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Connection

The official magazine of Composites Australia

Inside

How our training organisations are responding to changing industry needs

Advanced Composites Innovation Conference Melbourne, 13-14 April, 2016

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Joint preparation for GRP pipe fitting in Darwin. Image courtesy Challenger Institute of Technology.
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Feature article

Synflyt and Ryman Composites have developed a world-first solution to address the forecast global pilot shortage – a high-tech, low cost, outdoor flight simulator leveraging the benefits of composite materials.

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Publisher: Kerryn Caulfield, **Chief Executive**

Editorial inquiries: Liz Tunnecliffe

Advertising inquiries: Anna Civiti

Design: Stefan Morris, Tel. 0411 708 279

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Composites Australia
17 Rooney Street, Richmond, Victoria 3121
Tel. +61 (0)3 9429 9884
Fax. +61 (0)3 9421 5516
www.compositesaustralia.com.au

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President's letter

It is heartening to hear and see signs of optimism within the Australian composites sector, suggesting that we may be turning the corner in 2016. We have members reporting signs of growth through entrepreneurial leveraging of innovative composite technologies and applications. But with these come reports of a labour and skills shortage as companies seek employees with high-level technical and problem solving skills in addition to knowledge of composite materials and processes.

Investment in training is a long term business strategy that requires a vision for a company's future growth along with consistent commitment. Firms need confidence in the future to invest in equipment, staff, education and training. Training to gain productivity improvement is a no brainer, particularly in this globally competitive environment. Hence, this issue of *Connection* looks at composites training in Australia today and how it is evolving to meet changing needs (pages 8 to 12).

This issue also looks at automated composites manufacturing (page 18) and developments in 3-D printing (page 14) – technologies that herald substantial change for manufacturers and are the subject of presentations at the 2016 Advanced Composites Innovation Conference (ACI-16).

Workforce training is also a consistent theme across several industry presentations in the conference program.

Hosted by Composites Australia and to be held in Melbourne on April 13 and 14, the conference promises to be a valuable forum for the sharing of industry and scientific knowledge on new and emerging developments in composites technologies and opportunities for new applications and markets, as well as providing sessions to advance business management and marketing.

The conference would not be possible without the generosity of our sponsors and invaluable support of SAMPE-Australia and the Engineers Australia technical society – the Australian Composite Structures Society (ACCS).

We are fortunate to have global industry leaders attending, including Dr Leslie Jay Cohen, Senior Vice President, New Business Development & Strategic Technology with HITCO, from the USA, and Paul Marks, Chairman and CEO of Argosy International, from China. They will share their companies' experience introducing major change that has enabled them to succeed in today's highly competitive global markets.

The conference will be preceded by a half-day workshop, *Understanding, Developing and Predicting the Unique Capabilities of Composites*, developed and presented by engineering consultant and trainer, Dr Rik Heslehurst. Rik's training is highly regarded globally for the value of the content, delivery and practical application. For more details on the conference program see page 10.

The conference also offers unique networking opportunities, including the dinner, which is to be held at the iconic MCG (Melbourne Cricket Ground). This will be a great opportunity to thank valued staff and customers and/or treat your partner.

I look forward to welcoming you to ACI-16 in Melbourne in April.

Genelle Coghlan

Sykes invests in faster boats, more jobs

Geelong-based Sykes, a leading manufacturer of world-renowned rowing boats, has succeeded in gaining funding support to further develop the company's advanced manufacturing capability.

The funding, from the latest round of the Geelong Region Innovation and Investment Fund, is going towards establishing an advanced engineering laboratory equipped with the latest engineering design technology. The project is expected to generate 11 new jobs by 2017, primarily in engineering and production.

"We are building the Sykes composites engineering capability to expand our services to companies looking to develop composite products and components," says the company's Director of Innovation, Matt Dingle.

"We have seen increasing demand for our engineering design and advanced engineering design technology from both local composites companies and people looking to produce composite parts."

Since its first World Championship in 1974, Sykes Racing has worked closely with Australian rowing teams to provide the platform for four Olympic and 17 World Championship wins. In that time the company has introduced numerous performance boosting innovations that were revolutionary at the time and have now become standard in elite rowing boats around the world.

The $29.5 million fund was set up in 2013, in the wake of new job losses at Ford, and includes contributions from Ford, Alcoa and the federal and Victorian governments. Geelong-based Carbon Revolution and Quickstep have gained grants from previous funding rounds to expand their companies' manufacturing capabilities and create more jobs.

Grants available

Applications for Round 2 of the federal government's Next Generation Manufacturing Investment Programme close on Monday 18 April 2016.

The program is injecting $30 million into South Australian and Victorian industry to support capital investment in high value manufacturing capability.

Search the web under the program name or visit www.business.gov.au/grants

Winners

Abaris Training was recognised at the recent SME AeroDef/Composites Manufacturing Conference for the company's dedicated service to the advanced composite manufacturing industry for over three decades.

Well-known Composites Australia trainer Rik Heslehurst is Senior Engineer with Abaris, which has taught over 23,000 students in 63 countries about composite materials and processes, providing courses and services in engineering, manufacturing and repair of advanced composite structures.

ACS Australia has been awarded a JEC Asia 2015 Innovation Award in the Thermoplastics Category for COFA™, a novel assembly technology that allows thermoplastic brackets and fittings to be rapidly attached to thermoset composite structures without the need for traditional fasteners or adhesive bonding processes.

Paul Falzon, General Manager ACS Australia, said a number of customers were showing interest in commercialising the technology.

Aussie ingenuity launches world-first flight simulator

Five years ago Ross Maclennan, Engineering Director and founder of SynFlyt, came to Ryman Composites with the concept for an outdoor flight simulator that he had conceived five years earlier.

Owner, Chris Ryman admits he was immediately taken with the project and with Mr Maclennan's vision.

"This sort of project satisfies our creative bent – the customer having one question and requiring multiple aspects of our experience, knowledge and capabilities to provide the best possible solution," says Mr Ryman.

"It's often said that you are effectively putting your IP on the table in that initial meeting, but in my view the customer is buying both capability and ideas. You may run the risk of them going to someone else with your suggestions for a better way of doing the job, but you need to trust that you have made the right impression to secure the work.

"Ross had the clear concept of using composite components but to make it work out of composites and to take advantage of the material attributes we had to be very creative and follow a collaborative approach."

"It's all Australian, and we have a real desire to keep manufacturing here and export to the world. Whilst we are not relying on it, the low Australian dollar will certainly help."

The result demonstrates Australia's innovation capability, marrying technology with composites in a world-first outdoor, high tech yet affordable flight simulator for pilot training schools, large and small.

Top. The spherical pod sits on multi-directional wheels that respond to pilot controls.
Middle. Clever design with composites optimises manufacturing efficiencies and product performance.
Right. The Synflyt 3 Degrees of Freedom (3DOF) is an innovative flight simulator for local and international pilot academies.

Composites showcase

The design takes full advantage of the many attributes of composites: the ability to form complex shapes, seamlessly joined and laminated for a smooth, aesthetically appealing exterior and interior; their light weight, reduced part count and the durability to withstand the harsh outdoor elements.

This is evident in areas such as the base structure, where the one-piece fibreglass moulding incorporates pylons for the motion drives, fork-lift points and integrated mountings for tie-down points.

At the heart of the simulator is the fibreglass spherical pod that sits on multidirectional wheels, giving the trainee pilots the sensation of flight in response to their control inputs.

Early challenges for the Ryman team included coming up with the design and laminate engineering deflection testing using FEA.

One mould – multiple components

Clever design of elements of the outer shroud has enabled four interlocking panels to be made from the one mould, minimising tooling, overall size and additional support structure, whilst significantly reducing start-up manufacturing costs.

The latter is critical to the success of the project, says Mr Ryman. "Start-up companies face significant financial hurdles in order to meet the tight budgets of the initial investment funding. For SynFlyt this represented the local pilot training schools and academies across Australia and New Zealand that have neither the indoor space nor the budget to be able to afford conventional

$150k plus flight simulators.

"The business model will ensure it is within the budget of even the small ('Mum and Dad') pilot training schools operating at airports across the country."

While not a pilot, Mr Ryman enthuses about the way the 3DOF replicates every aspect of the flight experience, from the pressure on the rudder through the joy stick to the exact replication of the plane's controls, from the sensations of the plane's movement in flight to the visuals projected onto SynFlyt's 210° horizontal and 60° vertical screen. The training experience is further enhanced by Mr Maclennan's proprietary training software.

Supplier to investor

The project has so captivated Mr Ryman, both for its ingenuity and strong business case, that he has invested in SynFlyt and now sits on the board: "The company represented a good investment in light of the CASA regulators approving the use of flight simulators for up to 40% of new pilot flight training. In addition, there are well documented projections of high demand growth for pilot training internationally."

Mr Ryman is clearly relishing the opportunity to contribute to such an innovative project. "It has not only been about design for manufacture but about optimising design.

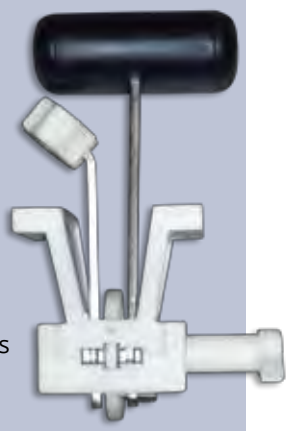
"It's all Australian, and we have a real desire to keep manufacturing here and export to the world. Whilst we are not relying on it, the low Australian dollar will certainly help."

SAVINGS WITH 3D PRINTING

The SynFlyt 3 Degrees of Freedom (3DOF) flight simulator is a showcase for the potential of 3D printing in manufacturing.

Starting with smaller replica aircraft components, such as levers, control buttons and connection parts, SynFlyt's 3D printing specialists moved to producing more complex components, such as housings for electronics, gears and instrumentation panels, and the throttle handles, at right.

"Now, a 3DOF flight simulator can have over 80 3D printed components, achieving significant cost savings – like $73 on an $80 off-the-shelf circuit breaker – while reducing production and communication time," says Synflyt Engineering Director Ross Maclennan.



Spotlight on Training

Technical training: an investment in future growth and profit

Opinion by **Mr Alain Michout** and **Dr Rik Heslehurst**.

In today's world, technical training suffers from an image problem.

While the cost can be clearly quantified by adding the cost of the training to the loss of productivity incurred by a traveling employee, the benefits of technical training are a little harder to comprehend, as they often reveal themselves in hidden ways.

No-one ever questions why a department produced 100% quality parts during a given time period; no-one ever wonders why a piece of equipment keeps on working without a glitch for months at a time. The list could go on. Hence a more qualitative analysis is required to reveal technical training benefits.

The real hard truth is that a company's best assets are its people. An educated workforce is a productive workforce. Knowledge of processes and equipment, and constant improvement – through methods such as Kaizen or Six Sigma – will give a company a huge competitive advantage in the marketplace.

While you can keep a car running through regular oil changes and preventative maintenance, a company will only retain its employees and allow them to thrive through regular training.

Technical training can be categorised as: (a) foundation training, (b) vocational training, and (c) future capability training. Formal institutes and colleges provide the first two categories, whereas the third training category is provided mostly by private technical training companies or industry associations, such as Composites Australia and the Society of Advanced Materials and Process Engineering.

The best time to invest in future capability training is before you need it. It needs to be an integral part of the business plan.

It is time for technical training to shed its image problem and be treated like the true profit centre that it is.

- Hear more on how to plan technical training for profit with Alain and Rik at the upcoming Advanced Composites Innovation Conference in Melbourne on 13-14 April 2016.

About the authors:
Alain Michout is President of M51 Systems Inc. a Dallas-based manufacturing management consulting firm: alain@m51training.com
Composites engineering consultant **Rik Heslehurst** presents courses and seminars around the world on the subject of composites and joint technologies: rik@m51training.com

Australia's first TAFE carbon fibre course

Australia's first TAFE course in carbon fibre, to be delivered by The Gordon in Geelong, Victoria, will be piloted in May with the first full intake starting in July this year.

Local companies Quickstep Technologies, Carbon Nexus, Sykes, Carbon Revolution and RPC Technologies along with Composites Australia, represented by board member Roger Cater, have been involved in developing the course since August last year, helping to tailor the curriculum to the advanced composites sector's unique needs.

Steering Committee chair Carl Dekoning of Quickstep Technologies says, "The carbon fibre sector in Geelong needed an accredited course for new entrants to the industry. This course focuses on carbon fibre composites manufacturing processes and materials."

Accredited in February this year by the Victorian Registration & Qualifications Authority, the course is an initiative of Skilling the Bay, a Victorian government funded project initiated and established by The Gordon and Deakin University in response to local economic and industry changes, including the closures of the Port Henry Alcoa smelter in August 2014 and Ford's manufacturing plant (scheduled for October 2016).

The Gordon's Head of Innovation and Strategy, Dr John Flett, says the six week course will give participants the background required to be 'fast tracked' into roles with growing advanced manufacturing companies that are using carbon fibre composites.

"We know, for example, that Carbon Revolution has major plans to expand its operations and double the size of its facility and will need a large number of people in the next 12 months or so, and others like Quickstep are growing quickly," he said.

Carbon Revolution has already ramped up its production workforce to meet its contract to supply carbon fibre wheels for every new Ford Shelby GT350R Mustang coming out of North America as well as growing demand from other OEMs, racing teams and high performance car enthusiasts. Production in the company's $24m factory in Waurn Ponds is already creating an additional 108 jobs in this initial phase of expansion, with potentially significant further growth to follow, says Carbon Revolution chief executive, Jake Dingle.

A contract with the Ford Motor company has created an additional 108 jobs at Carbon Revolution's $24 million factory in Waurn Ponds. Image courtesy Carbon Revolution

Quickstep has a contract with Thales Australia for the production of the bonnet, side skirts and mud guards for the Hawkei, the next generation of armoured vehicles for the Australian Defence Force. Quickstep will produce the parts at its Waurn Ponds automotive plant, where it has recently started production of an innovative carbon fibre air duct system for the Ford Falcon XR6 Sprint.

"We are proactively growing emerging industries in Geelong through targeted skills development initiatives," says Carley Brennan, Manager of Skilling the Bay. "We look forward to the course attracting new entrants to the sector and contributing to innovation in Geelong's composites manufacturing companies."

Above. Carbon Revolution's carbon fibre wheels will be on every Ford Shelby GTR350T Mustang.

Left. Quickstep is growing its Waurn Ponds workforce to supply an innovative carbon fibre air duct system for the Ford Falcon XR6 Sprint. Image courtesy Quickstep Holdings

Course information: Rory McNamara, Program Manager, Advanced Manufacturing Technologies, The Gordon
T: 03 52 466 046 E: rmcnamara @ gordontafe.edu.au

Spotlight on Training

Queensland: PARTEC Institute

There's something energising about every aspect of Australia's largest composites training centre, Queensland's PARTEC Institute. Its teachers, graduates and leadership are enthused about working with fibre composites.

"We want students to go back to their workplace energised and excited about what they have learned," says Manager Roger Cater. "They gain the skills and are motivated to contribute to their workplace.

"Training doesn't represent loss of productivity. Employers tell us productivity improves. It's the way we teach and our facilities. We are a simulated factory with the latest equipment and the teacher is their supervisor. It's non-classroom training."

The 500 square metre Brisbane composites training centre is set up as a small manufacturing enterprise and equipped for hand lay-up, resin infusion and gel-coat spray-up. Equipment includes a 3-axis CNC router, a pre-preg storage freezer (-30oC) and a temperature and humidity-controlled clean room for aerospace composites work.

A registered Training Organisation, PARTEC delivers the Certificate III - Composites Technician apprenticeship, plus short courses in areas such as tooling design, toolmaking and CNC operation, pipeline welding, injection moulding and FRP short courses. Tailored courses are also delivered to meet a company's particular needs.

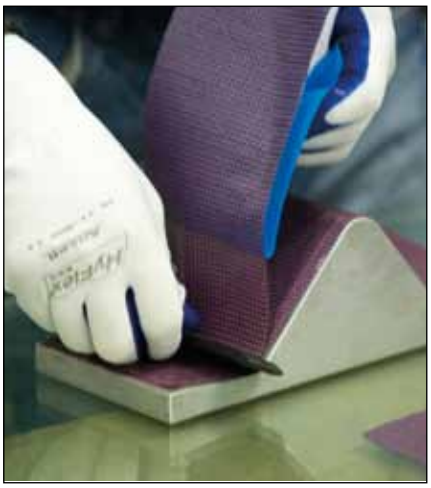
Apprentices currently come from as far afield as Tasmania.

An audit committee, made up of representatives from manufacturing, material suppliers and graduates, regularly reviews the centre's standard of training and identifies new and emerging industry requirements and overseas trends to keep pace with industry needs.

"We don't allow the training to fossilise," says Mr Cater, who is working towards establishing a similar centre in northern NSW to fill the gap left by the closure of Newcastle TAFE two years ago.

"We know there are manufacturers in northern and central NSW looking for apprenticeship training for their people. We are looking at providing half their course here in Brisbane at the training centre and half in the workplace. When it gets to the stage of being self-sustaining, then we can re-open the Newcastle centre," says Mr Cater. "Cross-border NSW and Queensland government collaboration is developing slowly, with the harmonisation of qualifications now being encouraged by Canberra."

More than 300 composite technicians have graduated from PARTEC's Composites Training Centre.



Industry, university education collaboration

The University of Queensland is building relationships with local composites manufacturers to provide students with applied research and education opportunities and the businesses with the opportunity to explore new technologies and solutions.

For Northgate-based composites transport specialists, Fibreglass Design Panels, the relationship began at the 2015 Composites Australia CRC-ACS Conference, where Director Leona Reif met Michael Heitzmann, a lecturer and one of the main drivers behind the University's recently expanded UQ Composites Group.

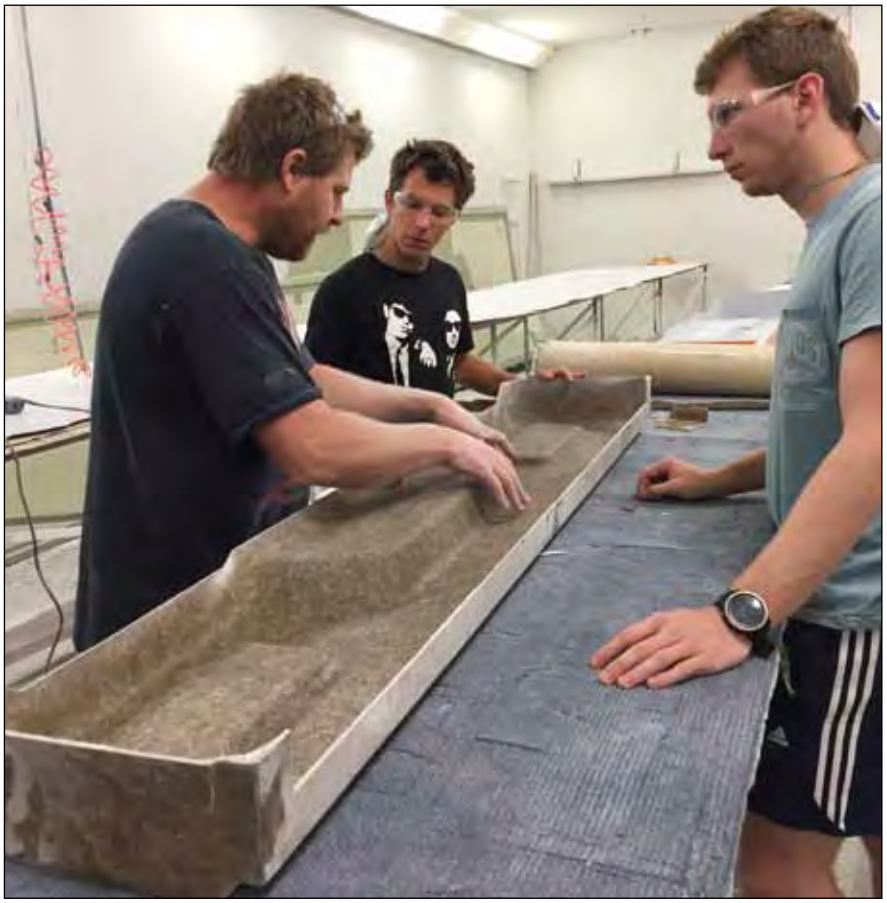
"UQ was keen to link their students with industry when undertaking their research projects and we were interested in exploring new materials and applications for composites and supporting education in the composites sector," says Ms Reif.

The decision was made to collaborate on the development of a biocomposites solution for one of FDP's existing products – a rear bumper bar used on food van conversions to suit trayback utilities.

"Biocomposites have been around for a few decades but the number of commercialised applications remains very low despite a lot of effort in this field. This is partly due to the complex supply chain which, in many applications, is not yet continuous from field to product, however a lack of end-product focus in the research is at least partially to blame," says Dr Heitzmann.

Fibreglass Design Panels offered practical support, providing the tooling and advice on manufacturing processes and current costings, plus a glass fibre product sample for comparison to the bio-fibre under investigation.

Students Nathan Basford and Fabian Fullenwarth visited the factory several times during the six-month project, which involved a comprehensive set of 'coupon level' tests to establish the material properties required for simulation and design. In the design phase finite element methods were used to develop a bumper that matched the existing fibreglass version in strength and stiffness. Ultimately, a series of manufacturing trials developed the manufacturing procedures and produced two demonstrator products.



L-R: Dieter Heydenrych, Production Manager with Fibreglass Design Panels, discusses the biocomposite demonstrator product with its developers, University of Queensland engineering students Nathan Basford and Fabian Fullenwarth.

The project used natural fibre non-woven mats, kindly supplied by the Composite Innovation Centre in Manitoba/Canada, along with a detailed business case for the mats.

The project demonstrated that the use of agri-fibre composites has the potential to achieve a cost as well as a weight advantage with comparable mechanical performance to a fibreglass design. However, the project also demonstrated that the gains are relatively modest and heavily influenced by material selection, component geometry and manufacturing method.

The students graduated with both research skills and knowledge of composites, and having gained invaluable industry-based experience. "The project also showed that industry/university collaborations don't always require lengthy funding applications and complicated legal agreements," says Dr Heitzmann.

For Fibreglass Design Panels the project marks the beginning of a working relationship with the university that can further explore the application of bio-composites, specifically targeting the requirements of product end-users.

Western Australia

Industry driven composites, marine craft training

Lloyds representative Rao Doddi verifies jointing quality during a Challenger training session in Darwin.

Western Australia's Challenger Institute of Technology has been providing training in composites and marine craft construction (shipwrighting) for more than ten years.

Since transitioning from the polymer processing certificate to composite engineering in 2012, there has been a decline in composites apprentices, says lecturer Duane Davison.

"In contrast, there has been a resurgence in student numbers for the marine craft construction apprenticeship training driven by the lower Australian dollar and led by Vikal designers and builders of luxury superyacht tenders and Echo Yachts, luxury yacht designers and builders.

"For the past 18 months, with our industry partners Lloyds Register and Peter Kirkwood, managing director of Resiglass, we have also been providing training and certification to GRP pipe fitters, supervisors and inspectors to ISO14692 Petroleum and Natural Gas industries standards.

"This certification is a requirement for those working on major LNG projects with Inpex in Darwin, Gorgon on Barrow Island and desalination plants," says Mr Davison.

Footnote: Challenger will become TAFE WA (South Metropolitan) in mid-2016.

Composites trade course for NSW

GOTAFE will start offering apprenticeship training in NSW from July this year.

Brett Ambrosio, GOTAFE Commercial Manager for Automotive, Engineering and Marine Craft Construction, says the course will fulfill the need for apprenticeship training for the composites manufacturing sector in the state.

The course will be delivered on-site by an experienced composites trainer and will be eligible for NSW government funding under the training provider's existing approval with the NSW Apprenticeship and Traineeship Training Program, says Mr Ambrosio.

Based in north east Victoria, GOTAFE took on delivering the Certificate III in Engineering – Composites Trade in 2015, taking over from Kangan Institute, which had launched the course in Victoria in 2014.

"We are fortunate to have highly respected and experienced trainers, including Phil Bovis, on the team," says Mr Ambrosio.

GOTAFE is now in its fourth year of delivering the Certificate III in Marine Craft Construction which has seen numbers grow to 40 students across Victoria.

"The qualification packaging has been designed on the assumption that competency will be developed through an integrated combination of on and off-the-job learning strategies, such as those delivered through a formal apprenticeship.

"Apprentices in both courses receive quality time in their workplace with GOTAFE trainers who provide practical training and interaction relevant to the workplace needs while extensively covering the curriculum and responding to questions face-to-face.

"There is no composites apprenticeship training program available in NSW at present and with an excellent team of composites trainers onboard we are looking forward to filling that gap starting mid-2016."

GOTAFE courses offer competencies in both manufacturing and repair, including developing and layup of composite parts and tooling, adjusting resin chemicals and selecting and using joining techniques.

More information: Contact Brett Ambrosio T: 1300 468 233 | E: bambrosio@gotafe.vic.edu.au.

Composites by design

Bespoke furniture design calls for composites

The Wishbone bench seats in Hobart's new Brooke St Pier create a striking sculptural impact for tourists taking the ferry to MONA. Photographer Peter Whyte.

The beauty of resin composites is centre stage in Hobart's new $12 million Brooke Street Pier, a remarkable floating structure that provides the gateway to the River Derwent for the state's most popular tourist attraction, the Museum of Old and New Art (MONA).

London-based furniture designer Brodie Neill designed the ferry terminal's Wishbone bench seats to create a striking sculptural impact for those art lovers and the curious who are embarking on the eclectic experience for which MONA is now world famous.

Commissioned by Brooke Street Pier Development Corporation, the 14 benches designed by Tasmanian-born Neill were built by Tasmania-based Penguin Composites.

Neill, who launches his furniture collections at some of the world's most famous design events, took his inspiration for this home-town commission from the whale vertebrae which frequently wash up on Tasmanian beaches. He chose Glass Reinforced Polymer (GRP) to realise the long, undulating three-way symmetry of his organic design. Continually experimenting with high concept, technology-driven design that pushes materials to the limit, many of Neill's pieces showcase the strength and fluid forms that only carbon fibre and resin composites can deliver.

Based on Neill's CAD design, John van der Woude's team at Penguin Composites engineered and manufactured the four black and eight white benches, CNC cutting the moulds for the Light RTM process and sensor cutting the plywood grid internal structure to the final matt paint finish. Delivered within a very short timeframe to meet the official opening date, the Wishbones are a notable addition to the diverse project portfolio for Penguin Composites.

Architect pushes the boundaries of advanced composite technology

Award-winning British architect Amanda Levete designed the 2015 MPavilion, a high-tech, ultra-thin forest-like canopy that 'sways' in the breeze, responding to the climate and landscape changes.

Ms Levete best known for her ground-breaking redesign of London's Victoria and Albert Museum entrance and the sci-fi inspired media centre at Lord's Cricket Ground, collaborated with Brisbane-based mouldCAM to realise her eccentric vision.

Standing in Melbourne's Queen Victoria Gardens throughout the 2015/16 summer, the installation comprises a series of five-metre wide translucent 'petals' that light up at night and transform into amplifiers for public performances. Each petal is a mere three millimetres thick.

MouldCAM managing director Toby Whitfield and his partner, Jaime Marina, drew on their expertise in advanced composite materials to create the complex shapes and structures, integrating the lighting and sound technology.

"It's a beautiful example of how new materials and technology can be taken outside their normal application to deliver unique results," says Mr Whitfield. "It looks absolutely amazing."

MPavilion is a unique architecture commission and design event for Melbourne, initiated by the Naomi Milgrom Foundation with support from City of Melbourne and the Victorian government.

Architect Amanda Levete's high-tech advanced composites forest features translucent petals, 5m wide and just 3mm thick, that sway in the breeze on their carbon fibre stems. Photographer John Gollings

Realising the competitive potential of composites additive manufacturing

Professors Milan Brandt and Murray L. Scott assess the potential of additive manufacturing in the design and production of composite parts directly from CAD.

Additive Manufacturing (AM) or 3D printing is now the fastest growing sector of manufacturing globally. The main driver is globalisation, which is changing the nature and economics of manufacturing in 'high-wage' countries such as Australia.

Big is possible: The Strati electric car, 3D printed in two days from carbon fibre reinforced plastic at the 2014 IMTS show in Chicago USA by Local Motors in collaboration with Oakridge National Laboratory and Cincinnati Incorporated.

With additive technologies, parts can be built directly from computer models or from measurements of existing components, bypassing traditional manufacturing processes such as cutting, milling, casting and grinding. AM also enables new designs that are not possible using conventional subtractive technology; it saves time, materials, wastage, energy and other costs and significantly reduces environmental impact and the time-to-market for new products.

Ever since composite materials were first introduced they have been pushing the boundaries of performance and lightweight design in all branches of engineering. Composite manufacturing processes are, in essence, additive processes. In order to reduce the reliance on labour-intensive manual operations and the need for a flexible automated composite process, organisations are investigating the feasibility of implementing AM techniques to aid the fabrication of composite parts.

AM can be implemented in the composite production process in a number of ways. This article highlights the potential of AM in the design and manufacturing of composite parts directly from CAD, in relation to fibre reinforced thermoplastics in particular.

MarkForged has developed a process for fusing carbon fibre to other thermosetting materials and is marketing a small desktop printer for this purpose. The printer allows users to embed electronics, sensors, ball bearings, hard mounting points, amongst other things, into 3D printed parts made with carbon, glass and/or aramid fibres.

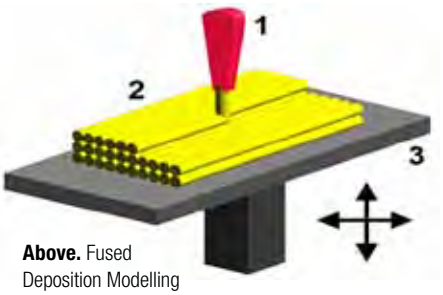
AM technologies relevant to composites have been around for a number of years and some have been used in production. The AM techniques that have predominantly been used with fibre composites are stereolithography (SL), fused deposition modelling (FDM) and laminated object manufacturing (LOM). In a powder-based AM technique, such as selective laser sintering (SLS), it is difficult to draw smooth layers of the powder-fibre mixture. Long or continuous fibres (instead of short fibres) are difficult to incorporate into composite processing, therefore their use has been limited to LOM and SL techniques.

FDM, pioneered by Stratasys Inc., is one of the most widely adopted AM techniques. In the fused deposition process, a spooled filament of a thermoplastic polymer is fed into a liquefier (as shown at right) with the help of a pinch feed mechanism. The incoming solid filament acts as a plunger in order to extrude the material, in the form of a molten bead, through a circular nozzle. The extruded polymer is deposited onto the build platform or previous layer according to a fill pattern, which is established by software pre-processing. When the layer is completed, the build platform is lowered and the cycle repeats. This AM technology, which uses the FDM filament-based extrusion technique, requires the material be processed into a filament form. This filament is extruded to a very high diametric tolerance. Parts obtained from the FDM process have mostly been used for model visualisation and form/fit verification; however, in recent years,

a number of new materials have been investigated that enable FDM to produce fully functional parts by incorporating a reinforcing material into the polymer matrix.

Researchers have experimentally produced a short glass fibre reinforced ABS (GFABS) polymer to use as an FDM feedstock material with fibre contents up to 18 Wt%. It has been shown that the addition of glass fibres resulted in a higher tensile strength under longitudinal loading, however the addition adversely affected the adhesive strength between the layers in comparison with pure ABS. The adhesive strength between the adjacent layers of GFABS improves with the increase in fibre content. This suggests that higher fibre content provides a better chance of the glass fibres bridging the adjacent layers prior to the solidification of the ABS matrix; however there has been limited research to date on the effect of fibres on the bond formation between adjacent layers.

The application of reinforced thermoplastics containing carbon nanofibre and carbon nanotube as feedstock materials for FDM has been investigated, showing that a high degree of fibre alignment is possible, resulting in an improvement in strength. However, a drastic decrease in elongation to the point of failure can occur as the fracture mode changes from ductile to brittle. The feasibility of using thermotropic liquid crystalline polymers (TLCPs) in a commercial FDM machine has also been studied. The mechanical properties of some basic shapes have been compared to parts created from ABS, showing that the tensile moduli of 40 Wt% TLCP composites were significantly greater than those of ABS.



Above. Fused Deposition Modelling Process (FDM): **1.** Nozzle ejecting molten filament; **2.** Deposited material (modelled part); **3.** Controlled movable table.
Source: Stratasys Inc

Above right. The Mark One MarkForged manufactured part with embedded sensor. Source: MarkForged

In conclusion, AM technologies are growing in importance globally because of the benefits they offer when compared to conventional techniques. In the composites arena, the major challenge for researchers and manufacturers is to improve the structural integrity of the parts through the addition of reinforcing filler materials and new deposition technologies.

About the authors:
Professor Milan Brandt is Technical Director of the Advanced Manufacturing Precinct and Director of the Centre for Additive Manufacturing at RMIT University.
Professor Murray Scott is Managing Director of Advanced Composite Structures Australia Pty Ltd and an Adjunct Professor at RMIT University.

Composite Sandwich Structure Design Requirements

Composite Engineer's Viewpoint
By Rik Heslehurst PhD, MEng, BEng (Aero) FIEAust, FRAeS, CPEng

Part 6 – Failure Modes and Analysis

This article covers Sandwich Panel Failure Modes and Analysis – Face Sheet Failure, Face Sheet Dimpling, Face Sheet Wrinkling, Core Shear Failure, Core Buckling Instability and Global Buckling.

The principal failure modes in composite sandwich structures are illustrated below. The basic design equations for the listed failure modes are provided and the important material and geometric properties indicated.

Face Sheet Failure

$$\sigma_{axial} = \frac{P}{2}\frac{1}{t_f}$$

For sandwich panels with $t_c > 4t_f$, then:

$$\sigma_{axial} = \frac{M}{ht_f}$$

Core Shear Buckling (Instability)

$$\sigma_{c_{buckling}} = \frac{G_c t_c h_c}{2dt_f} \quad \text{hollow}$$

$$\sigma_{c_{buckling}} = \frac{G_c h_c}{2t_f} \quad \text{solid}$$

Face Sheet Dimpling

$$\sigma_{cr_{dimpling}} = \frac{2\sqrt{E_1 E_2}}{(1-\upsilon_{21}\upsilon_{12})}\left(\frac{t_f}{s}\right)^2$$

Core Crush

$$\sigma_{c_{crush}} = \frac{V}{A_{c_{eff}}}$$

Face Sheet Wrinkling

$$\sigma_{cr_{wrinkling}} = \sqrt{\frac{2}{3}\frac{\sqrt{E_1 E_2 E_c}}{(1-\upsilon_{21}\upsilon_{12})}\frac{t_f}{h_c}}$$

Global Buckling

$$\sigma_{cr_{buckling}} = \frac{\pi^2}{4(1-\upsilon_{21}\upsilon_{12})}\sqrt{E_1 E_2}\left(\frac{t_c}{b}\right)^2 K$$

Core Shear Failure

$$\tau_c = \frac{V}{hb}$$

Skin Separation (wrinkle)

$$\sigma_{cr_{wrinkling}} = \sqrt{\frac{2}{3}\frac{\sqrt{E_1 E_2 E_c}}{(1-\upsilon_{21}\upsilon_{12})}\frac{t_f}{t_c}}$$

Failure Modes of Sandwich Structures

Where:

P = edge running load (N/m)
t_f = skin thickness
M = edge running moment (N.m/m)
V = transverse applied load (N)
h = distance between the skin centroids
E_c = core axial Young's Modulus
E_1 = orthotropic skin longitudinal Young's Modulus
E_2 = orthotropic skin transverse Young's Modulus
υ_{21} = orthotropic skin major Poisson's ratio
υ_{12} = orthotropic skin minor Poisson's ratio
s = distance across cell space
h_c = core depth
G_c = Core shear modulus
b = panel width
d = total panel thickness (2tf + hc)
t_c = core wall thickness
$A_{c_{eff}}$ = core effective cross-section area
K = edge constraint factor

In the next issue of Connection magazine, we will discuss Sandwich Panel Bending Behaviour – specifically the factors that influence the bending performance of sandwich panels with composite

All articles published in Engineer's Viewpoint are available on the Composites Australia website (www.compositesaustralia.com.au/industry). Rik welcomes questions, comments and your point of view by email to rikheslehurst@gmail.com

Industry and research leaders from across Australia, Asia, Canada, Europe, the Middle East and the USA are heading to Melbourne in April for the 2016 Advanced Composites Innovation Conference.

To be held on 13 and 14 April at the five-star Pullman Melbourne on the Park, ACI-16 is promising two days filled with stimulating presentations and unique networking opportunities for composite professionals to keep abreast of new and emerging developments and grow their business.

"This year's conference brings together an outstanding program of speakers and presentations," says Composites Australia Executive Officer Kerryn Caulfield.

"Topics range from new and emerging manufacturing processes and technologies to emerging new markets in housing and infrastructure construction; from planting the composites 'seed' in the minds of our future engineers and designers to advancing the skills and training of our current workforce; from supply chain management to composites recycling; carbon fibre to bio-composites."

"For many delegates and speakers the networking opportunities are a very important aspect of this conference, and this year the Conference dinner provides the perfect setting, Melbourne's iconic MCG."

The conference will be opened by **The Hon. Lily D'Ambrosio MP, the Victorian Minister for Industry and Minister for Energy and Resources.**

Plenary speaker **Mr Andrew Stevens is the chair of the newly established Advanced Manufacturing Growth Centre.** He will introduce the centre and the opportunities it offers our industry and R&D organisations.

In his keynote, **Dr Leslie Jay Cohen, Senior Vice President, New Business Development & Strategic Technology with HITCO Carbon Composites**, will provide an insight into the company's transition to fully automated ATL, AFP, Drape forming production.

China-based, Mr Paul Marks, founder and chairman of advanced composite materials supplier Argosy International Inc will share his company's best practices, from the supply chain perspective, that are helping aerospace manufacturers be more efficient and cost effective.

Growing markets

Mr Michael Kemp, General Manager of Queensland-based Wagners CFT Manufacturing will discuss the long term benefits that composite materials can offer to Local Governments in their marine and civil structures.

Dr Bill Humphries, former theme leader for advanced materials in the CSIRO Manufacturing and now with the ARC Training Centre for Advanced Manufacturing of Prefabricated Housing will discuss the opportunities to grow this market.

Dipl.-Ing. Andreas De Palmenaer, Head of the carbon fibre research group at the highly respected Institut für Textiltechnik RWTH Aachen University, will provide an overview of the current carbon fibre market, its trends and future directions for a broader market penetration.

These are a few of the highlights. The full program is available at www.compositesconference.com.au

TECHNOLOGY WORKSHOP

Highly respected composites engineering consultant and educator, Dr Rik Heslehurst, will present the pre-conference workshop on Understanding, *Developing and Predicting the Unique Capabilities of Composites.* This half-day course will be held at the conference venue, Pullman Melbourne on the Park. Rik will provide an overview of the unique behaviour with composite materials by delving into the constituent materials and manufacturing requirements; discuss the development of some unique performance outcomes with composite materials and the methods of numerical analysis used to predict the unique performance capabilities of composite materials.

Towards automated composites manufacturing

Australia's first automated composites manufacturing facility has opened at the UNSW Australia.

Featuring ATL (automated tape laying) and AFP (automated fibre placement) capabilities, a major focus of the new facility is to provide industry access, enabling the Australian composites industry to develop automated manufacturing capability for the fabrication of high performance bespoke components.

There is significant industry interest in the technology, with some 80 representatives from more than 50 organisations attending a tour of the facility in February, hosted by Composites Australia and the university last month.

Professor Gangadhara Prusty, UNSW Deputy Director of the Centre for Sustainable Materials Research & Technology and Head of the Advanced Structures and Materials research group in the university's School of Mechanical and Manufacturing Engineering, welcomed guests and outlined the R&D and educational objectives of the facility.

"This next-generation manufacturing technology will open opportunities for significant international collaboration and enable leading outcomes for Australasian science and engineering in aerospace, marine, civil, automotive, renewable energy and primary resources," said Professor Prusty.

Above. Garth Pearce, Director of Undergraduate Teaching at the UNSW Mechanical and Manufacturing Engineering explains the operations of the automated tape laying and fibre placement technology.

The development of automated manufacturing capability in Australia has lagged significantly behind other nations, and had been further complicated by the lack of industry and research access to a suitable development facility.

To address this need, UNSW Australia led a successful bid for Australian Research Council Linkage funding, involving nine Australian and international research institutions and two commercial companies (CST Composites and Advanced Composites Structures Australia) to establish the facility.

Clive Watts, Managing Director of CST Composites, told the gathering: "We would all like to be able to leave the factory floor and have a coffee and come back to find a machine has done the job for us but the reality is, to succeed in manufacturing today, with the high costs we face in Australia, automation can no longer be a pipe dream, it has to be reality.

"The investment in this technology is out-of-the reach of individual SMEs — even individual universities — but this facility gives us the opportunity to work together, develop knowledge and skills that, when the time is right, we can apply to our production line of the future."

Composites Australia Executive Manager, Kerryn Caulfield, congratulated Prof. Prusty and the members of the joint funding bid for their vision and support of the advanced composites manufacturing sector: "Composites manufacturers will be able to gain access to the technology and the leading expertise of the collaborating research institutions, to be able to evaluate the opportunities and benefits such technology could offer their business and customers in the future."

Below. There was keen industry interest with guests travelling from many corners of NSW and the ACT as well as Western Australia, Victoria and Queensland.

Events Schedule 2016

April

Tuesday 12
Melbourne

Pre-conference technical workshop
A half day technical workshop with international composites engineer Dr Rik Heslehurst on the topic: *Understanding, Developing and Predicting the Unique Capabilities of Composites.*

Wednesday – Thursday 13 -14
Melbourne

2016 Advanced Composites Innovation Conference
Hosted by Composites Australia this conference offers two days of knowledge exchange, networking and business development opportunities with a strong speaker line-up of global and national industry and research leaders.

May

Thursday 5
PARTEC, Qld

Technology Workshop: High performance joint design and fabrication for composite structures
A full day workshop with international composites engineering consultant and trainer Dr Rik Heslehurst.

August

Wednesday 10
Victoria

Technology Seminar: Developing composite solutions for facades and roofing

October

Wednesday 5
NSW

Technology Seminar : Composites for Infrastructure
Details to be advised.

Wednesday 26
Victoria

Graphene – the future for high performance materials
This half day technology seminar will outline the value proposition for graphene and its potential for new, high performance polymers and composite materials.

November

Wednesday 23
Perth

Technology Seminar: A road map to lower cost of carbon fibre
Next – Generation Composite Materials
Derek Buckmaster, Director of Carbon Nexus, Deakin University, will provide an overview of the global market for carbon fibre and the journey towards mainstream applications.

December

Thursday 8
Queensland

Technology clinic: Introductory Design of Concrete Structures Internally Reinforced with FRP Bars
A full-day technology workshop with Prof Brahim Benmokrane, an internationally renown leader on the innovative use of fibre-reinforced polymer composite materials in construction, and Dr Allan Manalo, senior lecturer at the School of Civil Engineering and Surveying at the University of Southern Queensland. The workshop will be followed by the Composites Australia end of year function – a networking event with refreshments.

For full details and to register go to
www.compositesaustralia.com.au/events

Disclaimer: This schedule was current at time of going to print but is subject to change. Composites Australia is not liable for any loss or expenses incurred due to changes in the program.