for example, enables the development of steel designs with tailored thickness (center) and tailored FRP organosheets (right).

Nature as a role model



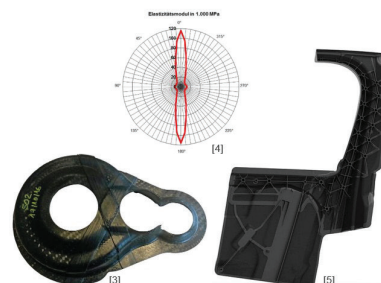
Industrialized metal construction

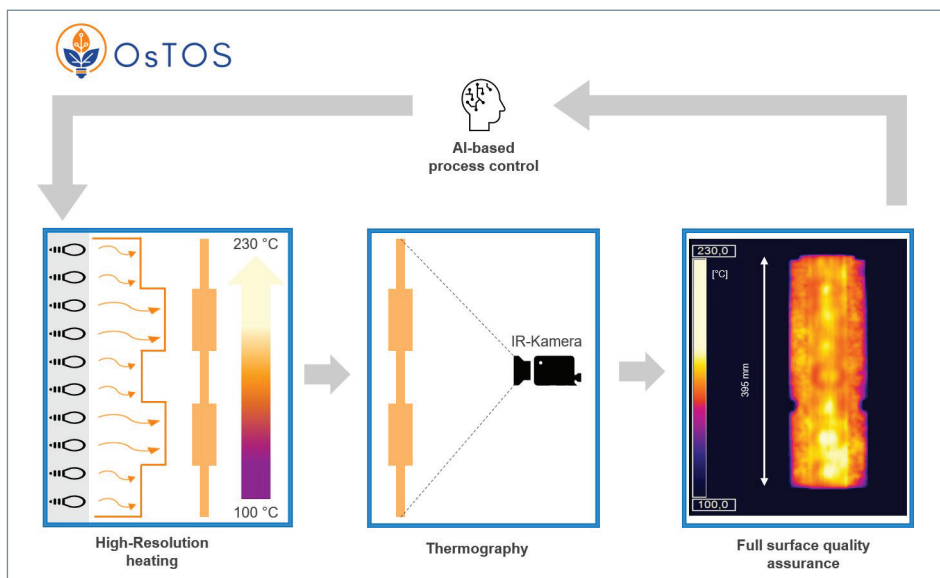
Steel design with tailored thickness



Fiber-reinforced plastics

Tailored organo sheets





■ The OsTOS concept is an advancement of the FiberForm system, bringing together localized heating with AI-supported process control.

traditional systems — typically relying on pyrometers to monitor individual points within the oven — through the integration of thermographic cameras. Instead of seeing only a few measurement points, operators gain visibility across the entire organosheet surface. Thermal images are generated both before and after heating, creating comprehensive insight into temperature distribution and process behavior.

This full-field monitoring helps identify disturbances, validate heating performance and provides the data necessary for advanced process optimization.

energy while thinner sections receive less. The resulting temperature profile more closely matches the thermal requirements of the actual part geometry.

This capability becomes especially valuable when processing heavily optimized structures where local laminate variations would otherwise create significant temperature gradients.

Notably, OsTOS also expands the sensor landscape of

Synchronizing temperature arrival

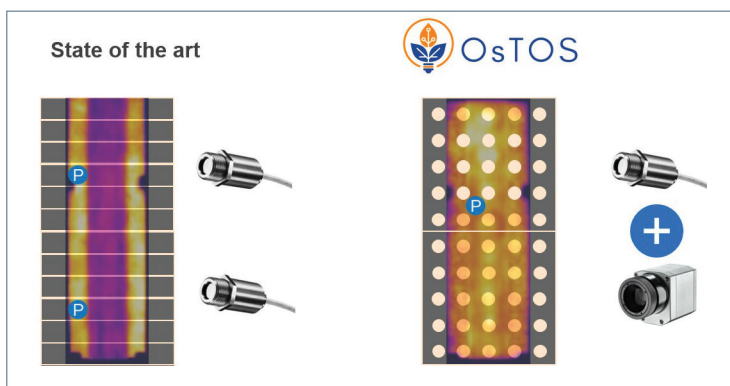
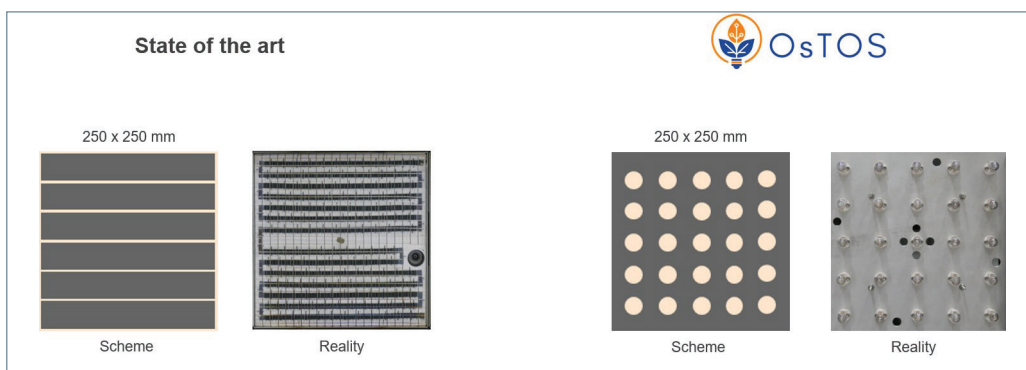
OsTOS also addresses the challenges faced when ensuring that all regions of a TPC part reach processing temperature simultaneously via the system's heating zone synchronization and dynamic

adjustment of local energy input throughout the heating cycle. The objective is to ensure that all critical regions approach the target temperature together, so that engineers don't have to choose between waiting for slower regions to catch up or risking thermal overshoot in faster-heating sections.

In conventional systems, some areas may reach the target temperature early while others remain comparatively cool. This synchronized

approach improves thermoforming consistency, reduces thermal gradients and creates more stable processing conditions.

Internal development work has demonstrated improvements in temperature homogeneity, reducing variation from approximately 15°C to approximately 5°C across the heated blank. Such improvements directly »



■ Comparison of a large heating zone versus an OsTOS emitter with 25X higher resolution (top) and a system comparison with a visualized heat gradient (bottom).



■ A comparison of conventional and OsTOS heating results demonstrate the latter's ability to intelligently preserve thermal consistency.

influence forming quality, dimensional stability and process repeatability.

Self-learning process control

Perhaps the most significant advancement lies in the integration of AI. Rather than relying exclusively on fixed recipes, the OsTOS platform incorporates a multistage learning strategy.

First, the system learns the behavior of the oven itself. Next, it learns the thermal behavior of a specific organosheet configuration. Finally, it continuously refines process parameters during production using comparisons between predicted and measured thermal responses. This creates a self-learning process capable of adapting to changing conditions.

If a temperature target is consistently exceeded, heating behavior can be adjusted automatically. If environmental factors affect thermal performance, compensation can occur without extensive operator intervention. As additional production data becomes available, model accuracy improves and process control becomes increasingly refined.

The result is reduced setup time, fewer teach-in cycles and improved process consistency.

Why FiberForm uses vertical infrared heating

A common question concerns KraussMaffei's continued use of vertical infrared heating within FiberForm systems. The answer is largely driven by automation and manufacturing efficiency.

Vertical heating systems occupy a smaller footprint while supporting double-sided heating of the organosheet. The geometry also integrates naturally with robotic handling systems, enabling efficient transfer between heating and forming operations. Minimizing transfer time is particularly important because it helps preserve thermal consistency and reduce temperature loss.

Furthermore, the vertical arrangement simplifies cell layout and enhances accessibility for automated handling systems operating within high-volume production environments.

The challenge, of course, is managing temperature gradients associated with natural heat rise. This is precisely where OsTOS' intelligent control strategy provides value by actively compensating for such effects during the heating process.

The future of intelligent composites manufacturing

The development of OsTOS reflects a broader transition occurring throughout advanced manufacturing, where the goal is increasingly not just faster production but also deeper process understanding, digital traceability and predictive

control. Heating systems are becoming data-generating assets capable of contributing valuable information to broader manufacturing intelligence platforms.

Future TPC cells will likely integrate heating, thermoforming, overmolding and quality assurance within connected digital ecosystems. Process data generated at every stage will support predictive maintenance, adaptive process control and accelerated qualification of new applications.

For TPC, this evolution is especially important. As materials become more sophisticated and designers continue pushing the boundaries of lightweighting, manufacturing systems must become capable of handling increasing complexity rather than avoiding it.

By combining decades of FiberForm experience with high-resolution heating, thermographic monitoring and AI-supported process control, KraussMaffei is demonstrating how advanced thermal management can help unlock the next generation of TPC production. What was once considered a simple heating step is rapidly becoming one of the most important enablers of high-performance, high-volume composites part manufacturing. **CW**



ABOUT THE AUTHOR

Eugen Schubert is a seasoned expert in injection molding with over 20 years of experience. Currently with KraussMaffei (Florence, Ken., U.S.), Schubert specializes in technical parts, particularly in composites and system solutions that integrate various processes, including injection molding and extrusion for direct compounding, and innovative technologies like ColorForm and FiberForm. In July 2023, he relocated from Germany to the U.S. to spearhead the introduction and transfer of KraussMaffei's latest technological advancements to the North American market. His extensive knowledge and hands-on expertise make him a leading voice in the industry.

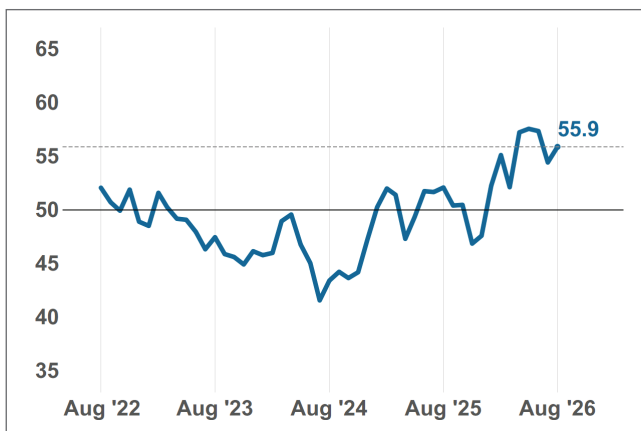


ABOUT THE AUTHOR

Mike Shirk, senior market research analyst, has been an essential part of GROW Industrial Intelligence for more than 8 years and has led research and analysis in various industries.
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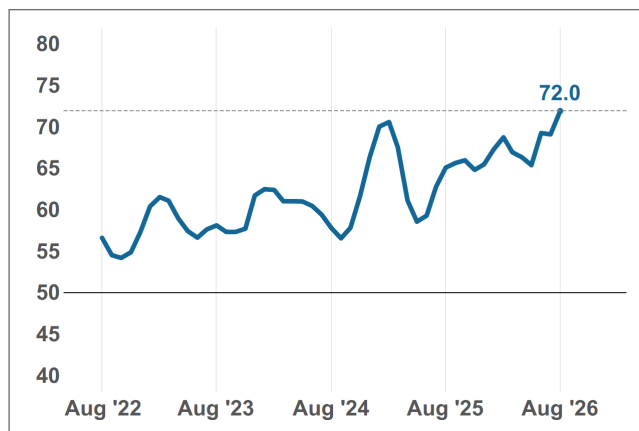
Composites Index Rebounds as Expansion Streak Hits Eight Months

COMPOSITES FABRICATING



The Gardner Business Index (GBI) is an indicator of the current state of composites fabricating considering survey responses regarding new orders, production, backlog, employment, exports and supplier deliveries. Over 50 is expansion. Under 50 is contraction.

FUTURE BUSINESS



GBI Future Business is an indicator of the future state of the composites fabrication market considering industry respondents regarding their opinion of future business conditions for the next 12 months. Over 50 is expansion and under 50 is contraction.

SCORECARD

	Change vs	
	Month Ago	Year Ago
Supplier Deliveries	▼	▲
Production	▲	▲
New Orders	▼	▲
Backlog	▼	▲
Employment	▼	▼
Exports	▼	▲

The Gardner Business Index (GBI) Components Scorecard reports the monthly change rate of primary composites market factors contributing to the overall monthly index reading.

READING THE SCORECARD:

Color indicates *where* a component value falls relative to 50 for the current month. Green is expansion; red is contraction.

Shade indicates a value's distance from 50; the darker the shade, the farther from 50.

Direction indicates a value's change versus the previous time period. Pointing up is always better.



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TRENDS

A half-day program brings CW's Carbon Fiber conference programming to Europe; KBC Corp. brings carbon-ceramic brakes to professional motorsports; Dufour's Aero-200 uses Axalp custom folding propeller blades; four filament-wound CFRP/metal hybrid legs supported Europe's fully fueled Themis T1H demonstrator; and more.

CARBON FIBER

CW, International Composites Summit Announce Carbon Fiber Track for 2026

CompositesWorld, a brand of Gardner Business Media (Cincinnati, Ohio, U.S.), and the International Composites Summit (ICS) have announced a new collaboration that will bring a half day of Carbon Fiber conference programming to ICS 2026, taking place Dec. 1-2, 2026, at The Drum in London. The partnership marks the first time CW's Carbon Fiber content will be presented as part of a European event, extending the must-attend conference for composites professionals in the U.S. to an international audience.

The new Carbon Fiber track at ICS will explore the latest trends and innovations in carbon fiber processes and applications, with sessions covering carbon fiber use across a range of end markets, including aerospace, defense, mobility, renewable energy, infrastructure and more. The program will feature the same caliber of technical, market-focused content that has distinguished CW's Carbon Fiber conference over the years as a leading forum for the carbon fiber supply chain.

"While Carbon Fiber has always welcomed international attendees, we are excited to bring the conversation to ICS

and make the event even more accessible for European attendees," says CW editor-in-chief Scott Francis. "As we continue to grow our Carbon Fiber event series through both in-person and online offerings, extending the conference seems like a natural next step. Our goal is — and has always been — to help educate, inform and connect industry leaders and innovators throughout the carbon fiber supply chain."

"ICS has always been about bringing the whole composites value chain together, so the collaboration with *CompositesWorld* feels like a very natural fit," adds Gemma Hardy, managing director, Fluency Business Group, which organizes ICS. "Carbon fiber is fundamental to so many of the markets our community works across, and bringing this established conference content into ICS gives attendees access to even more technical insight, market intelligence and industry expertise in one place. We are building ICS around what the industry tells us it needs, and this partnership is a great example of that. I'm really looking forward to seeing the conversations and opportunities it creates."

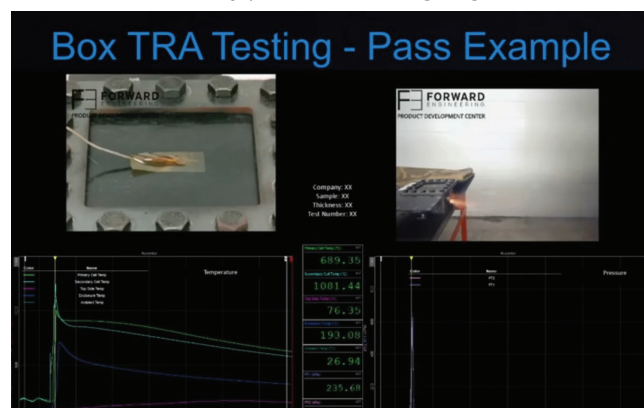
AUTOMOTIVE

Forward Engineering Box TRA Testing Evaluates Battery Enclosure Fire Protection

Forward Engineering North America (FENA, Oak Park, Mich., U.S.) recently highlighted its Box Thermal Runaway (Box TRA) test, describing the method's use in evaluating fire protection materials — including composite, metallic and multi-material battery enclosures — under representative thermal runaway conditions.

According to the company, the Box TRA Test is designed to evaluate a range of battery-related materials: thermal insulation materials; fire barriers and intumescent materials; composite, metallic and multi-material enclosure materials; and gap fillers, thermally conductive adhesives and thermal interface materials. Forward Engineering says the test measures temperature and pressure response throughout a simulated thermal event, allowing engineering teams to assess whether a candidate material limits heat transfer and

maintains structural integrity against defined performance criteria before battery pack-level testing begins.



MOTORSPORTS

KBC Corp. Brings Carbon-Ceramic Brakes to China Endurance Championship

KBC Corp. Ltd. (Yiyang City, Hunan Province), a China-based advanced carbon fiber composites manufacturer, has been named an official partner of the 2026 Xiaomi China Endurance Championship (CEC) season. Through the partnership, KBC is bringing its carbon-ceramic brake technology, already used in several high-performance production vehicles, to professional motorsport. Under the partnership, KBC Corp. will provide a dedicated carbon-ceramic brake package for CEC race cars and work with the series on race support, technology development and brand promotion.

The race-specific brake system is designed to withstand the sustained high temperatures and repeated braking cycles encountered in endurance racing. According to KBC, the system can withstand more than 400 minutes of

application environment for its carbon-ceramic technology. The demanding conditions of endurance racing also provide an opportunity to further evaluate the material and brake system under sustained high-temperature and repeated braking conditions.



continuous operation under extreme racing conditions while maintaining stable braking performance. The system is designed to provide high-temperature resistance and reduce thermal fade during prolonged use.

The application marks a further step in the commercialization of KBC's carbon-ceramic braking technology. The company has developed long carbon fiber-reinforced carbon-ceramic brake discs and has supplied carbon-ceramic brake components for several high-performance production vehicles, including the Hyper SSR, BYD Yangwang models and the Xiaomi SU7 Ultra.

The move into professional motorsport provides KBC with an additional

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AEROSPACE

Axalp Technologies Fabricates CFRP Propeller Blades for Dufour

Axalp Technologies (Olten, Switzerland) has designed and fabricated custom folding propeller blades for Dufour Aerospace's (Zurich) Aero-200 tilt-wing aircraft. The blades are made of carbon fiber-reinforced plastic (CFRP) and produced in-house by Axalp.

For Dufour's folding propeller mechanism, Axalp designed an optimized blade structure to meet tight constraints on geometry and weight. The company's in-house software tools allowed the design team to evaluate the full tradespace so the propeller could be optimized at the system level

rather than in isolated areas. Axalp's rapid prototyping capabilities then produced a batch of the custom blades to meet Dufour's ground and flight testing schedule.

Dufour's folding propeller system for the Aero-200 was developed to improve cruise efficiency during long-range missions. Large propellers are needed for hover and vertical takeoff, but they create additional drag once the aircraft transitions into forward flight. The Aero-200 addresses this by folding its outer propellers during cruise while the inboard pair continue providing forward thrust, a configura-

tion intended to maximize aerodynamic efficiency and extend operational range.

"We're proud to support the optimization and fabrication of this folding propeller system," states Axalp. The aircraft platform is aimed at medical transport, search and rescue, and other missions.

CW has reported on several other composite components across Dufour's Aero-200 (formerly Aero2) platform beyond the propeller blades. The aircraft's all-composite airframe is supplied by Connova AG, while Aerolite AG produces composite structural components for the nacelles and tail, and WAG Wernli AG produces composite brackets using sheet molding compound (SMC) materials, replacing the aircraft's original aluminum versions.



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NEW SPACE

Connova Group's Composite Rocket Landing Legs Carry Full Load

In late July, the European Space Agency's (ESA, Paris, France) Themis T1H demonstrator completed its first wet dress rehearsal at Esrange Space Center in northern Sweden — the first time that four carbon fiber-reinforced polymer (CFRP) landing legs built by Connova Group (Villmergen, Switzerland) carried the full weight of a fueled stage under operational conditions. ArianeGroup and the Swedish Space Corp. (SSC) ran a complete countdown and post-flight sequence on the pad, loading the stage with several tonnes of liquid nitrogen

vertical flight followed by a controlled landing — which will deliver final validation of the legs' maximum design loads. Series production is currently targeted for 2027/28, subject to the results of the flight campaign.



chilled to -200°C, which is close to the real propellants in temperature and density, but neither flammable nor explosive.

Themis is Europe's reusable launcher demonstrator. Its purpose is to show, for the first time in Europe, that a full-scale launcher stage can lift off vertically and land again. Standing on its legs, the T1H configuration measures 30 meters tall and 3.5 meters in diameter, powered by the reignitable, throttleable liquid oxygen/methane Prometheus engine. Connova Group produced the four landing legs as manufacturing partner to Almatech SA (Lausanne, Switzerland), a space engineering firm.

Themis pairs filament-wound CFRP tubes with high-precision machined aluminum and steel fittings. Against an all-metal solution, the hybrid approach saves roughly 25-30% in mass.

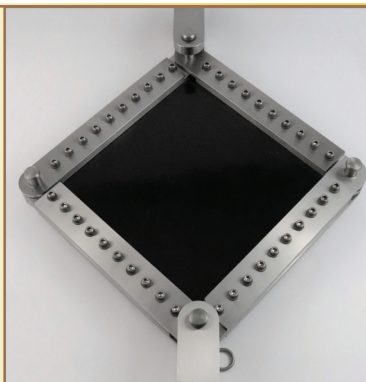
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AEROSPACE/DEFENSE

GKN Delivers Flight-Ready Composite Wings, Fins for CCA Prototype

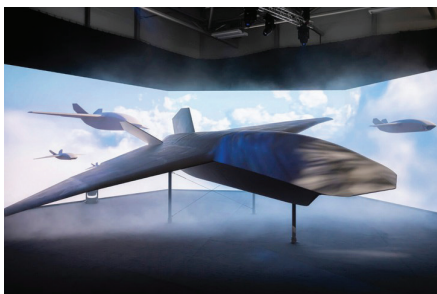
GKN Aerospace (Birmingham, U.K.) has completed the engineering, manufacture and full prototype integration of flight-ready wings, fins and control surfaces for the U.K.'s first collaborative combat aircraft (CCA) prototype, called *Brontanax*. Progressing from a clean sheet design within an accelerated timeline, BAE Systems (London, U.K.) used GKN Aerospace's advanced composites manufacturing and

assembly capabilities to meet strict technical requirements.

The components were manufactured at GKN Aerospace's state-of-the-art composite

design and assembly facility at Cowes on the Isle of Wight in the U.K. "The rapid progression from concept to prototype integration is a remarkable achievement," notes Mark Wilson, head of autonomous collaborative platforms at BAE Systems. "GKN Aerospace's industrial expertise, agility and commitment to collaboration have been pivotal in delivering high-quality, flight-ready structures within a very compressed timeline."

GKN Aerospace says its success required an agile approach to product development and supply chain management, its global connected network of sites and expertise in world-class composites manufacture, novel tooling design and complex product assembly. This achievement underlines the company's determination and willingness to apply its extensive sovereign industrial capabilities and expertise to meet the current and future needs of the U.K. defense sector alongside its other global customers.



ENERGY

AGY S2 Glass Fiber Reinforces Terra Supreme's Group 31 Bipolar Batteries

AGY's (Aiken, S.C., U.S.) S2 Glass fiber is being used by Terra Supreme Battery (Albion, Ind., U.S.) in the composite grids incorporated into its Group 31 bipolar lead-acid batteries.

Terra Supreme Battery combines pure lead with high-strength S2 Glass fiber to create dimensionally stable composite grids. The glass fiber reinforcement, reported to be 10X stronger than steel by weight, helps maintain the structural integrity of the battery's internal grid system throughout repeated charging and discharging cycles. In addition, the reinforced composite grid technology eliminates positive active-material shedding, which Terra Supreme identifies as a major failure mode across lead-acid battery chemistries.

Terra Supreme's battery uses a bipolar architecture with horizontally oriented plates, an efficient internal current path and no conventional internal busbars. The battery is designed as a direct Group 31 replacement that can operate without changes to an existing charging system.

"Our objective was to rethink the lead-acid battery from the inside out," describes Benny E. Jay, chief technology officer of TSB. "AGY's S2 Glass fiber provides the strength and dimensional stability required for our composite grids. This enables us to structurally secure the active material, extend service life and deliver significantly improved performance from a familiar, recyclable battery chemistry."

The battery is designed for high-power, engine-starting and deep-cycle applications across commercial transportation, industrial equipment, agriculture, aerospace, marine, railroad, off-grid and grid-tied energy storage markets.



AEROSPACE

Airbus Begins Belfast Site Extension for Composite A220 Wing Ramp-Up

Mid-August, Airbus (Toulouse, France) announced the start of construction for the 6,221-square-meter extension to its Belfast A220 wing facility. The project will support production ramp-up and is part of a wider multi-million-pound site investment plan.

Scheduled for completion in the first half of 2028, the extension will expand the facility's wing manufacturing

footprint and advanced composite capabilities. It will house a third autoclave alongside specialized wing tooling and cranes to support the A220 production ramp-up to 13 aircraft/month by 2028. Alongside the extension, Airbus will continue to modernize site infrastructure.

"Enhancing our wing facilities is a direct investment in the future of A220 wing production here in Belfast, building the capacity required to meet the growing demand for this aircraft," says Anthony Rouse, head of Airbus Belfast plant and site. "This commitment is also reflected in our ongoing skills development, including bringing onboard 40 new apprentices who will start in September this year [2026]."

As the exclusive global manufacturer of A220 wings, Belfast is central to the A220 program. The site is internationally recognized for pioneering the patented resin transfer infusion (RTI) manufacturing process used to construct the A220's advanced composite wings. This technology makes the structure approximately 10% lighter than traditional aluminum equivalents, directly reducing fuel burn and carbon emissions.



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■ Adrien Marchandise sails 754 with the foil extended. Source | Manon Le Guen via MiniLab



Sea Before Sky: Racing Toward Recyclable Thermoplastic Foils

For Avel Robotics, offshore racing isn't the destination, it's a fast, brutal test bed for proving thermoplastic composite materials and Avel's manufacturing technology before aerospace adopts them.

By Claire Steggall-Murphy / Contributing Writer

» “A flying carpet. That is what it feels like,” explains Adrien Marchandise, co-founder and chief technology officer of Avel Robotics (Lorient, France), when his monohull racing yacht, a Mini 6.50 named 754, finds its rhythm on foils. The rush of water around the hull goes quiet. The boat, usually heeled hard against the wind, comes upright. Then it accelerates; all onboard are subject to a new collection of forces and movement. “Pressing the correct button on the autopilot becomes a real physical challenge under the lateral movement of the boat constantly pushing and pulling me around the cockpit,” says Marchandise.

“When you reach such a high speed, at one moment all [of] the boat is just out of the water, because you finish by having too much lift,” notes Marchandise, acknowledging the challenge of hydrofoils — not just in producing them, but also handling them in the water. Push a foil hard enough, he says, and the boat can leave the water’s grip entirely. “The foil is not in the water anymore, and you lose your steering control. You lose any control whatsoever. Then it’s just a matter of where the cat will fall on the ground: Is it going to be on its foot, its head or its back? You can’t really control that.”

The foils in question are 90% thermoplastic composite (TPC), 10% of which comprises second-life recycled materials. They are built with technology that Marchandise has spent the better part of a decade developing, and have pushed 754 to 26 knots (30 miles/hour), which is up from roughly 20 knots without them.

That performance is the payoff from combining TPC with Avel's established automated fiber placement (AFP)-based manufacturing technology, already used to provide thermoset composite foils for some of the most elite offshore racing monohulls on the planet — the IMOCA 60 (60-foot hull) open class — including more than one-third of the field competing in the 2024-2025 round-the-world Vendée Globe challenge (read *CW*'s Avel Robotics plant tour, see Learn More).

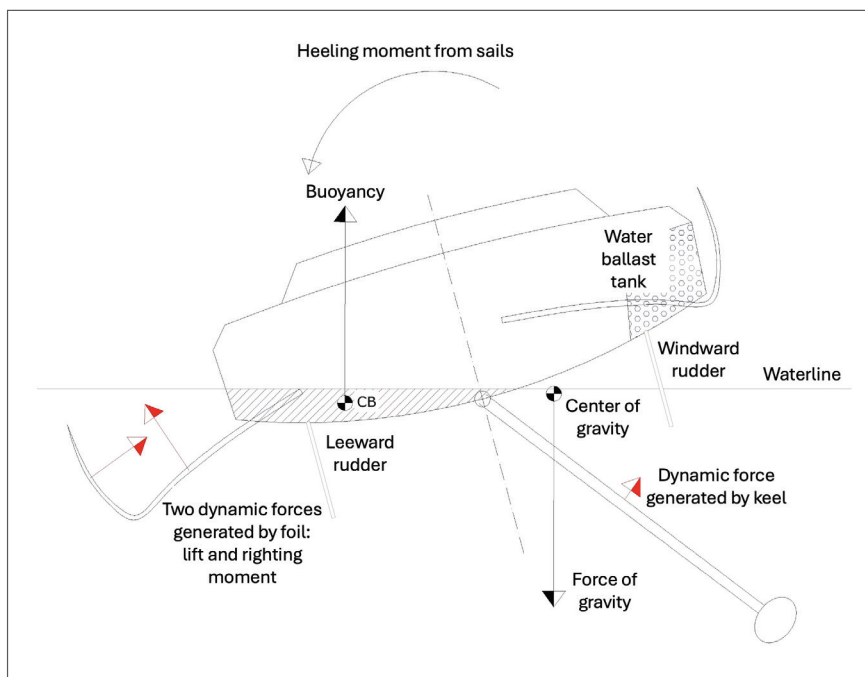
Hydrofoils function as underwater wings, generating lift to raise the boat hull out of the water and reduce displacement and drag. They were first tested on monohulls in the 1950s, and then more widely adopted on multihulls in the following decades. In the last 10 years, they have become a must-have to secure a podium finish in the premier races. From their first use in the nonstop solo Vendée Globe in 2016-17 — used by about 20% of the fleet — more than 50% of the fleet featured hydrofoils in subsequent races (2020-21 and 2024-25).

The 754 is owned by MiniLab, a collaborative research initiative launched in 2023 that brings together Avel Robotics, ComposiTIC, OpenSea Labs, IRMA, Diab and Victrex to test recyclable and eco-efficient materials and technologies for ocean racing hydrofoils. It is about one-third the size of IMOCA-class racers and has been an incredible living laboratory to explore what full-scale TPC foils

could offer when paired with Avel's advanced and automated manufacturing technology. Through MiniLab, Avel is now testing many

IMOCA Paprec 5 sailing with Avel Robotics-manufactured foils.

Source | Marin Le Roux via Avel Robotics



IMOCA appendages and forces. Forces marked in red vary with boat speed. Source | Cristian Pilo, Modern Wooden Boat

of TPC's most strident claims, including manufacturability, cost and recyclability to pave the way toward more widespread use in aerospace. Part of this journey also includes technology to monitor the structural health of the TPC parts in order to give credibility to their durability claims.

Hydrofoil anatomy, performance demands

The addition of foils transformed IMOCA racers from displacement monohulls — where a consistent amount of the hull is always in the water — into something closer to sailing hydroplanes.

A modern IMOCA foil is generally C- or S-shaped with a shaft that penetrates the hull and connects to the boat's actuation system. The elbow, which has the tightest radius of curvature of the foil, transitions the shaft into the lifting section that handles the craft's hydrodynamics when the foil is fully submerged in the water. The shaft passes through the hull via an integrated foil case, or trunk, which is a heavily reinforced structural box that serves as the primary load path between the foil and the boat. The shaft interacts with upper and lower bearings inside the trunk as hydraulic rams adjust the foil's angle and move the foil into and out of the water.

The hydrodynamic section of the foil has two jobs: to produce lift and side force. The lift reduces the hull's wetted surface and

»



■ Freshly painted thermoplastic composite (TPC) hydrofoil for 754 manufactured by MiniLab. Source | Avel Robotics

drag, while the side force counteracts the force of the sail by providing righting moment without the use of additional ballast. Because lift scales with the square of speed, the effect compounds: The faster a boat goes, the harder its foils work to keep it going faster still. The foils on 754 lift the boat's full weight of 1.2 tons, with a safety factor of about 2. The larger the boat, the more demand on the foil.

Out of any part of the hydrofoil, the elbow has the highest risk of failure. It is common to expect a serious knockdown in material properties in this region due to manufacturing challenges imparted

geometry straight onto a customer's boat.

Marchandise explains the engineering challenge of designing a hydrofoil compared to aircraft wings. "Because an airplane has very predictable load cases, you know that you're going to control speed and go through an element that's very soft. You don't have the same level of instability as in the water. In the water, you can't really control if you're going to have pure bending or mixed bending and twisting. We have a combination of very complex load cases that are on the foil and a very hard hypothesis when we do the design. The foil is subjected to severe bending and complex

Beyond the foils

The IMOCA 60 is limited to five appendages below the waterline. Modern foiling boats have a canting keel, two rudders and two foils. Older boats featured two straight daggerboards in place of foils, one rudder and a keel. Each appendage performs a distinct job and the whole system is designed with one goal in mind: to deliver more righting moment, which is the force that keeps the boat upright and the sails powered up. IMOCA designers aim to maximize that righting moment while keeping the boat as light as possible.

Canting keel. This is a fin with a lead bulb at the bottom that is mounted on a pivot so it can swing or "cant." The keel can swing up to 38° to the windward side (i.e., where the wind comes from). When the ballast weight is moved away from the centerline, the righting moment is multiplied far more efficiently than a fixed keel could manage. There is a trade-off, though. A

canted keel loses most of its ability to resist sideways movement through the water. That job, then, must be done by a different appendage.

Twin rudders. IMOCAs are wide, flat-bottomed boats that heel (lean) hard under sail. A single, centered rudder would spend much of its time partially out of the water under full foil power and thus be less effective at steering the boat. Two rudders positioned toward the sides of the boat mean the leeward (water side) rudder stays fully submerged, while the windward rudder rides partially clear of the water.

These appendages — the canting keel, the twin rudders and the foils — are not tuned independently, but as a system. The keel's cant angle, the foil's lift and the leeward rudder all share responsibility for keeping the boat upright and pointed the right way. The skippers and their teams are constantly rebalancing that system as the wind and sea state change.



■ Avel's first TPC hydrofoil batten produced using the AFP process (top) and TPC qualification test articles being laid up for consolidation and characterization (bottom). Source | Oceania Bordeaux via Avel Robotics

load cases, mixed wing bending, twisting and reverse loading as well." This load case makes simulation of foil performance very challenging, as interlaminar tensile stress is concentrated exactly where the foil curves the most.

The Mini has logged roughly 10,000 nautical miles across 10 races since its current TPC foil came off the line in early spring 2025. This mileage is a genuine fatigue loading dataset for a full-size foil. Furthermore, MiniLab fully controls the platform — from the design to the performance data — making it simple to share the knowledge with any customer, partner or end user.

Avel was able to celebrate a big win for its manufacturing capabilities and high-performance parts with its first customer,

skipper Charlie Dalin. The foils for his IMOCA 60 were delivered in September 2019. Dalin won his first race with them that November and placed second in the 2020-21 edition of the Vendée Globe, followed by first place in the 2024-25 edition with Team MACIF. Marchandise recalls that big win for Dalin, Avel and the rest of the Macif racing team. "It was quite moving. Charlie was someone who was very focused, reserved and professional all the time, but [when he won] he was really enthusiastic... we were so happy to be part of this celebration," says Marchandise.

Dalin passed away in June 2026 after a battle with cancer, which he fought during his Vendée Globe win. Marchandise describes Dalin's partnership with Avel. "We were very sad to lose this skipper and this incredible human. We met him before we knew he was going to be such a talented skipper in IMOCA. When he walked into the workshop, he would go to everyone and say hello and show his interest, not just in their work but in them as people. He was someone who was very generous and inspiring. We were very moved to learn of his passing. He was the first person to trust Avel and is part of Avel's success."

The manufacturing advantage of AFP

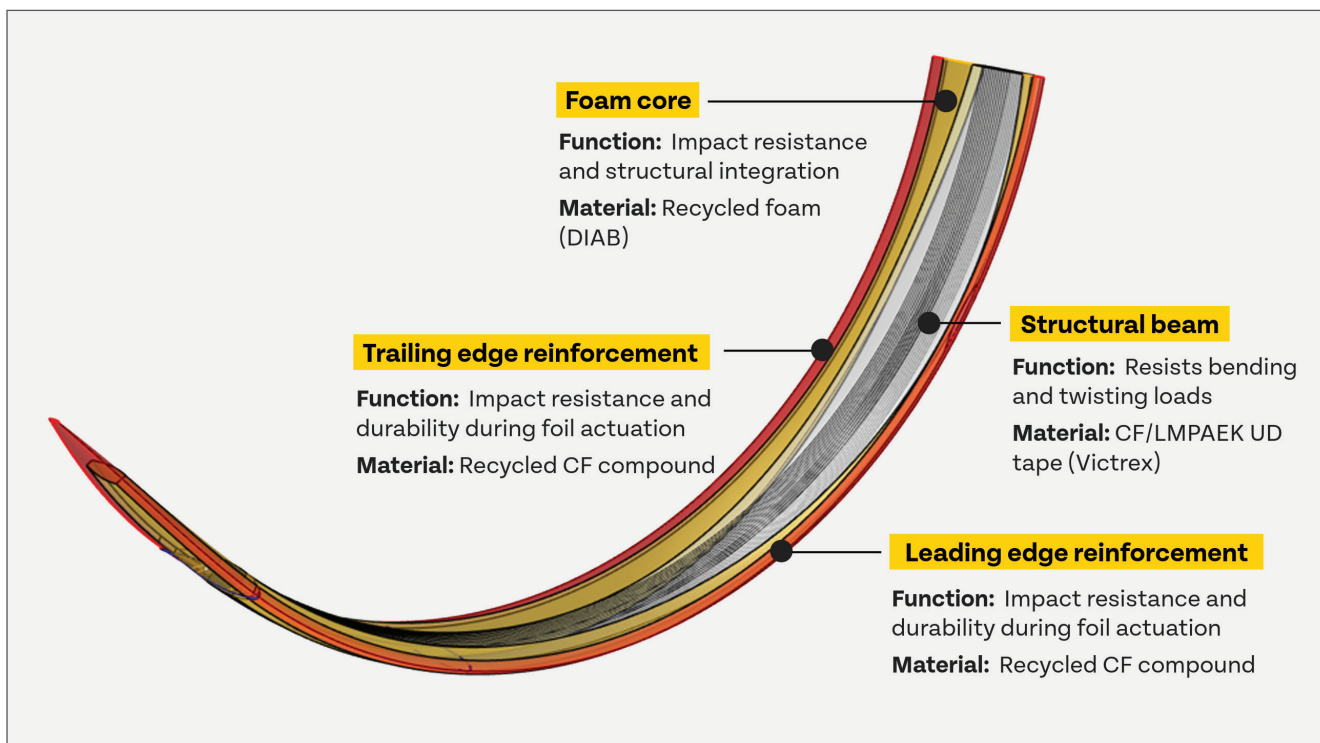
One of the keys to the TPC hydrofoil's success is the AFP manufacturing process developed by Avel Robotics. Marchandise co-founded Avel Robotics in 2017 with partner and mentor Luc Talbourdet. They were motivated to develop composites manufacturing that was not limited by the need for heavy and expensive tooling and that would yield complex parts using automated processes. Marchandise developed Avel's manufacturing technique around a repurposed Coriolis Composites (Quéven, France) C1 AFP machine.

"I came from prototyping with 3D printers, so for me it was just a new way to manufacture parts without a mold. The composite culture relies on mold[s], but we wanted to manufacture shapes that could not be done with standard techniques. It was a game changer, going into the composite industry with more manufacturing freedom provided by AFP tooling," Marchandise says.

A less-controlled process than the traditional AFP techniques used in aerospace, Avel's approach enables it to build complex curved parts without the tooling one would typically expect. The company has scaled from 15-kilogram foils for boat hull lengths under 30 feet to today's ~300-kilogram IMOCA foils that are 6-8 meters long. These carry 8-10 tons of load at top speeds, resulting in an extremely complex engineering problem to solve, including a high chance of colliding with floating debris.

AFP can typically steer thermoset unidirectional (UD) prepreg tape into a radius as tight as 2.5 meters without a drop in material performance. Avel's process qualification strategy informs the company of the impact of a tighter radius and allows it to control the impact of the radius on mechanical performance, and then incorporate that knowledge in the design. Furthermore, Avel's precise fiber placement technology enables tighter control over fiber angle and course boundaries than





hand layup. This allows engineers to orient fiber more closely to the principal load paths and reduces the margin typically reserved for manual placement variability. Ultimately, the structures built by Avel can operate closer to the material's theoretical strength and stiffness allowables.

Thermoset to TPC

Thermoset epoxy-based composite materials have been the default material for IMOCA foils since the class began foiling, providing an established process and a large dataset to prove performance. TPC materials offer a different set of properties. Damage tolerance and resistance to delamination are significantly different but TPC also offers assembly not only by adhesive bonding but also welding. Moreover, the ability to be reprocessed opens the pathway to fully recyclable parts.

Indeed, the main driver for Avel's interest in TPC materials was manufacturing, says Marchandise. "Luc and I have always been trying to find new ways to manufacture composites. After 8 years, we currently have 50% of the [IMOCA foil] market." Incorporating TPC is, in his view, a competitive edge. When Avel started, "there were seven manufacturers doing very big foils, and now there are only two," he says. He believes TPC could widen the gap further. "The great feature with AFP compared to hand layup is that you can steer the material because the tape width is narrow, and you can even go further with thermoplastic materials than thermosets — right now we have no quality difference between using a 1-meter radius and a fully straight section with TPC." This means that the allowables Avel can leverage while using TPC are higher

■ Working with its partners, Avel developed the MiniLab's TPC foils using unidirectional (UD) prepreg tape, thermoformed plates made from a molding compound using recycled Avel scrap materials and foam core to achieve the high load and impact resistance required while reducing waste and improving sustainability and life cycle assessment (LCA) performance. Source | Victrex

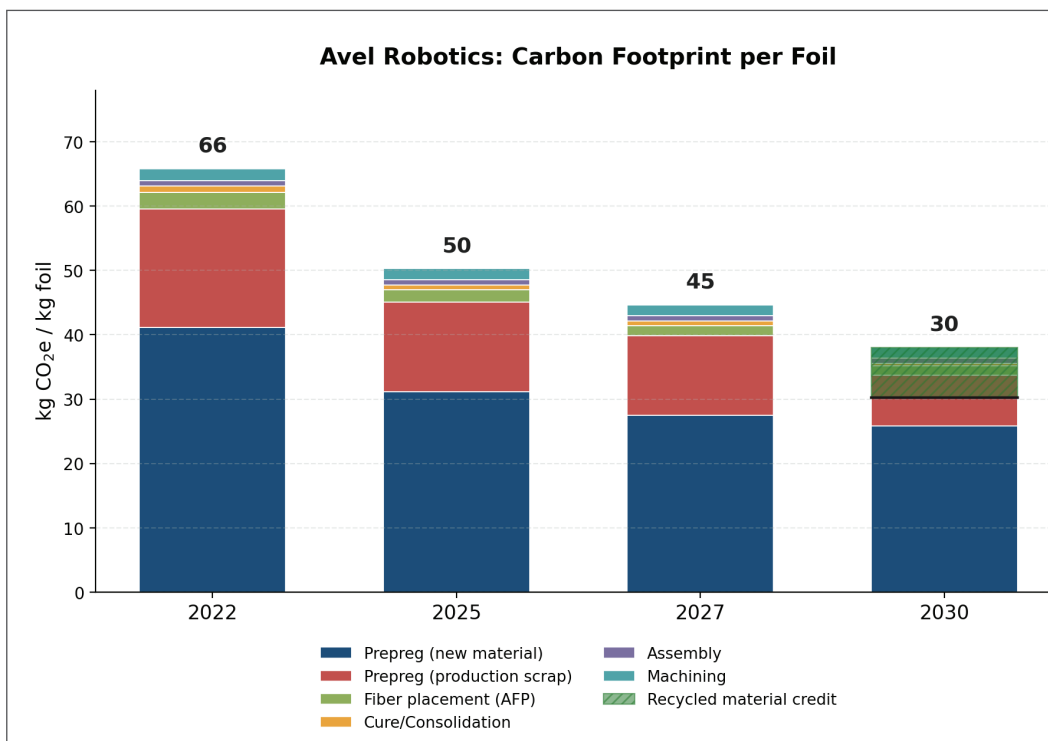
than thermosets in comparable or even less aggressive geometry, which sees a drop beyond the 2.5-meter radius mark.

Marchandise elaborates further, highlighting the manufacturing advantages offered by TPC. "I was drawn to the ability for manufacturing to be interrupted and resumed with TPC, rather than being beholden to an unstoppable chemical reaction during thermoset cure. Flat stacks of material can be stored and formed later, and a finished structure can be reheated and repaired after lamination in ways a thermoset part cannot. All these features, for me, are aligned with what composites in the 21st century will be, including a lot of very complex functions within the parts."

"Diab [Laholm, Sweden] has provided the foam cores that are in MiniLab foils," says Marchandise. "The foam is made with recycled materials. They are also involved in the foil trunk and the integration of it, so we've been testing a lot of different materials that come from them. Diab has a production site in Sweden that's fully run with non-fossil fuel energy, and they are one of the only manufacturers that have full life cycle analysis [LCA], reports on every material they make. So, they know the life cycle advantage of their products."

Avel is creating a new process to manufacture the 700-kilogram dagger boards for the 125-foot-long *Nomad 7* sailing catamarans. "To our knowledge they are the largest daggerboards ever made,

Avel Robotics: Carbon Footprint per Foil



Sustainable foils: Recyclability, EU requirements

"The foil is also an emblematic part for recycling," notes Marchandise. "It's key to what we hope to do with the offshore sailing industry — use the TPC foils to do a full product life cycle in a very short-term period — even before aerospace fully adopts this material."

"We will achieve the EU-required reduction of 30% way before 2030," he continues. "In 2022, we were around 66 kilos of CO₂ equivalent per kilo [kg CO₂/kg] of foil manufactured. We did the same analysis in 2025,

and now sit at 50 kilos of CO₂ equivalent. This is an improvement of 24% in 3 years."

He credits the drop in carbon footprint to manufacturing improvements. "We reduced scrap rates, increased throughput of our AFP robots and improved our autoclave cure cycles. We also began working with Toray Carbon Fibers Europe [Lacq] in the southwest of France; the impact of their fibers is much smaller than fibers that were previously manufactured in the U.S. Beyond that, we switched production from slit tape to towpreg developed with Toray. The towpreg doesn't need backing film and doesn't produce waste. We don't use wide rolls of UD tape that need backing film on both sides or a slitting operation." Marchandise estimates that current developments will converge in 2027 to help Avel reach an improvement of 32%. "We then should drop to 45 kg CO₂/kg of foil. We believe we will switch to a fully TPC foil [versus the current 90%] by around 2030."

Marchandise recognizes MerConcept for its advice and guidance as Avel worked toward reducing the carbon footprint. "Their excellence and skill in LCA helped us make sure we made good decisions while we moved along. They challenged us on the accuracy and way we measured our internal impacts and provided critical review."

Notably, TPC also create less waste than thermosets, even on an AFP machine. "Just by reducing the amount of waste, we should achieve a reduction of 54% of our CO₂ equivalent per kilo by 2030. That's without considering recyclability. When I look at our roadmap, a large portion of the calculation for kg CO₂/kg is the material we purchase. Beyond 2030, I can't imagine any other way to »

■ Avel Robotics' carbon footprint per foil. Source | Data from Avel Robotics, plot developed with assistance from AI

roughly twice the size of my first student flat," notes Marchandise. "It took a year to manufacture these

parts, around 7,000 hours of labor and did not use molds." The technology used, which is still confidential, incorporates a Diab material that allows Avel to produce sandwich structures that can be cured in an autoclave at high temperatures and pressures, have low moisture uptake and are cost-competitive.

Victrex (Cleveland, U.K.) is the inventor and sole manufacturer of the LMPAEEK matrix resin used in Avel's TPC foils. Gilles Larroque, industry manager – transport, spoke highly of Avel's work with thermoplastic materials. "Adrien benchmarked multiple materials and has done a huge amount of tests," notes Larroque. "He selected this material because it outperformed all the others. He tested a bunch of thermoplastic materials along with LMPAEEK and it was really outperforming the other materials in terms of processability. It was like, okay, let's shoot for the best and let's see how far we can go. So that was his approach and why he's been adopting LMPAEEK and targeting this foil for the moment."

Marchandise shares that when selecting a thermoplastic material, he aimed to maximize the combination of UD compression strength and interlaminar shear strength with carbon fiber reinforcement. For him, the benchmark was wet-lay epoxy. Out of the material systems he has tested so far, LMPAEEK has the winning combination of compression and shear strength regardless of polymer classification. Marchandise estimates that MiniLab is currently achieving about 80% of LMPAEEK's potential in mechanical performance and is seeking to continue to close that gap.

reduce this number than to recycle materials and use materials that can withstand several life cycles. There is a limit of CO₂ reduction that can't be surpassed unless you recycle. At Avel we hope to reach this challenge within the next 4 years."

When considering ongoing recyclability and reduced emissions goals, Marchandise looks further afield to how its own TPC hydrofoil materials will be processed, and for what industries. "After such a high-demanding application [offshore racing, aerospace], our strategy is to target those recycled materials for 3D printing, injection molding or plastic sheet forming. The industry that will be targeted will not need a high-performance material

The effort Avel has put into developing sustainable TPC foils will be translated into higher-stake aerospace parts.

[automotive, sporting goods]," he explains. "The difficulty, however, is to identify the mechanical performance of the material that we can produce, and to do it in a way that is economically sustainable. What we have been doing at MiniLab is not sustainable in terms of economics, but we have current projects to go further and address this challenge. We have estimated that on an IMOCA foil that weighs 350 kilos, the application for recycled material would represent approximately 70 kilos, 20% of the mass. On a full-size IMOCA there are 600 kilos of virgin thermoset material that could be replaced by recycled TPC material."

EU regulatory requirements shaped MiniLab's approach to achieve a sustainable composite foil: LCA rules only allow a company to claim a carbon-reduction credit for recycled content if that material is reused in the same application it came from. This is a large part of why Avel and MiniLab are solving recycling in-house rather than outsourcing it.

Foil Infinity, the MiniLab initiative behind this work, targets a fully recyclable racing foil by 2030. Today, 10% of MiniLab-built foils are recycled material. Avel uses manufacturing scrap, offcuts and milling dust, processed by CompositIC (Ploemeur, France) into a recycled material. That material is then consolidated under a hot press into panels of molding compound, that are then used exclusively in the foil's secondary, non-load-bearing structure in the leading and trailing edges (see TPC foil diagram, p. 26). These regions are also the most prone to impact damage and benefit from the use of tough thermoplastic discontinuous fiber composites. The primary load

path of the foil remains in virgin material. Recycling the scrap back into the virgin material's original application meets EU regulatory requirements to claim carbon footprint reduction in an LCA.

Marchandise says that Avel's success has been heavily impacted by CompositIC and University of South Brittany, which "are key drivers of technological development in our region. We would not be where we are without them, nor would we be so efficient in developing TPC foils." He also thanks Vincent Keryvin, professor at University of South Brittany, for his expertise when Avel was developing its AFP process to maximize mechanical properties, especially performance in compression.

SHM for foiling

Regardless of the foil material, once it is installed Avel carefully monitors the health of the structure with fiber optic sensors. Used to measure strain, the fiber optic technology and data acquisition are from Pixel sur Mer (Lorient, France), an expert on onboard systems. "They provided us with the fiber optics and all of the systems to get the acquisition of this data," says Marchandise. "We know more about what LMPAEC can withstand across a very long life cycle of a product thanks to their system. We've been working with them on a lot of the different foils we manufacture." MiniLab has been able to compare the sensor data to their performance prediction models with great correlation.

In addition to fiber optic sensors, acoustic emission sensors were also installed in the TPC foils for 754. The sensors were co-developed directly between Dupuy de Lome Research Institute (IRDL, Ploemeur, France), a research group at the University of South Brittany, and Avel.

"Acoustic emission sensors have been used for metallic structures for 35 years, and they have been used on composites for about 20," notes Marchandise. "With these embedded sensors within the foils, we believe we can detect if there were some cracks, delamination, etc. during the foil's life. It gives us a direct answer whether the foil is in good health or not, which is very different than fiber optic sensors, because fiber optics give you the level of strain and then load that the foil is experiencing, so it's less direct information than acoustic emission sensors can provide."

Marchandise points out that, taken together, these sensor systems have significance beyond ocean racing. "Using acoustic sensors could help aeronautical customers that want to quickly develop a new application and certify the part. For example, with a helicopter blade, we stop its life after a number of flight hours, but there's no validation that the material has actually fatigued. It's just based on statistics. With fiber optic and acoustic sensors, you could determine whether to extend its life cycle or shorten it after an unexpected event."

The 2024-25 Vendée Globe campaign supplied the largest real-world performance dataset Avel has seen. It manufactured foils for nine of the 25 foil-equipped boats in that race, logging about 250,000 nautical miles total, all captured with fiber optic sensors.

LEARN MORE

More about Avel | short.compositesworld.com/AvelRoboticspt

Read the article online | short.compositesworld.com/Avel-hydrofoils





■ Recycled scrap converted to material for leading and trailing edges of a TPC hydrofoil. Source | Avel Robotics

From ocean to aerospace and defense

Avel's move into aerospace and defense isn't a pivot so much as a return. In fact, Marchandise and Talbourdet built the company's manufacturing approach around aerospace manufacturing already used to build large commercial aircraft, including Coriolis AFP machines used by Airbus and Boeing. So this strategy was there from the beginning, says Loeva Malacarne, head of sales and business development, who joined Avel in 2021 after 11 years at aerospace firm Safran. Avel's first aerospace work was with Swiss aircraft manufacturer Pilatus in 2023, followed by different projects with Airbus and ArianeGroup, including a prototype built for ArianeGroup's satellite dispenser that Avel exhibited at JEC World 2026. Avel has now added ongoing projects in space and advanced air mobility (AAM).

After several years of discussions with aerospace customers, Malacarne was able to get serious traction for Avel with Aura Aero (Toulouse, France). Aura's first product is a two-seat training aircraft, which the company originally certified with conventional propulsion and then later with an electric propulsion version.

Aura's next product is slated to be a 19-seat aircraft designed as a replacement for the ATR 72. This aircraft will have hybrid propulsion supplied by Safran. Avel is building the wings and tailplanes for that program, with first flight targeted for the end of 2027. To support this work, Avel is building a second Lorient facility dedicated to aerospace production, to be operational by 2028. The new facility will add more than 3,000 square meters of production capability to its original 800-square meter site and will house its full-scale wing and tail plane production for Aura.

Avel is further diversifying into defense via partnerships with larger OEMs and Tier suppliers. Malacarne notes that the defense timeline pairs well with Avel's fast development capabilities. "It matches our habits of doing things very quickly," she says. "A

project generally starts, and 6 months later it's delivered." Avel is also engaged with AAM customers where this ability to move fast and deliver high-quality results aligns well with expected design cycles and timelines.

Bringing TPC to the sky

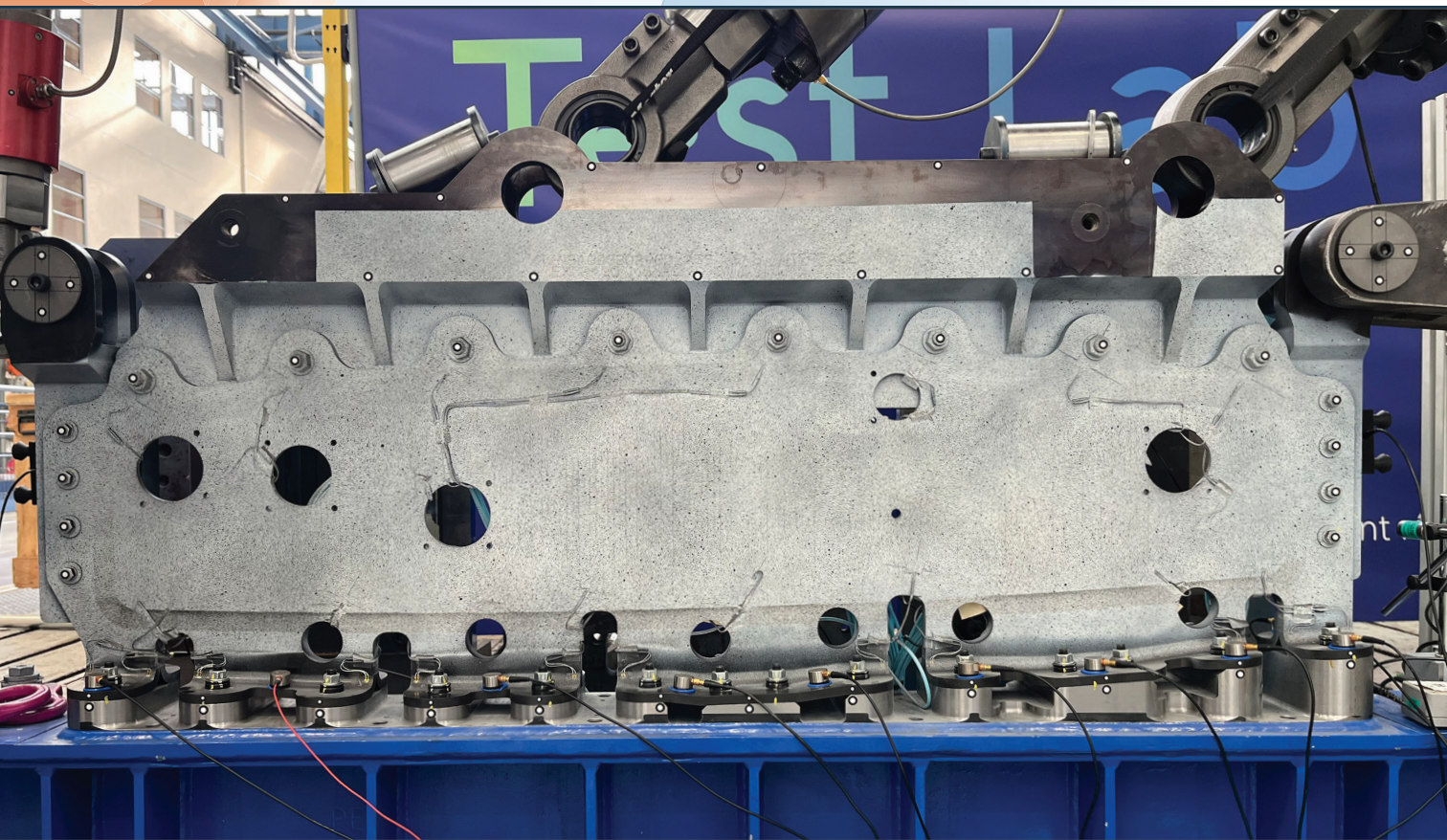
Marchandise believes that the effort Avel has put into developing sustainable TPC foil technology will be translated into higher-stake aerospace parts and add to the performance benefits of TPC materials. He sees Avel's AFP-steering capability extending well beyond marine. "For example, manufacturing TPC window frames and pans for aircraft with a hot press requires laminate blanks with a high level of steering, and mastering these steering parameters is of key importance. This could be transposable to multiple aerospace, defense and AAM structures."

"We will be able to start recycling the first TPC foils we manufacture before we see the first wing on a plane flying with these materials," he says. This was part of Avel's strategy from the beginning — to prove itself in high-performance offshore sailing and then target aerospace, providing comprehensive datasets and differentiated, advanced manufacturing technologies. Now, with its achievements in sustainable TPC materials and primary structures, Avel is bringing even further reduced carbon footprint technology and innovative composites to the skies. **CW**



ABOUT THE AUTHOR

Claire Steggall-Murphy brings more than 20 years of experience to her work as a consultant in the composites industry. She specializes in aerospace, application development, material and process qualification, and thermoplastic composites.



Thick Thermoplastic Composite Parts for the Next Generation of Aircraft

Daher's Highly Loaded Thermoplastic Wing Rib program proves out patented Direct Stamping and infrared welding processes and builds readiness, certification basis for critical structures on high-rate production aircraft.

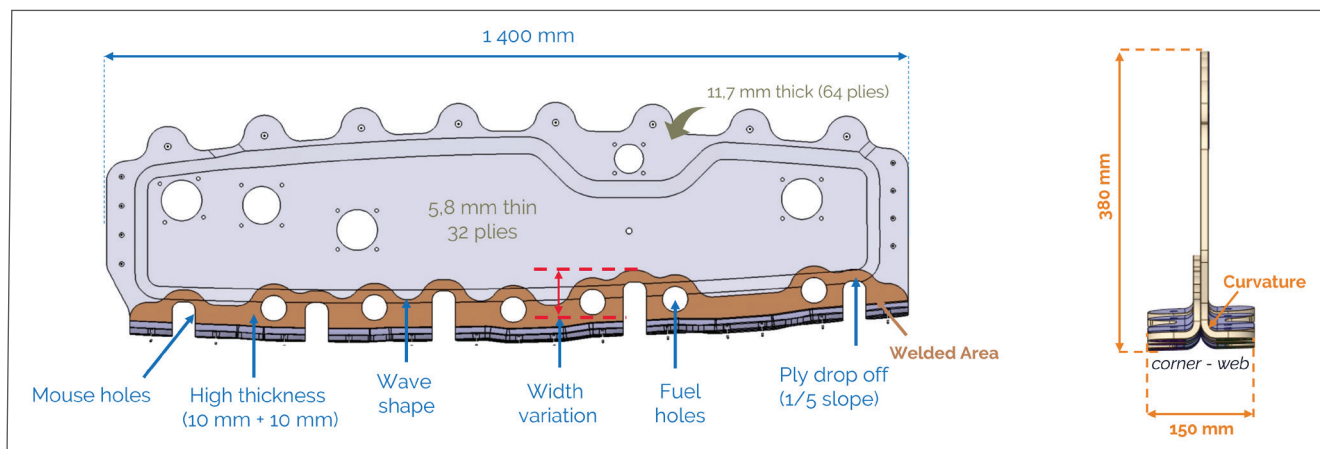
By Ginger Gardiner / Executive Editor

» Airbus' next-generation single aisle (NGSA) program is on track for launch in 2030 with entry into service by 2035-2040. The preparation program, called eAction, includes "a lot of research and technology development, comparison of technology solutions, pre-projects and simulations," says Airbus CEO Guillaume Faury, noting ongoing work with partners to review options for wings, fuselage, propulsion and industrial systems.

This activity includes thermoplastic composites (TPC), discussed in *Aviation Week's* article, "Composite aerostructures suppliers pitch thermoplastics, automation for next narrowbody." It explains that TPC offers shorter production cycles and welded assembly requiring just ≈ 15 minutes per join versus multi-hour thermoset (TS) cure cycles. Tier 1 aerostructures supplier Daher (Nantes, France) is highlighted in the article and is also a partner in the Spider research project — part of the French government-funded CORAC program — targeting stamping presses capable of handling parts up to 4×3 meters. Daher is also developing TPC pylon fairings, made by converting an end-of-life A380 engine pylon cowl into a smaller panel for A320neo pylons. This project — a collaboration with Airbus, Tarmac Aerosave and Toray Advanced Composites — demonstrates how Airbus also sees TPC as a path to circularity for composite aerostructures.

The baseline composite wing for NGSA could include TPC ribs in a TS box. This approach is already used in A320 elevators and more such hybrid structures are

■ ABOVE: Daher's Highly Loaded Thermoplastic Wing Rib being tested by partner Cetim. Source (All Images) | Daher



expected. Daher has produced TPC ribs for Airbus' Wing of Tomorrow (WOT) program, which has completed three 17-meter ground test demonstrators. After exploring the advantages of increased wingspan and more than 100 manufacturing and assembly technologies, the WOT has now entered a flight test phase.

Targeting a rib better optimized for the longer, slender wing shapes WOT is now testing, Daher launched the Highly Loaded Thermoplastic Wing Rib project in 2021. This project, part of the CORAC (Conseil pour la Recherche Aéronautique Civile) initiative funded by the DGAC (French Civil Aviation Authority), was achieved with partners Victrex (Cleveleys, U.K.), Luxembourg Institute of Science and Technology (LIST, Esch-sur-Alzette, Luxembourg), Cetim (Saint-Étienne, France) and AniForm Engineering B.V. (Enschede, Netherlands). The award-winning rib features up to 64 plies (12 millimeters) of unidirectional (UD) carbon fiber-reinforced LMPAEK polymer material from Victrex and integrates two key technologies:

Daher's patented Direct Stamping — which eliminates the consolidation step after layup — and the LIST-patented process for infrared (IR) welding.

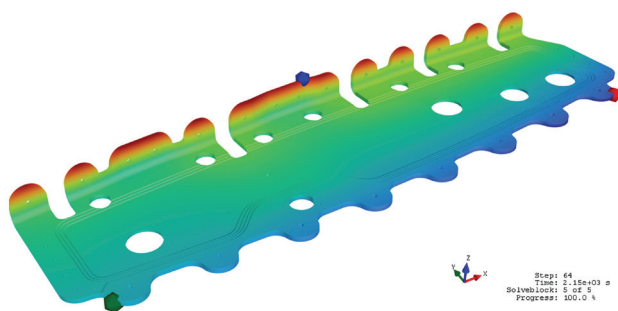
Compared to a machined aluminum reference, the 1,400 × 380 × 12-millimeter-thick TPC welded rib with varying thickness reduces weight by 22%. Compared to a TPC *bolted* rib, it reduces the production cycle by 25% and cost by 15% while meeting the high rate (75-100 aircraft/month) targeted for NGSA and other future aircraft. It also reduces emissions by 12.5 tonnes of CO₂ per rib over a single-aisle aircraft's lifetime. Meanwhile, recyclability/circularity has already been demonstrated by Daher with Airbus on A320 pylons and with the carbon fiber/PPS brake pedals for its TBM general aviation aircraft, made using waste from its production of stamped TPC clips and brackets for the Airbus A350.

Why a thick rib program?

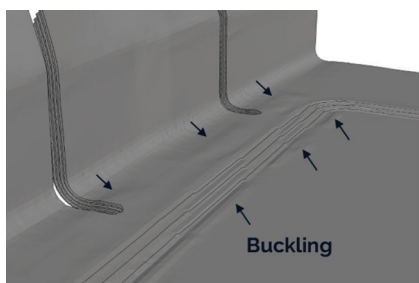
"Because we were one of the last partners to enter the WOT project, we had 2 years less than the other partners to design and produce a rib," says Dominique Bailly, director of R&D for Daher. "Thus, we were more conservative on what could be done to optimize that part." Daher was actually the first partner to deliver TPC wing ribs and vacuum bag-only (VBO) TS spars to Airbus U.K. for the full-scale wing demonstrator at the end of 2020. "But we knew

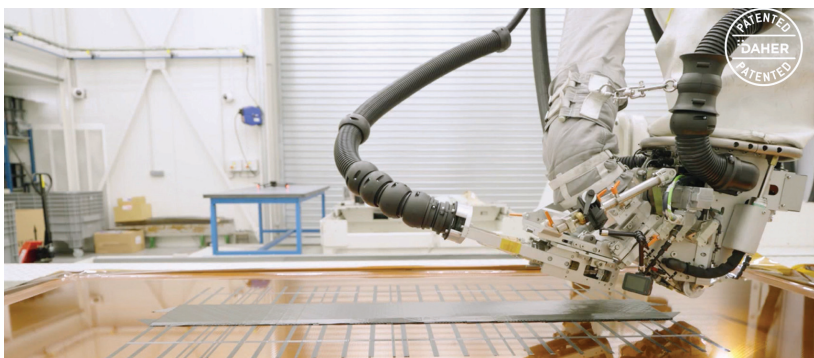
there were improvements possible in the rib's design, weight, cost and producibility for high production rates. That's why we launched another effort to continue optimizing the initial results we achieved in the WOT, but on our own."

Because this was not an Airbus program, the team decided to start with a generic metallic wing rib based on a Daher design. "First, we performed the analysis to



With partner AniForm, Daher completed simulations to predict warping (top), buckling (bottom) and other defects, including deformation of parts after stamping.





the same loads, the machined metallic rib is still 22% heavier.”

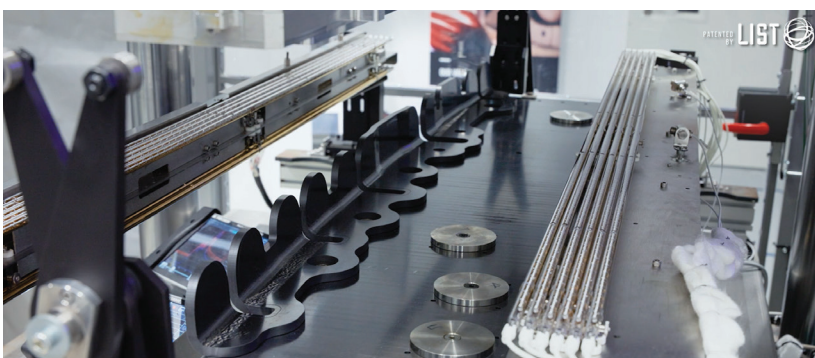
The resulting thick TPC rib has received awards, but Bailly says Daher sees where it can still be improved and is pursuing further developments.

Materials and design

Performance in welding and forming were key considerations in Daher’s choice for the TPC material. “The Daher WOT wing rib design is full of fasteners,” says Bailly. “But we have the ability to address that, being one of the few companies in the world that can weld highly structural TPC parts. We wanted to use this ability to eliminate or significantly reduce fasteners, and also incorporate our patented Direct Stamping process to reduce cycle time and cost.”

“At the beginning of the project, we had studied the different resins on the market, including PEEK and PAEK from a variety of suppliers,” explains Martin Denize, composite R&T project manager at Daher. “LMPAEK was the best candidate for weldability but also regarding degradation versus time at process temperature. The Victrex material was our best choice for this program and we fully characterized it to have the input data needed for simulation.”

Process and part simulation were indeed vital, aided by project partner AniForm. “We’ve worked with them for 5-6 years,” says Denize. “Their model to predict defects in stamped TPC parts is well-developed for fabric materials and is advancing UD materials.” Years ago, as Daher began manufacturing more complex geometry parts, it wanted to accurately predict defects like wrinkles. In this project, Daher not only worked with



■ Automated fiber placement (AFP) before Direct Stamping integrates Daher’s patented slit tape transfer solution (top). After heating both surfaces to be welded, the infrared (IR) lamps are removed, the press is closed quickly and the parts are welded (bottom).

optimize that metallic rib,” notes Bailly, “and then we used that as our basis to develop a more optimized TPC rib.”

Why is it so thick (up to 64 plies/12 millimeters)? “Composites are key to achieving the new long and thin wing designs being tested for NGS, which enable the reduced drag and fuel consumption being demanded,” says Bailly. “This new rib has been developed to meet those goals and it will see more load than ribs used in aircraft today. Our challenge was to make the same part in TPC but with improved weight, production rate and cost. And even though we’ve created a structure with 64 plies, we’ve also proven it weighs less and generates less CO₂ than the metallic rib. That also is the power of optimized composites and welding — even with

AniForm on further developing defect prediction, but also a new model to predict deformation of the parts *after* stamping.

“We often talk about springback,” Denize explains, “for example, the way the angle of an L or U shape will be more closed or open compared to the theoretical part due to thermal stress during molding. This AniForm model helps to predict these effects as well as any warpage or twist in the part.” For the moment, this model is still in development, he notes. “We have a research agreement with AniForm to help advance this capability for their commercial software.”

Development of the thick TPC rib iterated through several loops between the design team and the process team. “We began with a simple L-shaped part,” says Denize, “because our rib is basically two stamped L shapes welded together. We first modeled only one of these, but featuring the high thickness — which is not constant but varies — including ply drops and pickups. We

then progressed to warpage prediction for the full-scale rib. Next, we tested the rib in compression, shear and for buckling resistance, and refined the design based on the results. The AniForm software also helped us to make certain choices because we could see that some geometries were not able to be stamped or had a high risk of defects. Using the UD material meant that not every shape could be stamped. So, we again refined the design and the stamping process.”

Direct Stamping

Daher has produced stamped TPC parts for the A350 for 15 years. During that time, it has also developed and continued to refine its Direct Stamping process including applications and awards for 13 patents.

Automated fiber placement (AFP) is used to create the flat blank via fast layup that minimizes waste, explains Bailly. “We then use the stamping press to create the 3D shape and finish consolidation simultaneously. But the AFP parameters must be tuned to fit with the stamping. We don’t just lay a flat preform and put it in the press. Compared to conventional stamping, everything is different with Direct Stamping — from the part design to the AFP process to the way you stamp. All of the parameters must be aligned to reach the required level of quality and mechanical performance.”

“We produced a lot of reference samples with a classic stamping process using oven consolidation,” explains Denize, “and we compared those to Direct Stamping at every step in order to tune the AFP and stamping parameters to have the same performance. We also had to optimize Direct Stamping for high thickness; the process works easily for thin parts but had to be modified for these thick parts. This included a campaign to validate the inner quality and mechanical performance of the part.”

■ The wave shape in the lower L part and the top contour that follows holes for systems installations eliminate extra material and reduce weight.

“We also patented a smart way to transfer the parts from the oven to the press that eliminates the need for polyimide film,” says Denize. “We thus improved the buy-to-fly ratio by

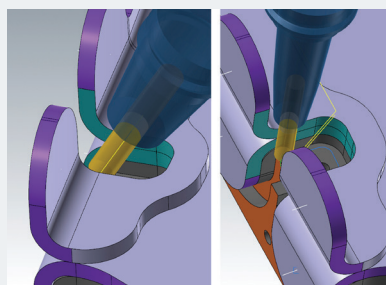
Machining of mouse holes

Machining system access holes into the thick, welded TPC rib was also a challenge. As explained by Daher composite machining expert, Sébastien Louvel, in an April 2026 article, conventional approaches, including tooling that relies solely on vacuum clamping, no longer work on these parts, where cutting forces can reach 1,000 newtons.

“They [parts] also remain highly sensitive to vibrations,” he says, noting that poor clamping quickly leads to degraded quality or even tool breakage. Vibration control becomes even more critical for high-rate production. All parameters must be considered, and a holistic process approach is needed, which includes cutting assistance, chip management,

instrumentation and data collection.

“Based on physical measurements during preliminary trials, we specified the equipment now installed at our Shap’in TechCenter,” says Louvel, “and this system is fully



instrumented to prepare for future production monitoring.”

This is essential, he adds, because small-diameter cutters are not suitable when machining 12- to 24-millimeter thicknesses. “Instead, we use tools with diameters of 12 or 16 millimeters. These are more heavily loaded and more expensive, so monitoring is key to ensure tool life and process stability. Our industrial production today is based on proven tooling designs validated on numerous prototypes to guarantee reliability, stability and repeatability without vibration issues or tool failures.”

generating less material waste but also by minimizing the need for such auxiliary materials required for vacuum bagging plus sealants required for fasteners.”

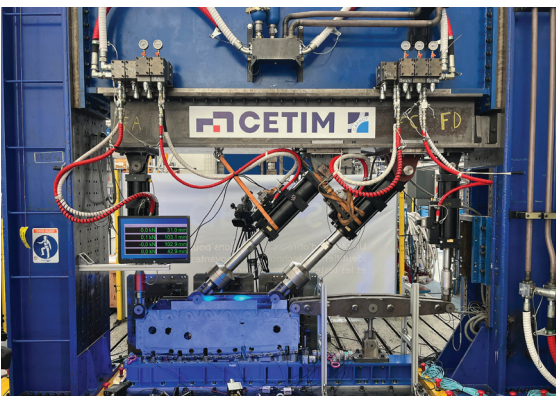
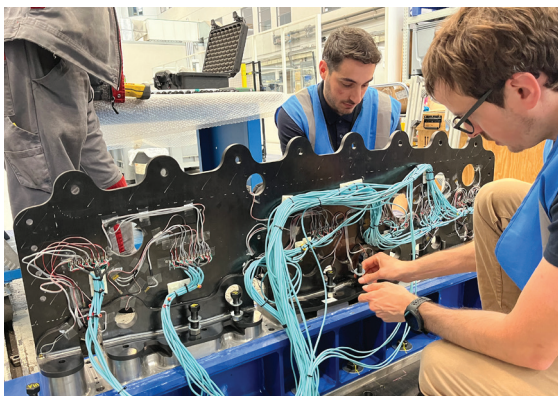
IR welding

“We knew we wanted to use welding,” says Bailly, “but also that our in-house solution for induction welding would be very challenging for the thick laminate. As the web of the rib is flat, we began discussions with LIST, which had proposed IR welding as a solution for large, flat surfaces.”

He points out that the induction welding Daher performed on the full-scale torsion box (based on the company’s TBM aircraft) exhibited at JEC World 2024 was a maximum width of 20 millimeters. “That works well for welding complex surfaces, but IR welding seemed a better fit for larger surfaces to achieve high-quality welds with a minimum number of welding passes,” he explains.

Bailly says IR welding is automated and robust — both important characteristics for high-rate production — controlled by its key process parameters: temperature, time and pressure. “The basics »





■ The full rib was equipped with numerous sensors, painted for digital image correlation and tested in simultaneous compression and shear load introduced via actuators.

are simple,” he explains. “You have two parts fixtured in a press — one on bottom and one on top. IR lamps are placed in between to heat both surfaces. You then remove the lamps, quickly close the press and the parts are welded.” Masks are used to isolate heat to only the surfaces being welded on each part, with general weld time between 5 and 20 minutes for the Daher thick rib.

The team will look at further industrializing the machine setup, says Bailly, “but for welding flat surfaces to each other, this is a good solution because you don’t have to push the power through the material thickness — you only heat the surface — so the thickness of the two parts does not have a big impact on the time required to heat the parts. For this type of thick rib, it’s perfect. It could also work well for smaller parts.”

It does have limits, he concedes, such as part size and shape complexity. “You still must apply pressure during welding to have the surfaces in contact,” he explains, “and when you push vertically on a curved surface, the pressure will vary due to the angle. You also need to have high-quality components with accurate geometry and collect all the process data for statistical process control.”

Bailly points out there is currently no confirmed nondestructive test (NDT) method for the interface of welded joints. “This is an important step. There are some prototype solutions to verify that you have the right level of adhesion between the two parts in the weld line, but we have identified other possible solutions and are working to evaluate those.”

Process integration, testing and wave design

The biggest challenge in this development was maturing the Direct Stamping and IR welding processes for this thick part, says Bailly. Denize agrees, noting that with IR welding, “we started at TRL 1. We wanted to end with a full-scale part that would pass mechanical testing, so we had to adapt the processes for this ambitious rib design and then validate the part performance and quality throughout.”

“We also validated the quality and mechanical performance of the *material* at every step of the testing pyramid,” he continues, “from coupon size to level two and three samples for stress, up to

subscale, then full scale. We have done the complete test pyramid, which you don’t see very often. You see a lot of demonstrators, but not a lot of information about testing and performance.”

“Results from

our CARAC TP program enabled us to directly target the right process windows for AFP and stamping,” says Denize, “reducing the number of tests we had to perform to reach the desired performance. It supported our need to go fast in this project but has also helped in other projects. We are always looking at the CARAC TP results to have a starting point for tests, and also to help choose the right materials, including ensuring they can withstand the environmental constraints of the part, such as higher temperatures near the engine.”

“For the IR welding, we completed the whole test pyramid again to validate the process across the part,” Denize continues. “Before we reached the final shape and weld design, we evaluated different welding thickness jumps and wave shapes in the lower L-shaped part. We also evolved that part’s contoured design to follow holes for systems installation in parallel with the welding tests. Our goal was to validate the process, but we were also optimizing the quantity of thermoplastic material via the shape to have just the right amount of material and where we needed it.”

Denize explains that extra material and length would be needed if the rib used fasteners, “because of the distance required between the fastener and the contour of the part. But you don’t need that when using welding to join the parts. So, you not only eliminate the weight of the fasteners, but also the extra material required.”

Full part testing and certification

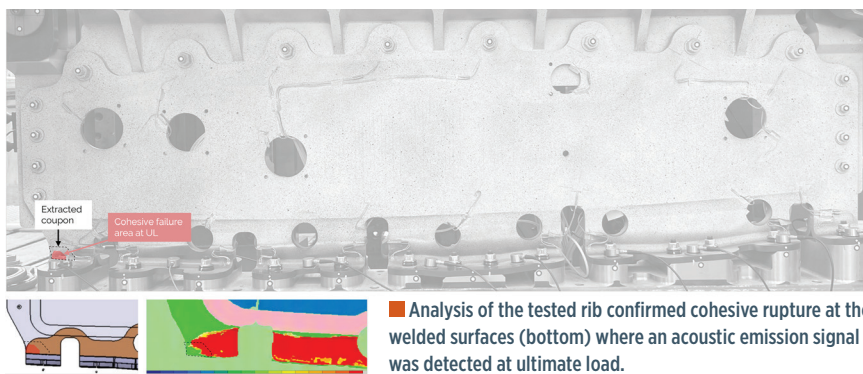
One end goal for Daher’s thick rib development program is a full part mechanical test to prove its performance and parity with the classic stamping process, notes Denize. Cetim was the partner for this full-scale testing.

Initial results in June 2026 showed the part survived beyond ultimate load without failure under combined loading conditions representative of what this rib would see in a single-aisle aircraft wing. The rib was subjected simultaneously to 25 tonnes of compression

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■ Analysis of the tested rib confirmed cohesive rupture at the welded surfaces (bottom) where an acoustic emission signal was detected at ultimate load.

Further optimization, functionalization

With the full-scale rib testing now complete, the project is in its final phase, comprising analysis of the test results and correlation to the modeling, says Denize. “We will then compile a final technical and economic analysis of what it costs to produce the part. We’ve already shown a 25% reduction in production time compared to traditional consolidation using oven or autoclave and assembly using bolts or rivets. This design and its process technologies also require less energy.”

“The actual cycle time depends on a lot of different factors,” says Bailly, “including installation of the part in the press, heating, cooling and demolding. So far, we have used a prototype setup for R&D, but we are now looking at how to automate and accelerate some of these phases for industrialization. Still, if you look at the speed Direct Stamping offers and compare what we’ve demonstrated in the welded rib to the multiple steps required for fasteners — drilling holes, cleaning them, inspection, applying sealant, etc. — our approach offers significant time and cost savings.”

“But we are improving the large thick rib design even further,” says Denize, “including overmolding using recycled materials from TPC clips and bracket production. This is part of our broader strategy for TPC parts, which includes not only zero-waste solutions in production but also recycling end-of-life parts.”

“Our first step is with a smaller, stamped thick rib,” adds Bailly, “which opens new possibilities for optimization because the overmolding enables different functionalizations.”

“This large thick rib we have achieved represents a significant step forward,” says Denize. “It helps to enable the innovative wing architectures necessary for NGSA and speeds wing assembly thanks to its simple design. Daher’s ability to produce very thick-walled parts could also help to reduce the quantities of wing components necessary for future aircraft.”

“We have always been a strong partner for OEMs,” says Bailly, “and have continued to invest in technology and production readiness for the parts required in future empennage, fuselage, wing and movables.” Daher is developing a production plant digital twin for thick and large TPC parts for future large commercial aircraft and amassing a foundation for certification. “We are also advancing fast-cure TS, machining and inspection — the technologies needed for high-rate aircraft production now and in the future.” **CW**

and 25 tonnes of shear on a test bench co-engineered with Daher and built by Cetim specifically for the program.

“The part was fixed at its foot or base and also on the side to represent the spars in a wing,” says Denize. “It was fixed on the top edges as well, while actuators at 90° and 45° introduced compression and shearing in the rib. Numerous sensors were placed on the part, including strain gauges and acoustic emission sensors, plus a camera to perform stereo correlation [digital image correlation], which will enable us to eventually replace some of the sensors with a camera. We are using all of this data to analyze the breakage in the part and compare the results with our stress modeling.”

This analysis is ongoing, says Bailly. “Our team was able to isolate and separate the small welded area (about 250 square millimeters) where an acoustic signal was detected at ultimate load. Analysis of the surfaces here confirms that the rupture was cohesive — as in coupon-level testing — and was located in the area with the highest theoretical load. This result is very promising for the IR welding technology, and we will provide more details and discussion in our presentation at ITHC 2026.”

For now, only static tests for the full rib have been performed. “But we will also have to do some fatigue testing,” says Denize. “We are currently doing this type of testing at the sample level on welded coupons made using the test setup of KVE Composites, a Daher subsidiary specialized in advanced TPC technologies. We then subject those to cyclic loading. Eventually, this will also be needed for a full-scale welded rib.”

“We have also been working with the authorities to see how we can certify this design,” says Bailly. The thick TPC rib program was aligned with European Aviation Safety Agency (EASA) CS-25 certification requirements for large turbine-powered aircraft. “The test pyramids we’ve completed in this program and this full part mechanical testing are the first steps. However, if we had to certify this part today, we would still be required to add chicken rivets. So, we are working to see what is the actual amount of rivets that we would have to add. So far, we’ve determined it’s only around 10, so that’s not a big weight and cost impact. But we are still working on it. We also want to build as much design and process intelligence as possible for the next generation of short- to medium-range aircraft.”



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Robotic Dry Fiber Cell and 2,400-Ton Composite Press Reduce Aerostructure Build Time by 90%

The University of Sheffield's Advanced Manufacturing Research Centre's Composites at Speed and Scale (COMPASS) facility hosts Boeing's IHSS program developing high-rate manufacturing of large composite aerostructures using automated ply placement, a matched-die resin transfer molding process and digital twin technology.

By Stewart Mitchell / Technical Editor

» According to an analysis by the Aerospace Technology Institute (ATI, Bedfordshire, U.K.), the next-generation single-aisle aircraft requires a production rate of 180 per month by 2046, with the underlying manufacturing technologies required to reach technology readiness level (TRL) 6 by 2030 to support entry into service in the mid-to-late 2030s. With single-aisle aircraft projected to account for roughly 70% of all deliveries through to 2050, and for manufacturers to significantly increase the amount of composite aerostructures throughout the aircraft, composites manufacturing rate needs to grow more than sixfold in comparison to the current state-of-the-art to capture this opportunity.

Boeing UK (Sheffield, U.K.) is building manufacturing intelligence to produce large composite aerostructures at high rate through the Isothermic High-Rate Sustainable Structures (IHSS) program, which develops, tests and automates an isothermal dry fiber resin infusion process. The IHSS program is an R&D initiative aiming to reach TRL 6 by its conclusion. Although it will validate

■ **LEFT:** The integrated COMPASS cell runs as one entity. Dry fiber cutting and preforming feed directly to the Langzauner composite press via FANUC robots traversing a shared 85 meters of track. Source | University of Sheffield AMRC

laminate quality through nondestructive testing and material characterization, the unique requirements of Boeing's commercial customers and certification will be addressed at a later stage.

"Some of the established composites manufacturing processes are hard to scale for consistent quality and speed," says Steve Belcher, Boeing's chief engineer on the IHSS program. "Continuing with that approach means replicating slow processes, and the business case weakens with each iteration. IHSS aims to produce high-quality composites at rate, in a scalable way."

IHSS is the first initiative to operate within COMPASS (Composites at Speed and Scale), a £54 million open-access facility that the University of Sheffield's Advanced Manufacturing Research Centre (AMRC, Sheffield, U.K.) opened in July 2026. This facility aims to advance composites manufacturing by moving processes out of the autoclave, which often limits the rate of production for large structures.

Isothermal goals

Autoclave cycles comprise ramping the prepreg part up to cure temperature, a dwell to achieve cure and then a cooldown. Each stage costs time and energy. In contrast, an isothermal process

infuses and cures at one constant temperature, often releasing the part while it is still hot without distortion. Removing the heating and cooling ramps cuts the cure time and energy costs while dry fiber processed by vacuum infusion or resin transfer molding (RTM) removes the autoclave. However, the latter introduces two other constraints: achieving complete wet-out of the preform and meeting porosity or void content requirements.

COMPASS uses matched-die RTM, with hard steel tooling on both faces. Resin injects into dry fiber under pressure, driving fiber volume fraction toward the roughly 60% structural laminates need. The system's tooling requires the preform to reach the mold in the correct shape and position every cycle because there's no flexibility to absorb error.

"The resin chemistry sets the limit," says Darren Wells, senior technical fellow at the AMRC, who leads the composites side of COMPASS. "The nirvana point of this project will be a fully isothermal component, but the resin chemistry isn't quite there yet. Aerospace-grade infusion resins carry heavy tougheners, which raise viscosity and lengthen cure time, so we drive up the glass transition temperature [T_g] and mechanical properties post-cure with controlled heating and cooling ramps in an oven in the meantime. Our benchmark is autoclave prepreg, but to achieve the anticipated production rates for a single-aisle, it needs to be closer to automotive RTM, which runs low-viscosity snap-cure resins in well under an hour."

»

■ A FANUC M-2000iA/1700L places material onto a curved tool. The system deposits 200 kilograms an hour in standard configuration against 20-50 for automated fiber placement (AFP). Source | University of Sheffield AMRC





Building the preform

The COMPASS production line starts at a 21.4-meter Zünd (Altstätten, Switzerland) cutting table where an ultrasonic head cuts plies from a roll of dry carbon fiber fabric. The Zünd system can hold ± 0.2 millimeter tolerance across 20 meters, cutting at one end while material lifts from the other.

Two 5-meter FibreFORM grippers from Loop Technology (Dorchester, U.K.) pick each ply off the table under high-flow vacuum. Each gripper carries close to 290 individually controlled suction axes, synchronized about a thousand times a second so the tool moves as one surface. The gripper end effectors are mounted on two of FANUC's (Oshino-mura, Japan) M-2000iA/1700L 4,683-millimeter-reach robots, part of a five-robot fleet on 85 meters of track within the facility.

"Placing a flat ply into a curved tool without wrinkling is the

constraint the system solves automatically," says Alun Reece, chief executive officer of Loop Technology. "A flat sheet wraps onto a single-curvature surface easily, but on a double-curvature surface like the shape of a real aerostructure, it cannot be covered by a flat sheet without shear, the same reason a sheet of paper will not wrap around a ball without creasing. FibreFORM predicts where shear will be high and where

it will be low, then grips firmly where the material should stay put and eases off where it needs to move, allowing the material to move predictably so it can follow the desired form."

The gripper system places to an accuracy of ± 2 millimeters and deposits 200 kilograms/hour in standard configuration, though in trials it has reached 350 kilograms/hour at full capacity, a significant increase over the 20-50 kilograms/hour for typical automated fiber placement (AFP) technology. A structured-light scanner reads every ply for position and defects as it is tacked, closing a machine vision check before the next ply lands. Subscale trials refined this preforming sequence and the cure tool design, drawing on the AMRC's RTM experience across aerospace and automotive. The cell builds the dry fiber preform under a consolidation hood and moves it to the press as one stack.

Press, injection and cure

The Langzauner (Lambrecht, Austria) composite press in the COMPASS facility is reported to be the largest ever built for aerocomposite parts. It applies up to 2,400 tonnes across a 10.5×3.5 -meter platen at roughly 8-10 bar over a typical press tool, matched to autoclave pressure so parts transfer into known process windows.

"The challenge was not simply to provide 2,400 tonnes of pressing force, but to control that force with very high precision across a tool of this scale," says Alexander Wiesner, executive vice president at Langzauner. "Each of the hydraulic cylinders runs closed-loop servo-hydraulic control, holding force accuracy to 0.1% and position to hundredths of a millimeter. The press is also equipped with

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active platen tilting and two-axis rotation, enabling controlled gap-injection strategies and allowing the process to be adapted to varying component thicknesses and resin-flow requirements.”

Heating across the press is zoned to match thermal mass throughout. Eight thermal oil units feed the tool, producing around a megawatt of heating with roughly 750 kilowatts of chilling, with zones that pull a cold region up without overshooting its neighbors. Resin arrives through a KraussMaffei (Parsdorf, Germany) impingement-mixing RTM unit taken from automotive practices, and enhanced for aerospace through sub-scale trials at the AMRC, which doses and mixes the two components and self-cleans between shots so the cell doesn’t have to stop for a manual purge.

A cure that runs 8-10 hours in an autoclave is the process the program aims to shorten substantially; the AMRC states IHSS targets a reduction in large-component manufacturing time from around 40 hours to 4. A 12-meter oven downstream post-cures to ensure T_g is where a part needs it, before robotic trimming against a coordinate measuring machine (CMM) datum takes place.

Every machine within COMPASS is digitally connected and reports into a digital twin of the entire facility. Sensor streams route through a lightweight messaging protocol called message queuing telemetry transport into a unified namespace, so a torque

or temperature reading carries its context down to the axis, robot and cell, then writes to an encrypted record that travels with the part as a digital passport.

“As the cell was built digitally connected from the start, the AMRC holds a validated digital twin of the line checked against machines whose real accuracy is known,” says Wells. “A company can simulate building a future factory against it before construction. That is a key part of the design of this facility that places systems that are produced in here at TRL 6.”

What COMPASS means for the supply chain

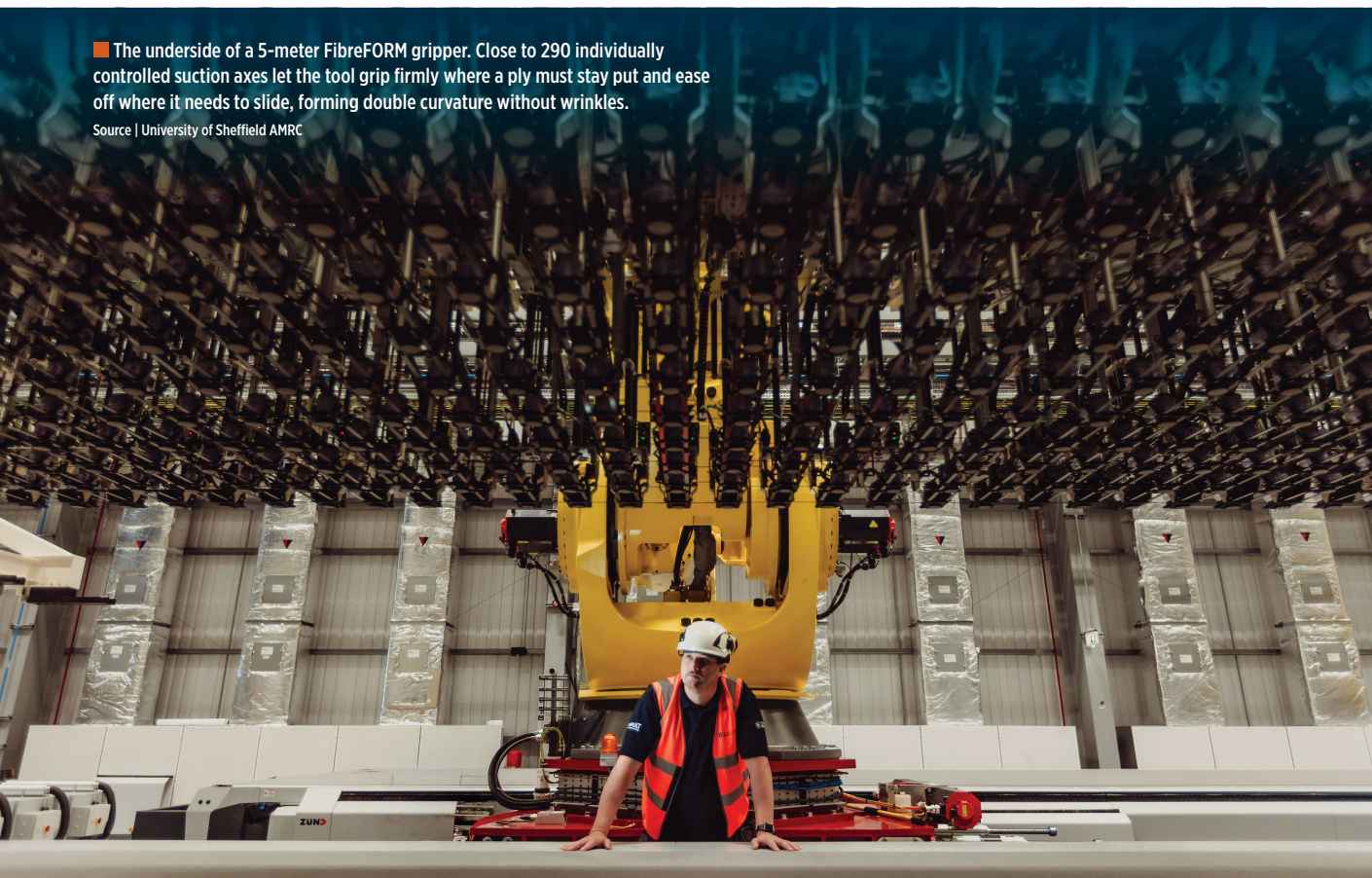
Boeing and the AMRC have successfully demonstrated the IHSS production process with subscale 3- and 4-meter-long representative aerostructure sections. Using existing equipment, they have translated the results into tooling, handling and cure specifications for the facility’s 8-meter demonstrator.

Despite the high quality of the test parts, constraints remain. The fully isothermal cure is not yet available and full-scale tooling was still arriving as the facility opened in July. “The main thing we’re waiting on is the RTM infusion tool that goes in the press,” Belcher says. “We’re still proving out the route to manufacture at full scale, but COMPASS shows the sequence holds at scale so far.”



■ The underside of a 5-meter FibreFORM gripper. Close to 290 individually controlled suction axes let the tool grip firmly where a ply must stay put and ease off where it needs to slide, forming double curvature without wrinkles.

Source | University of Sheffield AMRC





The £29.5 million equipment inside COMPASS forms part of an £80 million combined program with IHSS, held under open access. As such, any composite parts manufacturer can develop and de-risk a high-rate process using the equipment without buying it. That removes a significant cost barrier that has kept smaller firms out of primary composite aerostructures, potentially diversifying the industry. The facility is expected to support thousands of skilled U.K. manufacturing jobs and draw investment into the domestic aerospace supply chain.

IHSS aims to stimulate a wide range of advancements. "IHSS weighs manufacturability and serviceability from the start, down to cure tool maintenance and raw material waste," says Lane Ballard, Boeing's chief technology officer. "These are not academic exercises. They're practical steps to reduce waste, shorten cycle times, shrink factory footprints and lower energy use."

The automated placement, press cure and digital thread sequence demonstrated so far also applies to defense structures, wind energy, transport and urban air mobility — wherever large composite parts must be made at rate. "This is a real drive away from what industry used to deem as lightweight black metal parts," says Wells. "Here we design for composites and for high-rate manufacturing at the same time, using systems optimized for composites from the outset." **CW**

■ **ABOVE:** The Langzauner press is featured in the center of this image, reported as the largest built for integral aerostructure parts. Source | University of Sheffield AMRC

■ **BELOW:** Every machine reports into one data system, with sensor streams brought together and written to an encrypted digital passport that travels with every part. Source | University of Sheffield AMRC



ABOUT THE AUTHOR

Stewart Mitchell is a Bristol, U.K.-based engineering journalist with experience covering technology in Formula 1, electric and hybrid powertrain and autonomous systems. He has a degree in motorsport engineering from Oxford Brookes University (Oxford, U.K.), and is a member of The Institution of Mechanical Engineers (London, U.K.). smitchell@compositesworld.com

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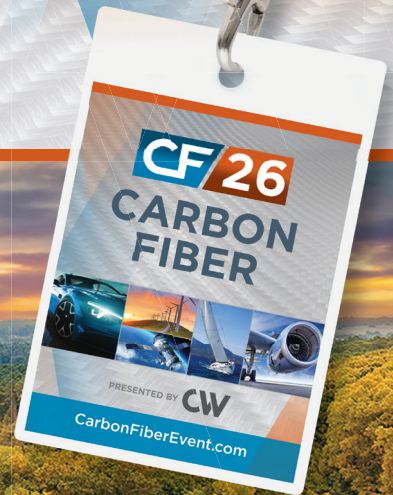


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APPLICATIONS

SiC Fiber Solves Signal Blocking, Weight Challenges in Electronics

Hunan Zerafiber has developed a new version of its silicon carbide fiber to provide a radio-transparent consumer electronics material option that is also thinner and stronger than other composites or plastics.

Edited By Hannah Mason / Technical Editor

» The structural housing components of consumer electronics like laptops, smartphones and smart glasses are conventionally made from lightweight, relatively impact-resistant, readily available metals like aluminum, magnesium or magnesium-aluminum alloys. However, the limitation has always been that these metals block electromagnetic waves and interfere with signal transmission, requiring workarounds in the device design like slots or plastic windows that allow transmissions to pass through. This issue becomes more prevalent when factoring in increasingly strong 5G/6G signals and beyond. Nonmetallic alternatives are typically unreinforced plastics, which solve this issue but sacrifice strength properties, light weight/thinness and/or premium aesthetics.

Founded in 2019 and designated as a Chinese national high-tech enterprise, Hunan Zerafiber New Material Co. Ltd. (Changsha) aims to address these limitations with the R&D and manufacture of a version of its silicon carbide (SiC) fibers designed for manufacture into resin matrix composites for consumer electronics. “The goal was to develop a material that combines high electromagnetic wave transparency, high mechanical strength and a metallic appearance for structural and exterior components of consumer electronic products,” the company says.

■ Hunan Zerafiber’s silicon carbide (SiC) fibers are manufactured into composite parts for a variety of high-end equipment applications.

Source | Hunan Zerafiber

Why SiC? Hunan Zerafiber’s founder and chief scientist Professor Huang Xiaozhong brings a strong background in SiC academic research, and the company, based in the Liuyang National Economic Technical Development Zone, employs three scientific research labs centered on SiC fibers and composites, as well as a large-scale industrialization production site.

Several years of R&D initiatives have resulted in an electronics-grade, radio-transparent SiC fiber, which combines electromagnetic wave transparency with high strength and a metallic appearance. The SiC fiber can be manufactured into a composite through compression molding or autoclave curing to produce thin panels or more complex curved components.

According to Hunan Zerafiber, the material has a very low dielectric constant, resulting in an electromagnetic wave transmission rate of 95% or higher in the 2-8 gigahertz frequency range “enabling reliable transmission of 5G/6G, Bluetooth, WiFi and GPS signals without requiring antenna isolation bands,” the company says. Compared to similar parts made with metal, the SiC composites reduce weight, maintain high strength and stiffness and offer high heat resistance to prevent deformation caused by heat from internal electronic components.

In comparison with glass or carbon fiber, the SiC fiber also enables thinner composite structures, allowing for an additional 0.1-0.2 millimeter of internal space within the device for larger batteries or precision optical components.

So far, Hunan Zerafiber’s new fiber has shown potential in applications such as laptop display frames, keyboard decks and bottom covers, smartphone back covers, AR/VR smart glass frames and structural components for drones. **CW**



CFRP/Graphite Heat Dissipation Device Enables Lighter, More Mobile Satellite Communication

A collaboration led by Mitsubishi Chemical developed a composite device to match thermal conductivity of an aluminum NTN satellite heat dissipation device while reducing weight by 47%.

» Non-terrestrial network (NTN) antennas connect smart devices or drones to satellites, and can be placed in fixed locations like rooftops or, increasingly, mobile ones such as vehicles, marine vessels or aircraft. The high-power electronics required to operate the system necessitate high levels of heat dissipation performance to protect the overall antenna, conventionally achieved with an aluminum heat dissipation device that conducts heat safely away from the structure. However, the desire for increasingly mobile and movable antennas creates the need for a lightweight structure.

In July 2025, four Tokyo, Japan-based companies started a collaboration to address this challenge: Mitsubishi Chemical Corp., the National Institute of Information and Communications Technology (NICT), electronics company Sharp Corp. and engineering and manufacturing company Techlab Co. Ltd.

The goal was “to jointly develop ultra-compact, lightweight satellite communication terminals for mobility applications, and address the excessive weight and thermal management limitations

■ The redesigned heat dissipation device combines carbon fiber prepreg with layers of graphite. Source (All Images) | Mitsubishi Chemical Corp.



■ The heat dissipation device, also called a thermal management device, sits between the antenna and modem.

of the conventional aluminum design,” explains Mitsubishi Chemical. The new structure also needs to maintain the antenna’s required electrical and heat dissipation performance.

First, partners defined the thermal and weight requirements of the device to determine optimal materials, then designed the structure. For lightweighting, the partners naturally turned to carbon fiber composites. For the thermal conductivity requirements, they settled upon graphite, commonly used for in-plane thermal conductivity in electronics but too brittle to be used on its own in a structural part.

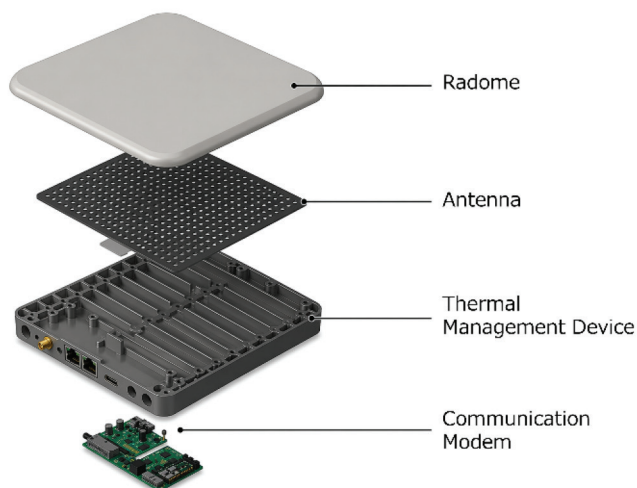
Mitsubishi Chemical developed and supplied carbon fiber prepreg (resin for this specific demonstrator application is undisclosed, but would commonly be an epoxy) and graphite sheet materials that would be layered together, while Techlab developed the mold and process technology for forming the final part.

As of June 2026, the new heat dissipation device has been completed and tested, integrated into the planar antenna, and the electrical performance of the antenna has been verified and its overall operation demonstrated. After manufacturing by Techlab, Sharp integrated the completed device into the NTN planar antenna and validated the electrical- and terminal-level performance.

The results? The device, which on its own weighs less than 1 kilogram, reduces overall antenna weight by 47%, from 5.5 to 2.9 kilograms. This supports “the broader aim of making satellite communication terminals practical for installation on drones, vehicles and other mobility platforms,” Mitsubishi Chemical says.

Regarding its thermal conductivity performance, testing showed no meaningful degradation in antenna performance compared to the conventional aluminum design. Radiation pattern differences remained within measurement error, and receive-gain characteristics were unchanged. The team also confirmed operation of the antenna with a model as a complete satellite communication terminal.

The project is now moving forward into further evaluation of thermal performance and mountability, along with continued prototyping and demonstrators toward practical deployment on drones, vehicles and other mobility platforms. **CW**



NEW PRODUCTS

» Surface films

SHD Presents SFX740 Composite Surface Films Range

SHD Composites (Mooresville, N.C., U.S.) announces SFX740, a range of easy-to-apply surface films.

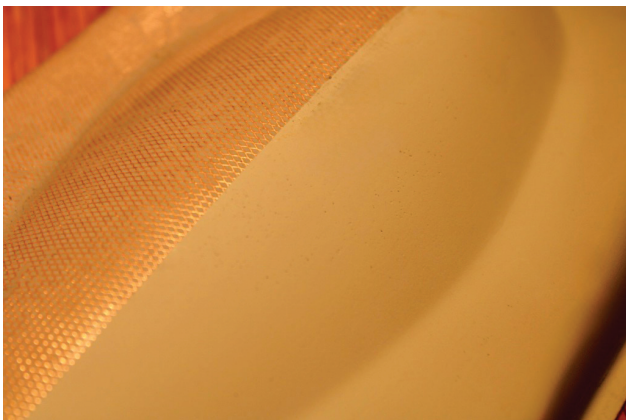
All three surface films — SFX740-LS, SFX740-LW and SFX740-HF — are engineered to reduce processing time and costs without compromising surface quality, are designed for out-of-autoclave (OOA) processing and have low temperature cure options. The SFX740 range replicates the mold details perfectly once demolded, SHD reports. Tailored surface tack makes placement in the mold simple and robust, and the base chemistry is formulated such that the three new surface films work together with all of SHD's VTC and MTC epoxy prepreg systems. Once molded, components come out ready to use with no postprocessing, or only requiring light touch preparation prior to painting.

SFX740-LS incorporates an integrated copper mesh layer to provide LSP with a lightweight carrier ply for conformability. It is developed for aerospace and advanced air mobility (AAM) applications.

SFX740-LW is a lightweight variant designed for applications where minimizing mass is critical without compromising surface quality or manufacturing efficiency.

SFX740-HF is a high-build solution engineered to further suppress fiber print-through. It is a final finish parasitic material for bench detailing and ultimate surface uniformity, often on challenging composite structures requiring high cosmetic standards for a paint finish.

SHD Composites | shdcomposites.com



» Website platform

Catalysium Launches Integrated Online Platform for Composites Innovation, Growth and Investment

Catalysium (Zurich, Switzerland) has launched a new platform and website, bringing together three complementary activities under one mission to build the future of composites and advanced materials.

Founded in January 2025 by composites engineer and entrepreneur Yannick Willemin, Catalysium has



rapidly established itself as a trusted partner for startups, industrial companies, investors and innovation organizations operating across the global advanced materials ecosystem. Rather than focusing on a single activity, Catalysium has been structured around three interconnected pillars:

- **Catalysium Advisory.** Supporting companies with strategy, fundraising, business development, market access and ecosystem partnerships.
- **Catalysium Insights.** Producing industry analysis, educational content, executive interviews and multimedia formats, including The Composites Catalyst YouTube channel.
- **Catalysium Ventures.** Currently under development, with the ambition of creating a long-term investment platform dedicated to composites and advanced materials. The initiative aims to support the industry across its life cycle — from breakthrough startups and growth companies to strategic acquisitions and distressed assets.

Since its creation, Catalysium has collaborated with more than 50 organizations across Europe, North America and Asia, ranging from startups and SMEs to multinational companies, industry associations and investors. Beyond advisory work, Catalysium actively contributes to industry dialogue.

Catalysium | catalysium.ch/

» Tooling board

Eptek's Precision-Cast Tooling Board Eliminates Bondlines for Automotive, Aerospace

Eptek Tooling Materials (Shanghai) Co. Ltd. (Eptek), a Chinese manufacturer of tooling materials, has developed a precision-cast polyurethane and epoxy tooling board technology that replaces traditional spliced board construction for large, complex molds and models.

Conventional tooling boards are supplied as standard rectangular slabs. For large parts or deep cavities, manufacturers must cut, glue, cure and finish multiple sections. This splicing creates bondlines that differ from the base material in hardness, thermal expansion and sanding behavior. Even after filling and painting, seams can reappear on high-gloss or Class A surfaces. Glue joints also become potential leak paths, and adhesive layers are weak points that can crack or delaminate under repeated loads.



Eptek's alternative uses a close-contour casting process. Starting from the customer's 3D data, the company designs a dedicated cavity and injects liquid polyurethane (PUcast) or epoxy (EPcast) resin to form a single, monolithic blank that closely follows the final part contour. Only minimal machining allowance is left, reducing roughing time — in some cases by more than 50%. For thick-wall or high-temperature applications, staged curing and post-curing are applied to minimize internal stress and stabilize dimensions.

The cast blanks eliminate bondlines entirely, offering continuous surfaces, better vacuum integrity and longer service life compared with spliced boards. While standard board stock remains economical for small, simple parts, the casting approach becomes more efficient for large, curved or vacuum-sealed workpieces.

In automotive modelmaking, which accounts for about half of Eptek's projects, the cast tooling boards are used for full vehicle styling models, data control models, interior/exterior trim tooling and check fixtures.

In aerospace applications — also about 50% of the portfolio — the material serves as transition mold blanks for composite parts such as wing skins, fuselage panels and doors. It is also used for vacuum milling fixtures, stretchforming dies for sheet metal and inspection tooling.

Eptek Tooling Materials (Shanghai) Co. Ltd. (Eptek)

» Pipe repair

Denso Introduces Composite Pipe Repair Systems

Denso Inc. (Houston, Texas, U.S.) announces its Composite Pipe Repair Systems, two nonmetallic solutions that avoid hot welding and minimize operational disruption, engineered to reinforce pipelines affected by corrosion, wall loss and mechanical damage.

Designed for non-through-wall pipeline defects, Denso's composite repair systems combine carbon fiber reinforcement with epoxy primer systems to form a durable, load-bearing composite layer that works with the existing pipe to restore structural integrity and extend service life. Protal 3200CF and Protal 2800CF are designed for applications including pipelines, process piping, offshore topside piping, oil and gas risers, pressure vessels and more. Both material systems are designed in accordance with industry standards such as ASME PCC-2 and ISO/TS 24817.

Protal 3200CF is Denso's high-strength composite repair system, combining dry carbon fiber fabric with

Protal 3220 epoxy saturant, Protal 7200 corrosion barrier epoxy primer and Protal 3210 load transfer structural filler. The system delivers a high tensile strength of 114 ksi and an elasticity modulus of 9.32 Msi.

For quick pipeline repairs, Protal 2800CF provides a moisture-tolerant composite repair option that uses Protal 7300 corrosion barrier epoxy, Protal 3210 load transfer filler and a pre-impregnated carbon fiber wrap supplied in a nitrogen-filled foil pouch. The system is designed so the wrap is activated by applying a continuous light water spray, simplifying field application.

Denso Inc. |
denso.com

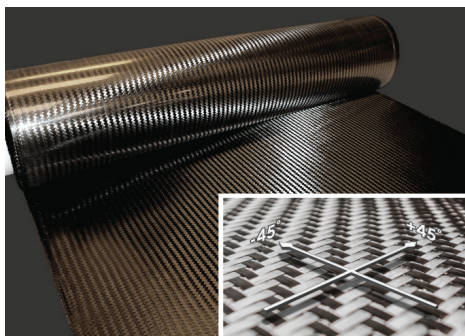


» Off-axis braided fabric

Toray Composite Materials America Expands 3960 Product Line

Toray Composite Materials America Inc. (Toray CMA, Tacoma, Wash., U.S.) announces the availability of its proven 3960 prepreg system in an off-axis $\pm 45^\circ$ braided fabric format. This format provides composite designers in the aerospace and defense markets with an alternative to traditional $0^\circ/90^\circ$ woven prepreg, engineered to reduce waste, improve manufacturing efficiency and increase production rates.

The $\pm 45^\circ$ bias fiber weave format, produced in collaboration with A&P Technology (Cincinnati, Ohio, U.S.), is ideal for any application requiring high-aspect ratio, off-axis reinforcement, particularly for aerospace primary and secondary structures such as wings, spars and stringers. Long, uninterrupted 45° plies are difficult to achieve with traditional woven prepreg, Toray CMA explains. Because 45° plies make up half of a standard quasi-isotropic layup (0° , $+45^\circ$, -45° , 90°),



manufacturers are able to divide nesting operations between $0^\circ/90^\circ$ 3960 prepreg fabric and $\pm 45^\circ$ 3960

prepreg, reducing scrap generated during the cutting and splicing of off-axis plies.

"The $\pm 45^\circ$ braided format gives our customers a real alternative to traditional woven prepreg, cutting scrap, speeding up layup and helping programs hit higher production rates without sacrificing structural performance," says Jeff Cross, principal director for defense programs at Toray CMA.

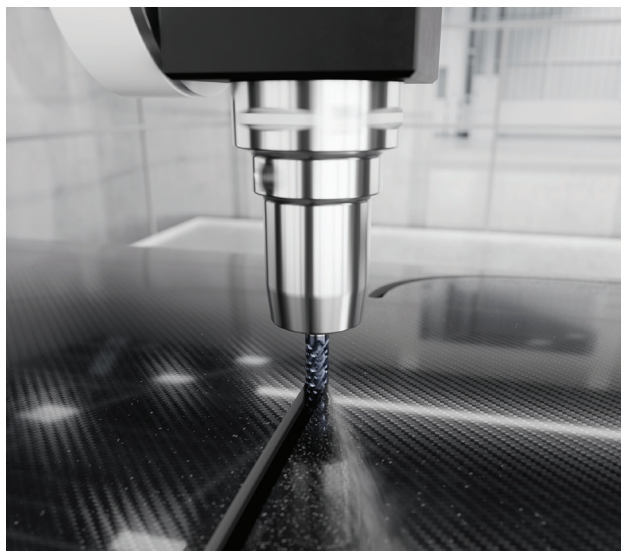
The material is made possible through Toray CMA's collaboration with A&P Technology, which has the ability to produce wide, continuous rolls of $\pm 45^\circ$ 2x2 twill fabric using Toray's Torayca T1100 fiber. Marketed by A&P as TX-45, the format is supplied in continuous 45° bias rolls, eliminating the need for splices. In a trade study conducted at the National Institute for Aviation Research (NIAR) comparing $0^\circ/90^\circ$ prepreg layup of a spar to 45° prepreg layup, TX-45 prepreg enabled a 30% reduction in waste and a 40% reduction in layup time.

Toray Composite Materials America | toraycma.com/

» Milling tool

Sandvik Coromat CoroMill Plura Composite Router Supports Longer Tool Life

Cutting tool specialist Sandvik Coromat (Mebane, N.C., U.S.) recently launched the CoroMill Plura composite 2P350 serrated router with a diamond-coated grade, O2AD. Engineered for ISO O workpiece materials, this upgraded cutting tool is intended to deliver productivity, tool life and process security gains when milling abrasive composite materials.



The CoroMill Plura addresses delamination, uncut fibers, vibration and rapid tool wear challenges through the router's patented dual-cutting mechanism, which provides a controlled, scissor-like cutting action for stable and predictable machining. Moreover, the O2AD grade is specifically engineered to withstand the abrasiveness of composite materials; field tests show up to 100% longer tool life compared to Sandvik Coromant's previous O12M grade.

CoroMill Plura composite 2P350 supports a wide range of demanding composite applications, including slotting, ramping and edging. Its large flute volume enables efficient chip evacuation and high material removal rates, while its low vibration cutting behavior contributes to a more comfortable sound environment on the shop floor.

Aerospace manufacturers producing fuselage structures, wings, stabilizers, spars, ribs and frames can expect substantial improvements in both part quality and productivity, Sandvik reports. The cutting tool also offers performance benefits for automotive, defense, space and nautical industries.

Sandvik Coromant Co. | sandvik.coromant.com/



Joe and Mark Annese

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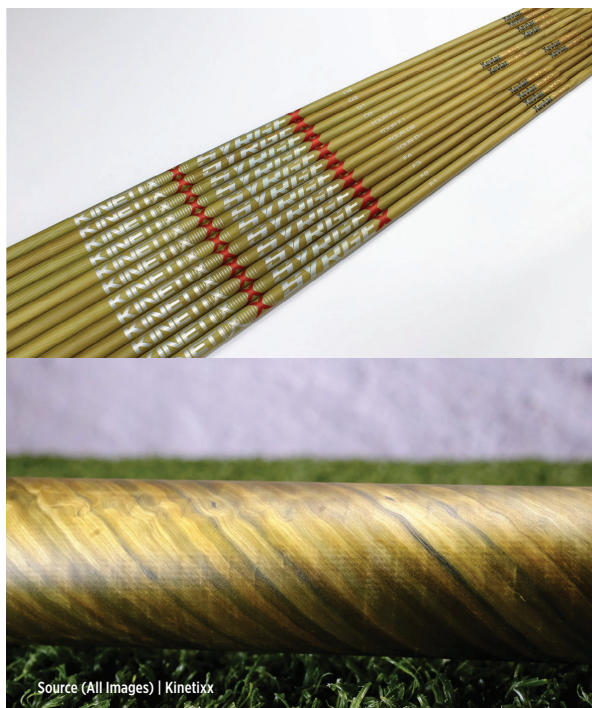
Highlighting the behind-the-scenes of composites manufacturing

Aramid Fiber Technology Creates Golf Shafts With High Power, Absolute Control

» Kevlar EXO, a next-generation aramid fiber developed through DuPont Kevlar (Richmond, Pa., U.S.) and owned by Arclin (Alpharetta, Ga., U.S.), is bringing high performance to carbon fiber golf shafts through a collaboration with Kinetixx (San Clemente, Calif., U.S.), whose ultra-premium golf shafts have previously used Kevlar and carbon fiber. Kevlar EXO's combination of high strength, increased elongation and controlled flexibility allows shafts to better absorb, control and return energy during the swing, improving stability, feel and durability versus traditional carbon fiber-only designs.

A filament-wrapped, vacuum-cured Kevlar EXO exoskeleton layer married with Kinetixx's high modulus carbon fiber golf shaft has enabled two designs, the FlexurX (with a unidirectional exoskeleton) and Syrgex (a twisted fiber exoskeleton), both of which resist "ovaling" to maintain concentricity, preserve ball speed and face control even on off-center strikes — in other words, power with guardrails.

Syrgex and FlexurX are available directly from Kinetixx's website with additional options coming soon. Meanwhile, Kinetixx and Kevlar EXO continue to explore where else this innovative fiber, paired with Kinetixx's manufacturing technology, can bring increased performance in sporting equipment and other composite applications. **CW**



Source (All Images) | Kinetixx

Show us what you have!

Every issue of *CompositesWorld* concludes with Post Cure, a section highlighting the behind-the-scenes of composites manufacturing.

The CW team wants to feature your composite part, manufacturing process or facility in an upcoming issue. Send an image and caption to CW senior managing editor Grace Stubbins at gstubbins@gardner.media.



CONTRAX 26

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WHO EXHIBITS:

Contract manufacturers, job shops, custom processors involved in:

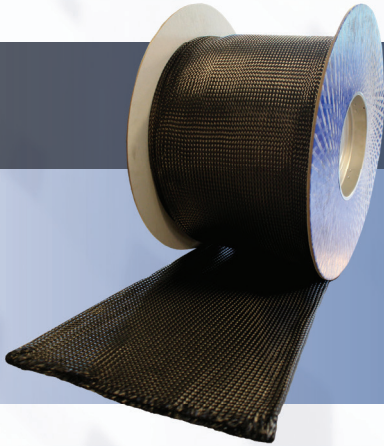
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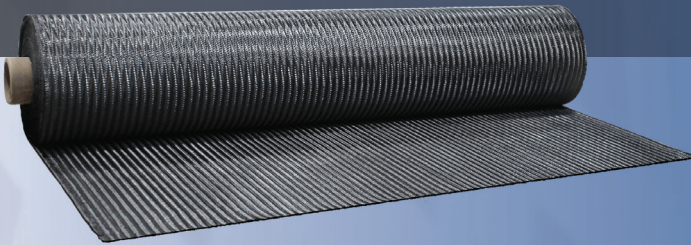
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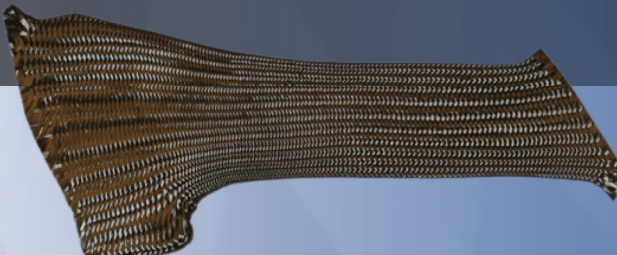
Sleevings

The Fiber Continuity of Braided Sleeveings Provides Increased Performance, Ease of Layup, Conformability & Repeatability



Fabrics

A&P's Braided Fabrics are Optimized to Create the Architectures and Areal Weights Required for Performance, Lightweighting, and Reduced Scrap



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