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CW CompositesWorld

Gen 2 Honda *Ridgeline:* HYBRID REMAKE SCORES NEW HIGHS

NOVEMBER 2017

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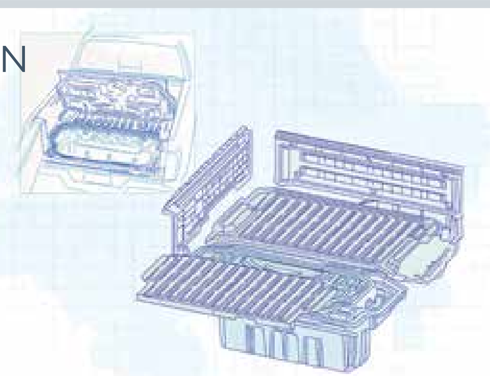
The updated Honda *Ridgeline* combines a weatherable SMC formulation, molded-in-color (MIC) pigmentation and special texturing that eliminates the need for paint in the Gen 2 pickup box, without sacrificing the mechanical and chemical performance of the Gen 1 model. Furthermore, it keeps the bed looking great longer, particularly for users who haul heavy loads and/or abrasive materials. Find out more on p. 44.

Source / Honda North America Inc.

FOCUS ON DESIGN



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When Hurricane *Irma* blew through Florida on Sept. 11, uncertainty about the path of the storm effectively shut down the entire state, forcing millions of people to flee, relocate and otherwise seek shelter from the storm. All normal activity was put on hold for several days before and after the storm blew through.

> Leading the change vs. following those who lead the change.

One of the casualties of the storm was CAMX 2017, scheduled for Sept. 11-14 in Orlando. Fortunately, CAMX was rescheduled, and will now take place Dec. 12-14, at the same venue, the Orange County Convention Center in Orlando. Which is good, because a cancelled CAMX this year could have been a tough blow to the composites industry.

CAMX has become critically important for several reasons. First, North America is the world's largest market for composite parts and structures. There is a level of composites manufacturing activity here that cannot be matched anywhere else in the world.

Second, CAMX is North America's largest composites conference and exhibition. As such, it represents the single best venue on this continent in which ideas, products and technologies for the design, tooling and fabrication of composites can be shared on a mass scale. This is not to say that CAMX is the world's largest composites exhibition — that title, of course, belongs to JEC World, held in Paris every spring. But if you don't live in Europe, getting to JEC each year is not always feasible. In fact, the number of North Americans that attend JEC's annual Paris event tends to be relatively small.

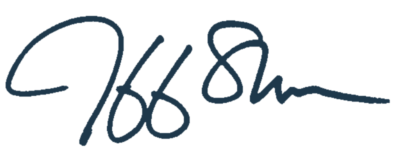
Third — and perhaps most importantly — the dynamic, fast-changing nature of composite materials and manufacturing elevates the importance of annual tradeshows as a way for all of us to catch up on the latest in materials, software, processes and services.

This dynamism is not trivial. The sheer number of resins, fibers and manufacturing processes used in composites fabrication guarantees nearly constant innovation and evolution. If you throw on top of that the current drive away from manual and touch labor and toward automation (Industry 4.0, anyone?), coupled with increasing design simulation capability, it's easy to see that change is inevitable.

My personal view is that each of us — as individuals, in groups, and as employees of companies — has a choice when it comes to dealing with change: We either anticipate, embrace and lead the change, or we wait for and follow while others lead the change. The former offers you the greatest agency and control, with the chance to act proactively in a timely and efficient manner. With the latter, you are reacting, constantly trying to catch up, recover and adjust.

Which takes us back to CAMX 2017. In the highly dynamic, change-chronic environment that is the composites industry, it is vitally important that we take advantage of every opportunity we have to see how the software, materials and processes we use are evolving. An event like CAMX offers a chance for us to meet the people and see the products we might work with to lead and shape the change.

So, in the spirit of leading the change and shaping the future of the composites industry, I hope you will make it to CAMX 2017 in Orlando, and I look forward to seeing you there.



JEFF SLOAN — Editor-In-Chief

One with Mother Nature

» In late August, the remnants of hurricane *Harvey* deposited 48 inches/120 cm of rain in 96 hours on the house in Houston, TX, US, where I grew up, and where my parents still live. Two weeks later, hurricane *Irma* lashed the Fort Myers, FL, US, home of my eldest son with greater than 100 mph/161 kph winds shortly after making landfall. Fortunately, while streets were flooded, rain did not make it into my parent's house and they were able to ride out the storm. My son evacuated Florida, but his house came through fine, although power was out for close to a week. As one can quickly deduce, I have been more than a casual observer of the weather this year.

Readers of *CompositesWorld* certainly know that *Irma* was responsible for the postponement of CAMX in September (now rescheduled for December), disrupting lots of careful planning and anticipated interactions in Orlando. It's been a wild year for weather in the US, from exceptionally high snowpack and spring rains, ending a six-year drought in the western US states, to the damage wrought by hurricanes *Harvey*, *Irma* and *Maria*. However, an exceptionally sizzling summer in the far west created a new drought and precipitated a record outbreak of destructive forest fires in late summer. In Indianapolis, IN, where I live, the first day of autumn recorded the highest temperature of 2017, exceeding anything seen in July and August. Clearly, we are in a new reality.

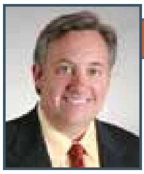
> I believe climate change is at least partly caused by the increase in CO_2 from the burning of fossil fuels.

That was on my mind in September, when I participated in the Partner Week event at the National Renewable Energy Lab (NREL) in Golden, CO, US. NREL, a core IACMI partner that heads up R&D in wind turbines, is celebrating its 40th anniversary this year. Founded initially as the Solar Energy Research Institute during the period of oil embargoes, NREL focuses on renewable sources of energy, including wind, hydro, photovoltaic solar and bio-mass, among others, and has extensive capabilities in measuring and forecasting energy demand. Like many of my fellow Partner Week participants, I'm in the camp that believes climate change is at least partly caused by human activity — in particular, the increase in CO_2 from the burning of fossil fuels. I also believe composites can play a role in helping to limit the further increase in greenhouse gases, via production of clean energy or reductions in energy usage.

In last month's column, I quoted from Carl Sagan's book, *Pale Blue Dot*, in which he notes that we must preserve the only home we have ever known, referring to Earth. David Houle, a noted futurist and author of the book, *This Spaceship Earth*, provided a compelling keynote address at the NREL conference, emphasizing that we must all see ourselves as crew, rather than merely passengers, if we are to sustain life on our planet. He believes sustainability is only meaningful if pursued on a planetary level. Houle forecasts that, when we look back 10 years from now, we will see the 2015-2017 period as "the beginning of the end of the fossil-fuel era" and that humanity must reach for 50%+ non-extractable energy by 2030. We no longer worry about running out of oil or natural gas — in fact, it is, today, both plentiful and cheap. We are, however, entering a period where renewable energy growth will accelerate, driven by rapidly declining costs and improved technology.

Composites already play a dominant role in the wind energy arena, and the energy used to produce the turbine is recovered in a couple weeks of turbine operation. The use of lightweight composites will extend the range of battery electric vehicles, and, perhaps just as significant, future battery-powered aircraft, both of which will expand sustainability. Increased use of bio-derived resins and reinforcements, more energy-efficient buildings enabled by composites, and the development of a viable recycling infrastructure for composites will help even more.

To do the above on a grand scale, however, will require an enormous investment in capital and people, be that for developing lower energy carbon fiber production capacity, molding machines, 3D printing capability and/or other technologies. Puon Penn, executive VP and head of technology capital for Wells Fargo, and a speaker at the NREL conference, believes we (worldwide) must make an additional investment equivalent to US$1 trillion annually toward sustainability over the next decade to have a chance to save ourselves from long-term climate effects. Notably, the money to finance this appears to be available. His biggest concern is that we have neither the infrastructure nor the talent to do it. "There are a lot of people 'interested' in sustainability," Penn says. "We need more people 'committed' to it." I think that is a challenge well suited for the composites industry and one we ought to — in fact, we must — take up as a united, worldwide community. CW



ABOUT THE AUTHOR

Dale Brosius is the chief commercialization officer for the Institute for Advanced Composites Manufacturing Innovation (IACMI, Knoxville, TN, US), a US Department of Energy (DoE)-sponsored public/private partnership targeting high-volume applications of composites in energy-related industries. He is also head of his own consulting company, and his career has included positions at US-based firms Dow Chemical Co. (Midland, MI), Fiberite (Tempe, AZ) and successor Cytec Industries Inc. (Woodland Park, NJ), and Bankstown Airport, NSW, Australia-based Quickstep Holdings. He also served as chair of the Society of Plastics Engineers' Composites and Thermoset Divisions. Brosius has a BS in chemical engineering from Texas A&M University and an MBA.

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Tackling the traceability of composite materials

» Have you ever looked outside an airplane window during in-flight turbulence and wondered how strong the wings really are and how much load they can take? Don't worry, they can take at least 10 times the worst turbulence you can imagine! We know that, because in the aerospace industry, what we call *traceability* of materials information plays a critical role in ensuring materials auditability and, thus, their eventual qualification for safe use.

Traceability, in short, is the ability to track the trail of data generated during product development, so that one can "follow the bread crumbs" to prove the performance of, and do quality assurance verifications for, manufactured products. The traceability trail, however, might be long and very detailed. For example, to qualify a composite material, one must ensure that it meets a variety of requirements, such as strength. Many tests must be performed. Test data must be captured and linked to information about the final material and product. This link, and access to the test information, is critical so that anyone, at any point, can prove what tests were done, and then inspect the test results.

You may be thinking that ensuring this level of traceability is only important for aerospace parts, but that isn't the case. Traceability is an increasingly important issue in the automotive industry, among energy producers and for materials suppliers as well. The ability to understand the context of your materials, and inspect those materials at any time, plays a pivotal role for auditability of design data and protection of intellectual property (IP).

Auditability becomes particularly important when multimillion-dollar decisions need to be made based on high confidence in the material properties, or when OEMs require the full proof and history that confirms that the materials meet specifications. Or when material properties are being used in simulations that ultimately will drive design decisions.

Regulatory risk. Another concern associated with traceability is the need to comply with regulations, such as the European Union's Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), and the US Environmental Protection Agency's (EPA) Toxic Substances Control Act (TSCA) Chemical Substance Inventory. Today, those who manufacture products that contain restricted substances, whether they are hazardous to humans, the environment or both, face potentially costly recalls, loss of consumer confidence, huge fines and even imprisonment. Traceability of materials and the substances they contain plays a crucial role in reducing that risk. It is possible to ensure that, during product development, a compliance report can be generated on both existing and new products to ensure they comply with all regulations.

Complex composites. Although, traceability is important and applicable to all materials, composite materials introduce a unique challenge to its application. They are far more complex than conventional materials, such as metals. Made up of multiple materials, reinforcements and matrices — each with its own behavior and properties — the composite system's final properties depend on the material combination's process history, the layup, fiber orientations and part geometry. All this complexity makes it more challenging to track data, ensure its traceability and understand the effect the various input parameters will have on the final composite's behavior.

Maintaining traceability. So how do you do it for complex composite materials? First, the necessary information must be acquired within the manufacturing organization and without, from its suppliers. Unfortunately, suppliers and even internal departments often do not supply all the necessary information and underlying raw data, either for reasons of intellectual property (IP) protection or because that information does not exist. It is critical, therefore, to demand minimum information gathering.

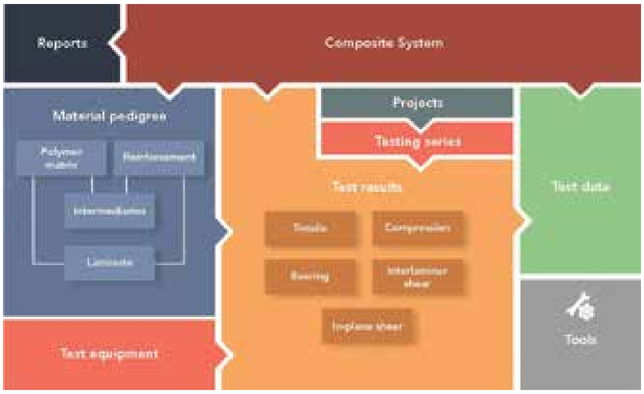


FIG. 1 A schematic of the composites data schema developed by Granta Design, in collaboration with the members of the MDMC. Source | Granta Design

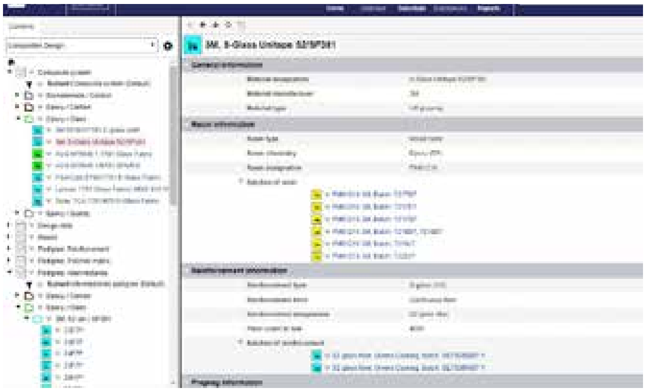


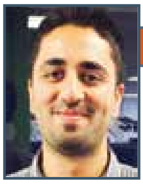
FIG. 2 Software tools import, analyze and manage the data to enable engineers to search, browse and apply it. For example, a material's full "history" is shown in this example datasheet. Source | Granta Design

Second, find a suitable database for information storage. Composites data are complex, with anisotropic material properties represented in multidimensional ways. For a single composite system, there might be volumes of data from multiple batches of resins and reinforcements, multiple laminates and multiple test coupons that represent different tests, such as tensile, compression and shear. Managing all of this in tools such as Excel or in nonspecialized databases would prove unsustainable, long-term, for obvious reasons.

Effective management. A sustainable way is to use dedicated materials data management software that can manage the complexity and the volume of composites materials information. The most important thing to get right is the database schema — the data structure that defines what data types can be stored, and their inter-relationships. A schematic of the composites data schema developed by Granta Design, in collaboration with the members of the Material Data Management Consortium (MDMC), is shown in Fig. 1 (p. 8). Software tools were developed to import, analyze and manage the data — and to enable engineers to search, browse and apply it. A sample datasheet is shown in Fig. 2 (p. 8).

A case in point. Airbus Helicopter (Marignane, France) implemented the GRANTA MI system noted above to support its strategy for rationalizing materials sources and to ensure all details of the composites materials were captured — from materials specs and testing to design information. Its requirements were to create a single source of company materials knowledge and to create a consistent and efficient workflow for test data management. As a result of this project, Airbus Helicopters ensured critical traceability of its materials and products, risk reduction and harmonization by providing that desired single source of both material *and* design allowable access for its entire enterprise.

Increasingly, organizations are realizing the importance of managing materials information, maintaining traceability and making sure valuable IP is secure and shared within the company. If we can ensure that all product material properties are complete and traceable, then reassuring both the anxious airplane passenger and the sleepless compliance director will be an easy job. CW



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Najib Baig is product manager – materials innovation at materials information technology company Granta Design (Cambridge, UK). Responsible for product management and strategic product direction, his specific responsibilities include management of Granta's additive manufacturing, simulation and composites products. In that capacity, he has worked with dozens of leading engineering organizations — in the aerospace, automotive and other industries — to meet challenges related to materials and process information management.

US composites industry: Another strong quarter

The Composites Fabricating Index registers 55.0 in September 2017.

» Registering 55.0 for September, the Gardner Business Index (GBI): Composites Fabricating added another strong monthly reading to an already impressive 2017 for the US composites industry. The reading raised the 2017 Index average through September to 54.6, and brought the third quarter to a close, which also registered 54.6. For the year-to-date and 12-month periods, the Index was up, as September closed out, approximately 11% and 8%, respectively. A Gardner Intelligence review of the underlying data for the month indicated that Production, Supplier Deliveries, Employment and New Orders lifted the overall Index higher while Backlogs and Exports pulled the Index lower. The only component that showed contraction (<50.0) for September was Exports.

Material Prices and Prices Received in the market continued to diverge through the third quarter of the year. The Material Prices subindex has moved higher than the subindex for Prices Received since the beginning of 2016, indicating that fabricators may not be passing some of their increasing costs onto their customers.

Find out more about the Composites Fabricating Index at **gardnerintelligence.com**. CW

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Michael Guckes is the chief economist for Gardner Intelligence, a division of Gardner Business Media (Cincinnati, OH US). He has performed economic analysis, modeling and forecasting work for nearly 20 years among a wide range of industries. Michael received his BA in political science and economics from Kenyon College and his MBA from The Ohio State University.
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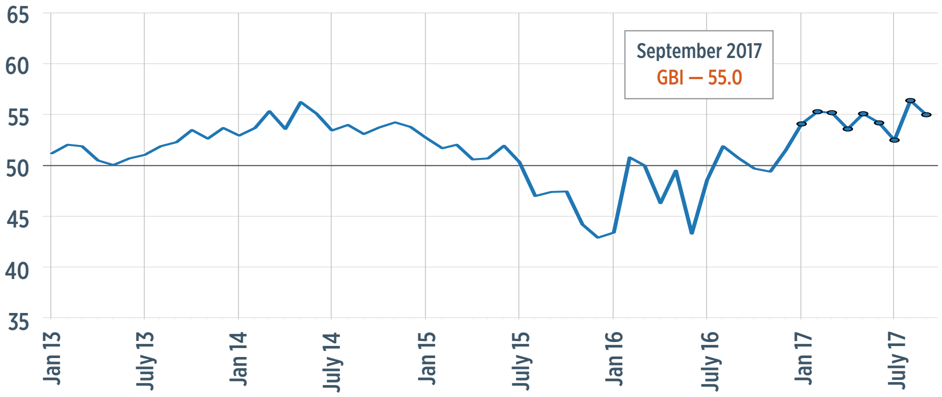
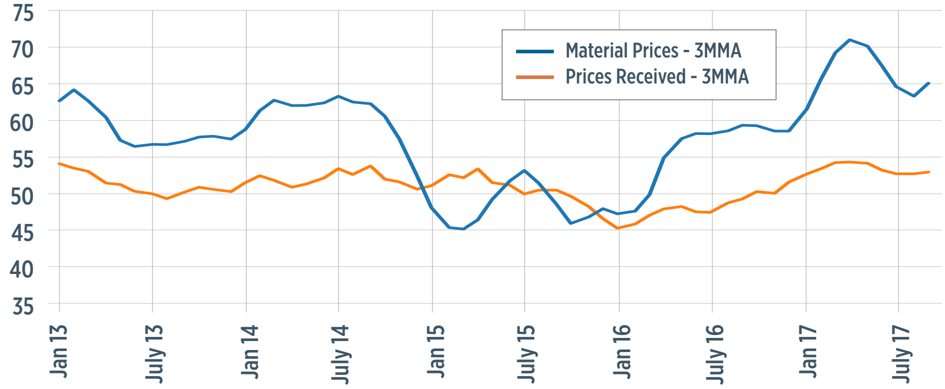
GBI: Composites Fabrication



Besting record highs set in 2014

The Composites Fabricating Index for the US composites industry is on track to register 2017 as the US composites industry's best year since before 2013 and is edging out the record set in 2014.

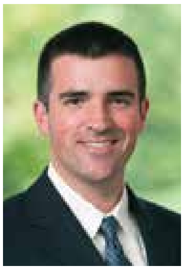
Prices Received and Material Prices (3-Month Moving Average)



Material Prices and Prices Received still divergent

Index readings for Material Prices and Prices Received first indicated a divergence in 2016. Since then the rate of growth in input costs have continued to outpace gains in Prices Received. This could indicate that fabricators are experiencing or are at risk of experiencing profit-margin compression.

An excerpt from the *CW* Talks interview with GE Aviation's Ryan Huth, plus highlights from the SPE Automotive Composites Conference & Exhibition and news about FRP architectural cladding in a new theme park.



Q&A: Ryan Huth, manager of ceramic-matrix composites, GE Aviation

Editor's note: CW Talks: The Composites Podcast, *features interviews with composites industry thinkers and doers. This Q&A is excerpted from* Episode 8 *of* CW Talks *in which Huth discusses GE Aviation's development of ceramic-matrix composites (CMCs) for the LEAP and other aircraft engines at its new Asheville, NC, US, facility. You can catch the full interview at* www.compositesworld.com/podcast, *or on iTunes or Google Play*.

***CW*: What is a ceramic-matrix composite?**

RH: A CMC is an engineered material system, and it's a silicon carbide fiber and a silicon carbide matrix. . . . Why would we choose CMC? There are three characteristics that differentiate it and help put it above the metal parts it will replace. One is that they are high-temperature-capable — actually around 500°F [260°C] more capable than the metal parts they replace. Second is that they are metal-like at about a third the density. What that means is that if you look at a stress/strain curve of a traditional monolithic ceramic, it's very brittle, whereas a CMC looks more like a metal in that it has an elastic region and an inelastic region. And the final piece is we can make complex shapes.

CW: What do the higher temperature capabilities achieve for a jet engine?

RH: Operational efficiency and thermal efficiency in the hot section of the engine is very important for achieving fuel burn requirements for our customers, and our customers are looking for a couple of things from us. One is a low cost of ownership, and the second is lower fuel burn. And so, running the high-pressure turbine in the hot section of the engine hotter allows us to gain thermal efficiency and deliver more fuel economy for our customers. As well as, since the CMC is more thermally capable than a metal part, it does not require as much cooling air.

***CW*: Talk about the growth of your facility. It is relatively new.**

RH: We have grown substantially year over year hundreds of percent. This year over last we'll grow four times in terms of volume output and the appropriate resources to deliver that type of volume increase. Next will be roughly the same. When you think about LEAP — so, the LEAP engine this year will deliver roughly 500 engines. Next year we'll deliver 1,100. And we also supply parts that go into the [GE]9X engine, so our growth rate follows the growth of new products from GE Aviation.

***CW*: What are some of the parts you will be making there?**

RH: We supply CMC shrouds for the LEAP application, so the LEAP 1A and 1C. The LEAP 1A powers the Airbus A320neo and the 1C powers the COMAC C919, as well the LEAP 1B shrouds, which powers the Boeing 737MAX . . .. And what we're moving into are more GE9X components. So, we're starting out with shrouds on 9X, which although similar are much different in size. The GE9X is far larger with the highest thrust of any jet engine in the world and therefore needs larger parts to accommodate that . . .. By the end of this year we are going to move into combustion liners as well as nozzles.

***CW*: How has big data been implemented in CMC parts production at GE?**

RH: When you think about a vertically integrated value stream, understanding how a process change at the fiber level — at the rawest raw material level — impacts the environmental barrier coating that we put on the part, or its response in melt infiltration, it's very important that we optimize the system, rather than sub-optimize a single piece of the process. . . . The other part of that is that as the parts go into service, we are able to get tremendous amounts of information about how the engine is operating, how the engine is performing, how the parts are performing in the engine, so we can be more predictive about any sort of maintenance that is required for the engine itself.

AUTOMOTIVE

Highlights: SPE ACCE 2017

On display at ACCE: The rear wall of the Audi *R8 Spyder*, manufactured by BENTELER-SGL.

The Society of Plastics Engineers' Automotive Composites Conference and Exhibition (SPE ACCE), held Sept. 6-8 in Novi, MI, US, remains the composites industry's go-to event for the latest on technology and equipment for automotive composites design, tooling and fabrication.

Ford Motor Co. (Dearborn, MI, US) served up a series of presentations summarizing work it did to design, develop and integrate a B-pillar reinforcement for the Ford *Focus*. Nestled inside a steel pillar, it was manufactured with a prepreg that combines DowAksa (Marietta GA, US) carbon fiber with Dow Automotive (Auburn Hills, MI, US) VORAFUSE P6399 epoxy. Ford developed an automated ply cutting and nesting process for building the laminate, using ultrasonic welding of the epoxy to "stitch" plies together prior to preforming and compression molding steps. The company is still evaluating part performance and options for integrating the part into its vehicle assembly process.

Sheet molding compound (SMC), definitely back in vogue (see endnote), was the focus of several presentations. Jeff Klipstein, closed mold technical service specialist at AOC LLC (Collierville, TN, US), discussed surface and performance properties of low-density SMCs (1.0-2.0 SG) and where they are and might be applied in automotive parts. Thomas Skelskey, group leader R&D specialties – transportation at Ashland (Columbus, OH, US) summarized work he's done on low-VOC, low-odor, low-styrene SMCs. He noted that low-styrene SMC is still relatively expensive, but becoming less so. In addition, he shed light on the obscure and difficult-to-characterize world of odor measurement.

Dave Erb, senior R&D program manager at the University of Maine's Advanced Structures & Composites Center (Orono, ME, US), described work *(continued on p. 14)*

(continued from page 13)

he did to reverse engineer a metallic differential cover for a 1998 GMC truck (General Motors, Detroit, MI, US), using thermoplastic resins combined with carbon and glass fiber molded via thermoforming.

Of interest in the project was a new material developed at the South Dakota School of Mines & Technology (Rapid City, SD, US), comprising recycled, chopped carbon fiber used to create quasi-oriented tapes and fabrics. David Salem, a professor at the school and director of the composites lab there, says the material offers designers a level of fiber orientation confidence not normally seen in chopped fiber products. Commercialization of the material is underway, and Salem is seeking pull from industry to help guide further development.

A keynote at ACCE was provided by Ford Motor Co. composites expert Patrick Blanchard. A summary of his presentation is presented in the *CW* October 2017 issue. The article also can be viewed online | short.compositesworld.com/PB-hurdle. He is also a guest interviewee of *CW Talks: The Composites Podcast* | short.compositesworld.com/CWTalks-PB

Read *CW's* recent coverage of the SMC resurgence in the following:
"SMC: Old dog, New tricks" | short.compositesworld.com/OldDog
"SMC: Old dog, More tricks" | short.compositesworld.com/OldDog2

BIZ BRIEF

Solvay (Brussels, Belgium) reported on Sept. 12 that it will begin producing polyetherketoneketone (PEKK) polymers (tradenamed NovaSpire) in the US in early 2018 at the company's Augusta, GA, US, location, to meet growing aerospace demand. PEKK is used in thermoplastic composites reinforced with carbon fibers and in additive manufacturing, also known as 3D printing, in a range of industrial applications.

Roger Kearns, a member of Solvay's Executive Committee, says, "This new capacity will address fast-growing demand for thermoplastic composites and 3D printing components in aerospace and in other markets."

In other news, Solvay reported on Sept. 19 that it has entered into a binding agreement with German chemical company **BASF SE** (Ludwigshafen, Germany) for the sale of its polyamides business.

"Solvay's planned divestment of Polyamides marks a tipping point in the profound transformation journey we began four years ago. Successful completion of this transaction will further reinforce Solvay as a multi-specialty chemical group, delivering superior growth and sustainable value," says Jean-Pierre Clamadieu, CEO of Solvay.

The transaction covers Solvay's upstream and downstream polyamides business in Europe, North America and Asia, as well as the downstream engineering plastics business in Latin America. Solvay will retain its upstream intermediates and downstream textile polyamide business in Latin America.

Solvay and BASF aim to close the deal in third quarter 2018, after customary regulatory approvals and the formal consent of a joint venture partner.

Roctool Inc. (Le Bourget du Lac, France) has created a new team of designers to meet the increasing demands from brand and equipment manufacturers for the development of plastic, composite and metal. The team, located in Paris, France; San Jose, CA, US; and Chicago, IL, US, will be responsible for understanding the current challenges faced by leading brands, assist them with the innovation needed for new consumer products, such as automotive applications or electronic consumer goods.

CW MONTH IN REVIEW

Notes about newsworthy events recently covered on the *CW* Web site. For more information about an item, key its link into your browser. Up-to-the-minute news | www.compositesworld.com/news/list

Gurit to produce carbon composite exterior body panels
The Wattwil, Switzerland-based supplier announced Oct. 16 a US$8.72 million contract to produce CFRP car body panels for an Italian premium automotive OEM.
10/16/17 | short.compositesworld.com/GuritABP

First 787-10 *Dreamliner* rolls out
Singapore Airlines is the launch customer of the Boeing 787-10 commercial airliner, which is 18 ft/5.5m longer than the Boeing 787-9.
10/09/17 | short.compositesworld.com/1st787-10

Composite liner for subsea oil and gas nears readiness
PETRONAS gives composite liner for subsea oil and gas lines a TRL of 7, paving the way for expanded use of the *in-situ* technology.
10/09/17 | short.compositesworld.com/PetronasCL

Boeing to acquire Aurora Flight Sciences
The specialist in unmanned aerial vehicles and electric aircraft propulsion will retain an independent operating model within the Boeing company structure.
10/09/17 | short.compositesworld.com/BoeingAFS

Sierra Nevada, German Aerospace Center sign MOU
The MOU provides a framework for cooperation in space-related technologies and transportation, utilizing the *Dream Chaser* spacecraft and space habitats.
10/09/17 | short.compositesworld.com/SN-GAC-MOU

IACMI officially opens new innovation facility in Detroit
Two years in the works, the IACMI Vehicles Scale-Up Facility offers the automotive industry a composite materials and manufacturing development innovation center.
10/09/17 | short.compositesworld.com/IACMI-Det

Teijin completes new aramid production line in Japan
TEIJIN ARAMID BV's (Arnhem, Netherlands) Aramid Business announced on October 3 the completion of the new line located in Matsuyama, Japan.
10/09/17 | short.compositesworld.com/TeijinLine

***Bloodhound* speed record car begins tests**
Bloodhound SSC Team (Didcot, Oxfordshire, UK) concluded first week of dynamic testing of EJ200 jet engine-powered car Oct. 6 at Cornwall Airport Newquay, UK.
10/09/17 | short.compositesworld.com/HoundTest

Spirit AeroSystems finalizes Boeing supply agreement
The agreement secures a contract that extends Spirit's supply of 737 MAX and 787 parts and structures through 2022.
10/02/17 | short.compositesworld.com/SA-Boeing

Hexcel completes Structil acquisition
Structil's product lines include prepregs, structural adhesives and pultruded profiles used in engine nacelles, aerospace interiors, military jets and more.
10/02/17 | short.compositesworld.com/HexStrucAc

BIZ BRIEF

Owens Corning (Toledo, OH, US) reported on Sept. 29 that it plans to invest US$50 million to rebuild a glass melter and expand production capacity by approximately 25% at its Chambéry, France, composites manufacturing facility. The investment will support the growing demand for glass fiber-reinforced thermoplastics in Europe. The melter is expected to be operational by mid-2018.

After the rebuild, all chopped strand products for the thermoplastics market coming out of the Chambéry facility will be based on the company's boron-free Advantex glass. Advantex fibers, contends Owens Corning, contributes to decreased emissions and reduces the environmental impact of manufacturing fiberglass, compared to standard E-glass. Advantex reportedly also provides superior performance in composites-facing corrosive environments when compared to E-glass.

"This investment will support our customers' growth in the thermoplastic chopped strand market by ensuring that we continue providing consistent, high-quality products," says Umberto Rigamonti, Owens Corning's VP and managing director of Glass Reinforcements Europe and Global Thermoplastic Products. "Our composites business benefits from a strong global footprint, R&D centers in five countries and assets available and committed to support the increasing adoption of composites. The strategic investment in Chambéry strengthens our value proposition to thermoplastic customers, supporting our respective growth agendas."

ARCHITECTURE

Use of composites in architectural cladding shows growth


Source | Scott Bader

Composite materials for building cladding have been shown to be lifecycle cost-effective, lightweight alternatives to steel, aluminum, fiber cement, terracotta and ceramic-based products, as *CW* has reported on numerous occasions (e.g., **short.compositesworld.com/ArchCladUp**). The use of composite cladding is growing, driven by consumer demand for new structures that meet 'green' building regulations and provide energy cost savings. Beyond the green benefits, however, more architects are seeing and embracing the design freedom composites offer in terms of new and unusual complex, curved shapes, says composite material supplier Scott Bader Co. Ltd. (Northamptonshire, UK, and Stow, OH, US). These cost, weight and design benefits will almost certainly expand composites use in building cladding and roofing applications in the coming years.

One recent example is the Ferrari Land theme park in Salou, Spain, officially opened to the public this year near Barcelona. This impressive 70,000m^2 themed attraction captures the spirit of Ferrari cars in both the design of park buildings and the activities on offer. Visitors can experience first-hand, on the park's rides and simulators, the adrenalin rush from the fast acceleration and high-speed performance of this iconic Italian brand's sports cars and Formula 1 racing cars.

Key landmarks are the spectacular Ferrari Experience building, with its classic "Ferrari red" exterior and engine hood-shaped entrance, and Red Force, Europe's tallest and fastest rollercoaster, at more than 112m in height. Capable of accelerating to 112 mph in five seconds, the ride is designed to approximate the 1.35 G-force and other conditions felt by a Formula 1 racing driver.

A combination of painted flat aluminum panels and approximately 1,500m^2 of more complex, curved FRP composite wall cladding and roofing sections cover the Ferrari Experience building's exterior and various sections of the Red Force rollercoaster structure, reports Scott Bader. The designs and specifications were developed by Permasteelisa España S.A.U. (Madrid, Spain), which also managed the building construction projects for the two attractions.

A total of 800 individual FRP parts were molded by architectural façades and parts fabrication specialist Look Composites (part of the Miraplas Group, Alicante, Spain). All the molded FRP parts, painted on site to ensure perfect color, had to meet the Euroclass B,s2,d0 fire specification stipulated for this construction project. Look Composites, with extensive experience with other prestigious exterior cladding projects in Spain involving fire-resistant curved composite panels, used a proven fire-resistant solution that employed alumina trihydrate (ATH)-filled Crestapol 1212 high-performance methacrylate-based resin from Scott Bader.

Look Composites needed eight months to complete part fabrication, which reportedly was very challenging due to size, design and dimensional accuracy requirements. Each part had either a double curvature design or was nonlinear, with curves and tight angles. All parts had molded-in fixing point flanges.

"Crestapol 1212 has proved to be the best laminate resin system for building cladding to meet the Euroclass B,s2,d0 fire specification," says Antonio Mira, CEO of Look Composites. He notes that the resin was suitable "for hand layup molding, even when very heavily ATH-filled." He adds that "with a little practice, you can easily laminate even complex-shaped, 3D parts."

Details about the resin's properties are available at **scottbader.com.**

Europe's 2017 glass-reinforced polymer market report

The AVK (Industrievereinigung Verstärkte Kunststoffe, or German Federation of Reinforced Plastics, Frankfurt, Germany), a member of the European Composites Industry Assn. (EuCIA, Brussels, Belgium) as well as Composites Germany (Berlin, Germany), has once again published its annual glass fiber composites market analysis. The report covers all glass-reinforced plastics (GRP, thermoset) as well as short- and long-fiber reinforced thermoplastics (LFT).

According to AVK, the composites industry in Europe is enjoying its fifth consecutive year of growth, and is expected to continue to grow at a rate of about 2%, to an estimated 1.12 million MT by year's end 2017 (see graph).

Trends differ from country to country, however. The largest markets for GRP continue to be transport/mobility and construction sectors, which each represent one-third of total production. The report says that although these applications are important, Europe lags behind the global growth trend in composites, so its share of global production continues to fall, despite a positive growth trend in absolute terms.

Sheet molding compound (SMC) and bulk molding compound (BMC) account for approximately 25% of total European composites production and are the largest market segment in the GRP industry; total 2017 production volume is estimated to reach 280,000 MT (two-thirds of which will be SMC). These will be followed by open mold processes, resin transfer molding (RTM, growing at 3.5%), continuous processing (including pultrusion), and pipes and tanks.

Thermoplastics, glass mat thermoplastics (GMT) and LFT continue to show above-average growth of 3.6%, but slightly lower than that recorded in 2016. The report points out that the market share of GMT/LFT products in relation to the total GRP market has risen from 5% in 2000 to 13% today, mainly in the automotive sector.

The report also points out that many decisionmakers are still unfamiliar with composites, which presents a significant challenge to the composites industry as a whole.

Read the entire report on the AVK Web site | www.avk-tv.de/news.php?id=341.

CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO

Irma aftermath: CAMX 2017 rescheduled for Dec. 12-14

CAMX 2017, North America's largest composites trade show and conference, originally scheduled for mid-September in Orlando, FL, US, has been rescheduled for Dec. 12-14. The location of CAMX 2017, the Orange County Convention Center in Orlando, remains unchanged.

Hurricane *Irma*, which blew through and shut down most of Florida, Sept. 11-12, forced the postponement. CAMX 2017 organizers reported at *CW* presstime that they were already well on the way in the process of reconfirming exhibitors and conference speakers and reorganizing other exhibition events to accommodate the new dates.

CAMX attendees and exhibitors are encouraged to keep an eye out for e-mail and other communications from show organizers for updates. The CAMX Web site (www.thecamx.org) also will include updates and news about the event.

BIZ BRIEF

Plataine (Waltham, MA, US), a provider of industrial Internet of Things (IIoT) manufacturing optimization software, announced on Sept. 19 that it has been granted US Patent #9740896, titled, "A Method and System for Managing an Efficient Production Floor via The Internet of Things."

The patent covers a set of IIoT- and artificial intelligence (AI)-based algorithms to drive context-aware alerts and recommendations to production floor management and staff, thus increasing production efficiency while ensuring product quality and audit-readiness.

"We're excited to receive recognition of our innovation and will continue to pursue our goal to create the most advanced Industrial IoT software available, as well as to protect its value with registered patents," says Avner Ben-Bassat, president/CEO of Plataine. Plataine's optimization solutions provide material and asset traceability, creating a traceable "digital thread" that links all test data and other acquired information pertaining to a developing manufacturing project, from raw material to end product.

"Manufacturing firms from all sectors have already realized the immense opportunities that AI and IIoT have to offer for production efficiency and improved on-time, on-quality delivery, says Ben-Bassat. "Plataine is proud to be at the cutting-edge of the process that turns production facilities into smart digital factories."

AEROSPACE

Composites add versatility to *Black Hawk's* capability


Source | Unitech Composites

Unitech Composites (Hayden, ID, US) has delivered the first production shipset of its Multi-Station Lightweight Armament Support Structure (MLASS) wings for use on the US Army's MH-60M *Black Hawk* helicopter. This is the first of nine shipsets that will be delivered to the US Army Special Operations Forces Support Activity (SOFSA). The US Special Operations Forces (SOF) already deploy

Unitech's Lightweight Armament Support Structure (LASS), a single-station weapons pylon for the MH-60.

MLASS is a lightweight, corrosion-resistant direct replacement for the External Stores Support System (ESSS). MLASS and LASS weapons stores interface with standard military bomb ejector racks and support a variety of weapons configurations, including the M230 30-mm cannon, the M261 rocket launcher and the M299 missile launcher.

A fully configured set of MLASS wings is 270 lb/123 kg lighter, have better center-of-gravity and drag characteristics and are quicker and easier to install than a set of standard metallic ESSS wings. Dan Kinney, military programs business development manager for Unitech Composites, says MLASS is a step up from its LASS predecessor, offering two weapons stations on each pylon, compared to one on each LASS.

More importantly, Kinney notes, the weight savings provided by MLASS increase the *Black Hawk's* versatility. He says the gross take-off weight of the current generation of *Black Hawks* used by the US Army is 22,000 lb/9,980 kg, which is reportedly too easily and quickly reached. As a consequence, Kinney says, mission operators of the *Black Hawk* frequently must sacrifice fuel for weapons, or vice versa, to keep the gross weight under the regulation military mission weight limit. Each MLASS pylon weighs 148 lb/67 kg, for a shipset total weight of 296 lb/134 kg. With wiring and bomb release racks added, total shipset weight increases to 540 lb/245 kg, which is 270 lb/123 kg less than the ESSS shipset weight of 810 lb/367 kg. Trimming 270 lb/123 kg from the craft allows that much more fuel or ammunition aboard the aircraft during missions. The capacity of each weapons store on the MLASS pylon is 700 lb/318 kg.

Further, Kinney says, the *Black Hawk*, historically, has been a utility helicopter, designed to carry troops and supplies. The option of arming them, which better weight management provides, makes them appealing to countries and governments that need such flexibility and/or cannot afford to acquire more expensive attack helicopters.

FIG. 1 Set to send CubeSats to LEO

This compact *Electron* rocket, which features carbon fiber composite casings, is the work of New Zealand-based Rocket Lab, and has been designed with the small satellite industry in mind. It's US$5 million dedicated-launch price tag is calculated to make it an attractive alternative to the big players in the LEO launch market.

Source (all photos) | RocketLab

Rocket Lab all-composite *Electron* launch vehicle

New player scaling up two-stage rocket to relieve small-satellite launch backlog.

By **Donna Dawson** / Senior Writer Emeritus

» There is a growing backlog of grounded satellites waiting to fly into orbit and get to work. Most of them are small satellites (SmallSats) and very small CubeSats (see the Side Story titled, "How small is a SmallSat?" on p. 28). But in position in low Earth orbit (LEO), they will help provide sizeable services, such as affordable Internet, live Earth observation for activities that include environmental monitoring, natural disaster prediction, search-and-rescue services, and up-to-date maritime data.

The missing piece is transport into that LEO. Currently, SmallSats and CubeSats must wait for space-available piggyback slots on high-powered rockets operated by major commercial players, such as United Launch Alliance (ULA, Centennial, CO) and SpaceX (Hawthorne, CA, US) in the US, or on European and Japanese launch vehicles, among others (see Learn More, p. 29). Piggyback launches often deliver these satellites to the International Space Station (ISS, altitude 420 km) first, where they are subsequently deployed by services such as NanoRacks (Washington, DC, US) to their destined orbit (see Learn More).

"Companies are currently facing long waits, often years, to get their satellites on orbit," claims New Zealander Peter Beck, CEO of Rocket Lab — a private company founded by Beck in 2006, with administrative, design and manufacturing operations located in Auckland, NZ, and in Huntington Beach, CA, US.

One among several commercial companies that have taken aim at this market, Rocket Lab has committed to a faster solution.

Mission: CubeSats to LEO

Beck defines Rocket Lab's mission as one that will "remove the barriers to commercial space by providing frequent launch opportunities to low Earth orbit." The company will offer orbital launches on its own *Electron* rocket from its own launch site on New Zealand's Mahia Peninsula.

In October 2015, the National Aeronautics and Space Admin. (NASA, Washington, DC, US) awarded Rocket Lab a Venture Class Launch Services contract, valued at US$6.95 million, for demonstration CubeSat launches to LEO on an *Electron* rocket. Provided with additional funding from Lockheed Martin (Bethesda, MD, US) and other sources, Rocket Lab was recently valued at more than US$1 billion.

Notably, Rocket Lab advertises dedicated (single-customer) launches at ~US$5 million — compared to a reported US$62 million for SpaceX's *Falcon 9* — and promises either a dedicated delivery "when and where required" or a rideshare service. Although ULA's *Vulcan* new-generation launch vehicle is projected to lift up to 20 MT to LEO in payload fairings 5.4m diameter and up to 26.5 m length, the 17m high, 1.2m diameter *Electron* is designed to lift a nominal payload of 150 kg (maximum 225 kg) to a 500-km sun-synchronous LEO. (In a sun-synchronous orbit, the satellite passes over the same part of the Earth at roughly the same local time each day.) The difference in size, power requirements and payload capacity, and the relative simplicity of *Electron* — its launch components are not reusable, so it does not need the high sophistication required of a system that must return to earth, refuel, and relaunch multiple times — make it an appealing bargain for small satellite launches.

Rocket Lab's *Electron* could help relieve the backlog of grounded SmallSats awaiting entry into LEO.

Customers signed up to ride *Electron* so far include NASA, Planet Labs (Planet, San Francisco, CA, US); Spire (San Francisco, CA, US); and Moon Express (Cape Canaveral, FL, US), which has contracted for three launches of its *MX-1* spacecraft to the Moon, including its Google Lunar XPRIZE shot (see Learn More). Payloads can be integrated at the launch site, following standard practice, or customers can choose to pack their satellites into a Plug-in Payload module in their own facilities, and then send the packed module back to Rocket Lab for integration with the *Electron* vehicle.

Rapid, frequent deployment

Rocket Lab's mission focuses on rapid deployment of small payloads and plans to achieve its mission through several strategic actions: First, its private launch facilities are located in a remote, underpopulated area of New Zealand. This removes launch activity from sites in crowded, more densely populated locales (e.g., Houston and Florida), thus allowing more frequent launches. "The remote location of the site, particularly its low volume of air and marine traffic, is a key factor in enabling »

FIG. 2 *Electron's* first stage

Rocket Lab's composites team manager Ben Malcolm stands near the first stage of an *Electron* launch vehicle. Visible are its nine 3D-printed Rutherford engines.

FIG. 3 Assembly in Auckland

Workers at the Rocket Lab plant in Auckland, New Zealand, assemble an *Electron* launch system.

FIG. 4 *Electron's* first flight

Rocket Lab's prototype launch, appropriately named *It's a Test*, passed muster on all points but one, entry into LEO. Its failure to place payload into orbit, however, was determined to be a ground control fault. At *CW* presstime, Rocket Lab announced a second test was on the docket for mid-October, with two commercial SmallSats aboard.

FIG. 5 Hospitable for launch

Rocket Lab has paired its launch system with a suitably remote launch site, on the Mahia Peninsula, NZ, to permit frequent launches with minimal chance of conflict with local air or marine traffic or surrounding population.

SIDE STORY

How small is a SmallSat?

According to common aerospace industry usage, the following terms and definitions apply, when describing the class of low Earth orbit satellites classed as "small."

A small satellite, or SmallSat, has a mass of less then 500 kg. Within that range, subclasses are denoted as follows:

- Mini-satellites weigh between 120 kg and 500 kg.
- Micro-satellites, 10 kg to 120 kg.
- Nano-satellites, have a mass below 10 kg.
- CubeSats is the special moniker for those satellites with a mass of 1 kg or less.

(Source | *Financial Times*, July 10, 2016, "Nano-satellites dominate space and spread spies in the skies")

unprecedented access to space, which is part of Rocket Lab's mission," Beck says.

Further, its *Electron* rocket and Rutherford engines are designed for rapid scale-up of production, including vertical integration of advanced composite materials and advanced manufacturing processes. "Rocket Lab has designed *Electron* to provide launches at exceptional frequency," Beck explains. "This, in our view, is what will change how we use and understand space. At full production, we expect to launch more than 50 times a year, and we're regulated to launch up to 120 times a year. In comparison," he notes, from all sources, "there were 22 launches last year from the United States, and 82 internationally." Production in Huntington Beach and Auckland is followed by assembly in Auckland and launches, primarily, in New Zealand.

Although Rocket Lab was unwilling to identify proprietary materials and manufacturing processes, *CW* learned that carbon fiber composites were selected for all of *Electron*'s primary structures, including the payload fairing. "We worked to ensure commonality between the structures in both stages of the rocket to allow rapid production at scale," says composites team manager Ben Malcolm.

A key to its rapid scale-up strategy was the use of additive manufacturing for the Rutherford rocket engines. Nine are used for the first stage of *Electron*, and one for its second stage. "The rocket engines are printed using titanium and super alloys. We use groundbreaking 3D printing techniques to rapidly print rocket engines, and are able to produce a rocket engine in a matter of days," Beck says. "3D printing also enabled us to rapidly iterate during our research and development phase and create an engine that would have been impossible to produce using traditional manufacturing techniques."

Although no composite parts are 3D-printed, the Rutherford engines are powered by oxygen/kerosene fuel, and Rocket Lab revealed that it has developed carbon fiber composite tanks that are compatible with the liquid oxygen component.

LEARN MORE

Read this article online | short.compositesworld.com/Electron

Read more online about transport into low Earth orbit in "The emerging commercial space industry" | short.compositesworld.com/CommSpace

Read more about small satellite release from the ISS in "The emerging commercial space industry: Habitats and CubeSats" | short.compositesworld.com/CommSP-HC

Read more about the Moon Express attempt to win the Google XPRIZE in "Google Shoots the Moon" | short.compositesworld.com/GLXP2

Rocket Lab is looking for experienced carbon composite technicians as it continues to rapidly scale its team. Interested parties should view the firm's employment Web page | rocketlabusa.com/careers/positions/

Near perfect first launch

The first *Electron* test launch, appropriately named *It's a Test,* lifted off May 25, 2017, from the Mahia Peninsula launch site. Although *Electron* reached space, it was unable to fulfill its goal of entering orbit. Beck nevertheless considers it a "hugely successful first test launch [with a] great first stage burn, stage separation, second stage ignition and fairing separation — all of the key, and generally most challenging, events. "We're committed to making space accessible and the test was a phenomenal milestone in that journey." That was confirmed in August when Rocket Lab completed an internal review that "found the launch had to be terminated due to an independent contractor's ground equipment issue, rather than an issue with the rocket. Rocket Lab's investigative board has identified the root causes and corrective actions." At *CW* presstime, another launch vehicle was expected to be ready for launch in mid-October, and after that, Rocket Lab would launch when ready. CW

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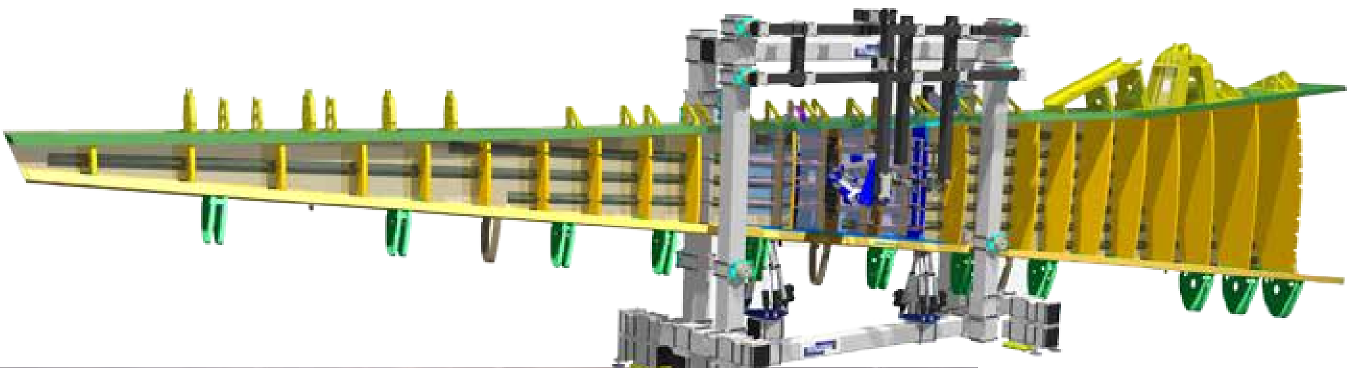
Reconfigurable tooling: Revolutionizing composites manufacturing



Shape *in*dependence

Producing the mold tools (e.g., lower left) and the fixtures (e.g., upper right) for assembly and machining of demolded parts is an expensive proposition. To reduce cost, toolmakers are devising ways to make tools and fixtures less shape-dependent.

Source | Curve Works/ADAPA

Source | Prodtex

Shape-changing molds eliminate tooling for large 3D panels while automated assembly fixtures go modular, using metrology to reduce cost and shimming.

By Ginger Gardiner / Senior Editor

» Although composites offer many benefits, the historically high costs and long cycle times required for manufacturing components from complex, fiber-reinforced materials have been and remain a challenge. Application of automation and digital technology to fabrication processes have yielded some spectacular cost-cutting success stories. Among them are automated fiber and tape placement, high-pressure resin transfer molding (HP-RTM) and, most recently, fast robotic processing of preforms. The latter has promised to eliminate a longstanding bottleneck in the production of complex 3D parts (see Learn More, p. 37).

Production of the mold tooling as well as the jigs and fixtures required for machining and assembling large composite structures, however, remain expensive and time-consuming production steps. In new commercial aircraft programs, for example, estimates are that these account for *one-third* of total nonrecurring costs.

Toolmaking's outsized and continuing contribution to part cost, in terms of time (notably, *lead* time) and money, can be traced largely to the fact that tools, historically, have been *shape dependent.* That is, a mold or a part fixture has had to precisely mirror — with carefully calculated allowances for shrinkage and differences in material coefficients of thermal expansion — the desired dimensions and geometry of the finished part. If a single dimension, or the radius of a curve, for example, in a part's design were to change, then in many cases an entirely new tool or fixture might have to be constructed.

One of the current toolmaking trends is a move *away* from shape-dependence in tooling and fixture design toward designs that are modular, reconfigurable and, therefore, adaptable to changes in a part's design, and also flexible enough to use in forming multiple parts of different, but similar design.

Molding a new paradigm

In one sense, reconfigurable mold tools have always been with us. Those who mold flat panels, both solid and sandwich-style configurations, learned early on that flat tables fitted with repositionable x and y borders made relatively inexpensive adjustable, reusable tooling systems. But for parts with dimensional and geometric complexity, not to mention a potential order of magnitude greater expectation in terms of dimensional accuracy, things haven't been so simple. Nevertheless, adaptable tooling has taken form on two distinct application fronts.

One is molds for preheating, consolidation and/or cure that can be reshaped and reused. This type is especially of interest for low-volume/one-off production of curved structures (e.g., yacht hulls, architectural facades).

The second front of the reconfigurable/adaptable push continues a long tradition: Reconfigurable/flexible assembly tooling has been researched for composite aerostructures production since the late 1980s. The large, permanent steel frames used to manufacture complex composite aircraft structures today are being transformed into automated fixtures made from reusable and reconfigurable modules. These recent technology advances have been driven by the commercial aircraft industry's need to meet high production rates (e.g., 50-60 aircraft/month).

Reshapable, reuseable molds

The hot topic on the reshapable/reusable mold tool front is multipoint forming (MPF). MPF has been used to shape sheet metal for decades. Featuring reconfigurable dies comprising numerous pins, MPF realizes the desired tooling surface geometry by adjusting individual pin height. This technology is now used by BMW AG (Munich, Germany) to shape preheated carbon fiber/epoxy prepreg patches before they are simultaneously bonded and cured onto steel B-pillars in its Carbon Core hybrid composite/metal body-in-white for its *7 Series* cars (see Learn More). Although a variety of companies and research organizations have pursued adaptation of MPF to composites, MPF recently has been commercialized by ADAPA (Aalborg, Denmark) and is now used by Curve Works (Zoetermeer, The Netherlands) to eliminate recurring tooling costs and, as a result, make production of one-off, 3D curved panels affordable.

FIG. 1 Fast forming of foam and composites

Curve Works uses a 3.6m by 1.56m ADAPA adaptive mold to form thermoplastics, composites and foam core, the latter shown here preheated at 150°C and molded into a doubly curved shape, which decreases resin uptake vs. scored foam to produce lighter composite panels. Source | Curve Works/ADAPA

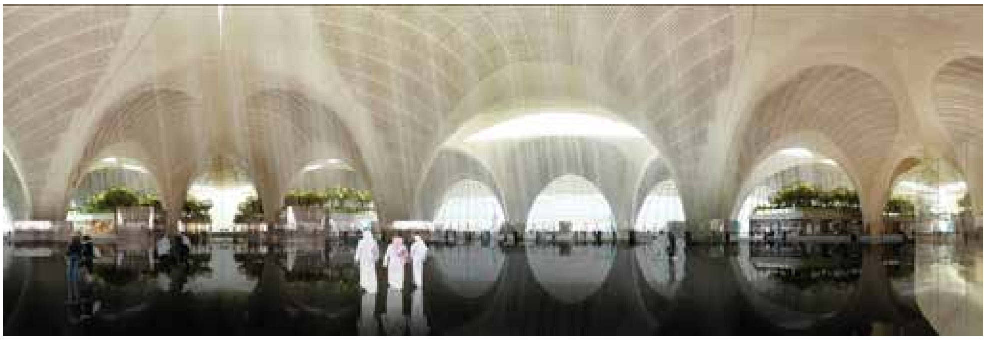
Retrospectively, Surface Generation (Lyndon, UK) applied MPF to composites moldmaking in 2005 via its Subtractive Pin Tooling (SPT) technology (see Learn More). Instead of milling a tool from solid metal billets, SPT delivered precision molds, and did so in days rather than months. Delft University of Technology (TU Delft, Delft, The Netherlands) and the University of Birmingham (Birmingham, UK) also pursed MPF for composites, the latter via the 2014-2017 Automated Manufacturing Process Integrated with Intelligent Tooling Systems (AUTOMAN) project.

The goal of AUTOMAN, however, was not to deliver molds but, instead, to build large 3D panels from metals and composites for use in trains, ships, aircraft and buildings. AUTOMAN aimed to develop the world's first fully reconfigurable pin-based tooling system with in-process sensing and computer control. Projected benefits were a 50-100% increase in panel manufacturing efficiency, cost savings of 80%, and 30-50% material and energy savings over the product lifecycle.

By project end, AUTOMAN did build and demonstrate a multi-pin tool as well as a numerical model for simulating forming of sheet metal, including predictions of forming limits and springbacks. However, additional development is needed, including further software and sensing integration, transfer to industry-specific applications and scale-up to large panels.

Years before AUTOMAN, architect and civil engineer Christian Raun Jepsen founded ADAPA Adaptive Moulds in Denmark to develop dynamic mold technologies and manufacturing of freeform architecture. Although its business has been built mostly in architectural and concrete applications, the company has spent the past two years learning about composites and thermoplastics. Curve Works is ADAPA's first customer in the composites industry.

The idea for Curve Works came while director François Geuskens worked at TU Delft: A shipyard wanted to build boats from composite panels. "This is standard with »



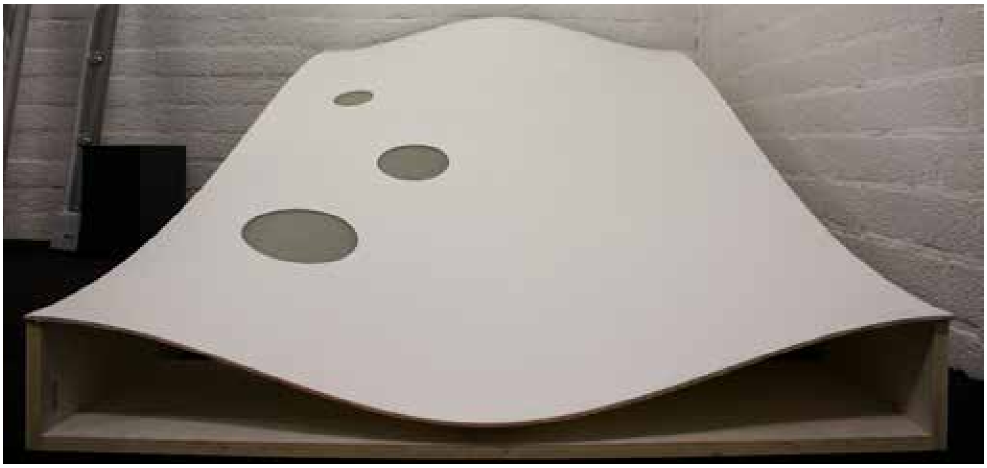


FIG. 2 One adaptive mold, myriad curved panels

ADAPA's adaptive molds are used to produce fiber-reinforced concrete panels, such as the 80 molds used to construct 40,000 unique curved panels that comprise Kuwait International Airport's new international terminal (top). Curve Works has used an ADAPA mold to produce curved composite panels using wet layup, prepreg and resin infusion for applications including architectural façades, boats and airship gondolas.

Source | Foster + Partners

Source | Curve Works

aluminum and steel," says Geuskens, "but with composites, you instead must build a plug, make the mold and then laminate the whole hull and deck, so there is a long lead time." And a large capital investment. After designing and developing composite structures for Airbus Defense & Space (Toulouse, France), Geuskens founded Curve Works in 2016.

"Multipoint forming is very old technology, with patents from 100 years ago," Geuskens points out, but notes, "What makes ADAPA unique is they have integrated pin beds with very nice 3D software." The Curve Works mold has 528 pins (Fig. 1, p. 31).

"So it must be automated digitally," Geuskens explains, "and the pins need to smoothly transform from one shape to another. ADAPA did an excellent job in the electromechanical design of these molds."

There is also an interpolation layer, which makes it possible to pull vacuum and have a smooth surface for molding composites. "This top layer must support the material, but also be flexible and stretch to form 3D shapes," says Jepsen. The typical silicone forming layer enables temperatures up to 200°C.

Jepsen points out that the technology developed by North Sails (Milford, CT, US) for its 3D molded sails is generally the same concept, "just a larger scale vs. our machines." Companies see the utility of this technology, he explains, "but don't have the ability to develop and apply it like North Sails. So this is our niche — we customize our adaptive molds to fit our customers' specific applications, including thermoforming glass, plastic, concrete and composites."

Adaptive molds, affordable products

Curve Works uses an infrared heater mounted above its mold to thermoform materials onto the curved mold surface, but has also built a 30-kW convection oven around the mold and can use stretchable heating blankets capable of 200°C. It also has used ultraviolet light for special fast-cure resins. "For thermoforming plastic, we place a panel on the mold, hold it with vacuum and then preheat," says Geuskens. With the push of a button, the mold starts to shape the plastic. "It reaches shape within 3 minutes," he adds, "so you are done very quickly."

"Cycle times can be quite low with our technology," agrees Jepsen. "If you have lower-cost, reusable tooling and low cycle times, you can have a competitive product."

Curve Works has made a composite architectural façade panel, using Parabeam 3D (Parabeam BV, Helmond, The Netherlands) textile hand-laminated with polyester resin. "With vacuum infusion, we use a different surface because silicone rubber doesn't do well with polyester and epoxy resins," Geuskens explains.

"We apply a foil/film release, shape the mold, lay fabrics, vacuum bag and then infuse. The same process can be used for prepreg. You can also put a rubber profile on the mold to produce a groove or slot, but this mold is best for smooth profiles and less-complex geometry."

"Our typical customer starts with a minimum radius of 400 mm," says Jepsen, "but we're doing a project now for forming down to 200-mm radius."

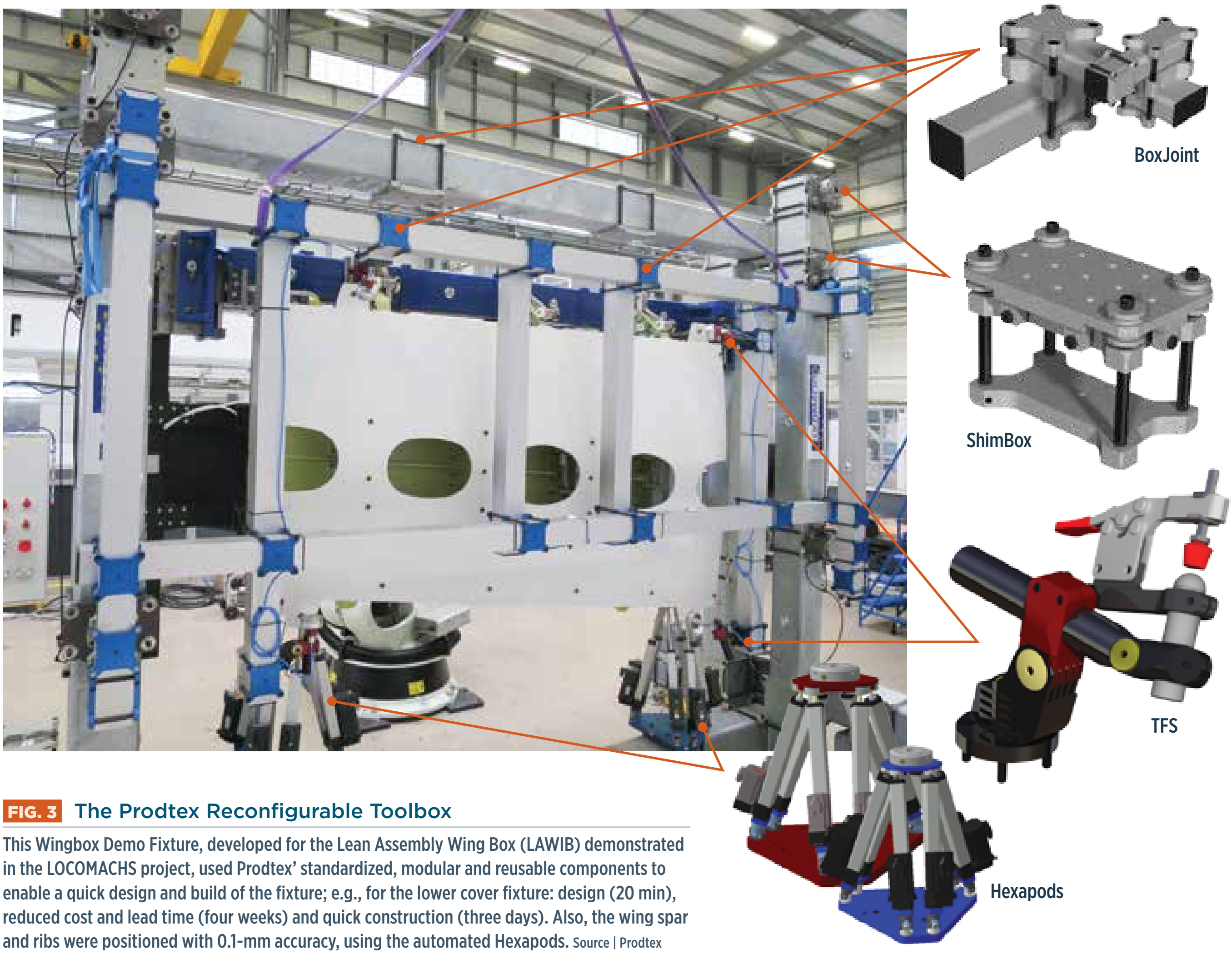


FIG. 3 The Prodtex Reconfigurable Toolbox

This Wingbox Demo Fixture, developed for the Lean Assembly Wing Box (LAWIB) demonstrated in the LOCOMACHS project, used Prodtex' standardized, modular and reusable components to enable a quick design and build of the fixture; e.g., for the lower cover fixture: design (20 min), reduced cost and lead time (four weeks) and quick construction (three days). Also, the wing spar and ribs were positioned with 0.1-mm accuracy, using the automated Hexapods. Source | Prodtex

ADAPA's machines range in size from 1-16m². The Curve Works' system, capable of parts up to 5m², falls within the 4-6m² required by most applications, says Jepsen. "A 2m-by-3m mold is a standard size in architecture for one panel, and you install multiple panels," he adds. Geuskens notes that nonrecurring costs are reduced if the adaptive mold is used to make multiple parts per day. ADAPA's molds cost between €100,000 and €250,000 (US$118,225 and US$295,995), which includes the electromechanical control system, software and 3D laser projector.

"Our molds are an open-loop system," Jepsen explains. "With the 3D laser projector, which is already used in aerospace composites and is ideal for our setup, we can scan the surface of the mold, evaluate vs. the part's digital design, and reposition. We have tolerances on the mold surface of ±1-2 mm, but," he claims, "we can actually go almost to zero."

"All we need to make a part is the CAD file," says Geuskens. "If it's a large structure, we divide that into panels using the adaptive mold software, then click on each panel to generate its output file, press the shape button and the mold transforms."

This ease of producing affordable, one-off shapes has been well-received in the architectural and construction industry for glass fiber-reinforced concrete façades. "We spray the mix of concrete and fibers onto the mold, similar to FRP [fiber-reinforced plastic] sprayup for boats," notes Jepsen. ADAPA recently signed an order to deliver 80 molds for construction of Kuwait International Airport's new international terminal (Fig. 2, p. 32). "It will use 40,000 unique concrete panels, all curved," says Jepsen. "Our technology offered the most cost-effective solution."

ADAPA molds are also used for glass-reinforced gypsum panels, like those used in the new Mumbai airport terminal. Lufthansa Technik has also shown interest in ADAPA's adaptive molds for aircraft repair applications. "They want to simplify their processes with respect to storing and retrieving molds," Jepsen relates. "DIAB also has interest in using our technology for cored panels. If you use pre-shaped foam instead of scored foam, the panels will decrease resin uptake, especially for 3D shapes, so the finished composites are lighter."

A reconfigurable fixture "Toolbox"

Historically, fixed assembly tooling/fixtures have been steel monuments, much larger than the part being constructed, used to locate and hold sub-assemblies and components to maintain tight »

FIG. 4 CFRP elements for smaller, lighter fixtures

The CFRP cradle used in a development assembly fixture for GKN's new STeM composite winglet is an example of Prodtex' Lightweight Structures products. Using CFRP tubes and plates by TETRAFIX, they are smaller, stiffer and lighter than metal alternatives, enabling smaller, faster, more cost-effective robots.

tolerances during machining and fastening. Designed for a specific aircraft, they are expensive to manufacture, with long lead times (e.g., 24 months) and may account for ≈25% of the total manufacturing cost. If design changes occur, these fixtures must be redesigned and remanufactured.

One effort to change that equation is the automated flexible fixture tooling demonstrated for the assembly of a hybrid metal/composite wingbox as part of the EU-funded LOw COst Manufacturing and Assembly of Composite and Hybrid Structures (LOCOMACHS) project. Led by SAAB Aeronautics (Linköping, Sweden), partners Prodtex (Gothenburg, Sweden and Bristol, UK), Chalmers University (Gothenburg, Sweden), the Manufacturing Technology Center (Coventry, UK) and others achieved project objectives: Manual labor was reduced; geometrical tolerance and variation management were integrated; and the recurring costs of shimming in structural joints — in this case, between the wing cover, leading spar and ribs — were cut by 50%.

"The aerospace industry is seeing more variation in products for the future, with shorter development cycles and lower production volumes," says Prodtex Ltd. director Peter Helgosson. "In these cases, it makes sense to have fewer fixtures that we can easily reconfigure. Right now, each company uses the same basic, heavy steel construction, but with their own methodology. Prodtex set out to make the fixture components very standardized, so it is easier and quicker both to design and to construct."

The modular, reusable components Prodtex uses to build reconfigurable fixtures include BoxJoint, Flexapod/Hexapod, ShimBox and TFS Units (Fig. 3, p. 33). Each unit type is manufactured in a set range of sizes and is readily available off the shelf. This reduces cost and fixture lead times to weeks vs. months.

BoxJoint beams are used to build the fixture's structural frame *without welding*. They may be made from steel, aluminum or composites. They are joined together using standard plates, bolts and nuts, pulled with high torque to give a rigid friction joint equal in stiffness to a welded joint and can be used to construct myriad configurations.

Compared to conventional steel beams, which are formed, heat-treated and then precision-machined per each fixture's specifications, BoxJoint units are less costly. "However, their surface is not precise," explains Helgosson, "so we use ShimBox modules to account for this. We can set the Shim Box in 6DoF and achieve a 0.1-mm tolerance in the fixture. We can handle ±6.0 mm in the frame components."

TETRAFIX Flex Support (TFS) units are adjustable, configurable pickups. "Pickups hold the assembled structure to its location points and surface tolerances," explains Helgosson. They define the fixture's shape. A designer will decide where pickups are needed and how they will hold the assembled structure. "For example, at one location the pickup will hold a component in x, y and z directions," he says, "but at another point, a fixed rotation around each axis may also be required, which means 6 degrees of freedom [6DoF]."

"The reason why massive steel frames have been used to hold pickups for the past 70-plus years," says Helgosson, "is because they are stiff and don't move, so that we know where the part is and can ensure proper fit and assembly." However, he contends that with laser trackers and new metrological and computing abilities, "we can very precisely measure where these pickups are, so they can be moved and reconfigured." Given that, Prodtex no longer needed to weld the assembly fixture frame elements. "This then led us to BoxJoint and ShimBox modular elements," Helgosson adds.

Developed by TETRAFIX AB (Kungälv, Sweden), the TFS unit pickups are modular and may be equipped with numerous end-effectors, offering a solution with flexible features for a variety of applications and industries. They are used as coordinate measuring machine (CMM) fixtures in automotive applications to double-check the dimensions of the manufactured part vs. the digital design and also in assembly trials to see if components mate as designed. Although they are completely adjustable and 6DoF-configurable, when fixed, TFS units have the same stiffness and strength as solid aluminum. "We work with TETRAFIX a lot," says Helgosson. "We've taken technology from automotive and are adapting it for aerospace."

The final elements in the Prodtex Toolbox are Flexapods and Hexapods. Both are Stewart Platform 6DoF positioning devices, which means they have a parallel top and bottom plate connected by six adjustable legs. Flexapods were originally developed with SAAB Aeronautics. "We needed a 6DoF positioning device that could be adjusted with an external metrology system," Helgosson explains. Although Hexapods have been around since the 1960s, says Helgosson, "most were either too accurate and expensive, or not accurate enough." Thus, Prodtex developed its own version, called Flexapods, which are manually adjusted to ±200 mm and include a tool-changing unit mounted on the top plate to attach pickups or metrology devices. For the LOCOMACHS project, Prodtex developed automated versions with electrically actuated legs, essentially bespoke Hexapods that use external metrology to deliver aerospace positioning accuracy at an affordable cost.

Less cost, time, shimming & risk

Given the flexibility afforded by digital metrology and the Prodtex Toolbox, tooling fixtures can be adjusted or configured automatically to cope with design changes or product variations. "It also enables live fixtures," says Helgosson, such as the lower cover fixture for the Lean Assembly Wing Box (LAWiB) demonstrator in the LOCOMACHS project. "The pickup locations in live fixtures can be tweaked even after the tooling fixture is built," Helgosson explains, "because we can precisely realign and recalibrate them." Hexapods were used as adjustable pickups in the lower cover fixture, developed for the LAWiB, which Prodtex designed in only 20 minutes. It was delivered in four weeks and construction was completed in a mere three days. "It only had eight pickups," he concedes, "but proves the potential of reconfigurable tooling. We wanted to challenge the industry."

Why is this important for composites? "Because composites are not very accurate," Helgosson replies. "For example, the thickness of an aircraft skin can vary by 8-10%, but tolerance for fitting parts to it is only 0.1 mm. This is a big problem." Until now, the solution has been more shimming vs. all-metal aircraft assembly. But according to Helgosson, the big goal for all four major OEM partners in LOCOMACHS was to reduce shimming costs by 50%. »

The tooling Prodtex demonstrated with its LOCOMACHS partners achieved the project's goal. "The objective was to enable this novel best-fit assembly method," Helgosson explains. "We did this by integrating an automated flexible assembly fixture, which demonstrated two major accomplishments." First, two synchronized Hexapods were used to position the front spar to the upper cover, hold it in place and maintain tolerance while withstanding 500N drilling forces during cover-to-spar assembly. Second, a 6DoF force feedback sensor, used with a third hexapod robot, managed rib placement as they were automatically positioned to best-fit locations in the wingbox. "We were able to manage the thickness variations of the parts without the need for shimming," Helgosson adds.

One of the most significant benefits of reconfigurable tooling is that it limits risks. Prodtex reconfigurable tooling is designed using Dassault Systèmes (Vélizy-Villacoublay, France) CATIA 3D CAD software and DELMIA V5 manufacturing simulation software. The latter is used to simulate robots and automation. BoxJoint, ShimBox, Hexapod/Flexpod and TFS Units are all integrated into CATIA and DELMIA. When a fixture is designed and constructed, pickups are mounted using a laser tracker to measure their locations and check against the digital mockup — the CATIA model translated into metrology software. "Automation demands precise position vectors for the robots to be able to interface with the parts," Helgosson explains. "If the assembly design changes, or if the tooling has to be modified with another pickup or tolerance change, you just adapt the CATIA model, add or subtract parts and recalibrate," says Helgosson. "It's almost concurrent engineering, which is invaluable in aerospace assembly, because it is so complex, with so many parts and processes dependent on each other."

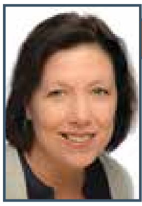
Reconfigurables, moving forward

Prodtex has supplied a variety of reconfigurable tooling solutions to Airbus (Broughton, UK), Embraer (São José dos Campos, Brazil), Marshall Aerospace (Cambridge, UK), Volvo Construction (Arvika, Sweden) and others. When GKN Aerospace (Bristol, UK) wanted an automated process for drilling wingskins, Prodtex developed test fixtures for GKN and KUKA Systems Aerospace (Le Haillan, France). "The overall project was complex," recalls Helgosson, "because GKN could not interrupt current production to see if the tools and system would work." Thus, Prodtex designed and built a fixture for trialing the new process and automated drilling robot. But before *this* test could be completed, KUKA needed to trial the new drilling end-effector it had developed. "So we built a smaller fixture using our technology," he adds, "which KUKA used before shipping the end-effector to GKN for their test."

Another example is an assembly fixture for the cost-effective winglet developed by GKN Aerospace (Isle of Wight, UK) from the STeM program. It features a carbon fiber composite lower skin as well as robotic and lightweight fixing techniques to cut weight, parts count and cost (Learn More). The winglet assembly tooling uses a lower fixture made from Prodtex BoxJoint, ShimBox and TFS units to locate the upper skin and metal components. A separate cradle fixture that comprises carbon fiber-reinforced plastic (CFRP) tubes is then used by a robotic arm to pick up the lower winglet skin and dock it into the lower holding fixture. "Then you can drill the lower cover and complete assembly," explains Helgosson. "Since the system is common and modular, we were able to combine stock and new parts to create the small-scale demonstrator fixture at very short notice," says Phillip Scott, GKN Aerospace technology project engineer. "We were also able to use Prodtex' CATIA tools to perform a significant redesign of a large fixture and then carry out the redesign process on the shop floor in three days."

The CFRP cradle, typical of Prodtex' Lightweight Structures products, uses CFRP tubes and plates by TETRAFIX. Spiderlike, these fixtures are smaller and lighter than metal alternatives, enabling smaller, faster, more cost-effective robots. "We also see drilling jigs where the operator has to lift up for docking into the holding frame for the structure being assembled [e.g., wing, car chassis]," notes Helgosson. "The lighter, stiffer CFRP fixtures make it easier for one person to lift and maneuver these jigs." A prime example is a fixture TETRAFIX built for hood installation on the Volvo *XC90* assembly line. Says Helgosson, "Volvo was able to replace the previous aluminum fixture, which required two operators, with a 3.5-kg fixture easily lifted by a single worker." Prodtex is now working on its first CFRP Flexapod (see *CW's* "Applications" story, p. 39).

What will the composites factory of the future look like? Increasingly automated, certainly, but given the cost/time savings and risk reductions already demonstrated, equipped with reconfigurable tooling and fixturing as well. CW



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CFRP BESTS STEEL IN PRECISION BALL JOINTS

Near-zero backlash in bearings and automation components

Source | Corebon

› As noted in *CW's* feature article on reconfigurable tooling (p. 30, this issue), modular fixture design firm/component supplier Prodtex (Gothenburg, Sweden and Bristol, UK) is not only changing the way that large composite structures are assembled, but also is using composites to build the fixtures themselves. In fixtures that must be lifted and installed by humans and/or manipulated by robots, reduced mass and high stiffness translate into less manpower/smaller robots, increased production speed and, as a result, reduced cost. Toward these goals, Prodtex is now working toward its first all-composite Hexapod positioning robot, using carbon fiber-reinforced plastic (CFRP)-based ball joints produced by Corebon AB (Arlöv, Sweden).

"The original idea was to redesign metal ball joints so that they would have less backlash," recalls Corebon CEO Tobias Björnhov. He explains that the company's ball joints and bearings, which feature CFRP housings, have near-zero backlash, meaning there is no gap or play between the parts, "so the joint is stiff before you put load on it." Ordinarily, "if you change direction of the force in a bearing, it could move," he points out, but claims, "Our structures do not move, because they are preloaded and very stiff."

Corebon began by reinforcing metal ball-joint housings with CFRP, which were also preloaded by shrink-press fitting the CFRP housing onto the metal ball (aided by the difference in coefficient of thermal expansion). "These were good," says Björnhov, "but expensive to make." So Corebon developed an all-CFRP ball joint housing, replacing multiple precision-machined metal parts that must be perfectly assembled around the ball with a single CFRP molding. Molding and preloading the two-part assembly (the ball remains metal) is achieved in a single step, using proprietary technology.

Corebon also makes sliding bearings and other kinematic pairs — i.e., two connected objects that impose constraints on their relative movement, such as a piston in a cylinder, ball joints and bearings — as well as parts for robots, like the CFRP domes pictured at top right. Björnhov explains that this dome comprises the robotic wrist of the end-effector, "where you would attach a motor/spindle for a machining tool or tape-laying head, etc." He notes that future iterations of these domes might also be used as nodes in the large yet lightweight "spider" fixtures for assembly, such as those made by TETRAFIX AB (Kungälv, Sweden) and Prodtex' Lightweight Structures. "Our first applications have been in robots where high precision is required. By reducing the weight of the end-effectors we increase precision and speed." How much weight reduction? "From 27 kg down to 5.5 kg for the robotic wrist/tool holder structure," says Björnhov.

Although the CFRP dome is cored with ROHACELL polymethacrylimide structural foam from **Evonik** (Darmstadt, Germany), Corebon also gains high specific strength and stiffness by maximizing fiber content. "We achieve a very high fiber volume — up to 80% — which is close to the theoretical maximum possible," notes Björnhov. This is not only startling, but it also has intriguing implications. "The fibers actually touch," he explains, "so we get high thermal and electrical conductivity, not only in-plane but in the z-direction as well."

The manufacturing process that enables this, now covered by an array of patents, was derived from efforts to improve resin transfer molding (RTM) and control of resin injection and heating. "We inject the resin, not only for RTM processing but also for compression molding and filament winding," Björnhov points out. "The key is that we heat from the *inside* of the composite, so we control the heat volumetrically, he notes, adding, "This is not bound to any specific type of matrix."

The key here is inductive heating technology. But Björnhov explains that Corebon's differs from other inductive heating-based composites manufacturing, "both in the inductors we use and how we control the electromagnetic field." The resulting instant and uniform 3D heating may be applied to almost any CFRP process, including prepreg cure and pultrusion. It reportedly offers cycle times 10 times faster than conventional composites processes, reduces energy costs by as much as 95% and uses molds that are 20 times lighter than steel. Corebon is licensing the technology, and already has partnerships with Japanese companies, including **Sumitomo Corp.** (Tokyo, Japan).

"Now we are looking at other applications, such as automotive suspensions and aircraft components that need kinematic pairs with high accuracy and stiffness," says Björnhov. Corebon also is preparing for the industrial scale required in these industries, with several projects in progress to demonstrate its ability to produce at high volume. CW

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Richard G. Kline, CEO

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SMC + D-LFT: A hybrid box for the Gen 2 *Ridgeline*

First use of weatherable SMC eliminates paint, reduces mass and stands up to tough-duty use while D-LFT optimizes vertical component functionality.

By Peggy Malnati / Contributing Writer

» Although it wasn't the first pickup with a composite box, when the all-wheel-drive Honda *Ridgeline* from American Honda Motor Co. Inc. (Torrance, CA, US) launched in spring 2005, it attracted significant attention for its abundance of clever features. It included a unique, lockable, weathertight in-bed storage trunk with a drain plug that doubles as a giant ice chest/cooler, plus a spare-tire tray forward of the trunk, a dual-action tailgate, integral tie-down cleats and in-bed lights, and bed floor guides to accommodate multiple off-road motorcycles. And it had high load-carrying capacity (up to 1,100 lb/499 kg). Further, its sheet-molding compound (SMC) composite box was 30% lighter than a comparable steel design and, thanks to the significant parts consolidation opportunity composites offer, part count was reduced from what would have been more than 100 in steel to a mere seven — which ultimately enhanced manufacturability, assembly and in-service durability, and would have been impossible or impractical in metals.

Honda's first foray into pickups so impressed judges that it won more than a dozen industry awards, including the prestigious 2006 *North American Truck of the Year*. Additionally, it was the first four-door/crew-cab pickup to earn five-star safety ratings from the US National Highway Traffic Safety Admin. (NHTSA), and it was the Insurance Institute for Highway Safety's (IIHS) Top Safety Pick in the pickup category in 2009, 2012 and 2013.

With all this going for it, it's no surprise that the first-generation *Ridgeline* developed a loyal customer base during its lifecycle between the 2006-2014 model years. When it was time to do a refresh for generation two, the pressure was on to create what Honda R&D Americas Inc. (Raymond, OH, US) calls "a worthy successor."

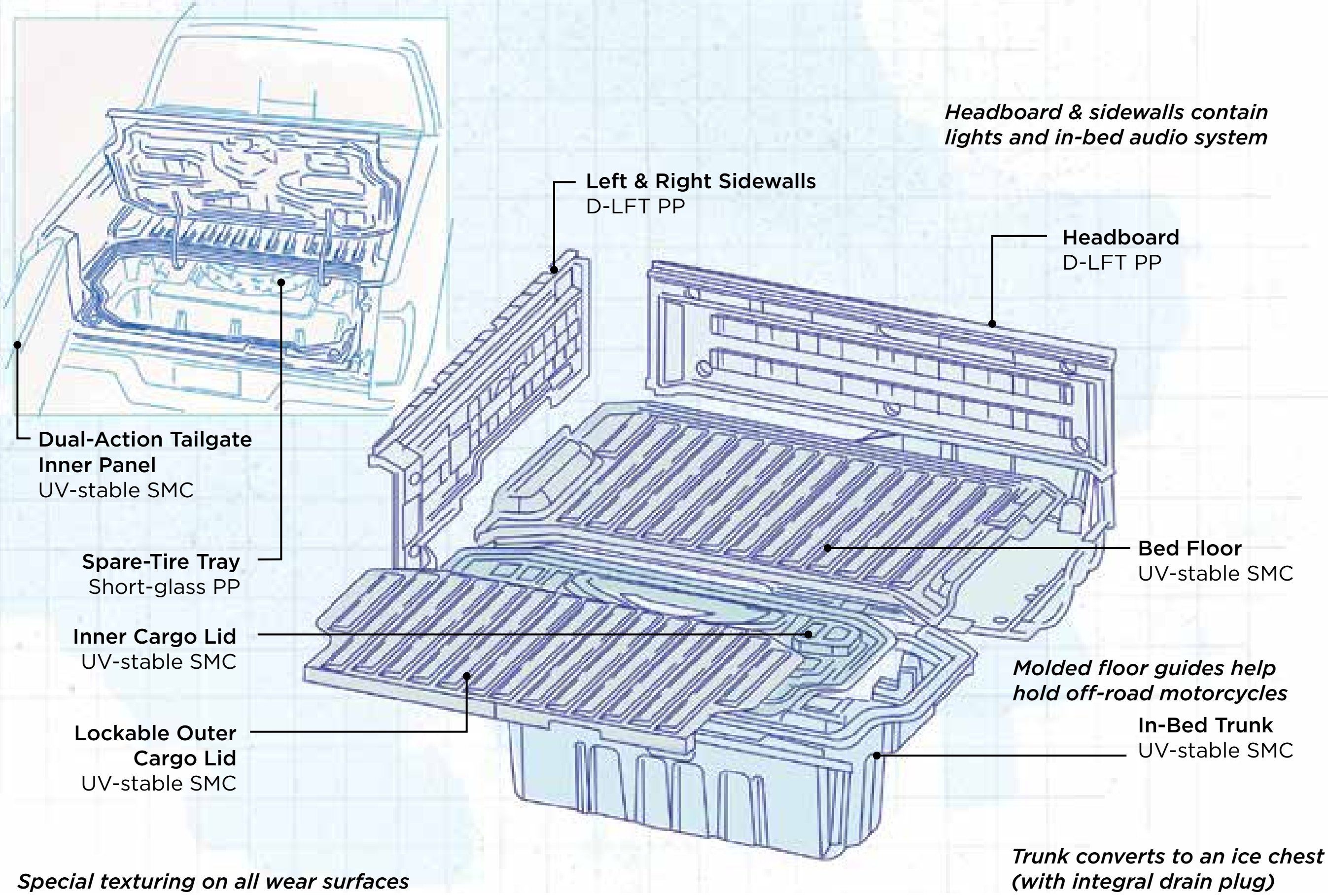
Not the first, just the most feature-rich

Although it wasn't the first pickup with a composite box, when the first-generation Honda *Ridgeline* from American Honda Motor Co. Inc. (Torrance, CA, US) launched in spring 2005, it earned a collection of honors, in part, for its feature-rich composite pickup box and unique in-bed trunk. When it was time to do a Gen 2 refresh, the pressure was on to create what Honda R&D Americas Inc. (Raymond, OH) calls "a worthy successor," pictured here.

Source (all photos) | Honda North America Inc.

Gen 2: Design flexibility the key

"Our first-generation *Ridgeline* broke new ground in terms of having in-bed storage, which we achieved using the design flexibility that composite materials afford," explains James Ryan,



DESIGN RESULTS — Gen 2 Honda *Ridgeline* Hybrid Composite Pickup Box Parts

- New, UV-stable SMC, plus special texturing and MIC black, eliminates need for paint on all loadbearing surfaces, hiding minor dings and scratches.
- Tough D-LFT PP reduces weight and cost but meets performance demands for pickup box sidewalls and headboard.
- Careful assessment of hybrid material system ensured excellent match between materials in terms of color, gloss and texture and confirmed overall usability.

Illustration / Karl Reque

principal engineer, materials research division, Honda R&D. Many of the system-usage targets for strength, durability and manufacturability on the Gen 2 composite truck box were built on the know-how gained from the first system. "We began by asking ourselves, 'How can we improve or add additional value for our customers?'" adds Ryan, who notes that everything from the shape of the bed's corrugations, and thickness of individual sections to the texture placed on wear surfaces and the material formulation, was examined and optimized to achieve the best performance for the customer.

The design team looked at many materials — polymeric and metallic — during preliminary design work for the first- and second-generation models. Choosing composites-intensive designs for both generations of *Ridgeline* pickup boxes was not without risks or challenges. "We already knew from our previous *Ridgeline* that the robustness that composites offered made them perfect for maximizing customer value," recalls Ryan. This approach follows Honda's philosophy of using the right material in the right place and incrementally improving it in terms of performance, quality and value to "maximize customer joy," he says.

"One thing about composites vs. steel and, in some cases, aluminum, is that these materials are younger in terms of total usage in the automotive industry," says Ryan. "A big challenge that we face, industry wide, is the need to educate people — from design to testing to manufacturing — about these materials and help them gain experience using them. Another aspect, and one that's extremely important at Honda, is our need to guarantee overall quality, safety and robustness for our customers. To do »

■ **Molded-in-color D-LFT + unpainted SMC**

To add features and reduce mass and costs for the Gen 2 pickup box, the team went with a multi-material system. Load-bearing surfaces (bed, trunk and liftgate inner) remained in SMC, but the box's sidewalls and headboard were compression molded from molded-in-color (MIC) black, fiberglass-reinforced direct-long-fiber thermoplastic (D-LFT) with a polypropylene matrix. This time, SMC parts were incorporated without the need for paint, thanks to unique formulation work by suppliers that enabled the use of a new weatherable structural grade of fiberglass-reinforced UP-SMC in the Gen 2 box.

that, we need to accurately predict performance up front and know we'll achieve good correlation with physical testing. It's vital to have reliable predictive capabilities for all the materials we use, and that's another issue we still face with composites."

From mono- to multi-material system

The Gen 1 design was essentially a painted, structural SMC system with bonded metal stiffeners and molded-in mounting collars produced by Continental Structural Plastics (CSP, Auburn Hills, MI, US). To add features and reduce mass and costs for Gen 2, the team went with a multi-material system. While all load-bearing surfaces in the bed, trunk and liftgate inner remained in SMC with stiffeners and mounting collars, this time, the box's sidewalls and headboard were compression molded from molded-in-color (MIC) black, fiberglass-reinforced, direct-long-fiber thermoplastic (D-LFT) with a polypropylene (PP) matrix. The spare-tire tray was injection molded from short-glass PP.

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"With any material, you have plusses and minuses," explains Ryan. "No single material is always right for every application across the board." Although researchers declined to provide details on the specific decision matrix used to specify the D-LFT and injection-PP formulations, team members did say that materials selection was driven by differences between the performance criteria for the box's vertically and horizontally oriented parts. The formulation was optimized jointly by Honda, CSP, and additive supplier Addcomp North America Inc. (Rochester Hills, MI, US).

Even the carryover SMC parts went through considerable scrutiny to see how much more value could be added. One area that was identified was paint elimination. Although SMC is known for its toughness, stiffness, chemical resistance, weight reduction, low scrap, design flexibility and relatively fast compression molding cycle times (2-3 minutes, button-to-button, even for large parts), it is not considered weatherable in typical vinyl ester or unsaturated polyester (UP) formulations. For that reason, it is generally painted for applications that will involve outdoor exposure. However, paint adds cost and environmental burdens that Honda wished to avoid.

Thanks to unique formulation work by resin supplier Ashland LLC (Dublin, OH, US) and additive supplier Chromaflo Technologies LLC (Ashtabula, OH, US), all the Gen 2 *Ridgeline's* visible SMC box components use a new weatherable (UV-stable) structural grade of fiberglass-reinforced UP SMC (specific gravity = 1.8). The MIC black material was compounded and molded by CSP, which also has produced SMC pickup boxes for Ford Motor Co. (Dearborn, MI, US) and Toyota Motor Corp. (Toyota City, Aichi, Japan).

"Ashland has been doing development work on weatherable SMCs since the 1990s," notes Dan Dowdall, Ashland global business development manager – transportation composites. "Honda and CSP had interest in a weatherable grade for the Gen 2 *Ridgeline* to improve the bed's durability and scratch resistance, but had very demanding requirements for color stability, gloss retention and mechanical properties. After extensive trials and testing, the Ashland-CSP SMC 834UV formulation was approved for use." He says this application represents the first commercial use of the material in any industry.

Tough and functional

Combined, the weatherable SMC formulation, MIC pigmentation and special texturing eliminated the need for paint in the Gen 2 *Ridgeline* pickup box without sacrificing the mechanical and chemical performance of the Gen 1 model. Furthermore, it keeps the bed looking great longer, particularly for users who haul heavy loads and/or abrasive materials.

Texturing of SMC wear surfaces was another area of focus to increase damage resistance and hide minor scratches. Previous research by Ashland showed that using different textures on SMC parts produced via identical formulation and molding conditions caused them to weather differently. That work, plus further input from CSP, the texture house and the toolmaker was used by Honda to select the final texture family, grain type and grain depth. Combined, the weatherable formulation, MIC pigmentation and texturing eliminated the need for paint without sacrificing mechanical or chemical performance vs. the Gen 1 model. Furthermore, it enhances user experiences by keeping the bed looking great longer — particularly for those who haul heavy loads and/or abrasive materials.

Additional work was done to ensure the SMC and D-LFT materials looked good side by side. "Given that we planned to use an unpainted, multi-composite system for all show surfaces, our team spent considerable time and effort focused on appearance and marketability criteria, including the as-molded appearance, color matching the SMC and D-LFT materials — considering not just base color over time and UV exposure, but also orientation, gloss and texture effects — and overall usability," notes Ryan.

Increasing customer joy

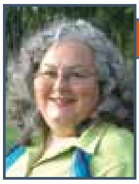
Other Gen 1 design and construction details were optimized to improve overall manufacturability and assembly and to optimize vehicle mass and performance. A notable addition is the smartphone-controllable, in-bed audio system, which features six weatherproof audio "exciters" (transducers) — two in each box's sidewall and two in the box's headboard. These transmit vibration from the truck's audio system and turn bed walls into resonant speakers — another industry first. That and the Gen 2's slightly smaller in-bed trunk/cooler, make the new *Ridgeline*, according to Honda, the "ultimate tailgate-party vehicle."

"Our end goal is delivering a product that exceeds customer expectations and maximizes the joy they experience from utilizing our products," adds Ryan. "We took great care to keep such considerations in mind throughout development."

The Gen 2 *Ridgeline* pickup made its debut in May 2016. Said to offer better hauling and towing performance than its predecessor and be the market's smoothest and quietest midsize truck, it offers greater interior volume (depending on trim level) and a wider, longer, more durable bed that is stronger than competitors' beds with similar payload capacity (see photo above). And for the first time, a front-wheel-drive version is available in North America.

What's next for the *Ridgeline*? "Lots of people are speculating about where the industry is going and how customers will use cars in 10 to 15 years," Ryan answers. "To keep maximizing value, we must keep finding the customer's value proposition."

Will composites continue to play an important role? "We need to look at where composites can enable quality, safety and robustness," he adds. "You can find clues as to where we're heading by looking at the products we've already launched. Hopefully we'll be able to continue to grow these applications by finding the right fit." CW



ABOUT THE AUTHOR

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