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thousands of miles by day and night without fuel. The plane’s carbon fiber structure helped
make the voyage possible. By Susan Keen Flynn

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3-D woven composite parts are poised to transform the aerospace industry. Last summer,
CFM International unveiled a new engine featuring advanced textiles that’s lighter and
stronger than other aerospace engines. By Angie McPherson
Make Your Voice Count

It is that time of year when you have the opportunity to stand up and let your voice be heard. By the time this issue of Composites Manufacturing magazine is published, there will be some changes underway in our government. There will be new faces in Congress, state capitols, city halls and perhaps even the White House. Whatever the outcome, I hope you were part of the process.

We are fortunate to live in a country where we have the right to vote for our leaders. We have a duty to stand up and voice our opinion and if we don’t, then we really can’t complain about the outcome. Who we vote into office on Election Day makes a difference for our nation’s future and determines the direction our country takes regarding its legislative agenda.

If you feel it won’t affect your livelihood or quality of life then you should reconsider that thought. I have seen the difference first hand, especially when it comes to regulations. Policies that encourage more manufacturing investment and jobs in the United States will benefit you and our industry.

The leader of the United States has the benefit and responsibility of appointing the heads of agencies that oversee and direct regulation. In recent years, federal regulations are on the rise, requiring businesses like ours to do more to adhere to these guidelines. This inevitably takes time away from focusing on your core business and impacts the bottom line. I encourage you to learn where elected officials and candidates stand and vote for people who understand that manufacturing should remain at the center of our nation’s legislative and economic agenda.

Thanks to generous contributions to the Composites Advocacy Fund, ACMA has been successful in fighting these regulations. But ultimately, the people running regulatory agencies affect how successful we can be. If you have the chance to talk with your elected officials, you should. They want to hear from you. Telling your company’s true story goes a long way toward showing them what it is actually like to live with the rules developed by our government. Elected officials can make more informed decisions when they are empowered with information and the opinions of their constituents.

I hope you voted on November 6 and continue to vote in upcoming elections. It is one of the most important civic activities you can participate in. It only takes a minute and goes a long way in making a difference for your company and your life. Don’t waste the opportunity you have been given. Voting is a gift: Make sure you use it!

Lori Luchak
Miles Fiberglass & Composites, ACMA President
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Simply put, a marketing strategy determines direction; tactics deliver results. More specifically, a strategy tells how you are going to win in the marketplace and tactics implement and execute the strategy. Winning in the marketplace is defined as identifying prospects, converting them to customers and keeping them long term. Tactics are plans devised to roll out your strategy, including the details of your offering, communication channels, messaging and timing. Often companies execute marketing tactics very well but lack a coherent strategy. This is frequently the case with small and medium-sized businesses. Companies may have a website, attend trade shows and run a few ads but lack an overall strategy to win in the marketplace. What’s more, by failing to implement a strategy, companies often fail to attract and retain the best, high-margin customers.

You must clearly define why you deliver value to your target customer, how you communicate that promise and what needs to happen to facilitate the buying process.

**Targeting Your Ideal Client**

Define your ideal client by answering these questions:

- What makes you different from their perspective – what do they value that you do?
- Where do you make the most profit?
- What are common characteristics of your most profitable client?
- What customers are you and your team most passionate about?
- Who are your repeat customers?
- What customers are raving fans of your company and why?
- Which customers refer you to other high-value prospects?
- Which ones will tell you why you were chosen?

If your prospects can’t differentiate between you and your competitors, they will select a partner using the one criterion they can compare – price.

Be very specific about your target market and who you want to work...
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Generating Leads

Targeting the ideal client will uncover your messaging, while lead generation activities communicate that message. Use a mix of inbound marketing, outbound marketing and sales prospecting tactics. Inbound marketing tactics are those that attract prospects using your website, search engine optimization, blogging and social media in conjunction with email list building. Outbound marketing encompasses tactics such as pay-per-click, direct mail, trade shows, trade journals, advertising and public relations. Sales prospecting covers activities that your sales team engages in to generate leads, including cold calling, referral generation and networking. A good marketing strategy incorporates all three tactics.

The key with marketing tactics is to test small and scale up with what delivers the best prospect leads. Determine the key metrics to measure for each tactic and hold your team accountable for results – generating revenue.

Converting Leads to Customers

A big part of a successful marketing strategy is understanding how your ideal customer buys your product or service.

- How do they consume information about solutions like yours? Where? When?
- How long do they take to make decisions? Who is involved? How are resources budgeted?
- How do they interact with salespeople?
- What encourages prospects to move through the buying process? What slows them down?
- Do they require demos, samples, tests, independent opinions?
- What is the best way to present your solution, pricing, delivery, service?
- How do they view your competitors?

In essence, how will they get to know you, develop confidence in you and then decide to invest in you?

Marketing success is not only about customer acquisition. A good strategy also depends on delivering enough value that existing customers buy more often and buy more per transaction. Your strategy should contain a detailed understanding of who is buying from you, how often, how much and when.

Developing a successful marketing strategy hinges on knowing your target market and focusing your efforts on the right prospects. This will give you the best chance at winning in the marketplace.

Todd Hockenberry is a frequent contributor to Composites Manufacturing magazine and the president and CEO of Top Line Results. Visit www.top-line-results.com/acma.
Juno Explores Jupiter, Protected by Composites

Space tourism to the relatively close areas of our solar system may be trending on the vacation-package end, but a team of researchers led by NASA is pushing the boundaries of both science and location to explore the interior of Jupiter. To aid in this quest, the group used carbon composites and – for the first time – implemented carbon nanotubes (CNT) in order to make the Juno spacecraft a successful mission.

The Juno mission is part of NASA’s New Frontiers Program where scientists and industry partners come up with projects to solve certain science questions. In the case of the Juno mission, Scott Bolton from the Southwest Research Institute based in San Antonio, Texas, wanted to understand the interior and various interactions within Jupiter and approached Lockheed Martin and NASA’s Jet Propulsion Laboratory to be on his team. Out of more than 20 proposals the team’s proposal won.

The specific goals of the Juno mission are to understand the origin and evolution of Jupiter. With its array of instruments, scientists will use Juno to investigate the existence of a solid planetary core, map the planet’s magnetic field, determine the water content of the atmosphere and monitor the northern and southern auroras. “Other missions that have gone to Jupiter have looked at surfaces and cloud structures but not much of the interior,” says Suraj Rawal, principle research scientist at Lockheed Martin Space Systems. “Whereas in the past they were only seen from a distance, for the first time we will also study the poles.”

However, going where no machine has gone before required careful planning by the team. One hurdle they had to overcome was protecting the spacecraft from the electrostatic discharge (ESD) while near Jupiter’s atmosphere. To do this, the team utilized carbon composite components and CNTs. “We used already proven materials like composites to make the overall structure, so we were simply building on methodology we’d already done. Specifically, carbon composites were chosen in order to reduce weight, increase stiffness and lower the overall mass,” says Rawal. “Launchers can only carry specific weight – a lot of it in the form of fuel. And from an engineering standpoint, the lighter the spacecraft, the more instruments we can include to collect valuable data.”

While the use of composites in creating Juno was not new, some of the problems they solved using composites were unique. “For example, it’s the first solar-powered mission this far from the sun, so the solar panels needed to be uniquely designed to fit in the spacecraft but large enough to absorb the sun’s rays. Many
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important parts also needed to be protected from the strong magnetic field around Jupiter,” says Rawal.

“Composites usage is an industry practice now but we wanted to insert nanotubes as a new technology replacement for aluminum foil for electromagnetic (EMI) shielding.”

“We were approached to provide protection against ESD for several critical components of Juno, such as the thrusters and the main engine cover,” says Peter Antoinetti, president of Nanocomp Technologies, Merrimack, N.H. “When Juno approaches Jupiter it has to slow down to be pulled in by the planet’s gravitational pull. Part of that process means traveling through Jupiter’s extremely strong radiation belts.” At that point the main engine will have been sitting untouched for five years; and it has to open and fire successfully. Coupled with that challenge was the need to protect Juno’s electronics, controls and motors from the ESD. To protect them, the group used a dry sheet nanotube, which was made into a prepreg and co-cured around the honeycomb core.

Rawal’s team at Lockheed Martin was involved in the development of an alternative ESD solution to the traditional aluminum foil that is typically bonded to the surface of composites. According to Antoinetti, the benefit of CNTs are their ability to be incorporated directly into the carbon composite. The group evalu-
ated other CNT-based solutions and chose CNT-based sheets even though it is a new material because it gave the protection the spacecraft needed without adding any parasitic weight. “Lockheed Martin was able to qualify Nanocomp’s CNT sheet material within a year because it’s in a format that engineers prefer,” says Rawal. “During manufacturing the CNT sheet layers were added during composite fabrication.” He adds that the CNTs were able to drop directly into the system, saving 10 percent of manufacturing time.

“The successful launch and the mission completion of Juno in 2017 are momentous occasions for composites and more, especially CNTs,” says Antoinetti. “It opens a way for broader adoption of these products. I’m confident they will continue to gain acceptance by conservative engineers because they solve problems, they’re easy to use and hopefully that means larger scale adoption into more primary structures. In a sense, the goal is to be a key component in the tool box of engineers to make better structures.”

Melinda Skea is a freelance writer based in Washington, D.C. Email comments to mskea@icloud.com.

For more stories like this, visit compositesmanufacturingblog.com and search keyword “spacecraft.”
From troop deployments and military surveillance to mobilizing disaster relief efforts, a new hybrid airship prototype holds promise as an innovative mode of aerial transport. When deployed, the 500-foot-long Aeroscraft airship will provide increased capacity to move massive loads into remote areas, including fragile terrains, says Mansoor Kouchak, vice president of engineering for manufacturer Aeros in Montebello, Calif. The vessel’s carbon composite and aluminum shell is central to the airship’s expansive payload capabilities as it provides structural strength for the craft, which has an anticipated range of 3,100 nautical miles and an estimated airspeed of 110 knots.

The Aeroscraft is in the final stages of assembly and all components have been validated and tested. The firm is ahead of schedule in testing the prototype and intends to scale up the production process, eventually constructing a 66-ton commercial airship. Aeros expects to conduct test flights by the end of this year.

The craft’s rigid framework is a key aspect of the invention, providing the vessel with “full authority when in low speed or hover mode,” says Sadia Ashraf, communications manager for the company. Most airships have non-rigid structures that are prone to puncture and are extremely light when cargo is offloaded, causing them to float away without a ballast.

By contrast, the Aeroscraft has an internal ballast system and a rigid structure to control lift at all flight stages and carry maximum payload while in hover mode.

Igor Pasternak, chief engineer and founder of the company, says the Aeroscraft is the only rigid variable-buoyancy air vehicle of its kind. The airship’s buoyancy system, which incorporates carbon fiber frames, has the potential to revolutionize air transport, says Pasternak, who launched the company in 1987 while still residing in the Ukraine. The aerospace inventor moved to the United States in 1993.

Several types of carbon fiber tubing, fabricated to achieve a high strength-to-weight ratio, were used to construct the ship’s trusses. A very strong, lightweight fabric covers the vessel’s skeleton.

The craft’s buoyancy management system uses compressed helium, which creates a vacuum inside the envelope, so the operator can adjust the vessel’s buoyancy. Controlling the level of helium makes the vessel lighter or heavier, allowing the pilot to raise or lower the craft. “When helium is compressed into pressure vessels, it creates a vacuum inside the envelope allowing for the air to fill in the expansion bags,” says Kouchak. “At this stage, the vehicle becomes heavy.”

The Aeroscraft buoyancy management system employs side engines capable of tilting the craft, which allows for vertical takeoffs and landings and eliminates the need for runways, ground support or any type of on-the-ground infrastructure. These capabilities will aid the U.S. military’s efforts to supply cargo to forces rapidly and efficiently in areas of conflict around the world that lack sufficient infrastructure. The Aeroscraft also could deploy troops to areas with rugged terrain, such as Afghanistan.

“There are commercial, military and other high-level interests in accessing those areas of the world that...
hold valuable resources that are inaccessible,” says Fred Edworthy, vice president of business development at Aeros. “We have also focused on logistics companies moving project cargo — particularly those working in austere environments with a lack of infrastructure, or those [transporting] heavy, irregular loads.”

Earlier this year, Reps. Grace F. Napolitano, Brad Sherman, Judy Chu and Adam Schiff secured $15.5 million in federal funding for commercial development of the airship, as the U.S. military stands to benefit from the technology. Aeros says it has also obtained funding from numerous other private and government entities.

Pasternak says the U.S. defense market already is a key client for other products supplied by the company. “Our tethered aerostats and FAA-type certified airships have been equipped with the high-tech surveillance gear and radio-telecommunication equipment that have helped various security agencies around the world to carry out their missions,” he says.

But military agencies aren’t the only ones interested in the Aeroscraft. Edworthy envisions other applications, such as shipping perishable fruit and vegetables, lifting pipeline components and assisting in rescue operations. Delivering aid to victims of a tsunami or transporting rescue teams into areas decimated by natural disasters are two possible scenarios.

Jan Fletcher is a freelance writer based in Spokane, Wash. Email comments to jan.fletcher@me.com.

For more stories like this, visit compositesmanufacturingblog.com and search the phrase “military air.”
Born on the Battlefield, Forged on the Gridiron

In September 2011, Dallas Cowboys quarterback Tony Romo cracked his ribs and punctured a lung during a game against the San Francisco 49ers. He led his team onto the field one week later wearing reinforced chest pads provided by Unequal Technologies, a Philadelphia-based manufacturer of protective gear made from composites.

Unequal Technologies created a line of athletic protective gear ranging from helmets to hip pads. The company adopted military-grade composite materials, such as high-intensity aramid fibers and polycarbonate blends, and engineered them into its EXO Armor and Concussion Reduction Technology (CRT) lines. “We adopted the composite technology because it is lightweight, thin, flexible and provides a better solution for protection,” says Rob Vito, CEO of Unequal Technologies.

The company’s protective products rely on three layers of composite material. Two layers of elastomer are sandwiched around a thin layer of Kevlar®. Together, they suppress, absorb and disperse impact shock.
“Kevlar is five times stronger than steel and the No. 1 shock suppression material,” Vito told a CNBC reporter in 2010. “You combine that with elastomers and all of a sudden you’ve got the best shock suppression system in the world.”

Hundreds of athletes on more than 20 NFL and NHL teams use pads from Unequal Technologies. Michael Vick, quarterback for the Philadelphia Eagles, began endorsing Unequal Technologies after breaking two ribs during the 2011 season. The company created a special vest to protect his sternum from future injuries. James Harrison, linebacker for the Pittsburgh Steelers, turned to CRT pads after fracturing his right orbital bone in a game last fall. “It’s like taking Novocain,” says Harrison. “You don’t actually feel the pain, just a little pressure.” According to the company, testing conducted by an independent lab confirmed that football helmets with CRT protection had 53 percent lower impact readings than standard helmets.

Typical pads are made from polyethylene opened-cell foam that you can easily squeeze between your fingers, offering little to no protection. Heavy weight or hard impact compresses the foam to its limit. Unequal Technologies says its composite pads work this way: The initial shock is dampened at the point of contact by the top layer of elastomer. Then the Kevlar disperses the remaining shock laterally throughout the pads, preventing most of the impact energy from entering the body. The third layer of elastomer acts as a comfort cushion between the padding and the athlete.

The CRT pads, which can be customized to fit any helmet shape and size, peel from a liner and stick inside helmets. Although they weigh only 2 ounces, athletes who use them...
say the pads are powerful. “I’ve had professional football players tell me they would’ve quit had it not been for Unequal Technologies and the protection from the pads,” says Vito. “I’ve had letters sent from parents telling me their child isn’t having headaches anymore after their games.”

Vito’s goal when he founded the company in 2008 was to develop technology for new military-grade composites. The 3-layer composite was initially engineered to withstand battlefield conditions faced by armed forces, law enforcement and government agencies. Vito has nearly 70 patents related to the company’s composite-based protection gear for sports and military applications. Currently, Unequal Technologies is redesigning padding for U.S. Army helmets.

“The military has a higher standard of testing when it comes to protection. As a company we always manufacture our products with that standard in mind,” says Vito. “Whether it’s a bullet, a blitz or a baseball, we want to protect users all the same.” He adds that technology originally designed for the battlefield is beginning to make its way into the sports world.

That’s good news for all athletes, from professionals to Pop Warner football players. The Sports Concussion Institute says that five to 10 percent of athletes will experience a concussion in any given sports season. And in 2009, nearly 447,000 sports-related head injuries were treated at hospital emergency rooms, according to the American Association of Neurological Surgeons.

With the proper training and protection, Vito believes that injuries can be avoided. He is banking on the EXO Armor and CRT protective lines to be a huge part of the solution.

Terin Bufford is the communications coordinator at ACMA. Email comments to tbufford@acmanet.org.

For more stories like this, visit compositesmanufacturingblog.com and search the phrase “sports protection.”
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Education Sessions and Technical Papers

1:30 PM – 2:45 PM
Opening General Session – Open to ALL Attendees

3:00 PM – 5:00 PM
Education Sessions and Technical Papers

5:00 PM – 6:30 PM
Opening Welcome Reception – Ticket Required

WEDNESDAY, JANUARY 30
8:00 AM – 9:15 AM
General Session – Open to ALL Attendees

9:30 AM – 5:30 PM
Exhibit Hall Open

12:00 PM – 1:30 PM
Awards Luncheon – ticket required

2:00 PM – 5:00 PM
Education Sessions and Technical Papers

5:00 PM – 6:30 PM
Specialized Networking Receptions – Ticket Required

THURSDAY, JANUARY 31
8:00 AM – 11:00 AM
Education Sessions and Technical Papers

9:00 AM – 3:30 PM
Exhibit Hall Open

11:00 AM – 1:00 PM
Lunch in the Exhibit Hall

1:00 PM – 3:00 PM
Education Sessions and Technical Papers

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— Stephen Balogh, Vice President, Mar-Bal, Inc.

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Vascular Composites Enable Varied Uses

Much like the human circulatory system pumps blood and oxygen through the body, a new vascularized composite material developed by University of Illinois researchers can transport liquids or gases through the composite. The material relies on sacrificial fibers that degrade at high temperatures, without affecting the structural composite material, creating tiny channels for liquid or gas transport. The channels can wind through the material in one long line or branch out to form a network of capillaries.

“We can make a material now that’s truly multifunctional by simply circulating fluids that do different things within the same material system,” says Scott White, a professor of aerospace engineering who leads the research team. “We have a vascularized structural material that can do almost anything.”

White and peers in the Autonomous Materials Systems Laboratory in the Beckman Institute for Advanced Science and Technology have created a sacrificial polymer fiber that is woven into the reinforcing fiber fabric. The polymer fiber had to meet several requirements. First, it needed to be robust enough to withstand the weaving process. Next, the fiber had to disintegrate at a temperature slightly higher than normal composite curing conditions, but not so high that matrix degradation would occur. “This gives us a very narrow temperature window to work with — approximately 180 C to 220 C,” says White.

Finally, the fiber removal process must occur under gaseous conditions. “We do not melt the fiber and extract by vacuum pressure. At extremely high aspect ratio channels (length/diameter) the melted fiber would simply remain in the channel,” says White. “Instead, we depolymerize the fiber to a monomer, which is then highly volatile at the temperature we do the extraction. So the fiber becomes a gas and escapes the composite quite efficiently.”

The sacrificial fiber is a polylactide (PLA) fiber. The researchers treat it with a catalyst — typically tin oxalate — to lower its natural degradation temperature. They have used PLA fibers to create vascular composites in high-temperature cured epoxy with glass or graphite fibers.

White’s team, supported by the Air Force Office of Scientific Research, has demonstrated various ways the material is useful. It can create self-healing composites that mend multiple times when subject to damage, such as an interlaminar fracture. The vascularized material can circulate coolants to lower the temperature in a composite subjected to thermal loads or increase the service temperature of a composite by active cooling. In addition, the magnetic structure of the composite can be changed by circulating a ferrofluid within the channels, which might prove useful for electromagnetic modulation. Lastly, the researchers have circulated a conductive fluid, showing that you can create conductive pathways within a composite on demand.

The research team has reached several milestones, including extraction from a 1 meter long, 5 millimeter diameter channel. But its work is not done. “We areperfecting a new way of making sacrificial fibers via melt spinning,” says White. “We are also beginning to explore how to weave fibers within fabric preforms to yield interconnected vascular networks.”

Scott White, Professor University of Illinois at Urbana-Champaign

“We have a vascularized structural material that can do almost anything.”

Susan Keen Flynn is a freelance writer based in Cleveland. Email comments to sflynn@keenconcepts.net.

For more stories like this, visit compositesmanufacturingblog.com and search keyword “university.”
Flight of Fancy

A solar-powered airplane performs the implausible, flying day and night without fuel.

By Susan Keen Flynn

In July, a lightweight airplane with a carbon fiber structure completed a two-month round trip journey between Switzerland and Morocco. At first glance, the voyage of more than 3,700 miles may not seem noteworthy. However, the flight was made without any fuel. The Solar Impulse HB-SIA traveled more than 131 hours in a series of eight flights powered exclusively by solar energy. It was the world’s first roundtrip solar-powered intercontinental flight.

“It’s been an extraordinary adventure not only for what we’ve achieved with this airplane – originally only designed to demonstrate the possibility of flying day and night with a purely solar energy – but also for what has resulted in a tightly fused team,” says André Borschberg, CEO and co-founder of the Solar Impulse program in Lausanne, Switzerland. For nearly a decade, the company’s team of 70 employees has worked with 80 partners to build and test the HB-SIA. Among those partners were composite material supplier Bayer MaterialScience and manufacturer Décision SA.

The skeleton of the wings, the fuselage, the horizontal stabilizer and the cockpit of the HB-SIA all feature composites made of a carbon fiber honeycomb sandwich structure. The top of the wing surface is covered with a skin of embedded solar cells, while the under sides are covered with a high-resistance flexible film. The wing achieves its aerodynamic profile and rigidity from 120
The Solar Impulse HB-SIA, shown here flying over Switzerland in 2011, has a giant wingspan of approximately 200 feet, yet weighs only 3,527 pounds. It flies at an average speed of 43 miles per hour.

The Project Takes Flight

Solar Impulse was born from the vision of two aviators – Borschberg and Bertrand Piccard. In 1999, Piccard made the first non-stop hot air balloon trip around the world. “He almost failed because of a lack of fuel,” says Martin Kreuter, project leader on the Solar Impulse program for Bayer MaterialScience. “Piccard made a promise to himself that the next time he would fly around the world, it would be with no fuel at all.”

Equally concerned with protecting the environment, Piccard hatched the idea of creating a solar aircraft to

carbon fiber ribs placed at 50 centimeter intervals.

Deciding on materials and building the solar-powered plane was not a simple task. The company devoted one year of studies, four years of design work, two years of building and a year of testing to the project before the HB-SIA prototype took to the air.
promote renewable energies and encourage energy savings. “Adventure in the 21st century consists of using creativity and the pioneering spirit to develop the quality of life to which present and future generations are entitled,” says Piccard, president of Solar Impulse. In 2003, he teamed up with Borschberg to launch the company and authorize a feasibility study for the project conducted by École Polytechnique Fédérale de Lausanne, a Swiss technical university.

The next several years were spent developing the concept, designing the airplane and building the HB-SIA. On April 7, 2010, the airplane made its maiden voyage, a two-and-a-half hour flight over Switzerland.

Materials Make the Difference

Bayer MaterialScience, based in Leverkusen, Germany, teamed with Solar Impulse prior to the first flight to supply high-tech materials for airplane components. Approximately 30 researchers work in the company’s laboratories on innovative ideas for lightweight construction and energy efficiency. The team is led by Kreuter and Bernd Rothe, leading engineer.

The materials provided by Bayer MaterialScience include polyurethane foams in the cockpit cladding, motor cowling and wings. The airplane’s structure comprises carbon layers impregnated with epoxy resin that cover honeycomb structures or foam cores.

Bayer researchers are currently devising solutions for the HB-SIB, the next generation of the airplane slotted for an around-the-world flight in 2015. One area of focus is the cockpit windshield, currently made of two highly transparent films with a cushion of air between them. “Because condensation forms quickly when the temperature drops and vision is impaired, we are looking for alternatives,” says Kreuter. “One possible solution would be to use a compact panel made of polycarbonate, but this is slightly heavier than the existing solution.”

Nanotechnology is another focal point. Bayer MaterialScience currently provides carbon nanotubes (CNTs) for the wings and other composite parts. “Our CNTs have been specifically developed to function in an epoxy matrix since they can make carbon composite structures much lighter due to advanced mechanical properties,” says Rothe. “But there is always room for improvement and new ideas.”

The Structure Is Built

Swiss company Décision SA manufactured the composite structure of the airplane then shipped the pieces to Solar Impulse for assembly. This was the first airplane project for Décision SA, which primarily builds boats.

Décision SA engineers advised Solar Impulse on construction methods, which influenced the design of each part. Solar Impulse then designed the airplane, pushing the technological limits of each component to make them as light as possible. “If, at 100 percent of the intended load the part breaks, then it must be too fragile,” says Borschberg. “But if it doesn’t break, there’s a good chance it’s too heavy!” The HB-SIA airplane weighs only 3,527 pounds – about the same as the average car.

Décision SA manufactured the molds and tools for each piece, while Solar Impulse engineers calculated the thickness of the structure to determine the lamination plan of the carbon plies and sandwich material. The next-generation HB-SIB will use a new laminating process called thin ply technology (TPT) from North TPT. It allows for complex laminates using carbon/epoxy tapes as light as 25 g/m², decreasing the weight of the airplane.

During manufacturing of the HB-SIA, Décision SA cut sheets of prepreg carbon fiber according to Solar Impulse’s technical drawing, glued the elements to shape each piece and baked those pieces in an oven to rigidify and fix them. Next, the company assembled all the main pieces of the plane, which were sent to Solar Impulse for final construction and testing.

Top: Bernd Rothe, left, and Martin Kreuter lead a project at Bayer MaterialScience to develop innovative materials for lightweight construction and energy efficiency of Solar Impulse airplanes. Here, they hold polyurethane foam used in the cockpit.

Middle: Bertrand Cardis, left, and Jean-Marie Fragnière construct the carbon structure of the HB-SIA. They work for Décision SA, a Swiss company and partner of Solar Impulse that manufactures composite structures.

Bottom: Engineers test the cockpit structure of the HB-SIA.
Big Buzz Surrounds Micro-robots

It sounds like the plot of a sci-fi film: Thousands of tiny robotic bees swarm a blazing fire on a search-and-rescue mission. But it may not be so far-fetched. Pratheev Sreetharan has developed the Monolithic Bee, a miniature robotic bee made from a variety of advanced structural materials and fabricated through a series of steps inspired by pop-up books.

“The robotic bee project provides an experimental platform to investigate flapping wing flight at the 100 milligram scale, advancing our understanding of nature while laying the groundwork for future flapping wing devices and machines,” says Sreetharan, founder of Vibrant Research in Cambridge, Mass.

But why bees? Well…pardon the pun, but they are a hive of activity. Bee colonies are renowned for their efficiency and coordination. Thousands of bees work independently to achieve a common goal using various sensors, distinct communication protocols and a defined hierarchy of task delegation. That inspired Sreetharan and his colleagues. “A swarm of small, disposable, cheap robotic bees can take the place of a single expensive robot,” says Sreetharan. “Strength in numbers can aid in tasks such as search-and-rescue missions and military surveillance.”

The machine bees, whose bodies are about the size of a penny, consist of a rigid airframe, a piezoelectric bending actuator, a power transmission and wings. The airframe is constructed primarily from carbon fiber composites to make it lightweight and extremely rigid. The high-performance wings are made manually: Carefully laid individual carbon fibers form wing veins when bonded to a polyester film wing membrane. Other materials incorporated in the structure include brass, solder, polyimide film and piezoelectric ceramics.

The robotic bee project has its roots in Dr. Robert Wood’s graduate work at the University of California, Berkeley on the Micromechanical Flying Insect. Wood achieved the first takeoff of a robotic bee as a Harvard University electrical engineering professor in 2008. Sreetharan was a graduate student working alongside Wood in the laboratory. He was assigned the laborious task of gluing miniature robots together under a microscope.

“I was determined to find a better way to fabricate the bees,” says Sreetharan. “In 2010, I co-invented the printed circuit MEMS [Micro-Electro-Mechanical Systems] manufacturing process that has created some of the most complex composite machines and mechanisms ever. The Monolithic Bee – or Mobee – was the first machine to demonstrate this process and is the first mass-producible robotic insect at the 100 mg mass scale,” says Sreetharan. The project is funded by a grant from the National Science Foundation.

Printed circuit MEMS fabrication is a sequence of micromachining and lamination operations. It begins with laser cutting complex patterns into thin layers of structural materials and adhesive films. The layers are stacked and aligned using precision pins. Heat and pressure bonds the layers together into a flat laminate. These laminates can be micromachined again, and combining a variety of materials creates a mechanical structure with rigid beams and flexible joints.

Mobee has five layers of carbon fiber for rigid components, two plastic layers for flexible joints, two brass layers for locking, one layer of titanium to mimic insect wings, two piezoelectric ceramic inserts for actuation and eight layers of adhesive bond. Mobee is fabricated as two parts – the machine components and a surrounding mechanism called an assembly scaffold. The scaffold links 22 origami folds and pops them up in a single motion. The robotic bee is then released by laser cutting all connections between the scaffold and the device itself.

Mobee is powered when a voltage signal is applied to the actuator. The tip moves approximately half a millimeter at 100 to 200 times per second. A transmission made from rigid carbon fiber beams and flexible polyimide film joints converts this half-millimeter motion into a 120-degree wing stroke, causing the wingtips to move about 3 centimeters.

Sreetharan started Vibrant Research to explore commercial opportunities for MEMS that extend beyond micro-robotics. He views printed circuit MEMS fabrication as a versatile process for creating machines at the millimeter scale. “It can embed electronics, incorporate high-performance materials and subcomponents, and be scaled into mass production.”
Powering the Plane

Flying without fuel requires the combination of an aerodynamic design and energy optimization. The wing and horizontal stabilizer of the HB-SIA were covered with more than 11,600 monocrystalline silicon solar cells, each 150 microns thick. They were selected for their lightness, flexibility and energy output.

The biggest challenge was storing enough energy in the lithium polymer batteries, situated in four engine nacelles beneath the wings. Each nacelle contains a 10 HP motor, a battery set and a management system controlling charge/discharge and temperature. While the Solar Impulse team could have chosen a more energy-efficient solar solution, other options would have added weight. Engineers and designers continually evaluated the necessity for a lightweight airplane against the advantages of various solar energy capture and storage systems.

Such considerations led to numerous calculations, tests and simulations throughout the project. During construction, wing-loading and vibration tests allowed engineers to fine-tune their models. Prior to the first test flights, Solar Impulse developed a simulator to train pilots on the airplane’s unique handling characteristics: It has a very small cockpit, a large wingspan and low wing-loading. The mission team conducted many simulated flights to study weather patterns, prepare for takeoff and landings and more.

All the work paid off on May 24, 2012, when the Solar Impulse airplane left Payerne, Switzerland, on its record-breaking intercontinental flight. Piccard and Borschberg took turns in the single-seat cockpit navigating the HB-SIA to Morocco and back. Now the focus is on the future – an around-the-world flight in 2015 – and beyond.

“Solar Impulse allows research on new material solutions beyond the daily boundaries, pushing technologies to the limit and paving the way for long-term business opportunities,” says Rothe. “It provides an innovation stimulus that goes far beyond the single applications that finally make it into the airplane.”

Susan Keen Flynn is a freelance writer based in Cleveland. Email comments to sflynn@keenconcepts.net.

For more stories on composite applications that harness the power of the sun, visit www.compositesmanufacturingblog.com and search the phrase “solar power.”
Material Innovation

A New Dimension For Aerospace

The growing interest for 3-D wovens in the aerospace market

By Angie McPherson

CFM International, a joint-venture between General Electric Aviation and Snecma, recently became the first company to successfully integrate 3-D woven composite parts into aerospace engine designs. The new engine, known as Leading Edge Aviation Propulsion (LEAP), demonstrates that 3-D wovens are not only a viable option for metallic engine part substitution but also can replace other metal and 2-D composite materials in a variety of applications.

As the name suggests, 3-D woven composites are fiber textiles characterized by their three-dimensional yarn orientation. They are reinforced in multiple directions, including the through-thickness direction. Unlike conventional laminate composites, which are typically only reinforced in the plane of the laminate, 3-D wovens can exhibit different material properties throughout a single component. For instance, a component might have increased axial stiffness in one area and greater shear strength in another.

3-D fiber textiles are constructed using traditional textile weaving techniques to create advanced pre-impregnated fibers (prepreg) that interlace multiple fiber layers across the horizontal and vertical axes. Since the fabric can be altered during the weaving process, the material can include smart sensors and stronger fibers depending on the needs of the composite part. According to Alistair McIlhagger, Ph.D., senior lecturer at the Engineering Research Institute at the University of Ulster in Belfast, Northern Ireland, the implications of this material advancement could mean large-scale change for the use of composites across major commercial markets such as automotive, wind and aerospace.

LEAP Demonstrates Successful Integration

CFM International established the LEAP project in 2005 to develop a successor engine for its CFM56 family of airplane engines. One focus for the project was to use a 3-D woven resin transfer molding (RTM) process...
developed by Snecma, a French aerospace engine manufacturer, to create an even more aerodynamic composite fan. The fan blade design went through numerous iterations. The finished engine fan – including 18 engine blades, a disk and fan case – features 3-D material that is woven and manufactured by Albany Engineered Composites (AEC), Rochester, N.Y.

To manufacture one LEAP engine fan blade, AEC weaves miles of carbon fiber using a continuous spooling process in large industrial jacquard looms. AEC weaves and cuts the preforms, injects the resin and cures the part using a patented RTM process. Once the initial preform is shaped, the company cuts the blade into the desired shape using water jets. The material is then injected with resin in a heated mold. The entire process takes 24 hours to complete. Snecma is then responsible for the final machining and painting of the parts that CFM International distributes to aerospace companies.

CFM International is not the first company to use 3-D woven technology. Both Boeing and Airbus have implemented 3-D woven parts in their new fuel-efficient aircraft models to help reduce weight. The importance of the 3-D wovens in the LEAP project is that the company used an advanced textile in a major structural engine component. This unique application has attracted attention to the advantages of designing with advanced textiles to enhance composite parts.

For example, CFM International weighed the LEAP engine series against its similar CFM56 engines, which employ heavier metal parts, and found the LEAP engine was lighter by more than 1,000 pounds. Compared to another composite engine, the GE90 produced by CFAN, the 3-D woven composite engine is smaller by 50 inches in diameter but strong enough to pass the same bird-strike test, according to the company.

Another advantage of 3-D woven RTM fan blades is that the prepreg is designed with different thicknesses. The blade is thinner at the top and thicker at the bottom. This reduces the delamination that typically occurs on similar 2-D fan blade parts. For markets like aerospace, the ability to seamlessly integrate smart sensors into the part without compromising part durability is critical for aerospace composite maintenance and repair.

Stepping into the New Dimension

Since the LEAP engine was launched at the 2012 Farnborough International Airshow in July, the company has sold more than $12.6 billion in orders and is expected to produce 32,000 composite fan blades per year by 2019 – or one every 30 minutes, according to CFM International. It will continue to develop the patented 3-D woven RTM process to work efficiently on a commercial scale.

AEC and its partners are enthusiastic about the level of response they have received from the industry. “The LEAP RTM fan is one of the revolutionary technologies that will change the face of commercial aviation,” says Jamie Jewell, director of strategic communications at
CFM International. “Our biggest challenge ahead is to finish refinement and industrialize the technology.” Snecma and AEC will open two new facilities with 200 employees operating each in order to meet the demand.

McIlhagger agrees with Jewell that the major challenge for 3-D wovens is introducing the new technology to the industry and producing these composites for high-volume applications. He believes that 3-D woven composites are a key tool for using composites more intelligently to fit the specific property or fiber direction of material. But to benefit from this technology, the industry needs to understand the weaving, preform and manufacturing process.

The industry must move from a fundamental understanding of advanced textiles to material usage, says McIlhagger. “It will take more discussion about the composite manufacturing processes and materials in order to fully introduce 3-D wovens to the industry. This will essentially change the way we currently think about composite manufacturing.”

McIlhagger also believes the future of 3-D wovens will lean toward automated manufacturing to meet high-volume needs. “There are other industries out there, such as the textile industry in the Republic of Ireland, that have the knowledge to develop the type of automated machines we need,” he says. “As engineers, we have a lot to learn from the textile companies.”

Angie McPherson is a freelance writer based in London. Email comments to mcpherson@gmail.com.

A Fan of Art
Composite fans are not only functional; they are considered a work of art. Since 2004, The Museum of Modern Art (MoMA) in New York has displayed a fan blade from a GE90-115B engine – the most powerful fan jet engine ever built, according to the Guinness Book of World Records. The blade is 4-feet long and weighs less than 50 pounds. It is made of carbon fiber and an epoxy matrix, making it extremely flexible yet highly resistant to impact.

The composite fan blade is included in MoMA’s Architecture and Design Collection. The museum first displayed aerospace art in 1934 with its Machine Art exhibit featuring airplane propellers, coils, ball bearings and other machine parts. A museum publication says the composite blade “is a fusion of cutting-edge engineering and design, and its astonishingly beautiful undulating form is a pure expression of its aerodynamic function.”
Growing the composites market for ACMA members begins with educating engineers, architects, designers, specifiers and consumers. Sometimes education focuses on creating awareness that materials and products exist and should be considered for upcoming projects. Marketing composites to decision-makers helps ensure they are knowledgeable about industry products and can make informed selections.

It’s more difficult, however, to educate savvy end users who have experience with a wide range of materials and products. Simple marketing does not guarantee a sale. The path becomes even more complicated if you are pursuing a new market or competing against well-established products in the marketplace. The ACMA Composites Growth Initiative (CGI) is a special program designed to help association members travel this difficult path. CGI partners with members to provide education.

The variety of ways people learn makes developing educational initiatives challenging. In an effort to reach as many people as possible with a clear, informative message, the CGI has provided education through numerous channels, including the three Ws: websites, webinars and workshops.

Many CGI Committees are currently developing websites that educate end users on composites. So far, the ICPA successfully launched www.mastercast.biz and the Corrosion Control Division introduced www.corrosionresistant.org. These websites provide consumers and engineers respectively with valuable information on why they should select composites over other materials. The Automotive Composites Alliance will re-launch an updated website soon. In addition, look for new websites from the Transportation Structures Council, FRP Rebar Manufacturers Council and the Pultrusion Industry Council.

Most of these websites – which are targeted to engineers, designers and specifiers – will have the same look, feel and navigation. Such consistency benefits the industry as a whole.
these web projects are complete, all 12 CGI Committees will have their own presence on the Internet.

Webinars and workshops are also integral to the success of the CGI program. During the last year, the Transportation Structures Council and FRP Rebar Manufacturers Council have participated in seminars and workshops organized by the Federal Highway Administration (FHWA). These CGI Committees have successfully leveraged their products into webinars and workshops that target the very engineers we want to reach.

For example, the FHWA has hosted five all-day seminars on construction materials, including corrosion resistant rebar as well as traditional materials. It also has conducted three regional workshops to educate transportation engineers on advances in materials and products that support accelerated bridge construction. As director of ACMA’s Composites Growth Initiative, I have given presentations on composites advancements at all these events. In addition, the Transportation Structures Council conducted a technical workshop at the 2012 International Bridge Conference in Pittsburgh in June on composites used in bridge construction. This marked the 12th year the council has participated in the conference and coordinated a technical workshop on composites.

While websites, webinars and workshops are great educational tools, perhaps the most valuable method is meeting customers on their turf to present composites. In September, members of the Automotive Composites Alliance conducted a meeting with engineers at Ford Motor Company in Dearborn, Mich. Representatives from the entire composites supply chain worked together under the association banner to present technology the OEM wants to implement into its platforms. This collaborative market development – where the entire industry comes together to share their knowledge and experience – helps us all grow the market.

With CGI as a partner, leader and planner, together we can grow the composites industry. But we need your help! If your company is in a market segment or manufacturing process covered by one of ACMA’s 12 CGI Committees, please consider joining that committee and helping us grow composites!

John P. Busel is the director of ACMA’s Composites Growth Initiative. Email comments to jbusel@acmanet.org.

For more information on CGI and to learn about the CGI Committees, visit www.acmanet.org/dac.
A Numbers Game

Our writers unearthed these fascinating figures while writing articles for this issue of *Composites Manufacturing*.

200 miles

It takes 200 miles of carbon fiber to create one LEAP engine fan for aerospace applications. Read about the LEAP project on page 27.

11,800 feet

During the world’s first solar-powered intercontinental flight, the HB-SIA airplane maintained an average altitude of 11,800 feet. For more on the flight and airplane, which incorporated a carbon fiber structure, turn to page 22.

150,000 feet

The Aeroscraft airship covered on page 12 is so large it needed to be assembled in a 150,000-square-foot hangar in a former Marine Corps air station in Tustin, Calif.

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Composites 2013 Is the Tip of the Iceberg

ACMA’s trade show – COMPOSITES – is a showcase of the association’s leadership in education and information, not just for North America but for the world. Participants learn not only the newest manufacturing processes but hear about the hottest markets and connect with suppliers and customers.

However, there is so much more to ACMA than COMPOSITES. The educational programming doesn’t stop when we depart Orlando. Our Certified Composites Technician (CCT) program will train your employees to produce better products faster and with less waste. Our webinars give you business insight into a range of issues. And our soon to be launched web-based learning portal will give all of it to you on demand 24/7.

ACMA is the only entity representing your company before Congress, the EPA, OSHA, the National Toxicology Program and other federal and state agencies. ACMA has saved the industry millions of dollars in burdensome regulations because of the work it does with policy makers. It is working to save the industry millions more in potential liability as a result of the flawed listing of styrene as a “reasonably anticipated carcinogen.”

ACMA’s Composites Growth Initiative (CGI) is working aggressively to open markets and create business opportunities for its members. Whether it is generating leads, setting meetings with OEMs or providing marketing materials, the CGI has one purpose – to make member companies more profitable.

There are too many additional programs we offer member companies to list in this column. You can learn about all of them on our new website coming in January at www.ACMAnet.org. Become a member and benefit from being a part of a dynamic association of the best and brightest in the industry.

See you at COMPOSITES 2013 in Orlando Jan. 29-31!
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Composites Manufacturing

Top CM Interviews of 2012

<Callaway Uses New Technology, Integrates Composites

Steve Ehlers is the vice president of golf club innovation and development at Callaway Golf in Carlsbad, Calif. Ehlers has more than 30 years of experience working with composites, 20 of them in the aerospace industry working with large structures such as spacecrafts and helicopters. Callaway developed a new driver using Forged Composite technology, a manufacturing technique using discontinuous fibers in a compression-type mold, to produce a competitive new driver.

The Power of Statistics in a Growing Industry>

Robert R. Lacovara, CCM, CCT-I, has been in the composites industry for more than 30 years, and he thinks composites manufacturing is at a crossroads. Traditional methods and thinking may facilitate the status quo, he says, but “real transformation is necessary to meet the challenges of our time.”

<Understanding the Automotive Composites Market

Gerson Meschut, Ph.D., is a lead material researcher at the University of Paderborn Laboratory of Materials and Joining Research (LWF) in Germany. He’s currently developing mechanical, adhesive, thermal and hybrid joining solutions for major automotive companies focused on advance vehicle lightweighting. German automotive manufacturers are interested in using carbon fiber in upcoming production vehicles like the BMW

To read the interviews with these and other leading members of the composites industry, visit www.compositesmanufacturingblog.com and click on “CM Interviews.”
Prior to rocketing into space on August 5, 2011, the Juno spacecraft underwent extensive tests, including acoustic and environmental testing. Read how composites played a critical role in the mission to Jupiter on page 8.

Confounded Composites!
Take a second look and see if you can find the differences in these two pictures.

Changes

1. X to the right of center removed
2. Add extra woman into group of two scientists, blocked by the one in blue
3. Red box on left-hand wall
4. Extra coil of wire on wall
5. Extra silver disk on wall with bar separating the two
6. Erase box on left-hand wall
7. Erase contents of tray on step-ladder on bottom left
8. A second silver funnel added to top of Juno
9. Piece of machinery sticking out of bottom right of picture removed

Photo Credit: Lockheed Martin