ICONIC

IMPROVING THE CRASHWORTHINESS OF COMPOSITE TRANSPORTATION STRUCTURES

EU Horizon 2020 Marie Skłodowska-Curie Actions Innovative Training Networks (ITN) - European Training Network (ETN) No 721256

Proceedings of the 2nd ICONIC Summer School - *Virtual testing and design of composite structures*

27-29th August 2018

The Graduate School, Queen's University Belfast (United Kingdom)

www.iconic-itn.eu

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Preface

The European aerospace, automotive, and rail industries are committed to improving their energy efficiency to meet targets set within the EU's climate, energy and transport policies. This is motivating the increased use of lightweight composite materials in lieu of heavier metallics. To implement this transition, these industries must reach, at least, the same level of crash performance achieved with metals, but at significantly lower weight and without increasing cost. This is viewed by industry as an exceptionally challenging goal and will require highly trained engineers, versed in the myriad aspects of designing cost-effective, crashworthy composite structures, and capable of harnessing the latest research developments in the fast-changing world of composites. ICONIC aims to cultivate such a new generation of young engineers; the researchers will acquire the skills to enable the sustainable and economically-viable design of a new generation of highly efficient, lightweight transportation composite structures with superior crashworthiness. Fifteen Early Stage Researchers (ESRs) are recruited across the United Kingdom, Germany, Greece, Italy, Republic of Ireland and Sweden, in an innovative, multidisciplinary and intersectoral structured research and training programme. ICONIC is supported by a strong consortium from academia, large industrial enterprises and innovative SMEs. A comprehensive training and secondment programme equips the researchers with transferable skills to ensure future employability and career progression.

The 2nd ICONIC Summer School is the second of three ICONIC summer schools. Each summer school is hosted in a different country and focusses on a specific aspect of the process of developing composite transportation structures. Each summer school is approximately aligned to specific technical Work Packages in ICONIC, so that each ESR will be exposed to aspects of the ICONIC research programme which may not be directly related to their own activities. The 1st ICONIC Summer School on 4-6th September 2017 at the University of Patras (Greece) focussed on the development and characterisation of novel composite materials for structural applications, the 2nd ICONIC Summer School is centred around virtual testing and design of composite structures, and the 3rd ICONIC Summer School in 2019 at the University of Limerick (Republic of Ireland) will focus on the design and optimisation of composite structures. The summer schools also provide a forum for transferable skills training.

During the 2nd ICONIC Summer School, a public communication training course for the ESRs, run by external provider Channel56, and a guided tour of the Bombardier Aerospace Belfast wing facility characterise the first day. The second day begins with a career development workshop, including a leadership skills analysis to identify strengths and potential gaps for the ESRs, a presentation by Steve Orr (Catalyst Inc.) on the transition from PhD to employment for Engineers, and career experiences by a company engineer coming from academia, Dr. Andrea Faggiani from Red Bull Technology (United Kingdom), and an academic lecturer having worked in industry, Dr. Declan Nolan from Queen's University Belfast. In the afternoon of the second day, Prof. Pedro Camanho from the University of Porto (Portugal) gives a seminar on analysis models for polymer composites at different length scales, and Dr. Michel Mahé (Airbus, France) presents on virtual testing at Airbus, with a focus on the A350 success story. The 2nd ICONIC Summer School will finish with a session on virtual tools used by different companies for composite materials and perceived needs, including a panel discussion with our ESRs. During this session, Frank Kirkland from Rolls-Royce (United Kingdom) and Bas Tijs from GKN Aerospace: Fokker (The Netherlands) present.

The organisers thank the European Union's Horizon 2020 research and innovation programme for funding ICONIC and all related training activities. We thank the team of the Graduate School at Queen's University Belfast for hosting us and helping with the organisation of the 2nd ICONIC Summer School. The organisers acknowledge the effort and availability of the invited speakers.

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1. Agenda

Monday, 27th August 2018

Time	*Description*	*Presenter*
8:30 - 9:15	*Registration / Tea and Coffee*	
Transferable skills training for ESRs only - Room TR7		
9:15 - 9:30	Opening of the Summer School and welcome from the Coordinator	Queen's University Belfast - Prof. Brian Falzon
9:30 - 11:15	Public communication workshop - Part 1	Channel56 - Angelina Fusco and Malachi O'Doherty
11:15 - 11:30	*Tea and Coffee*	
11:30 - 13:15	Public communication workshop - Part 2	Channel56 - Angelina Fusco and Malachi O'Doherty
13:15 - 14:15	*Lunch buffet*	
Guided tour of Bombardier Aerospace Belfast wing facility		
14:30 - 18:15	14:30 - 15:00 Bus from the Graduate School to Bombardier Aerospace Belfast 15:30 - 17:30 Guided tour of the Bombardier Aerospace Belfast wing facility 17:30 - 18:15 Bus back to the Graduate School	
18:45	*Dinner*: 3 level Asian Fusion (31 University Road, Belfast BT7 1NA)	

Tuesday, 28th August 2018

Time	*Description*	*Presenter*
8:30 - 9:00	*Tea and Coffee*	
Career development workshop - Room TR6		
9:00 - 9:05	Introduction	Queen's University Belfast - Prof. Brian Falzon
9:05 - 10:20	Skills analysis to identify strengths and potential gaps - Analysis of LPI 360 reports and development of plans for future skills training	Queen's University Belfast Graduate School staff
10:20 - 10:45	*Tea and Coffee*	
10:45 - 11:45	Transition from PhD to employment for Engineers	Catalyst Inc. - Steve Orr
11:45 - 11:55	*Short break*	
11:55 - 12:15	Case study: Experience of company engineer coming from academia	Red Bull Technology - Dr. Andrea Faggiani
12:15 - 12:35	Case study: Experience of academic lecturer having worked in industry	Queen's University Belfast - Dr. Declan Nolan

12:35 - 13:00	Panel discussion on career experience	Queen's University Belfast - Prof. Brian Falzon
13:00 - 14:00	Lunch buffet	
Technical programme - Room TR6		
14:00 - 15:00	Analysis models for polymer composites at different length scales	University of Porto - Prof. Pedro Camanho
15:00 - 15:30	*Tea and Coffee*	
15:30 - 16:30	Virtual Testing at Airbus - The A350 Success Story	Airbus - Dr. Michel Mahé
16:30 - 16.45	*Short break*	
16:45 - 18:00	ESR Council meeting	ESR Council members
19:00	*Dinner*: Shu Restaurant (253 Lisburn Road, Belfast BT9 7EN)	

Wednesday, 29th August 2018

Time	***Description***	***Presenter***
8:00 - 8:45	*Registration / Tea and Coffee*	
Technical programme - Room TR6		
8:45 - 9:30	Overview of virtual tools Rolls-Royce uses for composite materials, and perceived needs	Rolls-Royce - Frank Kirkland
9:30 - 10:00	Tea and Coffee	
10:00 - 10:45	Virtual Testing of Composites: Adding value in the Aerospace industry	GKN Aerospace: Fokker - Bas Tijs
10:45 - 11:00	*Short break*	
11:00 - 11:45	Panel discussion	Queen's University Belfast - Prof. Brian Falzon
11:45 - 12:30	*Lunch buffet*	

Event location:

The Graduate School
Queen's University Belfast
University Road
Belfast BT7 1NN
Google maps link

2. Invited speakers

2.1 Prof. Pedro Camanho - University of Porto

Analysis models for polymer composites at different length scales

Pedro Manuel Ponces Rodrigues de Castro Camanho

Faculdade de Engenharia da Universidade do Porto, Departamento de Engenharia Mecânica, Porto, Portugal

pcamanho@fe.up.pt https://sigarra.up.pt/feup/en/func_geral.formview?p_codigo=240020

An overview of the analysis models developed at different spatial and temporal dimensions to predict inelastic deformation and fracture of polymer composite materials is presented, following a bottom-up approach. Computational micro-mechanical models are developed to understand in detail the effects of the constituents on the response of the composite material, to predict the effects of defects and to validate the models developed for the homogenised composite material. The main building blocks of the micro-mechanical models are an algorithm to generate a random distribution of fibres, and appropriate material models for all the constituents: matrix, fibre and fibre-matrix interface. The computational micro-mechanical model is also used to provide insight into the effects of ply thickness on transverse matrix cracking for several loading scenarios. The meso-mechanical models are based on a homogenised representation of the composite plies and on cohesive elements at the interfaces. The mechanical response of the composite plies is based on a directional plastic or visco-plastic mode coupled with a smeared crack model. The predicted capabilities of the model are tested by comparing its predictions with experimental data obtained in test coupons of increasing complexity. The models based on non-linear finite element models are not well-suited to perform fast preliminary optimisation of composite structures. Therefore, the use of Finite Fracture Mechanics, which combines both stress and energy-based criteria, is proposed to predict the notched strength of composite structures, including open-hole tension and compression, and large damage capability of composite structures.

About Pedro Camanho

Prof. Pedro Camanho (MSc in Mechanical Engineering, University of Porto, 1995) received his PhD in Composite Materials from the Department of Aeronautics, Imperial College London (United Kingdom), in 1999. In the same year he joined the Institute of Mechanical Engineering and Industrial Management (INEGI) as Director of the Structural Integrity Unit and the Department of Mechanical Engineering of the University of Porto as Assistant Professor. Since 2014 he has been Full Professor at the Department of Mechanical Engineering of the University of Porto. He is currently the Vice-President of INEGI. Pedro has been a Visiting Scientist at NASA-Langley Research Center since 2000, and was a Visiting Scientist at the U.S. Air Force Research Laboratory. He was a Royal Society Visiting Professor at Imperial College London (2005) and a Visiting Professor at the Laboratoire de Mécanique et Technologie, Ecole Normale Supérieure (ENS) de Cachan (2014).

His main research interests are the mechanics of deformation and fracture of advanced polymer composite materials, and new concepts for lightweight composite materials for aerospace applications such as hybrid, nano-structured, and ultra-thin composites.

Pedro is a member of the Editorial Board of Composites Part A (Elsevier), European Journal of Computational Mechanics (Taylor and Francis), and Computers, Materials and Continua (Tech Science Press). Pedro is member of the Advisory Board of the European Mechanics Society (EUROMECH), the Council of the European Society for Composite Materials (ESCM), and the Engineering Panel of the European Research Council (ERC). He is former Director of the MIT-Portugal Engineering Design and Advanced Manufacturing (EDAM) focus area doctoral programme in Leaders for Technological Industries, and is External Examiner of the MSc in Composite Materials course from the Department of Aeronautics, Imperial College London. He coordinated several research projects funded by the European Space Agency, Airbus, NASA, Embraer, Daimler AG, Aernnova, European Union, FCT and U.S. Air Force. He was invited to give several plenary lectures: 7th EUROMECH Solid Mechanics Conference (2009), International Conference of Composite Structures - ICCS (2009, 2011 and 2013), Composites Testing and Model Identification Conference - CompTest (2013), Conference on Numerical Methods in Engineering - CMN (2007 and 2013), Spanish Conference on Fracture Mechanics (2012), Spanish Conference on Composite Materials (2011), 5th ECCOMAS International Conference on Computational Modeling of Fracture and Failure of Materials and Structures (2017), and 5th ECCOMAS Thematic Conference on the Mechanical Response of Composites (2017). He also presented a plenary lecture at the 2013 EADS Composite/Metallic Days Conference in France, and was the chairman of the 3rd Composites Testing and Model Identification Conference - CompTest (2006) and the 1st ECCOMAS Conference on the Mechanical Response of Composites (2007). He presented invited seminars at several Universities, including Stanford University, MIT, Imperial College London, University of Bristol, University of British Columbia, University of Victoria, Instituto Tecnológico de Aeronáutica, TU Delft, TU Munich, University of Limerick, Oxford University, EPF Lausanne, Monash University, Université Catholique de Louvain, Polytechnic University of Catalonia, and ENS-LMT Cachan.

Pedro is the recipient of the 2006 NASA H.J.E. Reid Award for Outstanding Scientific Paper, the 2005 Young Researcher in Applied and Computational Mechanics Award from the Portuguese Association of Theoretical, Applied and Computational Mechanics, the 2005-2009 Engineering Fracture Mechanics Most Cited Articles Award, and the 2016 Mechanics of Materials Highly Cited Research Award. He has published over 100 papers in international peer-reviewed journals that received over 6800 independent citations (Scopus h-index of 44, independent citations). His work has been successfully transferred to the industry and services: finite elements implemented by ABAQUS (Dassault Systèmes),

materials models implemented in LS-DYNA, failure criteria in HYPERSIZER, ESACOMP and ANSYS, and test methods that are used by both the automotive and aeronautical industries.

2.2 Dr. Michel Mahé - Airbus

Virtual Testing at Airbus - The A350 Success Story

Michel Mahé

Airbus, Toulouse, France

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Latest aircraft developed in the past decade by major aircraft manufacturers have pioneered composite fuselage, for example Boeing B787 and Airbus A350, aiming at increased performance targets together with lower maintenance efforts while addressing at the same time recurrent costs and non-recurrent cost challenges.

The development of composite or hybrid composite-metallic fuselage has naturally raised questions from airworthiness authorities, aiming at demonstrating a similar level of safety as compared to existing metallic fuselage designs. Implementation of new technologies and innovative design principles, enabling taking full benefit of latest generation composite materials, has at the same time raised new challenges in terms of structural behaviour anticipation and demonstration.

These challenges have especially been accessible thanks to virtual testing, from lower level material coupon tests up to complete aircraft level. Virtual testing has supported all phases of the aircraft development, from architecture trade-offs up to certification demonstration, including active support to detailed design optimisation hand in hand with manufacturing engineering.

The classical building-blocks test pyramid approach has been used jointly between physical testing and virtual testing, demonstrating ability to predict damage from local failure modes up to overall failure mechanisms. Moreover, in the case of the A350 programme, virtual testing capability has actively and directly supported the seven years of aircraft development, covering static, thermo-elastic, fatigue, dynamics/crashworthiness up to the first flight and certification.

About Michel Mahé

Michel Mahé, PhD, is Senior Expert for Dynamic Analysis at Airbus Commercial Aircraft. Graduating in Structural Mechanics from ENS Cachan in 1986, Michel received his doctorate degree from SUPAERO in Toulouse (France) in 1990.

Since he joined Airbus in 1987, Michel has been leading diverse non-linear FEA simulation solutions in the areas of both static and dynamic applications. His expertise is especially covering bird strike, tyre debris impact, open fan blade-out, hail, ballistics, crashworthiness and ditching. Michel led the A350 Fuselage Crashworthiness development up to certification and the first Airbus operational application of complete aircraft non-linear FEA Virtual Testing, contributing to de-risk A350 static testing. Michel has been involved in several accident investigations, leading dynamic analysis and testing, and presenting outcomes during trials, in front of courts.

Michel has taken part in international research projects including six European Union-funded projects. He has authored over 40 international journal and conference papers, and is member of the scientific committee of scientific organisations such as NAFEMS, 3AF and CMH17. Additionally, Michel is Professor of Computational Structural Mechanics at SUPAERO and Eurosae in Toulouse.

2.3 Frank Kirkland - Rolls-Royce

Overview of virtual tools Rolls-Royce uses for composite materials, and perceived needs

Frank Kirkland

Rolls-Royce, Derby, United Kingdom

https://www.rolls-royce.com/

Frank Kirkland's presentation will focus on the industrial challenges of structural engineering with particular focus on composite materials. It will introduce some of the issues in the real world when designing and analysing structures. This will be backed up by some discussion around what can happen when this is not done correctly and Rolls-Royce's approach to ensure that this is not the case.

About Frank Kirkland

Frank Kirkland has over 30 years of experience at Rolls-Royce. He has held roles ranging from Chief Designer Engineer to Chief Audit Engineer and Engineering Executive for one of Rolls-Royce's internal operating units. He is also Chairman of the Aerospace Partnership between the Institution of Mechanical Engineers, Institution of Engineering and Technology and Royal Aeronautical Society.

Frank has a wide range of expertise, but his main interests reside in the areas of Mechanical Design, Integrity, Analysis, Materials and Certification issues. He also has specific knowledge of fatigue & fracture, fan blade off, handling of structural loading and approaches to system/robust design.

2.4 Bas Tijs - GKN Aerospace: Fokker

Virtual Testing of Composites: Adding value in the Aerospace industry

Bas Henricus Antonius Hermanus Tijs

GKN Aerospace: Fokker, Papendrecht, The Netherlands

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With the recent growth in available computational power and advanced modelling techniques, the use of efficient simulation tools has the potential to enable economic advantages for the aerospace industry. This presentation summarises the recent developments and implementation of a Virtual Testing methodology in an industrial environment to predict the mechanical behaviour of composite material through the different scales of the conventional physical testing pyramid.

At the lower end of the testing pyramid, material behaviour is tested by means of coupon testing. These coupons form the basic building-blocks during the conventional design & certification approach of aircraft structures. However, availability of design allowables is generally limited early on in the design and the reliance on physical testing makes it difficult to achieve confidence in new structural concepts. Large-scale tests, such as (post)buckling test panels and full-scale components, are expensive and take place at a stage when it is difficult to make changes. In order to mitigate these challenges, it was decided to start the development of a Virtual Testing strategy to provide an alternative for physical testing and to increase the understanding of the failure mechanisms of new structural concepts.

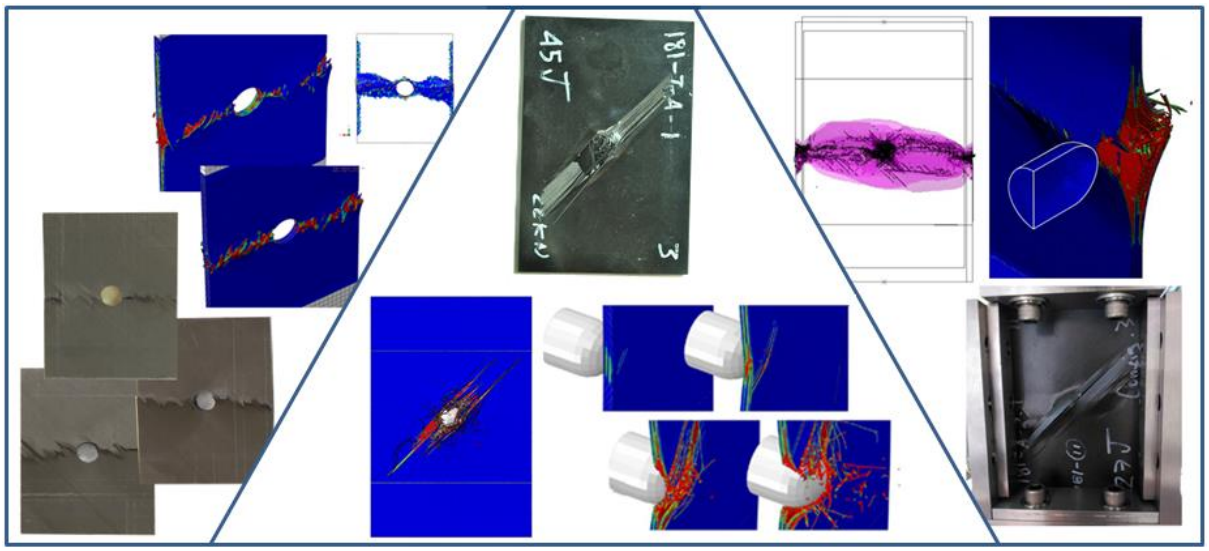

Figure 1. Virtual Coupon Testing, simulation versus test result (Tijs *et al.*, 2018).

At the coupon scale, a Virtual Coupon Testing strategy (Lopes *et al.*, 2016; Falcó *et al.*, 2018)

implemented in the finite element package ABAQUS takes into account the physical mechanisms of damage at lamina level. Modelling the coupons is automated by means of Python scripting to allow for rapid generation of virtual allowables. Both the progressive failure mechanisms and the failure load have been predicted with high accuracy with respect to the results obtained experimentally for plain, open-hole, low-velocity impact and compression-after-impact tests (Figure 1).

Higher up the testing pyramid, at structural detail and panel level, it is not computationally efficient to model the composite structure in full detail. At this scale the emphasis is at global structural behaviour, for example during (post)buckling and the performance of critical interfaces such as skin-stiffener connections are of high importance.

During the development of the Thermoplastic Orthogrid Fuselage Shell (Figure 2; van Ingen, 2016; Tijs *et al.*, 2018), which features new thermoplastic materials and a fastener-free design, a hybrid simulation-physical testing approach was chosen to allow for an increased understanding of failure mechanisms and structural response through the different scales of the testing pyramid.

For the development of a thermoplastic fuselage for the next generation aircraft, as part of the STUNNING project, the Virtual Testing strategy will be further developed and coupled with taking into account the influence of the manufacturing process in order to allow for zero-defect and high-rate manufacturing.

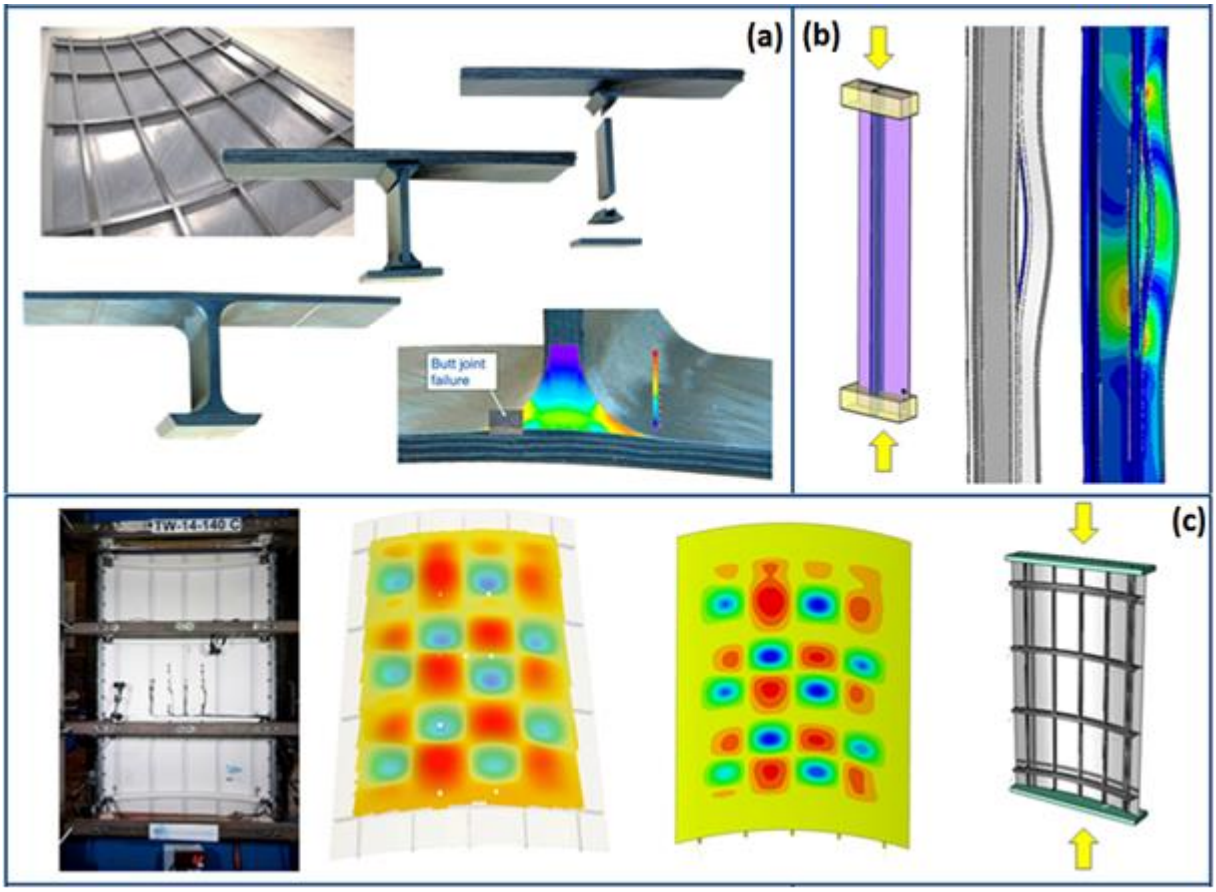

Figure 2. (a) Manufacturing of orthogrid and stress concentration at SFRP filler. (b) Simulation of Short-column test specimen with delamination. (c) Post-buckling compression panel test (van Ingen, 2016; Tijs *et al.*, 2018).

References

Lopes, C.S., González, C., Falcó, O., Naya, F., Llorca, J., and Tijs, B. (2016). Multiscale virtual testing: the roadmap to efficient design of composites for damage resistance and tolerance. *CEAS Aeronautical Journal* 7(4), 607-619, doi:10.1007/s13272-016-0210-7.

Falcó, O., Ávila, R.L., Tijs, B., and Lopes, C.S. (2018). Modelling and simulation methodology for unidirectional composite laminates in a Virtual Test Lab framework. *Composite Structures* 190, 137-159, doi:10.1016/j.compstruct.2018.02.016.

Tijs, B.H.A.H., Lopes, C.S., Turon, A., Bisagni, C., Waleson, J., van Ingen, J.W., and Veldman, S.L. (2018). Virtual testing of thermoplastic composites: towards a hybrid simulation-physical testing pyramid. *Proceedings of the 18th European Conference on Composite Materials (ECCM18)*, 24-28th June 2018, Athens, Greece.

van Ingen, J.W. (2016). Thermoplastic orthogrid fuselage shell. *SAMPE Journal* 52(5), 7-15.

About Bas Tijs

Bas Tijs has over 10 years experience as a stress engineer at Fokker in the Netherlands (now GKN Aerospace), where he started his career with the fatigue & damage tolerance certification and full-scale testing of the NH90 helicopter.

During his career he developed a strong interest in the development of Tools & Methods and joined the Stress Methodology group in 2012 where he has supported the development of several projects such as the Gulfstream G650, Dassault F5x and Airbus A350.

Since 2015 he is leading the development of advanced simulation techniques such as Virtual Testing & Manufacturing in collaboration with academia and is chair of the GKN Aerospace Community of Practice on Virtual Testing.

He is now combining his research at industry with a PhD programme at the Technical University of Delft where he will contribute to the development of a thermoplastic fuselage for the next generation aircraft.

3. Transferable skills training

3.1 Career development workshop

Leadership Practices Inventory (LPI) 360 leadership skills assessment

All ICONIC ESRs and affiliated PhD students were asked to conduct a LPI 360 leadership skills assessment online. LPI 360 is an observer-based tool for leaders and managers at all levels to gather important insights from the students' own perspective and others who have direct experience of the individual person in a leadership role. The goal is to define management and leadership skill gaps of each young researcher to define personal development plans for future skills training.

LPI 360 involves a LPI self instrument, completed by the students, and the LPI observer survey. For the latter, approximately 8-10 people should be chosen to complete the survey for the students. This should involve people who have had an opportunity to observe the students' leadership behaviours.

During the 2nd ICONIC Summer School, a session is conducted on reading the final reports from the completed LPI 360 leadership skills assessment, screening each section and reflecting on the feedback. This is followed by a group session together with experienced staff members from QUB's Graduate School to talk about different approaches to be taken to fill the skill gaps. In the end, the ICONIC ESRs and affiliated PhD students complete a Personal Development Plan for themselves to plan skills training.

Transition from PhD to employment for Engineers

Steve Orr

Connect, Catalyst Inc., Belfast, United Kingdom

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The nature of work is changing more rapidly now than at any time in history. Steve Orr, Director of Connect at Catalyst Inc., provides information on how early career researchers in Engineering can apply and adapt their skills to make sure that they thrive in the age of automation, not dive.

As co-founder and Director of Connect at Catalyst Inc., Steve Orr is responsible for developing the support ecosystem for entrepreneurs in Northern Ireland, to create and scale innovation companies. Steve spent ten years prior to his role at Catalyst Inc. in California where he co-founded Kineticom Inc., a San Diego (CA)-based technical talent firm in 2000. The firm ranked #33 on the Inc. 500 list of the fastest-growing, privately-held U.S. companies in 2006. Steve graduated in 1994 from Northumbria University (Newcastle upon Tyne, United Kingdom) with a degree in Business Information Technology.

Case study: Experience of company engineer coming from academia

Dr. Andrea Faggiani

Red Bull Technology, Milton Keynes, United Kingdom

Dr. Andrea Faggiani from Red Bull Technology will provide some insights into his career pathway, starting in academia and going into industry to work as an engineer. He will discuss important skills and experiences to attract his positions, and problems encountered during his career, to get where he is today.

Andrea graduated with a MEng in Aeronautical Engineering from Imperial College London (United Kingdom), in 2004, followed by a PhD in the same department, supervised by Professor Brian G. Falzon and with the thesis title 'Optimization of Postbuckling Stiffened Composite Structures'. Following his PhD, Andrea moved to Monash University, Melbourne (Australia), in 2008 and continued working with Professor Falzon on a variety of research projects in the field of non-linear FEA and optimisation, as well as composite damage modelling.

In 2011, Andrea returned to the United Kingdom and made a start to his career in the Formula 1 industry at the Renault F1 Team in Enstone, Oxfordshire, working first as a Stress Engineer analysing both composite and metallic car components, and then in the aerodynamics department looking at coupled CFD and FE analysis to optimise performance of structures. In 2013, Andrea moved to McLaren Racing, where he was in charge of developing an FE methodology for dynamic crash simulations, as well as moving forward the team's composite analysis methodology.

In 2017, Andrea started work at Red Bull Technology in his current role as a Senior Structures Engineer. Andrea is responsible for leading the design and analysis of a multitude of car components, from composite parts such as the bodywork components and suspension members, to complex metallic assemblies such as suspension uprights. Most recently, Andrea is in charge of all structural analysis of the 2019 composite chassis.

Case study: Experience of academic lecturer having worked in industry

Dr. Declan Nolan

School of Mechanical and Aerospace Engineering, Queen's University Belfast, United Kingdom

Dr. Declan Nolan from Queen's University Belfast will provide some insights into his career pathway, starting in academia, transferring into industry twice, and ultimately returning to academia as a lecturer. He will discuss important skills and experiences to attract his positions, and problems encountered during his career, to get where he is today.

Declan is Lecturer in Mechanical and Aerospace Engineering at Queen's University Belfast, with significant industrial experience. Upon graduating with a Master's Degree in Mechanical and Manufacturing Engineering from Queen's University Belfast in 2008, he undertook a role as a Stress Engineer with Williams F1. As well as an enhanced understanding of structural analysis, this gave him first-hand experience of CAE software and the challenges and limitations which it presents.

The drive to help tackle these problems and be part of future simulation solutions brought him to his first research role with Queen's University Belfast. As a Research Assistant, he worked on various CAE related research projects with a focus on integrating simulation more effectively into the overall design process, being awarded a PhD for the work in 2013.

Once again, he then returned to industry as a Composites Structural Analyst and later Senior Structural Engineer in the Composites Research and Development Group at B/E Aerospace (now Rockwell Collins), leading the structural design of lightweight composite aircraft seating components. His passion for research brought him back to Queen's University Belfast in 2017, to pursue his research interests in next generation Design/CAE systems, Composites Simulation and Bio-inspired design systems.

3.2 Public communication workshop

A four-hour workshop on public communication for our ICONIC ESRs and affiliated PhD students will help them to develop confidence and the ability to make their scientific research accessible to non-experts using clear, concise and simple language, so that diverse audiences from funders, potential employers in the public, private and academic sectors as well as the general public will understand their research efforts.

The workshop includes a mixture of short lectures, case studies and exercises with feedback, and covers the following areas:

- Identifying and targeting your audience - who are your stakeholders?
- Elements of a good story
- Key messages
- Identifying platforms for communication on traditional and digital media
- Develop a Social Media strategy
- How best to separate your personal and professional online personas and actively manage your 'net rep'

Exercises involve turning a technical conference abstract into a Facebook post, Twitter message and a blog. Participants are asked to work in groups to develop a story for a school radio programme - interviews are recorded and played back with feedback.

A follow-up session with the students two days later, during the 4th ICONIC Project Meeting, is used to test and refresh the learnings of the workshop with updated practical exercises and a more concentrated focus on social and digital media, including benefits and pitfalls and next step actions.

The public communication workshop is run by two trainers from Channel56, Angelina Fusco and Malachi O'Doherty. Channel56 is Northern Ireland's leading provider of media and communications training. Their trainers are all media professional practitioners; they do not just talk the talk, they write real stories and broadcast on television and radio. They provide a deep and practical insight into the effectiveness of the client's media communications. The Channel56 team teaches basic and advanced media management techniques to groups and individuals, tailoring the content to the client's needs.

Angelina Fusco is an independent media and communications trainer. She spent more than 30 years in BBC Northern Ireland's newsroom in Belfast working across all aspects of television, radio and Social Media. For 15 years, she was Head of TV News 'BBC Newsline', leading a team that delivered an hour of live television news across the day. Angelina also delivers training in journalism and trauma in post conflict zones such as Ukraine and Armenia. She is a member of the Content Board of Ofcom in London, a board member on Tourism NI and a member of the Heritage Lottery Fund's NI Committee.

Malachi O'Doherty, MSc PhD, is a freelance journalist/broadcaster and author who has worked with many clients from statutory and private sector organisations, training them in communication and media skills, presentation and Social Media activism. He is a regular contributor to news, current affairs and topical programmes on BBC Northern Ireland, network BBC and UTV as well as newspapers.