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Completion of the MFFD: WELDING TECHNIQUES ADVANCE FUTURE DUSTLESS ASSEMBLY

FEBRUARY 2025

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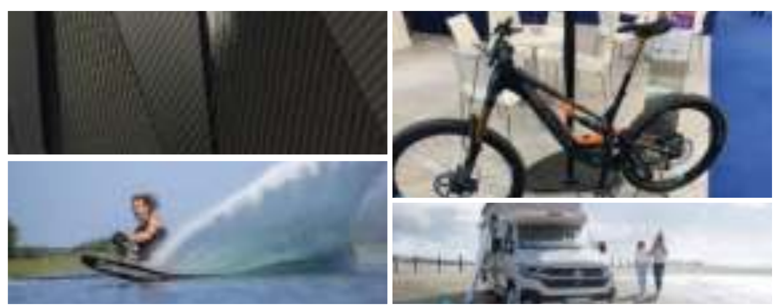

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After nearly 10 years, Clean 2 Sky's all-thermoplastic composite fuselage demonstrator, the MFFD, has been completed. The final steps — aimed to showcase "dustless assembly" — involved continuous ultrasonic welding of the right-hand longitudinal fuselage joint and resistance welding of couplers to join upper and lower fuselage frames. The MFFD is already serving as inspiration in numerous follow-up projects and initiatives. See p. 30.

Source | Clean Sky 2 MFFD, MultiFAL and WELDER projects

FOCUS ON DESIGN

52 Pultruded CFRP chassis enables 36% payload increase for specialized commercial vehicles
CarbonTT's quadraxial NCF composite chassis adds 185-kilogram capacity to Borco Höhns' 3.5-ton Fiat *Ducato* market vehicle.
By Stewart Mitchell

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Expanding your horizons at new industry events

Manufacturing in general offers a multitude of trade shows — and the composites sector in particular has its fair share. For many of us, there are always those few events that we know well, having attended them often. And while those more familiar conferences and trade shows may be an integral part of our annual planning, venturing beyond one's comfort zone to events that may cater to some of the other markets the composites industry serves can reveal new opportunities and insights.

Having served as an editor at Gardner Business Media for 7 years, I've seen the vital role that industry events like JEC World, SAMPE and CAMX play in connecting industry professionals and driving business — not to mention being a treasure trove for *CW*'s editors to discover leads for the content we share throughout the year.

However, our curiosity about less-familiar events has grown. Traditional manufacturing-focused events are essential for face-to-face interactions and idea sharing, but exploring new venues can lead to fresh contacts and new opportunities. Admittedly, it would be impractical to attend every event that touches the various markets that composites manufacturers serve. Nevertheless, stepping into a few different arenas has become a strategic initiative for *CW* in 2025. By doing so, we aim to provide a more comprehensive view of where composites intersect with various industries, fostering new connections and understanding.

AIAA's SciTech Forum covered a range of aerospace topics from from software and avionics to innovations in aircraft structures. Source | *CW*

This interest led us to the SciTech Forum in Orlando, Florida, an event organized by the American Institute of Aeronautics and Astronautics (AIAA). The show is quite different from many of the composites and aerospace events *CW* has experience attending. Attendees were a diverse mix, from students to defense industry professionals. The content spanned a wide range of topics, from software and avionics to aircraft structure innovations. The show felt more like a technology showcase than the manufacturing-focused gatherings we typically attend.

And that was the whole point.

"It's easy for us, when we think about the aerospace industry, to focus exclusively on composite materials and structures," says *CW* brand VP Jeff Sloan. "Events like AIAA's SciTech provide a much-needed reminder that there is a universe of non-composite disciplines — simulation, testing, AI, ablation, avionics, combustion, flow control, hypersonics — deployed to design and launch a craft, whether it's within the atmosphere, in low-Earth orbit or for traveling to the moon or Mars. Such a reminder is critical to putting composites in context as one piece in a multipiece puzzle that must be solved for successful flight."

AIAA's SciTech is touted to be the world's largest event dedicated to aerospace research and technology. This year's theme, "Energize the Future," highlighted a shift toward new transportation modes, sustainability, advanced tools and inclusivity in aerospace. The technical conference program was massive, featuring nearly 3,000 presentations addressing everything from digital engineering to hypersonics. More than 70 expert speakers from various sectors provided fresh perspectives, while more than 80 exhibitors showcased their latest innovations. In addition, the event was co-located with the AIAA's 26^{th} International Space Planes and Hypersonic Systems Conference.

Not all of the content at such an event is the right fit for our audience — something we were well aware of headed into it. But the value behind experiencing a broader perspective on aerospace, defense and space was immediately apparent. While the details on materials and manufacturing may not have been given as much focus, the big-picture visions of emerging trends and cutting-edge applications that are pushing the boundaries of what is possible emerged front and center. By stepping outside our usual circles, the *CW* team has quickly realized it can uncover unexpected synergies, discover new ways to collaborate, and explore fresh perspectives and new ideas.

Looking ahead, *CW* is looking forward to attending a few more of these "unconventional" composites events. Maybe we'll see you there. CW


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Functionalizing surfaces for sustainability

By **Ginger Gardiner** / Senior Technical Editor

» A biomimetic technology inspired by the skin structure of sharks, riblets are myriad micrometer-sized "ribs" that when aligned with the direction of flow reduce fluid-dynamic drag by up to 8%, cutting fuel consumption and emissions for aircraft, trains, cars and boats, for example, with corresponding benefits in noise reduction. Up to 8% less fluid friction in pipes improves efficiency in fluid transfer, combustion and other industrial processes. Applied on wind turbine blades and propellers, riblets can increase power output by up to 7% and achieve a significant reduction in power consumption for pumps and compressors.

The study of riblets has increased steadily since the 1980s. Riblets can be straight or curved and applied to 2D or complex 3D surfaces for a wide range of materials including metals, polymers and composites. They can be achieved via films and coatings, directly engraved into a surface using a laser or molded into a surface by machining negative riblets into a molding tool. (Note, riblet-like features are also being added to parts using additive manufacturing as discussed by *CW*'s sister magazine, *Additive Manufacturing Media*.)

Bionic Surface Technologies (BST, Graz, Austria) was founded in 2008 by two engineering students, Peter Adrian Leitl (CEO/CTO) and Andreas Flanschger (CEO), who began studying and developing riblet technology for industry. The company has since developed advanced computational fluid dynamics (CFD) and physical testing capabilities to design and tailor riblet surfaces per application and has completed more than 800 projects worldwide.

As composites are asked to provide multiple functions beyond lightweighting to improve sustainability, using riblet films, coatings or molded surface textures could offer unique opportunities to provide new solutions.

Applications evolution

The first important project for BST was in 2009, when it applied riblets as a film on an acrobatic aircraft that competed annually in the Red Bull Air Race World Championship. "The pilot was very happy with the performance, and we only removed it after 4 years because the airplane got new branding," says Flanschger. "It could have lasted for at least 5-6 years." Riblets were used in other such aircraft and BST continued to collect and analyze data on their design and performance.

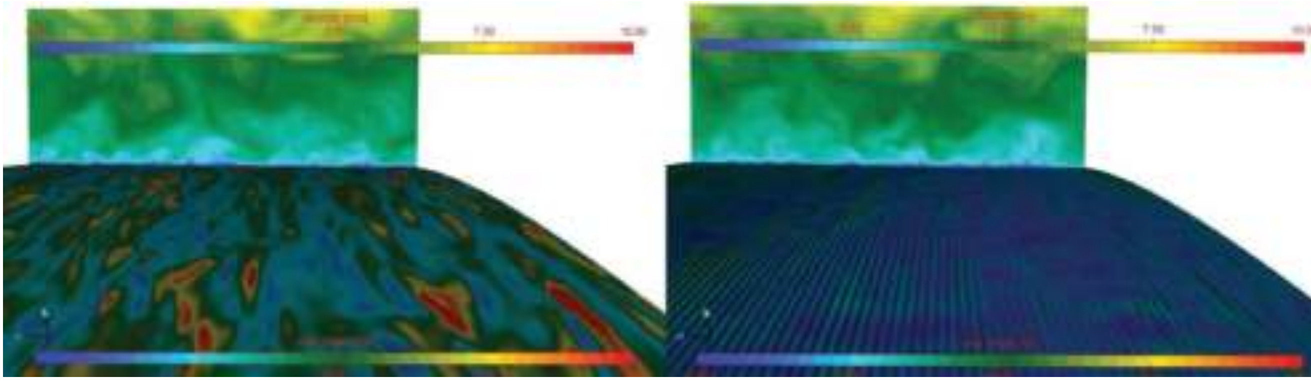
The second key application was for motorsports. Audi Sport (Neckarsulm, Germany) began with BST wind tunnel testing with riblets film on GT race cars in 2010. "The results were impressive, and for 3 years we were very successful in motorsports," says Flanschger. "This was another important step to establish the technology. But we couldn't talk about the programs publicly. And then in 2013, the use of riblets was banned in many motorsports because they gave such an advantage yet weren't available to all teams because there were no other suppliers."

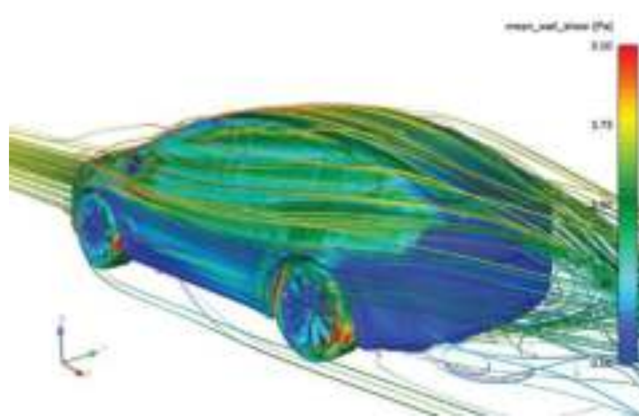
However, in 2014, another key application began via collaboration with aircraft services provider Lufthansa Technik (Hamburg, Germany), which eventually led to its AeroSHARK technology.

Inspired by the skin of sharks (bottom left), micrometer-sized riblets (bottom right) are being used to reduce drag for a wide range of surfaces, including the AeroSHARK technology applied by Lufthansa Technik to aircraft fuselages (top).
Source, AeroSHARK | Lufthansa Technik. Source (All Other Images) | Bionic Surface Technologies

AeroSHARK

Although BST is prohibited from discussing AeroSHARK technology in depth, Lufthansa Technik has covered it widely in videos and on its website. It is described as a durable film manufactured by BASF Coatings (Münster, Germany) with millions of 50-micrometer-high prism-shaped riblets. Already applied to Boeing 747 and





Computational fluid dynamic (CFD) analysis shows high fluid flow resistance (top left) eliminated by using riblets (top right). Early applications included carbon fiber-reinforced polymers (CFRP) in motorsports, and riblets are now being explored for electric vehicles (right).

777 aircraft by six airlines, AeroSHARK has logged 138,000-plus flight hours, saved 7,500-plus metric tons of jet fuel and avoided 26,000-plus metric tons of CO_2 emissions.

"You apply it like you would a decal film or foil," says Flanschger. Airlines already apply their liveries as a decal, and even though AeroSHARK application is more complex, Lufthansa Technik reports that once in service, the cost savings from fuel savings provides a return on investment in just 2 years.

"In 2022, BST applied tailored riblet film to all surfaces of a business jet — around 80 square meters," says Flanschger. "Even though this included very complicated shapes, the film was easy to handle and it took two people only 2.5 working days to complete." He notes BST measured a 9% reduction in fuel consumption — compared to only 1% for the fuselage of large commercial aircraft — but this included riblets also on the small jet's wings, nacelles and empennage. "We didn't use them on the rudder or control surfaces because it is not yet fully understood how to optimize riblets for those structures," he explains. Still, it's obvious that the fuselage is only the beginning of what is possible.

"The issue if you want to put riblets on the wings and empennage is obtaining certification," says Flanschger, "because you have additional loads and it's much more complicated than putting it only on the fuselage." The testing required for certification on wings is also lengthy and expensive. Flanschger notes that the drag reduction possible also depends on the aircraft. "The reduction in fuel consumption depends on the flight altitude, which determines the air density, and also the flight loads," he explains. "So, with mid-size commercial aircraft you may reach 4-5% savings."

An article in Lufthansa's *Innovation Runway* series reports Lufthansa Technik is already planning to certify AeroSHARK for other aircraft types and also other surfaces beyond the fuselage. Meanwhile, in addition to its Novaflex AeroSHARK film, BASF has developed a second riblet film, Novaflex BladeUp, for wind turbine blades.

Wind turbine, helicopter rotor blades

In 2022, BASF Coatings announced it had teamed up with wind turbine maintenance company Omega-Tools GmbH (Ritterhude, Germany) and turbine operator Energiekontor AG (Bremen) to equip the latter's turbine blades with Novaflex BladeUp film. The company reported that riblets reduce the formation of air turbulence on the blade surface, increasing power output by up to 3% on an initial 1.3-megawatt SWT 1,300 turbine (produced by AN Bonus) in Germany. Omega-Tools added that installation of the films can be done without long downtimes for the turbines. »

Riblets can be applied as films, by hand or using automation (bottom), and can be laser engraved (top) into surfaces and molding tools, the latter enabling riblet-functionalized composite parts.

BASF is working to extend Novaflex BladeUp to other wind turbine and blade manufacturers and believes that the riblet film could be integrated into the blade manufacturing process, enabling new wind turbines to generate a higher electricity yield.

Flanschger notes BST has trialed riblets on other blade structures, including rotor blades on helicopters. “There, we saw a massive improvement — more than 5% greater lift for the helicopter. This is especially interesting for forward flight.” Unlike fixed-wing aircraft, a change in forward air speed causes a “dyssmmetry of lift,” where one half the disc of the rotating rotor blades advances into the air flow and the other half moves with it. This increases the airspeed on the advancing side, generating significantly more lift, and decreases it on the retreating side, opening the risk of “retreating blade stall” which can cause the helicopter to roll and pitch uncontrollably. Currently, this issue is addressed by a variety of design and control measures, including letting the blades “flap.” Flanschger estimates riblets could provide an additional tool to improve blade design, “but this is ongoing research for us at the moment.”

Laser engraved and molded riblets

Riblets have also been used on aircraft engine fan blades as well as low-pressure turbine blades and shrouds. Some of this work has been completed by Nikon Corp.’s Advanced Manufacturing Business Unit (Belmont, Calif., U.S.). Possible benefits include reducing the amount of bypass air flow required or using current air flow to increase power output and efficiency, reducing fuel consumption and emissions.

Nikon is a key partner for BST, and the companies have been working on this and other projects for more than 5 years. However, for these structures, riblets are not achieved by applying a film but instead laser processing to create customized riblet patterns on metals, polymers and already-applied films and paints.

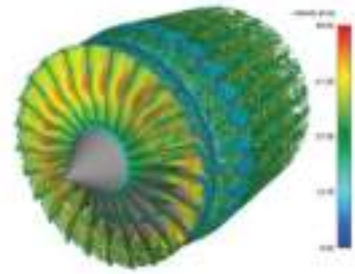
Similarly, riblets can be applied to the blades of impellers used in pumps, compressors and turbomachinery. “We have done many projects on pumps, including an ongoing project at the moment, and also with power plants,” says Flanschger. “And here too, riblets are directly lasered into the coating or into the metal. But this is also a technique possible for the composites industry, by engraving the riblets into the mold and then producing a part that is optimized and ready to use.”

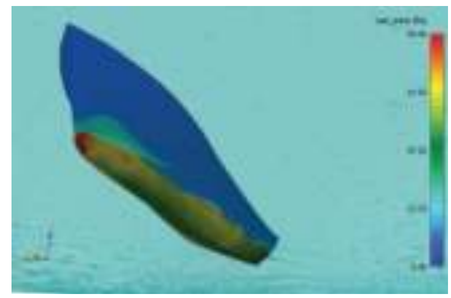
This approach has been used for impellers but also has potential for pipes. BST is working with a company in Norway that produces glass fiber-reinforced composite water pipes. “By engraving riblets in the molding tools,” notes Flanschger, “they could produce, for example, an 8-meter-long water pipe with riblets inside.”

Propellers, ships, hydrofoils

BST is also pursuing research on carbon fiber propeller blades for aircraft, where Flanschger believes the benefits would be significant. “We have applied for EU-funded projects and are still looking for partners,” he says. “The application would be to laser engrave negative riblets into the aluminum mold for curing the prepreg or infused laminate and the resulting parts will have the tailored riblets.”

Ship propellers are similarly interesting. In tests on commercial ship propellers, BST has achieved a 3-5% increase in efficiency. “If you calculate this for a large container ship — for example, one of the latest from China that are 400 meters long — this would equate to 200,000 less liters of diesel consumed per





■ CFD is an essential tool to optimize riblets for improving efficiency in a wide range of aerodynamic and fluid dynamic applications, including boat hulls and hydrofoils.

year and the corresponding emissions," says Flanschger.

However, many companies are resistant, believing their expertise in producing very shiny, super smooth propellers is what demonstrates their quality and expertise. "In reality, we are in a new era that demands new solutions," he observes. "For example, maritime applications also includes riblets for defense, because if you apply them on submarines, torpedoes and underwater drones you have less noise from the hull and also from the propeller because turbulent flow is reduced."

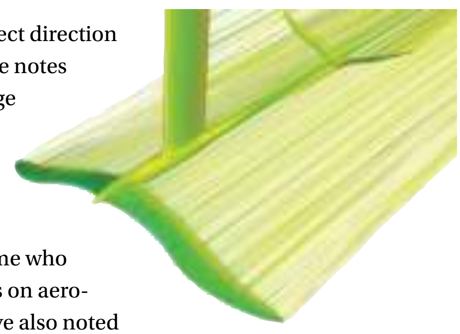
It seems riblets would also be perfect for hydrofoils. "Yes, they have a massive effect on foils," says Flanschger. "The foil is not really large, yet riblets produce an extremely high efficiency increase compared to the area." And though they are forbidden for use in sports applications, riblets could boost efficiency for foiling electric boats — including water taxis and ferries — where every bit of performance helps to offset the weight of batteries, for example, further extending vessel payload and/or range.

A key example for these propeller, hull and hydrofoil applications is the regulation starting Jan. 1, 2026, that all tourist ships and ferries under 10,000 gross tons traveling in the West Norwegian Fjords must be zero-emission vessels. This will extend to larger ships on Jan. 1, 2032. Again, a 3-5% increase in efficiency could directly apply to the bottom line for vessels adopting battery electric, hydrogen fuel cell and/or biogas to power zero-emission propulsion systems.

CFD analysis, challenges and next-generation riblets

But isn't the CFD analysis required for such applications very complicated? "Yes, but this is our business, to perform these CFD analyses and help to optimize use of riblets on a wide range of structures," says Flanschger, noting the CFD tools that BST has developed make the process much easier, including simulation automation and a vast database of designs and results. He also points out that riblets are not magic — they cannot make something that is bad good, "but if there is something good, then riblets can make it the best."

But Flanschger acknowledges that repair of structures using engraved or molded riblets could pose a challenge. "You need the riblets to remain very precise," he explains. "For example, they



must be in the correct direction and orientation." He notes this is one advantage of using a film — you can simply repair the part and reapply the film as needed. Some who have studied riblets on aeroengine nacelles have also noted that if they become dirty, their performance is diminished. "Therefore," says Flanschger, "material experts play a major role to develop materials for riblets which are dirt-repellent."

Over the last few years, BST CTO Leitl, has developed a new generation of patented riblets that promise even higher performance. Where AeroSHARK and other applications have shown up to an 8% drag reduction, with these new riblets, Leitl is targeting 12% with potential for up to 14% drag reduction. "The initial results from testing in 2024 look promising," says Flanschger, "but much work remains and we are still looking for a commercialization partner." He notes BST knows many potential partners and discussions are ongoing, "but it's important to engage with new companies and possibly identify new applications that could really have an impact on the challenges we face in industry and sustainability." CW

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Crashworthiness testing of composites: A building block approach, Part 2

By Dan Adams / President, Wyoming Test Fixtures Inc.

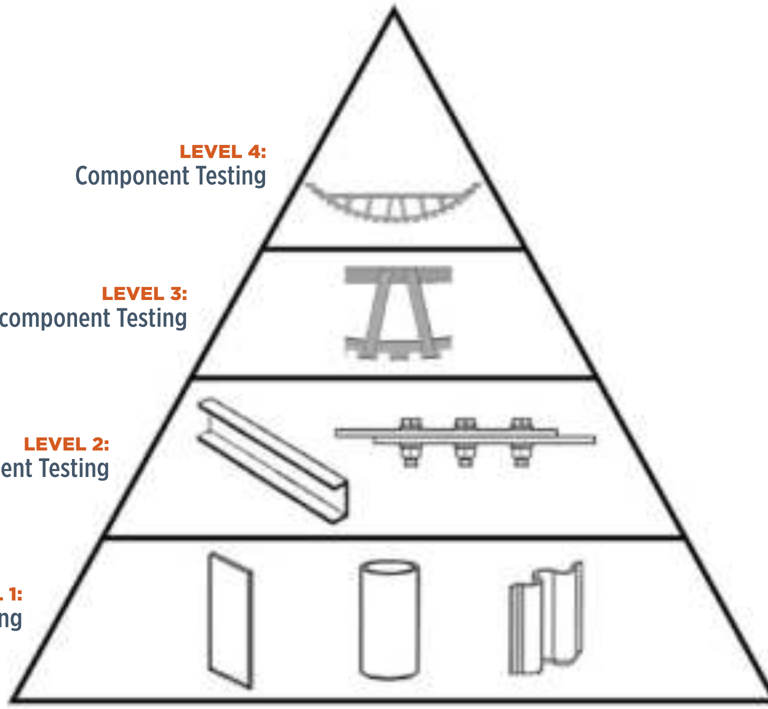

FIG. 1 Building block approach for crashworthiness-related testing associated with composite structures. Source (All Images) | Dan Adams

» In my November 2024 column, I began discussing the *building block approach* for crashworthiness testing of composite structures. This approach features a multistep process for designing composite structures with crashworthiness requirements, in which the complexity of testing increases and the number of tests decreases. The building block pyramid shown in Fig. 1 illustrates the first four levels of crashworthiness testing associated with a composite transport aircraft structure.

Previously, I focused on the initial coupon-level crush testing used to identify composite laminates and ply stacking sequences that produced high crush stress and energy absorption values. From this testing, two carbon fiber/epoxy laminates, $[90_2/0_2/\pm45/0_2]_S$ and $[90/+45/0_2/90/-45/0_2]_S$, were identified for use in element-level testing. These flat-coupon crush test results also were of use in establishing crush properties and modeling parameters associated with specific finite element analysis (FEA) methodologies. However, the quantity and types of coupon-level crashworthiness testing are dependent on the numerical modeling approach being used.

Following flat-coupon crush testing, test results from the two selected composite laminates were provided to Crashworthiness Working Group members for use in performing finite element analyses of the initial coupon-level crush tests. These initial coupon-level crush simulations were also used for establishing modeling parameters and crush-related properties for use in predicting progressive crushing at higher building block levels.

In this column, I'll focus on the crashworthiness testing associated with the element, subcomponent and component levels of the building block. Additionally, I'll continue to focus on the commercial aviation industry, for which an ongoing building block exercise is being performed and documented by the Composite Materials Handbook-17 (CMH-17) Crashworthiness Working Group[1].

Element-level testing

The group's recent focus has been the element-level crush testing and numerical crush simulation of composite C-channel specimens. These specimens represent the stanchions used to support the lower cargo floor in a transport aircraft fuselage. The C-shaped cross section of the stanchions provides structural stability and permits flush attachment to adjoining structures in the aircraft fuselage. In addition to serving as structural members during normal aircraft operations, these stanchions also serve as primary energy-absorbing structural elements in the event of a crash.

Starting with element-level testing, additional emphasis has been placed on the development of predictive capabilities for crush behavior and energy absorption through the comparison of FEA predictions with crush test results. Element-level crush testing was performed using C-channel specimens fabricated using the same two composite layups as for flat-coupon crush testing. The C-channel crush testing was performed using a vertical drop tower at the University of Utah as shown in Fig. 2. A bevel-shaped trigger mechanism was machined into the top end of the specimen to initiate crush failure. Crush testing was performed using two initial impact velocities. The initial impact event and progressive crush behavior were recorded using a high-speed video camera as shown in Fig. 3. (p. 12) Additionally, force versus displacement data was recorded during progressive crushing for use in assessing the predictive capabilities of the various FEA methodologies being investigated.

A total of nine finite element modeling approaches were used to simulate the C-channel crush testing. Analysis teams were provided with the flat-coupon crush test results for the two laminate configurations as well as the C-channel test specimen geometry and drop-weight crush testing information. Each team performed finite element analyses using a different numerical modeling approach to predict the crush behavior and resulting energy absorption for the C-channel crush test specimens. After the analysis teams had submitted their predictions for the two sets of C-channel specimens, the experimental crush test results were distributed to all participants.

FIG. 2 University of Utah drop tower used for C-channel crush testing[2].

Subcomponent and component testing

Currently the CMH-17 Crashworthiness Working Group is focusing on establishing best practices for numerical modeling of subcomponent-level composite structures similar to that shown in the Fig. 1 building block. For transport aircraft, this subcomponent is an assembly of element-level structures that includes the primary energy absorbing C-channel elements from the previous building block level. Therefore, future subcomponent-level crashworthiness testing and analysis will also focus on the mechanical connections and the resulting interaction of elements within the subcomponent assembly.

In addition to assessing the crashworthiness of the proposed subcomponent configuration, subcomponent-level crush testing is used to investigate the interaction of the structural elements forming the subcomponent. Test results may also be used to ensure that the analysis methodology is properly predicting the load transfer and resulting structural element crush behavior observed during crush testing. Multiple subcomponent crush tests are typically performed when designing subcomponent-level structures for crashworthiness to ensure that the proposed structural configuration will perform as intended.

At the component level of the building block, a larger assembly of elements and subcomponents that represents a significant portion of the primary crush structure are tested and analyzed. In the current CMH-17 building block exercise, a candidate component-level test »

FIG. 3 Progressive crush behavior of composite C-channel specimen recorded using a high-speed video camera[2].

article would include a portion of the aircraft fuselage barrel as shown in Fig. 1. In addition to assessing the effectiveness of element-level energy absorbing features within the component, crush testing may also be performed to assess the connections between adjacent elements and subcomponents. Similar to the lower levels of the building block, test results are used to validate the numerical modeling approach, including the input modeling parameters and crush-related properties.

Although not shown in the crashworthiness building block in Fig. 1, a full-scale test is often performed as a final crashworthiness validation test. For transport aircraft, possible test articles include a full barrel or partial barrel section of the complete aircraft fuselage. Further information on the crashworthiness building block approach for composites is provided in Volume 3, Chapter 16 of the "Composite Materials Handbook-17 (CMH-17)[1]." CW

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A legacy of innovation in advanced thermoplastic composites

By Scott Francis / Editor-in-Chief

ATC Manufacturing (Post Falls, Idaho, U.S.) has been providing advanced composite solutions to the aerospace and defense industries for more than two decades. Founded in 2004 by former Boeing engineer Dan Jorgensen, the Idaho-based company strives to be a pioneer in the use of thermoplastic composites for aerospace parts and structures. Today, the company continues to specialize in continuous fiber thermoplastic composites, offering durable, lightweight and high-performance parts for a variety of aerospace applications.

"Our focus is on high-rate, cost-saving applications where thermoplastics can really shine," explains ATC business development manager Jason Merrifield. "Picture stamping out a new part every few minutes versus laying up and curing parts; it's a more efficient process."

ATC Manufacturing places focus on realizing the full potential of thermoplastic composites.

Source (All Images) | ATC Manufacturing

The company says its two core processes — continuous compression molding (CCM) and stamp forming — enable it to rapidly produce complex composite parts at a fraction of the labor costs associated with traditional thermoset layup and with reduced material waste. The speed and efficiency of these processes make them a good fit for a range of aerospace components from simple clips and brackets to larger structural parts and more complex assemblies. ATC has long-term agreements with Boeing for such components and works directly with Boeing as well as with the company's Tier suppliers including Spirit Aerosystems and Leonardo.

"When we talk about aerospace parts at automotive rates, thermoplastics are definitely a candidate for that because you can scale up quickly," says Merrifield. "Anywhere you have a high volume of simple parts, that's where thermoplastics really excel."

In addition to clips and brackets, the company is capable of larger thermoplastic composite parts with longer profiles — parts that normally tend to be more expensive because they are often made of metal or thermoset materials.

ATC's continuous compression molding systems can produce larger structural parts such as ribs and bulkhead components.

What is continuous compression molding?

In continuous compression molding (CCM), a continuous feed of fiber-reinforced thermoplastic prepregs or tapes is consolidated and/or shaped in a heated compression die. Material is fed from creels to form the stacked plies that will comprise the finished laminate. Near endless production is made possible by a feeding unit, which opens and closes cyclically, pulling the prepreg materials through the press unit, typically an inch at a time. As the material is pulled through the compression die, it passes through multiple zones, specified to heat the prepreg polymer to its melting point and then cool it back down at a controlled rate to produce the crystallinity required for high mechanical properties. The laminate that emerges is fully consolidated.

CCM systems may also produce shaped profiles, like the four-axis CCM profile machine at ATC. Fed by the same creel-based system as ATC's flat laminate CCM line, it instead outputs C, T, H, J, U and other complex shapes used for various aerospace components. Where the flat laminate CCM line has one set of hydraulic actuators moving in one direction, the shaped profile CCM has actuators moving in two directions, applying pressure to a four-piece die that forms the shape. As the fully consolidate shape emerges, it is cut to length.

"Ribs, control surfaces, bulkhead components, door surrounds — our CCM is capable of making long C-channels, I-beams and similar parts for those kinds of applications," Merrifield says.

A focus on high-rate production, sustainability

The niche that ATC occupies is by design. The company was founded with the ambition to leverage advanced thermoplastic technologies to address the aerospace industry's growing demand for stronger yet lighter materials. While traditional thermoset composites continue to be widely used in the industry, they present limitations in terms of recyclability and high-rate scalability. Thermoplastics offer an alternative — a material that not only meets aerospace specifications, including weight reduction and strength, but also provides a path to optimized production and sustainability. Merrifield explains that thermoplastic composites processing is naturally high-rate due to short cycle times.

From its inception, ATC's goal was to optimize production efficiency, reduce production times and reduce costs without compromising quality. This motivated early strategic investments in the latest automated systems and developing in-house expertise in composite forming techniques. Now, the company operates a 67,000-square-foot facility equipped with automated assembly lines, precision molding tools and advanced testing

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laboratories. It offers a range of services, including custom tooling design and high-volume production via CCM and stamp forming. Additional operations include CNC trimming, finishing and quality inspection including NDI, as well as R&D.

ATC Manufacturing is AS9100 and Nadcap certified. The company is International Traffic in Arms Regulations (ITAR) compliant and working toward Cybersecurity Maturity Model Certification (CMMC) and Controlled Unclassified Information (CUI) certification.

A vision for the future

While aerospace remains the core of ATC's business, the company does have an eye on new markets and is always seeking ways to further leverage the potential of thermoplastics. This includes emerging markets like urban air mobility (UAM), where the combination of high-production rates and stringent aerospace requirements play directly to the company's strengths. Within the UAM sector, the company is looking at applications such as ribs, control surfaces, structural beams and brackets, as well as structural elements and seatback components.

ATC is also investing in research to improve the performance characteristics of thermoplastic composites, making them even more versatile for next-generation aerospace and industrial applications. The company is engaged with industry groups like the American Aerospace Materials Manufacturing Center Tech Hub, Thermoplastic Composites Research Center (TPRC), Society for the Advancement of Material and Process Engineering (SAMPE) and the American Composites Manufacturing Association (ACMA). Merrifield says these collaborative platforms help ATC stay ahead of the latest material and process developments. The company also uses tools like *CW*'s Top Shops Benchmarking Survey, which it has been participating in for 5 years, to aid in its continuous improvement practices and to also gain insights into its performance in relation to its peers in the industry.

"These groups provide an environment where we can see what the industry is looking at and what customers are looking for when it comes to thermoplastics so we can position ourselves to take on some of that work," Merrifield says. Much of that work ahead involves education and validation of the benefits of thermoplastics and overcoming misconceptions about what is possible.

"We try to collaborate at early stages in the project where we can influence the design from the start, rather than influence after the fact," says Merrifield. "The same fibers that you have in a thermoset, you can have in a thermoplastic. T700s, T1100s — all the standard modulus and intermediate modulus fibers — all those fibers are still available, as well as woven fabrics. The playing field is a little bit more even than you might think."

As ATC looks forward, Merrifield says the focus is both on growing its business and influencing the broader industries it serves to shape the future of how thermoplastic composites are leveraged. By embracing automation and digitalization, the company aims to continue setting benchmarks in precision and scalability.

"We're not just a shop — we're actively involved in pushing the technology forward," Merrifield says. "We know thermoplastics aren't the answer for every application, but wherever speed, cost and performance are critical, we believe they have a real competitive edge." CW

ABOUT THE AUTHOR

Scott Francis is the editor-in-chief of *CompositesWorld* and *Products Finishing*. He has written for numerous publications including *Writer's Digest*, *HOW* and *Popular Woodworking*.
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JEC World 2025 at a glance

WHAT:	JEC World 2025
WHEN:	March 4-6, 2025
WHERE:	Paris Nord Villepinte Exhibition Centre, Paris, France

Conference sessions and panels cover topics like sustainability, AI, automation and more. Depicted here was a session on sensors from JEC World 2022. Source | *CW*

By Hannah Mason / Technical Editor

This year marks the 60th anniversary of the JEC World trade show. As in years past, attendees can look forward to the latest composite materials and process technology, networking with professionals across the global composites industry and opportunities to attend a variety of educational conference sessions.

The world's largest composites industry trade event is expected to feature more than 1,350 exhibitors showcasing more than 600 new products and innovations. The theme for JEC World 2025 is "Pushing the Limits," which organizer JEC Group (Paris) hopes to do with an anticipated record attendance of 45,000 visitors from more than 100 countries.

In addition to exhibitors on the show floor, the event also features two Innovation Planets presenting parts from companies and R&D centers on the latest in Mobility and Industry. JEC World 2025 will also include an expanded version of last year's inaugural Live Demonstration Area on the show floor, sponsored by Aerovac Composites One (Keighley, U.K. and Schaumburg, Ill., U.S.), Magnum Venus Products (Knoxville, Tenn., U.S.) and Thermwood (Dale, Ind., U.S.). Visitors will have the chance to see exhibitors demonstrating various new technologies firsthand throughout the show.

LEARN MORE

CW editor-in-chief Scott Francis recently had the chance to interview Eric Pierrejean, CEO of JEC Group, ahead of JEC World's 60th anniversary.

Pierrejean celebrates the last 60 years of both the event and composites industry, and discusses industry trends such as sustainability, data and AI, and evolving standards. Scan the QR code for the full interview.

Attendees can also visit areas dedicated to Innovation Award and Startup Booster competition finalists. From a pool of 33 Innovation Award finalists over 11 categories, the award winners, selected by a panel of industry judges, were announced via the JEC World 2025 Premiere event on Jan. 13 in Paris and online.

The JEC Composites Startup Booster competition is open to entrepreneurs, SMEs, startups and academic spinoffs, and is reported to have supported more than 1,100 projects from more than 60 countries since its start in 2017. The 20 startup finalists selected to participate in this year's event were announced at the JEC World 2025 Premiere, and the three winners will be announced during the show itself on March 5.

Beyond the exhibit hall, the show also presents opportunities to learn from speakers and panels comprising subject matter experts on topics like AI, hydrogen storage, high-volume aerospace manufacturing and various aspects of sustainability.

Conference programming will take place on the Agora stages in both Hall 5 and 6 each day of the show. For the first time, JEC World is teaming up with the Society for the Advancement of Material and Process Engineering (SAMPE, Diamond Bar, Calif., U.S.) to provide SAMPE Technical Sessions on March 5. For full conference program information, visit www.jec-world.events/program.

Find registration information for this year's show at www.jec-world.events/visit/badge. If you need a refresher on last year's event, revisit JEC World 2024 with the *CW* editors' post-show highlights. CW

ABOUT THE AUTHOR

Technical editor Hannah Mason has been writing and editing about composites for *CompositesWorld* since 2018. She has a master's degree in professional writing from the University of Cincinnati. **hmason@compositesworld.com**

TRENDS

A combination of flax and glass fibers went into the development of 880 openwork, panels for an international school in France; irradiation testing experiment validates composite cladding robustness and integrity; Sonaca and Aciturri Aerostructures aim to become an independent global aerospace player; and more.

CONSTRUCTION

Bcomp, Temca achieve intricate composite cladding for French school façade

Bcomp's (Fribourg, Switzerland) flax fiber composites and Temca's (Xertigny, France) manufacturing expertise have been combined to create the cladding panels for the façade of the new Cité Scolaire Internationale Jacques Chirac in Marseille, France. Designed by Rudy Ricciotti and manufactured by Temca for general contractor Bouygues Bâtiment Sud-Est (BBSE), the shade-providing panels are assembled into an intricate, decorative trellis that clads 5,000 square meters of the school building.

The trellis is made of 880 openwork panels, using five different molded shapes arranged to achieve energy efficiency by adapting shading to sunlight exposure while maintaining a distinctive building design. Almost 8,000 square meters of ampliTex technical fabric was used. The panels, a combination of glass fiber-reinforced polyester and ampliTex fibers, were manufactured using RTM. Each panel is coated with a white gelcoat formulated to withstand exposure to outdoor elements like UV rays, rain and pollution. The materials also meets fire requirement specifications.

According to partners, the cladding offers numerous benefits in addition to its nature-inspired aesthetic, which is visible from both classrooms and street level. The panels were designed and carefully placed in positions on the building's façade to obscure the levels of heat and glare in specific locations.

The integration of flax fibers in the composite materials used for the panels also reduces the weight of the openwork cladding. Weighing between 18-37 kilograms each, the panels are mounted to the building's exterior using stainless steel inserts bonded with structural adhesives, lightweighting the façade relative to standard materials like concrete.

ENERGY

General Atomics completes SiC SiGA-cladded fuel rod testing

General Atomics Electromagnetic Systems (GA-EMS, San Diego, Calif., U.S.) has completed its first round of testing at Idaho National Laboratory (INL, Idaho Falls, U.S.) on unfueled nuclear fuel rod samples using the company's SiGA high-temperature fuel cladding material.

SiGA is a silicon carbide (SiC) composite material that forms the basis for the development of nuclear reactor fuel rods that can survive temperatures far beyond that of current materials. This initial experiment is part of a series of tests with the U.S. DOE to commercialize the fuel cladding early next decade.

According to GA-EMS, the SiGA-clad fuel rods successfully survived a 120-day irradiation testing period in INL's Advanced Test Reactor (ATR). Testing was conducted to validate the robustness and integrity of the SiGA cladding after exposure to high neutron flux in a pressurized water reactor environment. Following the test, SiGA-cladded rods remained intact and showed no significant mass change, indicating promising performance. More detailed examinations are underway to further evaluate post-test data to validate individual rod integrity to remain gas-tight, with no evidence of degradation, leaking or structural change.

"The testing results offer critical, quantifiable and independent validation that our SiC cladding technology is on the right path to provide a safe, suitable, accident-tolerant fuel cladding solution for the nuclear fleet," says Scott Forney, president of GA-EMS. "This success is a key milestone on SiGA cladding's development path to enhance the safety of the existing U.S. fleet of light water reactors. It could also do the same for the future generation of nuclear power systems."

SiGA's multi-layered SiC composite cladding structure is sealed with a fully SiC joining process, enabling high stability during operational temperature cycling. According to the company, this material provides greater stability and safety at temperatures up to 1900°C, well beyond that of metal fuel rod claddings. SiGA cladding would also enable higher power and longer fuel lifetimes, thereby enhancing overall reactor performance and economics.

"We look forward to continuing our partnership with the DOE and the national labs to accelerate the irradiation testing to demonstrate the performance of fueled SiGA-cladded rods. The planned test series progressively builds up performance data to show that SiGA cladding can effectively contain the fuel and any gases that are produced when subjected to irradiation and high temperature," adds Dr. Christina Back, vice president of GA-EMS Nuclear Technologies and Materials. "In parallel, we are scaling up to full-size, 12-foot-long SiGA rods and will then be doing the irradiation testing in actual commercial reactors with deployment targeted for the mid-2030 timeframe."

AEROSPACE

Sonaca, Aciturri Aerostructures to become single European aviation entity

On Dec. 13, 2024, Aciturri (Mirando de Ebro, Spain) announced that it had reached an agreement with Sonaca (Charleroi, Belgium) for the latter to acquire 51% of Aciturri's aerostructures activities, with the support of the Belgian firm's historic shareholders. Through this union, the two companies aim to lead the global aerospace industry's design of next-gen aircraft. To build this European champion, both Spanish and Belgian shareholders will remain active in the governance of the combined entity.

Aciturri is a family-owned business created in 1977 in Spain. It primarily operates in the aerostructures field but also has an aeronautical engine parts division. Aciturri's aerostructures business has nearly 2,500 employees and expects a turnover of €400 million in 2024. The company is widely recognized for its expertise, especially in the manufacturing of composite aerostructures, which are essential to the development of new, more eco-friendly aircraft. Aciturri's engine components business, the Caetano Aeronautic plant in Portugal and Aciturri Tech, are outside the scope of the acquisition.

Sonaca, with an expected turnover of €700 million in 2024, globally develops, certifies and manufactures aircraft structures and system integration. With a presence in six countries and 3,700 employees, Sonaca serves major OEMs with competences that extend over the civil aerospace, defense and space markets.

The announced integration is, above all, an industrial partnership. Sonaca's expertise in the manufacture of metal structures, and Aciturri's in composite structures, together will form a group of approximately 6,200 employees across seven countries, with a turnover of more than €1.1 billion in 2024. Together, Sonaca and Aciturri will reportedly become the third independent global player (excluding the subsidiaries of major prime contractors like aircraft and engine manufacturers).

In a sector that is stepping up R&D efforts to create low-carbon air transport solutions, the combination of Aciturri and Sonaca will enable the acceleration of some of these research programs to contribute to the development of a low-carbon aircraft by 2035 and achieve carbon neutrality by 2050, objectives set by the entire aeronautics sector.

"In the face of the aerostructure sector's global consolidation, Sonaca and Aciturri are joining forces to play a leading role globally," emphasizes Yves Delatte, CEO of Sonaca. "Only by coming together will we enable Europe to retain a leading position in the design and production of future sustainable aircraft."

The combination of Sonaca and Aciturri Aerostructures will ensure the continuity of business activities at all current locations and maintain management teams in each country.

MOTORSPORTS

VCARB, Holy Technologies demonstrate composites recyclability potential

Formula 1 (F1) Visa Cash App Racing Bulls (VCARB) and Holy Technologies (Hamburg, Germany) have successfully completed an 18-month joint R&D project to demonstrate the potential of Holy's Infinite Fiber Placement (IFP) technology. The project achieved optimal results, resulting in the manufacture of an existing component of VCARB's 01 race car with 20% weight reduction while ensuring it is fully recyclable.

This collaboration has led to the development of a fully recyclable wing mirror housing that is said to not only meets the rigorous quality standards required for F1, but also achieves significant weight reduction compared to traditional manufacturing methods.

Unlike conventional methods that rely on prepreg materials with pre-aligned fibers, Holy Technologies' approach uses a single, robotically placed carbon fiber strand embedded into a recyclable epoxy resin, enhancing the structural integrity and recyclability of the component. This process also enables the separation of the epoxy from the carbon fiber for its reuse in the same high-performance application.

"Holy Technologies is taking a different approach to the manufacturing process that is normally used for carbon fiber components," says Paolo Marabini, chief designer at VCARB. "It opens up the opportunity to reuse the same carbon fiber and therefore has the potential to significantly reduce the overall amount of material we use for our car components, while at the same time optimizing the performance of those components."

The technology was tested during a Grand Prix to demonstrate its use in the harsh environments common to a motorsport race weekend. Both companies plan to continue exploring further innovations in sustainable manufacturing.

PROCESSES

McClarin Composites partners with ExxonMobil to accelerate high-speed RTM

McClarin Composites (Hanover, Pa., U.S.) has announced a joint development agreement with ExxonMobil's (Houston, Texas, U.S.) Proxxima business, aiming to accelerate the growth of high-speed, closed mold composites manufacturing. The collaboration follows McClarin's strategic acquisition and relocation of select polyolefin thermoset molding facilities from ExxonMobil affiliate Materia Inc. in 2024.

As part of the agreement, McClarin is making a multimillion-dollar investment in automated resin transfer molding (RTM) capabilities at its Oklahoma City, Oklahoma, facility. The company says it has partnered with top-tier RTM equipment innovators to bring advanced solutions to its manufacturing sites in Pennsylvania and Oklahoma. McClarin anticipates that these developments will enable it to become a Tier 1 OEM supplier in the mobility and construction/infrastructure sectors.

Central to this partnership is the integration of ExxonMobil's Proxxima polyolefin thermoset system. Together, the two companies aim to develop and validate a machine-driven RTM technology that delivers cost-effective, high-performance composite solutions. The Proxxima system is distinguished by its reduced carbon footprint, which is reported to be approximately 60% lower than epoxy resins and nearly 50% lower than vinyl ester resins, based on cradle-to-gate analyses.

ExxonMobil expects the RTM technology to outperform traditional sheet molding compound (SMC) processes, producing tougher, lighter and stronger parts with reduced cycle times. The initiative aligns with growing market demands for sustainable supply chains by aiming to quantify and lower carbon emissions in composites manufacturing.

"ExxonMobil brings global reach, long-term vision, R&D capability and economy of scale to lift the composites industry and to open markets that had been previously inaccessible," says McClarin CEO Mike Gromacki.

HYDROGEN

Infinite Composites, ORNL to advance long-term H_2 storage

Infinite Composites Inc. (Tulsa, Okla., U.S.) has announced a cooperative research and development agreement (CRADA) with Oak Ridge National Laboratory (ORNL, Oak Ridge, Tenn., U.S.) to advance the manufacturing of hydrogen storage tanks for long-term storage and high-rate production.

This collaboration aims to further develop lightweight, high-pressure tanks that surpass current Department of Energy (DOE) gravimetric efficiency targets. The project will focus on optimizing Infinite Composites' hydrogen storage tank capable of operating at 700-bar pressure, significantly improving upon existing composite tank options.

Potential key innovations of this research include the development of integral gas barrier materials to replace permeation barrier layers; application of novel, high-aspect ratio 2D nanofiller-based barrier coatings; and the use of additive manufacturing techniques to aid tank production.

In 2023 the global hydrogen market generated more than $242 billion in revenue and is expected to grow at a 7.8% compound annual growth rate until 2030, where revenues are projected to reach more than $410 billion.

"Advanced manufacturing techniques can drive the adoption of hydrogen storage tanks by improving production efficiency, reducing costs and enhancing performance," adds Dr. Ahmed Arabi Hassen, group leader for composites innovation at ORNL. "These innovations can enable scalable, lightweight solutions, accelerating industry-wide adoption for a sustainable energy future."

The research will be conducted in two phases, focusing on barrier material development and tank manufacturing optimization. This work aligns with the DOE's Advanced Materials and Manufacturing Technology Office (AMMTO) mission to accelerate the adoption of innovative materials and manufacturing technologies in support of a clean, decarbonized economy.

AUTOMOTIVE

SwRI announces JIP to spur H_2 refueling, infrastructure for heavy-duty vehicles

Southwest Research Institute (SwRI, San Antonio, Texas, U.S.) has announced a joint industry project (JIP), H_2HD REFUEL (Hydrogen Heavy Duty Refueling Equipment and Facilities Utilization Evaluation Laboratory). It aims to strengthen the acceptance of hydrogen (H_2) fuel use by heavy-duty vehicles to help the mobility industry meet its decarbonization and zero-emissions goals by advancing H_2 refueling station (HRS) technologies. Over the next 4 years, SwRI researchers will use hands-on experiments, system modeling and theoretical studies to strengthen existing HRS equipment and procedures and explore potential alternatives.

"There are less than 60 H_2 refueling stations in the U.S., but only one or two currently exist that can meet the specific needs of heavy-duty H_2-powered vehicles," says Dr. Thomas E. Briggs Jr., Institute engineer with SwRI's Powertrain Engineering Division. "Many light-duty H_2 stations face significant technical challenges, including supply chain issues, mechanical failures and lack of infrastructure."

The H_2HD REFUEL JIP hopes to address these issues by connecting H_2 vehicle manufacturers, OEMs and refueling station operators to develop innovative, dependable and compatible HRS technologies. The program will investigate a broad range of HRS-related topics, such as discovering the best

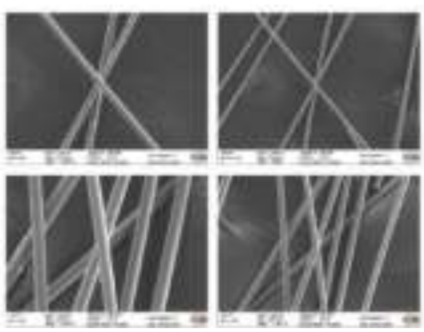
onboard H_2 storage method: liquid H_2, cryo-compressed H_2 or H70 gas, and comparing the performances of HRS flow components. The JIP also plans to study H_2 losses from cryogenic systems resulting from boil-off as well as system inefficiencies.

"Connecting industry stakeholders is vital to developing compatible, reliable H_2 refueling technologies and associated infrastructure," says Angel Wileman, the JIP's project manager from SwRI's Mechanical Engineering Division.

RECYCLING

Nlcomp, Composite Recycling reveal results for rComposite recyclability

In a collaboration between the two sustainability-focused startups, Northern Light Composites (nlcomp, Monfalcone, Italy) and Composite Recycling (Ecublens, Switzerland) have announced interesting results in the recyclability testing of nlcomp's rComposite material. These findings, both partners report, highlight the material's high potential for circular economy applications, and are a "significant step forward for the credibility of our technology," according to Fabio Bignolini, CEO of Nlcomp.



Composite Recycling has developed a thermolysis-based recycling process for end-of-life (EOL) treatment of carbon and glass fibers, recovering high-quality fibers and oils. Nlcomp engaged Composite Recycling to evaluate the recyclability of its rComposite material, which combines a thermoplastic matrix — Arkema's (Colombes, France) Elium resin — with low-impact raw materials. The test results from Composite Recycling's recycling process are reported to have exceeded expectations.

The *reclaimed fibers* exhibited no visible impurities and demonstrated a soft, pliable texture. Electron microscope imaging revealed minimal residue, confirming their high potential for reuse in new composite materials. In *recovered oil*, analytical testing identified nearly 80% of the recovered molecules as methylmethacrylate, a valuable component for producing new materials.

These test results build upon nlcomp's DNV recognition achieved in October 2024, verifying the recyclability of rComposite under ISO 14021:2016 standards. Both companies have also earned recognition in the composite industry and particularly from the marine sector via the Monaco SmartYacht Award and the Metstrade Boatbuilder of the Year Award.

MARINE

Breton companies launch recyclable hydrofoil design project

French companies Avel Robotics (Lorient), ComposiTIC (Ploemeur) and Mer Concept (Brittany) have launched the Foil Infinity project to design recyclable hydrofoils made of thermoplastic composites. The goal is to equip offshore racing yachts by 2030.

Each partner is bringing its composites expertise to the project. Avel Robotics is a manufacturer of composite parts for the nautical and aeronautical industries. ComposiTIC is a technical research institute from the Université Bretagne-Sud, specializing in the design of materials and automated processes based on robotized fiber placement technology and 3D printing. MerConcept is a French designer and builder of boats for ocean racing.

"The goal is to improve the environmental impact of hydrofoils by using thermoplastics, while maintaining the same performance as traditional foils," explains Adrien Marchandise, co-founder and technical manager of Avel Robotics, "because the materials that make up the foil have a lifespan of 50 years. But the wing itself is obsolete after 5 years." By using thermoplastics, recyclable and reusable materials, "we hope to reduce the carbon footprint of foils by 30%."

A small wing (2.50 meters), made of 95% recycled or recyclable materials, is being tested as part of the collaborative MiniLab project that brings together Avel Robotics, ComposiTIC, IRMA and

Victrex. Since 2023, this laboratory boat has been testing different eco-efficient materials and technologies in the field of ocean racing.

"After a year of research, we saw that we would be able to find outlets," says Marchandise, who founded the MiniLab initiative to advance sustainability and reduce the sailing industry's environmental impact. "To move on to the industrialization stage, we started building Foil Infinity in January 2024."

Continuous ultrasonic welding of the MFFD's right-hand (RH) longitudinal fuselage joint (left) and resistance welding of upper and lower fuselage frames (right).
Source | AIMEN

Source (All Images) | Clean Sky 2 MFFD, MultiFAL and WELDER

Assembling the MFFD: The final welds

Building the all-thermoplastic composite fuselage demonstrator comes to an end with continuous ultrasonic welding of the RH longitudinal fuselage joint and resistance welding for coupling of the fuselage frames across the upper and lower halves.

By Ginger Gardiner / Senior Technical Editor

» The Multifunctional Fuselage Demonstrator (MFFD) is a Clean Sky 2 (now Clean Aviation) project spanning roughly 10 years that has produced the largest aircraft structure — an 8 × 4-meter-diameter fuselage section — completely fabricated from thermoplastic composites (TPC). Furthermore, its myriad components are welded together, aimed to demonstrate "dustless assembly," which could eliminate the multistep process chain, labor, time, cost and weight of drilling holes and installing fasteners in composite primary structures.

CW has reported on this project for years via multiple articles and news releases. As explained in *CW*'s 2023 article, "Manufacturing the MFFD thermoplastic composite fuselage," assembly of the MFFD's lower and upper shells began with the left-hand [LH] side butt-strap longitudinal fuselage joint. That work was completed in the BUSTI project, as announced in March 2024, where the 8-meter-long join was achieved using a CO_2 laser-based continuous joining technology called CONTIjoin (see YouTube video, Learn More), developed by the Fraunhofer Institute for Material and Beam Technology (IWS, Dresden, Germany).

Following CONTIjoin, the last steps to complete the MFFD assembly included welding the right-hand (RH) overlap joint using continuous ultrasonic welding. Finally, fuselage frame couplers in the upper and lower halves were resistance welded to achieve continuous structures across both LH and RH joints.

As explained in my 2020 blog, "Proving out LMPAEK welding for the MFFD," the welding techniques used in the MFFD's various assembly steps were decided early on. "MFFD will demonstrate many technical approaches," noted Ralf Herrmann, Airframe R&T Typical Fuselage at Airbus Operations GmbH (Bremen, Germany) and leader of the MFFD program, "so it is not the same as in manufacturing an actual fuselage, but instead is designed as a vehicle for demonstrating and maturing technologies."

The RH overlap joint and welding of the fuselage frames were completed within the MultiFAL (2019-2023) and WELDER (2021-2023) projects by leading partners The CT Engineering Group (Madrid, Spain), AIMEN Technology Centre (O Porriño, Spain) and the Aitiip Technology Center (Zaragoza, Spain) with help from ultrasonic equipment supplier Dukane (Saint Charles, Ill., U.S.) via its subsidiary in Prague, Czech Republic, and production automation specialist FFT (Fulda, Germany). This article will walk through the MFFD's final assembly steps and the technology required for their success.

MultiFAL and WELDER projects

For both of these projects, Airbus was the Clean Sky topic manager and The CT Engineering Group was the consortium coordinator. MultiFAL was also managed by Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) in the Research Center CFK NORD (Stade, Germany), where final assembly of the MFFD would take place.

"We were tasked with developing and supplying the automated system for joining the upper and lower fuselage halves," says José Maria Rodríguez Valenzuela, R&D project manager at CT Engineering. He explains the purpose of MultiFAL was to reuse a Fraunhofer IFAM prototype assembly station, integrating hardware and control systems for the necessary positioning and welding operations. The consortium also included FFT and AIMEN, which developed an online monitoring system. The 3DExperience platform from software supplier Dassault Systèmes (Vélizy-Villacoublay, France) enabled the collaboration between the team and stakeholders to support CAD/CAM, assembly and simulation.

"The first goal was to design and propose some concepts to the topic manager for the assembly facility according to the requirements," says Valenzuela. "IFAM and Airbus then selected the preferred concepts, and we designed the facility [the assembly platform and system] into which the fuselage halves would be installed based on analysis of the stress and all the process loads during welding. We then proceeded with manufacturing the facility with its positioning systems. First, we prepared a digital mockup of the assembly process in our design. The result is not only the facility's steel structure, but also FFT's control system for the welding end effectors that would be integrated later during the WELDER project, as well as all of the mechanics of the operations and tolerances required. We had to consider not only the assembly of the fuselage shells but also the activities of the operators, including how to provide access platforms and the necessary mechanisms and software to manage the various placement, welding and measuring activities.

"Airbus and its partners were designing the upper and lower fuselage shells at the same time we were developing the designs for the automated assembly facility," continues Valenzuela. "Two years later, we started the WELDER project." The main objective for WELDER was to design, develop and deploy two robot-based, modular and flexible welding solutions, including tooling and auxiliaries, for completing the 8-meter-long RH fuselage joint and subsequent connection of upper and lower fuselage frames across the RH and LH fuselage seams. AIMEN developed the end effector for continuous ultrasonic welding of the fuselage joint, working with ultrasonic equipment supplier Dukane. Meanwhile, Aitiip designed and built the resistance welding end effector as well as the required TPC couplers for joining the fuselage frames. "The coupler parts had different geometries, made using a hot forming press," says Valenzuela. "They were trimmed and delivered to Germany along with the welding tools to be installed in the MultiFAL assembly station [Fig. 1]. We then installed the ultrasonic welding end effector on an external linear axis and the resistance welding head on a linear axis inside the fuselage."

"We led the development of the welding, including the system setups and lots of coupon tests to define the process window and optimal parameters for both processes," says Dr. Elena Rodriguez, head of advanced composites technologies at AIMEN. "We also collaborated with Aitiip for the heating elements in the resistance welding and provided the online monitoring system to capture the data for both types of welding operations."

FIG. 1 The MFFD in the automated assembly facility developed in the MultiFAL project. Source | AIMEN

Welding the RH longitudinal joint

In ultrasonic welding, a sonotrode sends vibration through a TPC laminate to create heat at the weld interface, but this typically requires an energy director — a layer of unreinforced resin, traditionally with triangular protrusions, to help focus the energy — between the two parts being welded. Although ultrasonic welding is well-developed for spot welding, it is much less mature for continuous welding, notes Dr. Massimiliano Russello, team leader for composites welding at AIMEN. He notes there were numerous challenges in developing a *continuous* ultrasonic welding process for the final MFFD fuselage joint, including developing a continuous process for such a long weld (8 meters) and also how to achieve the overlap joint design.

"We finally decided to do this in three steps," »

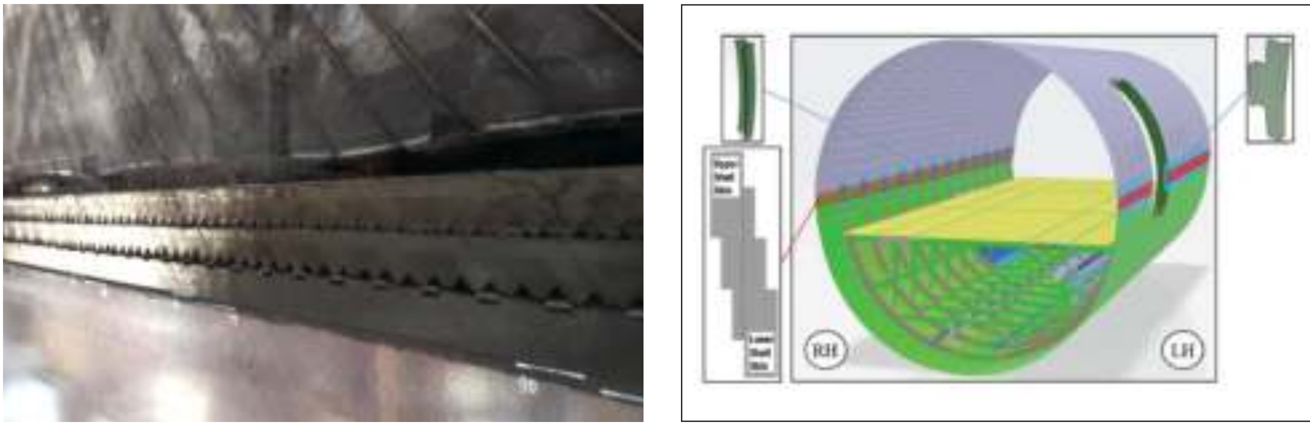


FIG. 2 The RH longitudinal joint was welded in three steps, or passes, each with a different thickness and optimal set of parameters. The diagram at right also shows TPC couplers for welding the upper and lower fuselage frames. Source | AIMEN

says Rodriguez. These three steps, or three passes of the welding tool, enabled joining the stepped laminates in the upper shell to the stepped laminate in the lower shell (Fig. 2), but the process parameters were different for each. "It was a challenge to design a tool that could weld all three steps while ensuring contact pressure and stability between the parts. Also, the continuous welding machine we had at lab scale was limited to less than 1 meter, so we had to work on parametrization of the process to scale it up."

"And to use it in a continuous mode for the high-temperature TPC materials used in the MFFD — [mainly Toray Advanced Composites (TAC, Nijverdal, Netherlands) unidirectional (UD) tapes of carbon fiber-reinforced LMPAEK polymer from Victrex (Clevelys, U.K.)] — in such large and thick parts was especially a challenge," adds Russello. "To weld the upper shell to the lower shell in a continuous and fast way, we had to weld from only one side and use the three different passes with different thicknesses, up to 3.5 millimeters. And the greater the thickness, the more difficulties we had in the welding." This is because it's difficult to vibrate a very thick part and have the vibration propagate to the weld interface.

WELDING END EFFECTOR. In addition to the ultrasonic head, a roller on the right ensures the parts are in contact and a cooling or consolidation block on the left applies pressure on the part after heating for consolidation (Fig. 3) explains Russello. "That block also absorbs heat coming from the weld interface." In the final ultrasonic welding head, the aluminum cooling block was replaced with a copper block for higher conductivity and heat absorption, resulting in much higher surface quality.

PARAMETERS AND SCALING THE PROCESS. There are many parameters that affect the welding process, including pressure, ultrasound amplitude, time and cooling. Also, the layup, conductivity and thickness of the part are important. These all affect the temperature distribution, heating behavior and energy dissipation — a complex, interrelated mechanism that is constantly developing during the process, says Russello.

"We started at lab scale with a very simple setup, and then scaled in complexity to have the final welding head that we integrated into the MultiFAL facility," he continues. "Starting at lab scale, we installed monitoring systems, including thermal cameras and temperature sensors, and did a long study of all the different parameters, including numerical models, to understand the effect on temperature development and weld quality, and how we could use the monitoring system to ensure quality.

"We then moved to a medium scale, where we welded 2-meter-long strips to validate and compare versus what we had at lab scale," says Russello. "We calibrated the parameters and performance on the 2-meter panels, where the welding looked very good, and these were tested mechanically and with NDT. Using the monitoring system, numerical models and simulation, we could then correlate to the full-scale demonstrator. We were able to show the parameters for the medium scale were also valid for the entire fuselage section, which was a very key result."

FIG. 3 The ultrasonic welding head (center) with roller on right and cooling/consolidation block on left. Source | AIMEN

TEMPERATURE CONTROL. The next challenge was to have a well-designed head temperature control. During continuous welding, explains Russello, "the welding time depends on the speed at which you're moving the welding head." Note, this includes cooling, which must fall within a precise window to develop the necessary crystallization in the LMPAEK polymer for mechanical strength. "But you also cool actively during movement, which means that the cooling rate depends on the way you move the welding head," notes Russello. "So, if you move faster, you have less time to cool down the part. Either you have to optimize the parameters or reengineer the cooling because you need that speed for welding. It's all interconnected."

For the MFFD, the AIMEN team welded from the external side of the fuselage. But inside, there were metal holding blocks to prevent movement during the pressure application that would also extract heat from the components being welded. This comes back to the three welding steps or passes, and how each required different parameters. "When the back laminate being welded is very thin," says Russello, "the heat easily goes into the holding block. But at the topmost, thicker step, it takes longer to transfer the weld heat to the blocks and this means that if you don't provide enough cooling, the weld will delaminate in this area.

"By simply analyzing the temperature after the cooling block," he continues, "we were able to understand how the part would behave after welding. When the temperature was below 145°C, we never achieved consolidation of the part. But when the temperature went above 150°C, we were experiencing some delamination. By monitoring the temperature after the consolidation unit — which was on the surface, not at the weld interface — and calibrating that to the process parameters, we were able to ensure that we achieved sufficient cooling and avoided delamination after welding."

FIRST-TIME RIGHT. "Ultrasonic welding is very efficient and fast compared to other technologies we have investigated," says Russello, "but it was difficult to complete this fuselage weld in one shot, first-time right without having previous historical information."

Valenzuela agrees, emphasizing, "We had only one chance to make the weld for each step, and even though AIMEN performed so many tests to define the parameters, when the team went to weld the MFFD, the laminate in the upper shell was not what they expected and was different from what they had tested." So, the team had to adjust some parameters, but their system of calibration and monitoring helped, and in the end they were able to achieve the weld quality required. This was really important, says Valenzuela. "It was the main goal of the project."

Resistance welding the fuselage frames

After ultrasonic welding was completed, and the upper and lower fuselage shells were joined, the WELDER team used resistance welding to connect the fuselage frames. Aitiip was in charge of manufacturing the TPC couplers that would join the structural frames, followed by resistance welding them on the RH and LH sides of the interior fuselage.

AUTOMATED TOOL. The first challenge was how to position the couplers (dark green parts at left of Fig. 4) onto the fuselage frames, explains Iván Monzón, head of robotics at Aitiip. "Initially, it was envisioned to do this with a robot, thus allowing more flexibility. But the space inside the fuselage was very limited. So, we needed to create a specific tool for managing the components and putting them in the right area to weld them." »

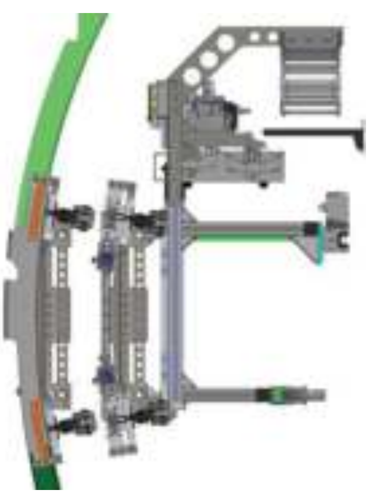


FIG. 4 Aitiip developed a tool that could be moved along a linear rail to position and then resistance weld TPC couplers (green parts at left of top photo) onto upper and lower fuselage frames, creating integrated structures across the RH and LH fuselage joins. The tool was also reversible, capable of being disassembled and mounted on the other side of the fuselage, to weld both RH and LH frames (below). Source | Aitiip

FIG. 5 (a) Three coupler parts were made in one set of matched molds that featured (b) springs in the center to keep tension on the laminates during stamp forming. Preheated TPC sheets were placed into the mold set in (c) an injection molding press where they were stamp formed into (d) double-curved parts that were then trimmed and ready for welding to frames. Source | Aitiip

The team devised a tool mounted onto a trolley that moved along a linear rail inside the fuselage. It was automated, using control software to place a coupler in the position where it would be welded. The tool weighed 15 kilograms, measured 600 × 450 × 250 millimeters and totaled 1,200 × 450 × 800 millimeters and 50 kilograms with the trolley. "This is lightweight," explains Monzón, "considering this device acts like a press during welding and needs material stiffness. It also performed the resistance welding action via two different heads for welding the upper versus lower positions as well as four types of coupler geometries."

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WELDING THE COUPLERS. The welding was achieved by passing electrical current through two contact points in the coupler. This melted the thermoplastic matrix in both coupler and frames, while pressure was applied to fuse the parts with a pneumatic cylinder on a swivel. The pressure was monitored using a load cell in the pressure point. "This operation was made at the same time in the lower and upper areas," says Monzón, "joining the whole structure perfectly. And this was completed for every one of the MFFD frames.

"The coupler welding tool could adapt to all curvature possibilities thanks to a system of curved guides," he adds. "These spanned the distance between the frames being joined and ensured the conductive elements on the coupler touched both frames to enable welding. This system also enabled adaptation to accommodate mounting and positioning errors of up to 30 millimeters from the theoretical positions of the couplers to the frames."

Piet Wölcken, WELDER's topic manager and Airbus Integration work package leader, explained: "With the frame couplings being the last major joints, we were always aware that geometric nonconformities and basic tolerances would all accumulate in this assembly step. As a result, we selected the reasonably fault-tolerant resistance welding technology for the frame coupling integration even if it meant that additional degrees of freedom were required in the installation."

He notes the tool was also reversible. "We could disassemble it and then mount it on the other side of the aircraft, in the opposite orientation, and it worked the same." Indeed, this approach enabled the team to join 14 frames on the ultrasonic-welded RH side, disassemble the tool, remount it and then join 12 frames on the previously laser-welded LH side, which had fewer frames due to a door cutout.

One mold, three stamped couplers

"The way we made the couplers with novel technology was also important," notes Monzón. "We used a stamping process with a heated mold set in an injection press machine that produces parts very quickly." He explains that injection molding is a core expertise at Aitiip, "so we used that knowledge and machinery for making these couplers. We started with flat carbon fiber-reinforced thermoplastic composite sheets made with UD tapes for high structural properties. These were cut to shape and placed into the mold." They were then preheated to between 360°C and 400°C using an array of ceramic lamps placed within the injection press. Once the preheat temperature was reached, the lamps were hydraulically actuated out of the press, allowing it to close.

FIG. 6 The MFFD with welded assembly completed. Source | Aitiip

"This whole process was controlled and completed in less than 10 seconds so that the material did not cool down," he adds.

Three parts were press formed in the same mold with 4 minutes of lamp heating + 10 seconds for closing + 3 minutes cooling for crystallization + 10 seconds of opening for demolding for a cycle time of less than 8 minutes. This not only makes production quicker, says Monzón, "but also helps to maintain symmetry between the bending forces during molding, which makes the process viable. As you can see in the parts [Fig. 5], there was not just one curvature — some of the areas had two or three different curvatures, so the geometry was quite complex. It wasn't possible to just bend the sheets without wrinkles or distortions — there would be areas with a lack of material or excess material in these curvatures. So, we dealt with this by using springs in the center of one mold half [Fig. 5] that were able to keep tension in the part throughout the process, which prevented wrinkling."

The parts were cooled in the mold to below glass transition temperature (147°C) and then removed. A six-axis robotic milling machine was used to extract and trim the three parts to their final tolerances. Monzón says this process reduces the cycle time by more than 50% compared to traditional thermoset composite parts, doubling production with a minimal investment in manufacturing equipment.

MFFD completion, follow-on projects

The major welding operations for the closure of the MFFD were completed with precision and sufficient time to install final local parts before the July 2023 milestone of transporting it to the ZAL Centre for Applied Aviation Research GmbH in Hamburg (Fig. 6), says Wölcken. "This milestone was only achieved thanks to the extreme dedication and collaborative mindset of the people in the various MFFD project consortia and the amazing work of the WELDER and MultiFAL consortia together with Fraunhofer IFAM and Airbus."

At ZAL, the MFFD moved to its next stage as a demonstrator for Clean Sky's NextGen Cabin and Cargo concept that standardizes the interfaces between the airframe and the customized cabin and systems components. This included a new "Crown Module" comprising the ceiling area and "hat-rack" as well as electrical, air conditioning and oxygen supply components and numerous mechanical fixings. Pre-assembled and installed into the fuselage in a single attachment step, the MFFD Crown Module was constructed with ultra-light rods made from Teijin Carbon Europe (Wuppertal, Germany) TPUD HT CF-PPS thermoplastic slit tape in combination with Spiral RTC's (Enschede, Netherlands) recycled Spiral light PPS CF40 compound. These adjustable length rods are a great example of how TPC parts production waste can be reused in TPC airframe systems.

"The MFFD continues to be assessed and is the source for further work and inspiration in numerous follow-up projects and initiatives," says Wölcken. These include FASTER-H2, PENELOPE (EU Horizon 2020 project), ZEUS and HESTIA, the latter part of the German-funded LuFo aviation research program. "The MFFD is a good example of using a major spearhead project to demonstrate a high number of individual CFRTP technologies — and in some cases, even technology variants — with respect to their potential. Subsequently, some of these individual technologies were selected for further, highly driven development. For example, the LuFo HESTIA project contains, among others, key development bricks for the high-rate production of large, complex fuselage frame structures."

"The WELDER project exemplifies how innovative manufacturing technologies can enhance both structural integrity and sustainability in aerospace," says Monzón. "By leveraging thermoplastic composites and reducing cycle times, the team achieved significant efficiency gains while minimizing resource consumption. Furthermore, this approach democratizes the use of composite materials by making their production more accessible and cost-effective, while also facilitating their recyclability and reusability. This not only improves manufacturing throughput but also aligns with the industry's goals for environmentally conscious and circular production systems." CW

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The market for composites in sporting goods and recreation applications is vast, including carbon fiber composite plates in athletic shoes (top left), bicycle frames and other bike components (top right), panels and roofs for recreational vehicles (bottom right), and snow and water skis (bottom left). Source (clockwise from top left) | Carbitex Inc., *CW*, Knaus Tabbert, John Yan

Composites end markets: Sports and recreation (2025)

The use of composite materials in high-performance sporting goods continues to grow, with new advancements including thermoplastic and sustainability-focused materials and automated processes.

By Hannah Mason / Technical Editor

» Composite materials have risen above other high-performance materials like titanium in many elite sporting goods applications for their high strength-to-weight ratio, vibration damping ability, lack of corrosion issues and ability to be tailored in the design and manufacturing process to meet very specific or custom requirements.

According to the most recent "Composites in Sporting Goods Market" report from market research firm Lucintel (Irving, Texas, U.S.) published in July 2024, the future of composites in the global sporting goods market "looks promising," expected to reach an estimated $1.5 billion by 2030 with a CAGR of 10% from 2023-2030. Light weight and high performance are cited as major growth drivers.

Lucintel projects that golf clubs and shafts will remain the largest application segment over the next several years, with opportunities for growth in other applications including skis and snowboards, bicycle parts, rackets, hockey sticks and fishing rods. Carbon fiber is the most used reinforcement for sporting goods, with the best strength-to-weight ratio for high-level performance in elite sports.

New applications

In addition to growth in these conventional markets, over the past year, *CW* has also covered the adoption of composites into new applications, as well as trends toward more sustainability-focused materials or manufacturing technologies.

For example, the JEC World 2024 trade show (Paris, France, March 2024), which was held a few months before the 2024 Summer Olympics in Paris, provided an opportunity for manufacturers and suppliers to display their latest materials and process advancements in this field, including new uses of natural fiber composites, thermoplastics and more.

Among the parts on display were watersports manufacturer Cobra International's (Chonburi, Thailand) carbon fiber composite surfboard. "These are gaining in popularity among athletes," notes CEO Danu Chotikapanich, for their ability to reach higher speeds and better springback compared to fiberglass boards. Also highlighted were glass/carbon fiber composite IQFoil boards used in the Olympics. In addition, Mel Composites (Barcelona, Spain), a first-time exhibitor at the show and a distributor of custom foam, epoxy resins and consumables used in vacuum infusion, showcased padel rackets manufactured by customer Karbondesign (Barcelona). Padel is a fast-growing sport that is a mix between tennis and squash.

Beyond JEC World and the world of sporting goods, one example of a new sports equipment application for composites is modular, multi-material, multisport tracks manufactured by startup X-Track (Sherbrooke, Quebec, Canada). Developed initially as a safer, more durable, easier-to-transport and -install alternative to traditional outdoor dirt tracks often used for bike and motocross racing, X-Track modules comprise an aluminum frame topped with a curved composite sandwich panel produced by partner bespline (Sherbrooke) with integrated rubber surface material.

The composite panels are manufactured using adaptive molds, preshaped foam core and vacuum infusion. In a recent *CW* article (see p. 44), X-Track's co-founder explains that the complex shapes needed for race track modules, and the durability required to withstand repeated impacts from race vehicles, wouldn't be possible without composite materials.

A variety of advancements in sports and recreation applications have also been *sustainability-focused,* featuring recycled materials and/or bio-based fibers or resins. For example, watersports equipment manufacturer HO Sports (Snoqualmie, Wash., U.S.) launched its Sabre water ski developed in partnership with biotechnology company Checkerspot (Alameda, Calif., U.S.), featuring a bio-based foam core designed specifically for water skis. Developed through Checkerspot's Wing Platform, the foam is custom-formulated from algae-derived biomaterials to meet desired performance properties with less reliance on fossil fuels.

Another example recently covered by *CW* is the Värmdö sea kayak from Melker of Sweden (Solna), launched in late 2024. It incorporates ampliTex flax fibers from Bcomp Ltd. (Fribourg, Switzerland), GreenPoxy resin and GreenCoat gelcoats from »

LEFT: X-Track's composites-intensive track modules can be used for indoor or outdoor racing events in a variety of sports, designed for easy transport and assembly as well as durability. Source | X-Track

LOWER LEFT: Ahead of the 2024 Paris Olympics, a variety of composite sporting goods were on display at the JEC World 2024 trade show. Source | *CW*

BELOW: In 2025, all Melker kayak models will feature Bcomp flax reinforcement fabrics, Amorim cork and plant-based resins and gelcoats from Sicomin. Source | Melkor of Sweden

Sicomin (Châteuneuf les Martigues, France) and a cork core. The kayak won Product of the Year 2025 in the Sea Kayaking category at the Paddle Sports Show in Strasbourg, France. Also incorporating Sicomin's GreenPoxy resin, Notox Surfboards (Anglet, France) has unveiled a line of custom-built, tow-in surfboards made from GreenPoxy 56, upcycled aerospace carbon fiber fabrics, woven flax fiber fabric from Libeco (Meulebeke, Belgium) and agave core.

Similarly, Head Sports GmbH (Kennelbach, Austria) also recently announced that it is developing prototype tennis rackets and pickleball paddles made with bio-circular carbon fiber from Toray Carbon Fibers Europe (Paris, France).

Within the larger sports and recreation category, bicycles, athletic shoes and recreational vehicles have recently grabbed a lot of headlines. While not an exhaustive list, several new developments covered by *CW* are outlined below.

Bicycles: Developments toward thermoplastics, automation

Carbon fiber composite bicycle frames, particularly for high-end sport bikes, have become increasingly popular in recent years as the ultimate lightweight material option with high strength, natural vibration damping and no corrosion issues compared to metal bike frames.

Canadian bike manufacturer Argon 18 currently makes road bikes based on thermoset composites, but sees a place for thermoplastics to grow in the future. This TPC seat post demonstrator showcased design and manufacturing possibilities. Source | CDCQ, LxSim and Argon 18

According to Lucintel's July 2024 global bicycle market report, the global bicycle market size was $47.8 billion, expected to grow about 4% annually to $62 billion by 2030. Lucintel cites "rising fuel prices, government programs to build bicycle paths and roads, increasing health concerns/fitness consciousness, growing environmental awareness and increasing traffic congestion" as top drivers for this growth, with Europe leading demand and e-bicycles as the market segment projected for the highest growth.

Market research firm Technavio (London, U.K.), looking specifically at the high-end bicycle market (including those made with carbon fiber composites or titanium), as of December 2024, projects $6.5 billion in growth between 2024 and 2029 at a CAGR of 7.5%.

According to these cited reports and *CW*'s 2022 feature on carbon fiber-reinforced polymer (CFRP) bike frame manufacture, a majority of this fabrication occurs in Asia, producing up to 99% of CFRP bike frames globally. Most of these are produced via hand layup using carbon fiber/epoxy prepreg.

However, many companies in North America and Europe have reported goals in the last few years of becoming more competitive in this space, including adoption of automated processes and thermoplastic composite (TPC) materials.

For example, as reported by *CW*'s Ginger Gardiner, Argon 18, a high-quality bike manufacturer in Montreal, Canada, worked with the Quebec Composites Development Centre (CDCQ, Saint-Jerome, Canada) and engineering simulation specialist LxSim (Bromont, Canada), as well as composites automation company Addcomp (Sherbrooke, Canada) to evaluate six different TPC materials. It developed an optimized layup for 2D blanks which were made using automated fiber placement (AFP), shaped onto a mandrel and then compression molded using a »

As demonstrated by this bicycle on display at JEC World 2024, Dieffenbacher and Rein4ced have collaborated on a fully automated, thermoplastic composite bike frame production line. Source | *CW*

bladder-based process to produce and test two of these materials in a bike seat post demonstrator.

Seeing success in this first demonstrator part, the company is working to refine the process and push the technology further. As Vincent Lemay, VP of R&D at Argon 18, summarizes: "We do see a big shift coming in the cycling industry. Everything is geared right now to use thermoset composites, but we've seen companies start to use TPC in mountain bikes and Rein4ced is also working with it in road bikes. But there are also significant challenges in developing the manufacturing processes. You can't just go and buy the equipment off-the-shelf. It's not there yet. So, we need to develop the recipe and the equipment according to what we need, and that's why this type of project was so valuable."

As Lemay mentioned, in 2024, composites manufacturer Rein4ced (Leuven, Belguim) and equipment supplier Dieffenbacher (Eppingen, Germany) teamed up to propel large-scale production of carbon fiber-reinforced thermoplastic (CFRTP) road bicycle frames. A serial production line was built to produce frames from unidirectional TPC tapes. The line, built at Rein4ced's facility, is based on Dieffenbacher's automated Tailored Blank Line, which lays up tapes and consolidates them into blanks, followed by a thermoforming line containing an oven and Fiberpress, which forms the blanks into their final part shapes. As of early 2024, Rein4ced said it was planning to use its Leuven facility as a pilot plant for production.

Athletic shoes: Increasing applications, sustainable materials

Carbon fiber composites can also be incorporated into elite athletic and protective gear, most notably in the form of plates in the midsoles of elite running shoes. These stiff structures serve as a sort of springboard for the foot to increase propulsion and speed and to improve running efficiency by optimizing energy return. The "super shoes" phenomenon began with Nike's Vaporfly 4%, popularized when the top three male finishers in the 2016 Summer Olympics marathon wore them. Since then, most running shoe companies have released running shoes with carbon fiber plates. (Note: World Athletics has since imposed some limitations on their use in competition, to mitigate risks of unfair advantages.)

Over the past several years, Carbitex Inc. (Kennewick, Wash., U.S.) has developed a line of flexible carbon fiber/thermoplastic plates for use as soles in athletic shoes. These plates, designed to flex with the human foot but add strength and stiffness in needed areas, have been launched to the market with various brands in shoes for soccer, golf, running, watersports, snowsports and more. In October 2024, the company announced it had secured new funding and is projecting a fivefold sales growth in 2025.

Shoe plates are also one of several focus areas for Arris Composites (Berkeley, Calif., U.S.), a company founded in 2017 commercializing its Additive Molding technology that combines automated preforming of thermoplastic prepregs followed by consolidation.

In early 2024, Brooks Running launched its Hyperion Elite 4 running shoe featuring carbon fiber composite plates manufactured by Arris. Also in 2024, Arris announced that its continuous carbon fiber composite plates are being evaluated in a study by the U.S. Army for use in the insoles of military shoes, as well as its first direct-to-consumer brand Aurrora by Arris (AXA) to sell products including carbon fiber shoe plates online and at pop-up events.

There are also several companies working on new developments for the manufacture of composite shoe

Carbitex Inc. supplies several different patented designs of carbon fiber/thermoplastic plates for soles in athletic shoes. The fibers are oriented in various ways per each design depending on the needs of each type of shoe. Source | Carbitex Inc.

Arris Composites' Additive Molding process is used for a variety of products ranging from consumer to aerospace markets, including continuous carbon fiber composite plates used in elite running shoes and under evaluation for military applications. Source | Arris Composites

components made with *recycled* materials. For example, recycling company Thermolysis Co. Ltd. (Taichung City, Taiwan) has released a study proving that its injection-moldable pellets made from 20% short recycled carbon fiber (rCF) and polycarbonate and 30% rCF with polyphthalamide meet or exceed flexural and tensile strength of virgin carbon fiber. The company has launched a line of bicycle water bottle holders made with this material, and says it is working toward rCF composite shoe midsoles.

In early 2024, global energy company Acciona Energía (Alcobendas, Spain) and El Ganso (Madrid, Spain) launched a limited edition sneaker featuring fiberglass and epoxy from recycled wind turbine blades directly incorporated into the rubber in the shoes' soles, demonstrating the potential of shoes as an option for wind blade recycling.

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Recreational vehicles and beyond

Beyond sporting goods, fiberglass composite materials are also used in many other types of consumer products and recreational equipment, including inground swimming pools and spas (with composites reportedly making up about 12-15% of the U.S. market, which is growing), as well as the wall panels, roofs and floors of recreational vehicles (RV).

»

Representing a new end market for Greenboats, the Greenlander *Sherpa* was launched at JEC World 2024 and the Caravan Salon 2024. Source | Greenboats

Knaus Tabbert camper sports its styrene-free composite roof. Source | Knaus Tabbert

The RV Industry Association's (RVIA, Reston, Va., and Elkhart, Ind., U.S.) Winter 2024 quarterly forecast, prepared by ITR Economics for the RVIA and released in December 2024, projects 2024 RV shipments to reach 324,100 units, and then to increase in 2025 up to the mid-300,000 unit range.

"Wholesale shipments are edging up slightly over last year's total in the face of stubborn interest rates and stretched consumer finances," says RVIA president and CEO Craig Kirby. "The market is poised for additional growth next year with dealer inventories at healthy levels, continued strong consumer interest in RV ownership and interest rates that are expected to ease."

Fiberglass composites are common in RV components for their light weight and durability, though some carbon fiber composite designs have also been developed, and recent innovations have included moves toward bio-based or styrene-free materials.

For example, the flax fiber composite-intensive Greenlander *Sherpa* RV was launched in 2024. It was developed by Greenboats GmbH (Bremen, Germany), a company founded originally to manufacture boats from natural fiber composites and which has since expanded into the manufacture of flax fiber composite panels, custom components and now RVs.

The Greenlander *Sherpa* is a premium camper developed with design partner Langefreunde Design Studio (Schwerin, Germany) and manufacturing partner Borco Höhns GmbH (Rotenburg, Germany). All of the exterior structures for the camper are constructed from Greenboats' flax fiber composite sandwich panels. The company built the first few iterations of the RV, which was presented to the composites industry at JEC World 2024, and to the RV industry at the Caravan Salon 2024 in Düsseldorf, Germany, at its own facility. Ultimately, partner Borco Höhns will build the production vehicles using panels supplied by Greenboats.

As the company scales up sales of its product, one goal is for customers to be able to return Greenlander *Sherpa* vehicles back to Greenboats at their end of life, and for the company to reuse the composite panels to build new campers or other applications.

Another materials innovation reported recently is the development of a fiberglass composite camper roof made from styrene-free resin and gelcoat. Produced by plastic fabrication company Indupol (Arendonk, Belgium), resin supplier AOC (Schaffhausen, Switzerland) and composite solutions company Büfa (Rastede, Germany) for customer Knaus Tabbert, the resin transfer molded (RTM) roof was designed to meet new European legislation changes requiring very low levels of volatiles.

To meet these new requirements, Indupol used a styrene-free gelcoat and RTM formulation combination for making components with close-to-zero emissions. AOC proposed a novel styrene-free Beyone 215-A-01 formulation, enabling a smooth injection process, which Büfa supplied to Indupol; both AOC and Büfa have spent many years developing these products, and report that they are expecting the technologies to be broadly commercialized in the near future. CW

ABOUT THE AUTHOR

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APPLICATIONS

Modular, curved racing track design enabled by composites and adaptive molds

X-Track worked with bespline to develop an easy-to-install, reusable, customizable composite sandwich panel alternative to dirt BMX and motorcross tracks.

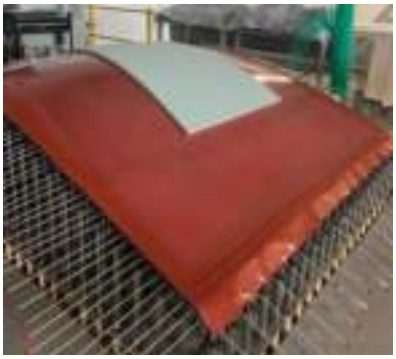
Startup X-Track's multisport tracks combine an aluminum frame, composite sandwich panels and a weatherproof rubber surface material to provide a durable, reliable alternative to traditional outdoor dirt tracks. Source (All images) | X-Track

» Outdoor dirt tracks have traditionally been the norm at BMX and motocross race events, but startup X-Track (Sherbrooke, Quebec, Canada) aims to provide a cleaner, safer and longer-lasting alternative with its multi-material, modular track designs.

X-Track was founded in 2022 by Pascale Larocque, Donald Tremblay and former competitive BMX and motocross rider Steve Lussier, and came out of the Idenov Group. According to Larocque, the idea to develop and commercialize an alternative track design grew from recognition of issues that traditional dirt tracks present to both riders and venues. For example, riders are exposed to dust inhalation, which can pose health concerns. Dirt tracks also require a multiday installation and disposal process for dirt to be trucked in and removed, as well as constant maintenance during the event itself as vehicles carve grooves into the track. Outdoor dirt tracks are susceptible to damage from weather, and increasingly fewer indoor arenas are permitting the use of dirt tracks because of potential damage to ventilation systems and other equipment.

The X-Track team set out to investigate various materials and manufacturing methods that could be used to build a prototype track. They found that much of the structure could be made from an aluminum frame, but the curved track surfaces proved more complex, especially as these surfaces vary from track to track.

To manufacture each module, bespline uses Adapa reconfigurable molds (left) to make foam preforms, and to vacuum infuse near-net-shape composite sandwich panels (right).



Ultimately, X-Track's team found a solution in nearby Sherbrooke composites manufacturing startup bespline. "We had originally looked at doing the track all in aluminum, but we really couldn't do the traditional complex and curved shapes without composites," Larocque emphasizes.

Bespline, founded in 2021 and co-located with sister company Addcomp, uses reconfigurable molds from Adapa (Aalborg, Denmark) to make 3D composite panels or thermoformable foam kits — without the need to build a distinct mold for each shape and part.

Composite sandwich panels are ultimately bonded between an aluminum frame an exterior rubber surface material.

"We started with one very small piece of a track as a prototype, and tried a couple of different constructions," explains Yoann Bonnefon, CEO of bespline. Essentially, bespline helped design and manufactured a curved, fiberglass composite sandwich panel cored with foam, which would be bonded to an aluminum support structure made by a manufacturing partner, and topped with a granular rubber surface material optimized for weatherproofing and for the amount of grip needed for a bike or motorbike.

First, in bespline's typical manufacturing process, the adaptive mold is configured from the CAD file to the needed shape, and cut foam is thermoformed to create a preform — bespline markets these as Shaped Foam Kits for use by a variety of industries. Next, the preshaped foam is laid up, again on the reconfigurable mold between fiberglass fabric skins, and cured at room temperature with liquid epoxy resin via vacuum infusion to create a composite panel with dimensions up to 6 × 10 feet. The near-net-shape panel is trimmed and then ready to be installed with the rest of the track module. Bespline also helps integrate the panel onto the aluminum structure via adhesive bonding.

After manufacturing and testing the first prototype module, bespline and X-Track worked on optimizing the panels, including reducing the thickness and trying a variety of materials, including flax fiber fabrics, bio-based epoxies from Gurit (Wattwil, Switzerland), recycled PET foam and Arkema's (Colombes, France) Elium recyclable thermoplastic resin. "We have various material options we can use depending on what mechanical properties are required, or if they want to use bio-based or recycled materials. We have different design options such as pre-programmed shapes, and thickness and width that can be changed depending on whether it's a track for a lighter BMX bike or heavier motocross bike," Bonnefon says.

In order for its tracks to be used in competitive sport, X-Track technology is currently certified with La Fédération Québécoise des Sports Cyclistes (FQSC, Quebec Cycling Federation), and Larocque says the company is working toward certification with the Union Cycliste International (UCI) in Europe.

X-Track started trialing its track in 2023 at a professional practice site in Florida. In summer 2024, X-Track participated in the Red Bull Tennessee Knockout motorbike racing event in Nashville. X-Track provided 12 curved bump modules that were integrated into the rest of the traditional dirt track for the one-night event. "This was a great opportunity to showcase the technology, to show how much easier it is to transport and install, and their quality during competition. Any doubts have been dissipated," Larocque says. "It also showed the option of incorporating a hybrid design, with both dirt and X-Track modules."

Following this success, the company has begun developing not only bump modules for other dirt tracks, but full track designs for BMX and motocross, for individual competition events and permanent indoor arenas. X-Track also works with an engineering firm on customized track designs, and subcontractors for the surface material and aluminum structures. Larocque adds that the tracks have also started attracting interest from other types of competitive bike/motorbike racing and other sports, such as ice cross for competitive skating.

"There is a lot of interest, and we are building a market for our product," Larocque says. "Part of the process is proving out the technology to show that it is worth the cost — we are competing, after all, with dirt — and also to continue innovating our materials and technology to bring costs down where we can continue to offer options for a variety of sports." CW

NEW PRODUCTS

» Cloud-based materials platform

Integrated, AI-guided platform makes materials innovation more accessible

Materials informatics company MaterialsZone (Tel Aviv, Israel) has launched its AI-Guided Product Development feature, providing MaterialsZone users with direct access to AI-generated experiment suggestions to streamline development cycles within their existing workflow.

Founded in 2018, MaterialsZone was developed to offer a versatile, industry-agnostic solution. The company works with customers across a wide variety of industries, ranging from chemicals and advanced materials to fast-moving consumer goods. Its platform is reported to be very flexible in terms of the types of data and data structures it supports, including for fiber-reinforced composite materials.

Building on successful use cases, the AI-Guided Product Development feature transforms trial-and-error-based experimentation by providing real-time experiment recommendations to guide researchers through iterative improvements. An AI-driven feedback loop gradually narrows the parameter space, accelerating progress toward achieving product requirements and researcher goals while considering critical material and process constraints, including cost optimization and carbon footprint reduction.

As each suggested experiment is completed and documented within the MaterialsZone platform, the AI model is used to refine recommendations according to the latest data, enhancing precision and efficiency. Notably, it integrates data enrichment, machine learning, experiment synthesis and feedback, all within a no-code framework. **materials.zone**

» Sustainable epoxy resins

Epoxy products reformulated with bio-content

Gurit (Zurich, Switzerland), a supplier of high-performance epoxy products, continues to deliver on market and customer formulation needs, now including options that are more environmentally friendly and safer for customers to use. Gurit says it provides a complete range of formulated products including adhesives, in-mold gelcoats, laminating and multipurpose systems with bio-content as standard. This includes its Prime resin infusion range for composite tooling and components and Ampreg wet laminating range.

Prime infusion systems applications range from single-operation molding of carbon fiber yacht masts, wind turbine blades and 80-foot yacht hulls. Gurit says these liquid epoxy systems have been developed for "under the bag" infusion processes, including the Seeman composites resin infusion molding process (SCRIMP), resin infusion under flexible tooling (RIFT) and vacuum-assisted resin transfer molding (VARTM).

Prime 37 has been developed to deliver optimal laminate quality for a range of liquid infusion composite processes. In addition to optimized cure characteristics (mixed viscosity remains lower for longer; faster through-cure avoids a low-strength "sugary" phase; and improved exotherm control), Prime 37 is also Lloyd's certified and is produced with bio-based content as standard. By using Ampreg 3X low-toxicity hardeners, Prime 37 also has "market-leading health and safety," Gurit says and enables customers to take advantage of the blendable hardener speeds which can be tailored to suit each application.

The Ampreg 3X series is used for the manufacture of large composite structures in the marine, wind and construction industries. The portfolio comprises a single range of low-toxicity, blendable Ampreg 3X hardeners that can be used in conjunction with the following resins:

- Ampreg 30 low-viscosity resin
- Ampreg 31 drainage resistance resin
- Ampreg 36 premium performance resin.

Notably, Ampreg has been reformulated to prioritize user health and safety through careful selection of base chemicals. The new low-toxicity resin matrix is CMR, SVHC and AEP free and the hardeners are classified as environmentally non-hazardous. **gurit-resins.com**

» AI-based workflow management

AI agents suite orchestrates, automates and optimizes manufacturing operations

Plataine (High Point, N.C., U.S.) has released its suite of AI Agents, designed to address the complex challenges faced by advanced manufacturers. The AI Agents suite — intelligent, connected and interoperable agents — intends to address a wide range of complex workflows and manufacturing challenges, including day-to-day operational scheduling and execution — Able to Promise, Equipped to Deliver, Materials Optimization and Allocation, Tools Management and others.

Plataine provides an example of how this system could work in a composites manufacturing facility: "Plataine Scheduling Agent (A) communicates with Plataine's Materials and Tools agents (B) at the customer/OEM site. Material Agent will suggest a pick list with relevant materials based on their ETL and expiration date. Same for Tools Agent. The scheduling agent will create the most optimal and practical schedule based on results received from other agents and systems."

All agents can operate either in an autonomous or semi-autonomous configurable mode, orchestrating decisions and operations among themselves, with other enterprise AI Agents and with the various members of the production team, from senior management to floor operators. Each Agent is set to optimize its own tasks, and the suite is operated in an orchestrated manner, balancing multiple optimization goals and weighing the associated tradeoffs according to business priorities.

Integrated with Plataine's Supply Chain Connectivity Manager, AI Agents are capable of operating across the supply chain, thus automatically coordinating operations between suppliers and customers.

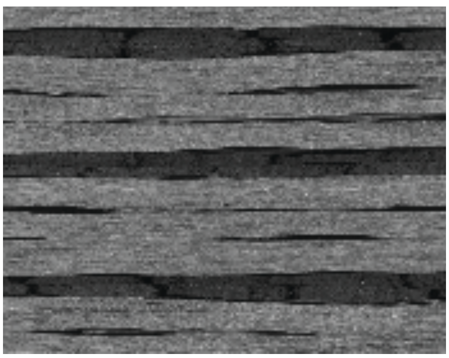
Plataine's enterprise-grade of Agents support multiple personas and complete workflows, while integrating data from a range of ERP, MES, PLM and CRM systems, machine and sensor data, and user input to address complex challenges on a large scale. plataine.com

» Resin degassing

Real-time resin degassing measurement enhances part quality

Composite Integration (Saltash, U.K.) has unveiled a significant addition to its Ciject range of infusion and injection machinery: real-time resin degassing measurement technology. Ciject equipment is reportedly easy to use and enables high-quality parts production. This new functionality furthers its quality capabilities across critical sectors, including aerospace, wind energy and marine.

In environments where the precision and integrity of composite materials are crucial, knowing how well degassed a resin system is has seldom been well understood or measured. Recognizing this limitation, Composite Integration's technology offers consistent and precise measurement and control. It uses sensors and software to continuously monitor the state of resin during the degassing process. Integrated with real-time analytics, it can detect and quantify the presence of gases within the resin, enabling immediate adjustments. This ensures optimal resin quality throughout the infusion process, reducing the risk of defects and improving the overall integrity of the finished composite.



The image at left showcases resin-infused laminates that use degassed resin with Composite Integration's measuring technology. Correctly degassed resins, constantly monitored and maintained by Ciject technology, produce laminates with negligible void content.

The Ciject range of resin infusion and injection machines are equipped with features such as remote access and designed with the user in mind. They are engineered for use in vacuum infusion, RTM and Direct Infusion processes, giving engineers ultimate control over resin quality, according to the company. Their straightforward usability further simplifies operation, resulting in few mistakes and a lower cost of ownership. **composite-integration.co.uk**

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CarbonTT's carbon fiber-reinforced polymer (CFRP) chassis is integrated into the Borco Höhns Fiat *Ducato*. The advanced composite design reduces the chassis weight by 185 kilograms, enhancing payload capacity and operational efficiency. Source | Borco Höhns

Pultruded CFRP chassis enables 36% payload increase for specialized commercial vehicles

CarbonTT's quadraxial NCF composite chassis adds 185-kilogram capacity to Borco Höhns' 3.5-ton Fiat *Ducato* market vehicle.

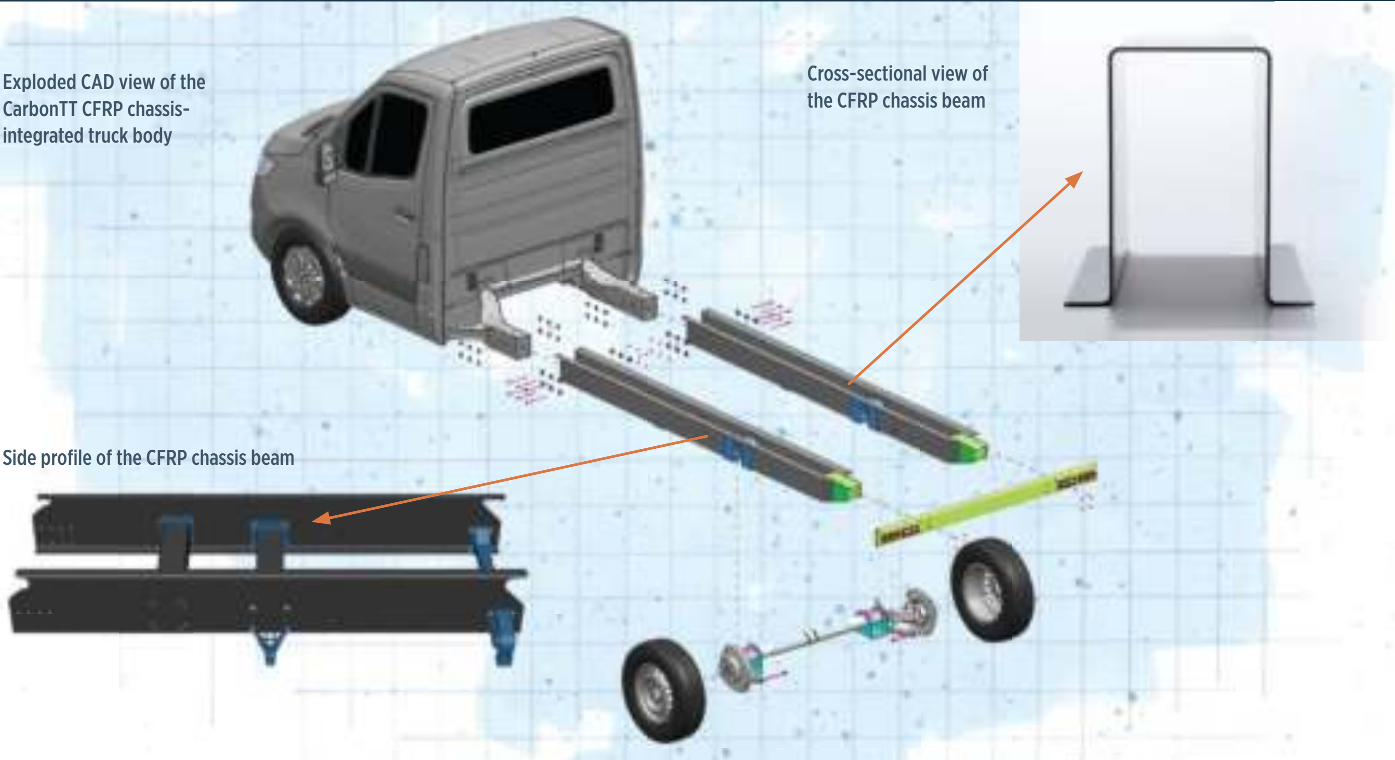
By Stewart Mitchell / Contributing Writer

» In the evolving landscape of urban logistics and mobile commerce, the demand for specialized, lightweight commercial vehicles has surged. Driven by rapid urbanization, the boom of on-demand services and industries spanning last-mile delivery, food distribution, mobile healthcare and specialized maintenance are increasingly relying on compact, adaptable vehicles. These vehicles enable efficient, flexible service in densely populated areas and restricted zones where larger vehicles face operational and regulatory barriers.

A key constraint in these sectors is the strict 3.5-metric ton (MT) weight threshold — a regulation pivotal in most European and many global markets that separates light commercial vehicles (LCVs) from heavy goods vehicles (HGVs). Crossing this limit typically incurs additional costs (such as tolls), requires specialized driver licensing and subjects operators to more intensive regulatory oversight. For companies striving to optimize logistics while minimizing expenses, staying within the 3.5-MT classification is essential.

In 2023, specialized retail vehicle seller, Borco Höhns (Rothenburg, Germany), set out to enhance the commercial efficiency of its 3.5-MT max weight vehicles by minimizing the base vehicle weight. To address this, Borco Höhns collaborated with Carbon Truck & Trailer GmbH (CarbonTT, Buxtehude, Germany), a company specialized in the development and automated production of structural composites, to develop a carbon fiber-reinforced polymer (CFRP) chassis for its Fiat *Ducato*-based retail vehicle, replacing the steel version.

Following 18 months of development, the resulting CFRP chassis led to a 185-kilogram weight reduction for the sub-3.5 MT Fiat



DESIGN RESULTS | **Pultruded CFRP vehicle chassis**

- Achieves significant weight reduction to increase payload capacity within the strict 3.5-MT vehicle classification.
- CFRP chassis design is capable of withstanding real-world loading conditions, with durability equivalent to or exceeding traditional steel chassis.
- Developed pultrusion process maintains precise fiber orientation and high production speeds, enabling high-volume manufacturing.

CarbonTT | Illustration

Ducato while maintaining the necessary robustness for specialized retail vehicle applications. This enhances the 510-kilogram payload of the steel chassis version by 36%, translating to a proportional boost in revenue potential for each load transported.

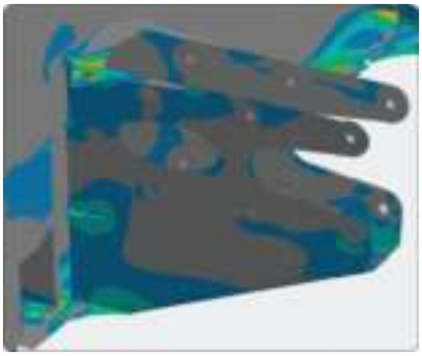
"By reducing vehicle weight, we give customers more flexibility — whether that's carrying additional goods, adding equipment or staying under weight restrictions that affect licensing and road access," explains Gerret Kalkoffen, CEO of CarbonTT. "This could be a game changer for the industry."

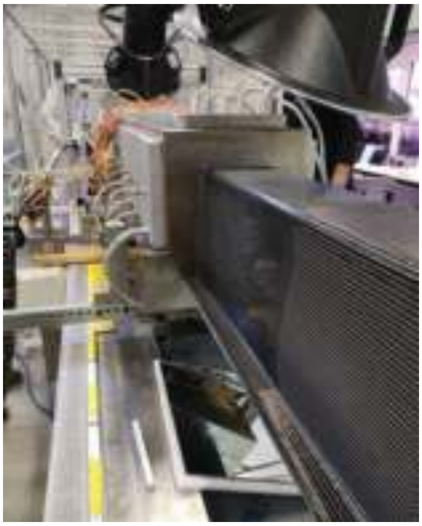
Design challenges and material selection

CarbonTT designed the CFRP chassis, which included an optimized fiber layup, resin chemistry and development of a novel pultrusion manufacturing process. "Pultrusion manufacturing necessitates a uniform profile thickness," explains Kalkoffen. "When loads are unevenly distributed — such as in centrally located interfaces versus vehicle overhangs — it is challenging to find an optimum of load, weight and cost. Looking at global loads, fibers costs and production speeds, we did not want to exceed 3 millimeters. This was only possible with our patented interfaces that transfer and translate loads from steel to composite."

The chassis design uses a symmetric quadraxial noncrimp fabric (NCF) architecture made with Zoltek (St. Louis, Mo., U.S.) 50K tow PX35 carbon fiber, showcasing 0°, +45°, -45° and 90° fiber orientations. "The stitching characteristics are crucial for determining fabric shapeability," notes Kalkoffen. "We carefully define the stitch strength and yarn type to balance stiffness for pultrusion processing against the fabric's ability to conform to complex profiles. This approach means precise fiber control during manufacturing while maintaining the material's ability to handle both longitudinal and torsional loads." »

Finite element analysis (FEA) simulation of a chassis mounting bracket under load. Stress concentrations are visualized to optimize the composite design. Source | CarbonTT





The custom-designed pultrusion line developed by CarbonTT for manufacturing CFRP chassis beams ensures precise fiber orientation and seamless resin infusion. Source | CarbonTT

Custom pultrusion technology, methodology

At the heart of CarbonTT's solution is a bespoke pultrusion manufacturing technology. Built on a Pultrex/KraussMaffei (Manningtree, U.K.) pultrusion line, the system features custom-designed fiber racks, shaping units, grippers, an automated tension control system, saw and an injection box. Based on a Covestro (Leverkusen, Germany) polyurethane system, CarbonTT formulated a specialized resin that incorporates various functional additives to facilitate smooth processing through the pultrusion process. These additives regulate viscosity and cure kinetics to achieve complete fiber wet-out within the injection stage. Additionally, the inclusion of UV stabilizers and heat-resistant compounds in the resin provides long-term durability for the chassis in service.

"Traditional pultrusion struggles with complex fiber architectures," Kalkoffen says. "Over several years, and with countless struggles, we have developed a unique control system using multiple sensors to maintain precise fiber feed positioning relative to the tooling. These sensors continuously monitor fiber position and orientation, feeding data to the automated tension control system that makes real-time adjustments to prevent fiber misalignment, wrinkling or the formation of cavities that could compromise structural integrity." This technology enables CarbonTT to produce profiles with complex shapes at high production speeds without wrinkles, which is key to achieving good material properties and minimizing the cost of fibers per application.

LEARN MORE

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CarbonTT also developed proprietary technology for generating and controlling pressure gradients within the injection zone. "Generating adequate pressure in the injection system requires precise control of multiple variables," notes Kalkoffen. "Because of the continuous nature of pultrusion, the injection box is open on two sides — so if you need a certain pressure for the resin to reach the central fibers, you can't just increase the pressure on your metering machine. We had to develop the resin to penetrate and cure with this challenging scenario."

Material testing, chassis validation

Material validation followed a rigorous protocol developed to address both performance and long-term durability requirements. Initial testing began with coupons placed in environmental chambers configured to simulate extreme service conditions. Test specimens underwent temperature cycling from -40°C to +80°C while exposed to salt spray environments, with specific attention paid to material interfaces and bonded joints. Each cycle included controlled humidity variation to evaluate moisture resistance and potential degradation mechanisms.

Full-scale chassis testing employed sophisticated hydropulse equipment to simulate real-world loading conditions. Composite-to-metallic interfaces received particular attention during this stage with test procedures to evaluate adhesive bonding and mechanical fastening methods. "We conducted fatigue testing applying 500,000 load cycles simulating payload operation, followed by 200,000 cycles at 20% overload, equivalent to approximately 160,000 kilometers of service," details Kalkoffen. "The composite chassis showed no measurable fatigue or degradation through these accelerated life tests. We then applied the hydropulse's maximum force but could not break the chassis."

Vehicle-level dynamics validation followed. This involved specialized tests using a fully instrumented vehicle and test track to gather performance data on stability, including emergency maneuver scenarios, which verified the composite chassis' impact. Each phase went through certification processes with TÜV

Interface validation test setup for composite-to-metal connections in the CFRP chassis. Load measurements in multiple directions ensure robust joint performance. Source | CarbonTT

The Borco Höhns Fiat *Ducato* is equipped with CarbonTT's CFRP chassis during a dynamic performance test on a controlled track. The composite chassis significantly improves handling characteristics. Source | Borco Höhns

Rhineland (Cologne), Germany's vehicle certification authority, ensuring compliance with industry standards.

Design and market impact

The lightweight composite chassis also offers significant benefits from an operational standpoint. "Lower mass means a higher payload in one direction and a lower vehicle weight in the other," says Kalkoffen. "This has a positive effect on energy consumption — whether using traditional fuel or electricity — and thus reduces the CO_2 emissions per delivered good. Lower energy consumption also means a greater range, allowing operators to optimize routes. For fleet owners, a payload increase of 10-20% may mean reducing your fleet size and required drivers by that same amount."

The design of CarbonTT's chassis is unconventional. While a traditional chassis consists of a ladder frame with two long beams and multiple cross beams for torsional stiffness, the CFRP chassis only features long carbon fiber beams, which manage to bear the torsional loads by merely stiffening any standard floor plate. "The absence of cross-members creates accessible space for additional equipment installation without compromising structural integrity," explains Kalkoffen. "This space can be used to safely integrate large traction batteries or water tanks in recreational vehicles."

CarbonTT has also considered repair methods for the composite chassis in the event of damage to ensure the Fiat *Ducato*s don't reach end of life (EOL) prematurely. "Our approach includes methods for assessing damage, specifying repair mechanisms and ensuring that any necessary repairs can be performed by a local automotive shop," explains Kalkoffen. "Although these repairs won't create a Class A surface finish, we are confident that our solutions — involving patches applied to the rear of structures — will provide an acceptable aesthetic, safe and functional result, maintaining a low-cost and efficient repair process."

Kalkoffen concedes that while composite production initially carries a higher carbon footprint than traditional steel manufacturing, CarbonTT's life cycle analysis demonstrates an environmental impact payback within 1-2 years of regular service. This rapid return stems primarily from reduced operational mass which reduces fuel consumption and lowers operational emissions throughout the vehicle's service life.

Future potential

On the potential of the composite chassis for specialized, lightweight commercial vehicles, Kalkoffen says: "The pultrusion process is inherently scalable, but we're not content with just scaling production. We're actively investigating ways to improve sustainability across our entire manufacturing chain." Current initiatives focus on further developing the resin system, such as exploring bio-based alternatives that maintain the critical processing and performance characteristics achieved with the current formulation.

"Collaboration with resin manufacturers in developing thermoplastic alternatives that could facilitate easier separation of resin and fiber at EOL, while maintaining the precise processing control required for the open-ended pultrusion system is also ongoing," he continues.

The company's research program is also exploring recyclability options, prioritizing reuse over recycling where possible. Cost optimization also remains central to future development, with efforts focused on minimizing material waste, particularly in handling impregnated fibers. The current production system demonstrates impressive efficiency, with a single line capable of producing parts for up to 70,000 vehicles annually. "The company's efforts in minimizing scrap rates at this high volume, combined with a more sophisticated quality control system, will help offset the higher material environmental and financial costs associated with CFRP chassis components for this commercial vehicle application," highlights Kalkoffen.

As urban delivery and mobile retail continue expanding, with increasing pressure for reduced emissions, lightweight solutions are poised to play a crucial role in the 3.5-MT vehicle industry's evolution. The combination of significant payload increases enabling higher revenues with less trips, and advancing sustainability metrics, suggests that composite chassis technology may become increasingly prevalent in commercial vehicles in the future. CW

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**

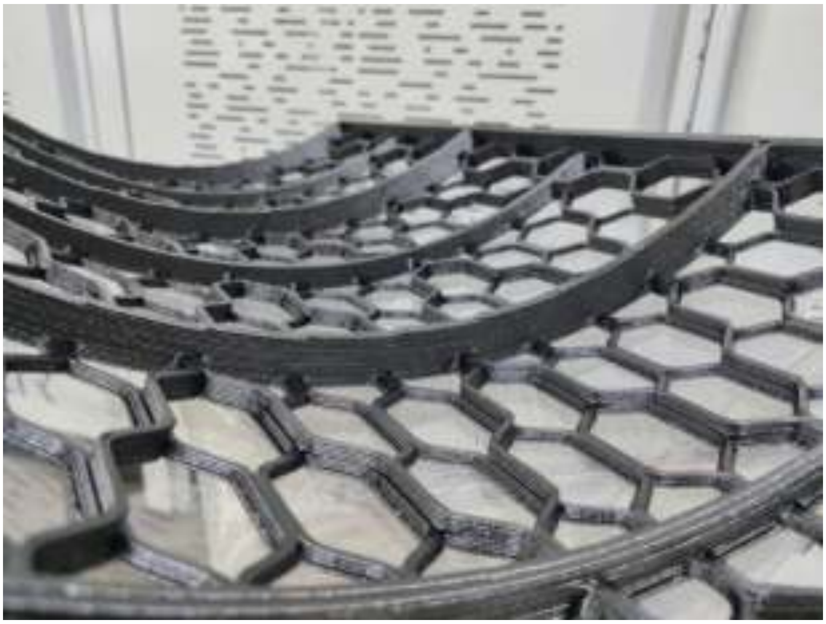
POST CURE

Highlighting the behind-the-scenes of composites manufacturing

Tool-less direct extrusion enables efficient, complex composite structure development

Through more than 100 years of engineering experience and collective knowledge sharing with partners like aibuild and Reichenbacher Hamuel, Hans Weber Maschinenfabrik GmbH (Kronach, Germany) seeks to enhance the adoption of large-format additive manufacturing (LFAM) for key applications.

One project involved the printing of a custom curved print bed, which was then used to print a complete 4-millimeter-wide and 1.5-millimeter-tall Savonius wind turbine blade — a vertical-axis wind turbine that converts the force of the wind into torque via a rotating shaft. The blade was achieved in under two hours (118 minutes) using Airtech Advanced Materials Group's (Huntington, Calif., U.S.) Dahltram C-250CF resin with chopped carbon fiber.



Source | Hans Weber Maschinenfabrik GmbH

The final part weighed only 2.1 kilograms. The use of AiSync — AI-powered 3D print software that reportedly makes customer tool paths 86% quicker and 90% more efficient, with 65% less failed builds and parts that are three times stronger than with conventional software — provided precise control of the Weber extruder. Aibuild's in-house material testing also automatically set key printing parameters based on the material properties and behaviors. CW

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The *CompositesWorld* team wants to feature your composite part, manufacturing process or facility in next month's issue.

Send an image and caption to *CW* senior managing editor Grace Nehls at gnehls@gardnerweb.com, or connect with us on social media.

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