ICONIC

IMPROVING THE CRASHWORTHINESS OF COMPOSITE TRANSPORTATION STRUCTURES

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Proceedings of the 3rd ICONIC Summer School - *Design and optimisation of composite structures*

11-14th June 2019

Deutsches Zentrum für Luft- und Raumfahrt e.V. - DLR - Stuttgart and Augsburg (Germany)

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 a 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 3rd ICONIC Summer School is the last 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 was centred around virtual testing and design of composite structures, and the 3rd ICONIC Summer School focus on the design and optimisation of composite structures. The summer schools also provide a forum for transferable skills training.

During the 3rd ICONIC Summer School, the first day begins in the afternoon with a technical seminar, a workshop about Dassault Systèmes software for structural optimization and simulation of the lifecycle management given by Danie Kurfess (Dassault Systèmes). In the morning of the second day, after a welcome presentation by Prof Brian Falzon (Project Coordinator, Queen's University Belfast), Dr Stefan Barauer gives a seminar on IPR, technology transfer, commercialisation and entrepreneurship. The afternoon is dedicated to the first part of the technical program with two presentations given by Stephen Mc Burney (BAB) and Oswaldo Querin (university of Leeds).

In the morning of the third day two technical further seminar are given by Dr Eoin Hinchy (University of Limerick) and Julian Schäfer (Daimler) while the afternoon is reserved to give the ESRs the possibility to visit the Mercedes-Benz Museum, an occasion to appreciate the history of the design and technical development of the automotive industries.

A guided tour of the DLR Center for Lightweight Production Technology characterises the last day. During the visit, DLR researchers give presentation on the most advanced automated manufacturing technologies for the production of lightweight composite parts.

The organisers thank the European Union's Horizon 2020 research and innovation programme for funding ICONIC and all related training activities. We thank Nathalie Toso, Nicole Waibel and DLR for hosting us and helping with the organisation of the 3rd ICONIC Summer School. The organisers acknowledge the effort and availability of the invited speakers.

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1. Agenda

Tuesday, 11th June 2019

Time	*Description*	*Presenter*	*Venue*
14:00 - 14:30	*Registration / Tea and Coffee*		
Transferable skills training for ESRs only			
14:30 – 17.00	Dassault Systèmes: presentation on the use of optimisation tools and simulating lifecycle management	DS - Daniel Kurfess	Maria Gräfin v. Linden (Hörsaal) room

Wednesday, 12th June 2019

Time	*Description*	*Presenter*	*Venue*
Transferable skills training for ESRs only – IPR, technology transfer, commercialisation and entrepreneurship			
11:15 - 12:00	*Registration / Tea and Coffee*		
12:00 - 12:15	Welcome and opening of 3rd ICONIC Summer School	Queen's University Belfast - Prof. Brian Falzon DLR - Dr. Nathalie Toso	Maria Gräfin v. Linden (Hörsaal) room
12:15 - 13:00	IPR and technology transfer	DLR - Stefan Burauer	Maria Gräfin v. Linden (Hörsaal) room
13:00 - 14:00	*Lunch buffet*		
Technical programme			
14:00 - 16:00	The Challenges of Developing, Designing and Certifying The CSeries Composite Wing	Bombardier - Stephen McBurney	Maria Gräfin v. Linden (Hörsaal) room
16:00 - 16:15	Tea and Coffee		
16:15 - 17:15	Topology optimization techniques and their application for the design of composite fuselage structures	University of Leeds - Ozz Querin	Maria Gräfin v. Linden (Hörsaal) room
18:30	*Summer School Dinner* at **Wichtel**		

Thursday, 13th June 2019

Time	*Description*	*Presenter*	
9:00 - 9:30	*Tea and Coffee*		
9:30 - 10:45	Joining large-scale, light-weight composite structures using Digital Twin Technology	University of Limerick - Eoin Hinchy	Maria Gräfin v. Linden (Hörsaal) room
10:45 - 11:00	*Tea and Coffee*		

11:00 - 12:00	ESR Council		Maria Gräfin v. Linden (Hörsaal) room
12:00 - 12:45	*Lunch break*		
13:00 – 13:45	FlexCAR – A Technology Platform Concept for the Future Cyberphysical Vehicle at the Research Campus ARENA2036	Daimler - Julian Schäfer	Maria Gräfin v. Linden (Hörsaal) room
13.45 - 18:00	Suggested: Mercedes-Benz Museum		

Friday, 14th June 2019

Time	*Description*	*Presenter*
	Visit to DLR Augsburg (Center for Lightweight Production Technology)	
8:00 - 10:30	Bus transfer from DLR Stuttgart to DLR Augsburg site	
11:00 - 11:15	Welcome and introduction of DLR Augsburg	DLR Augsburg - Nicole Waibel,
11:15 – 11.45	Factory of the future	DLR Augsburg - Dr Roland Glück,
11.45 – 12.15	Automated process chain - the production of a CFRP rear pressure bulkhead	DLR Augsburg, Christoph Frommel
12:15 - 13:00	*Lunch break*	
13:00 - 13:30	Thermoplastic composite technology	DLR Augsburg – Dr Frederic Fischer.
13:30 - 14:30	Tour of DLR Augsburg facility	
14:30 - 15:00	Tea and Coffee	
15:00 - 17:30	Bus transfer back to DLR Stuttgart	

Meeting location:

DLR Stuttgart
Institut für Bauweisen und Strukturtechnologie
Pfaffenwaldring 38-40
70569 Stuttgart
Google maps link

DLR Augsburg
Zentrum für Leichtbauproduktionstechnologie
Am Technologiezentrum 4
86159 Ausgburg
Google maps link

2. Invited speakers

2.1 Daniel Kurfess - Dassault Systèmes

Use of optimization tools and simulating lifecycle management

Daniel Kurfess

Dassault Systèmes · SIMULIA EuroCentral CoE

Germany · Karlsruhe, Baden-Württemberg

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Efficient design and rational use of materials are crucial to obtain a structure as lighter as possible letting the engineers increase the payload and reduce energy consumption and emission of complex transportation systems.

Nowadays, the try-and-error approach left the place to computational tools based on optimization models automating this design step with a consequent high-cost saving in terms of time, human resources and money.

TOSCA Structure is a tool providing optimizing solutions for lightweight, high and durable performances by maximizing the structural response and minimizing the weight of the structures. The simulation-based approach allows the designers to sensitively reduce the designing time and cost even keeping the desired boundary conditions. **TOSCA** is a valuable tool for the optimization of the topology, shape and dimensions.

Insight enables engineers and researchers to integrate and automate simulation processes including the geometry design, structural simulation, fluid dynamic analysis and cost simulation maximizing the design options and driving to optimal results. Using **Insight** delivers significant benefits since it allows the industries to reduce the engineering cycle times, the product cost, the manufacturing costs, the risk and the amount of test and, on the other hand, to improve the product quality, its performance and its reliability.

About Daniel Kurfess

Dr Daniel Kurfess has over 10 years of experience in the field of simulations and optimization. He has worked at Dassault Systèmes in the last 5 years holding the role of senior technical sales specialist and senior solution consultant.

Daniel has a wide range of expertise with a particular interest on finite element simulation, computational mechanics, structural optimization, tectonic and Geodynamics. He has also published 10 research works in international peer-reviewed journals and as conference proceedings.

2.2 Stephen McBurney - Bombardier Shorts Belfast

The Challenges of Developing, Designing and Certifying The CSeries Composite Wing

Stephen McBurney

Bombardier Shorts, Belfast, United Kingdom

stephen.mcburney@aero.bombardier.com https://uk.bombardier.com

The presentation focus on the challenges addressed by Bombardier Short Belfast during the design and certification process.

Bombardier Short Belfast is a company operating in the field of the aircraft manufacturing and it specialises in the development of complex advanced composite and metallic aerostructures for civil transportation and logistics including fuselages, wings and nacelles. The C-Series represents the most advanced proposed solution exceeding the customer requirement being an outstanding competitor in the medium medium-range jet airliners. The C-Series design allows having outstanding advantages in terms of emission and noise reduction with improved efficiency and top quality components.

The use of composite wings parts pushed engineers to adopt novel approaches during the manufacturing process such as the Resin Transfer Injection (RTI). Consequently, new challenges arise during the certification process comprising a set of test ranging from the structural characterization according to *damage tolerance* and *fail-safe* philosophies to the analytical and numerical studies.

About Stephen McBurney

Frank Kirkland has over 25 years of experience at Bombardier in Belfast. He has held roles ranging from stress Engineer to Head of Stress C-Series wing.

He is Chief Engineer and Head of Stress and Mass Properties for Bombardier Aerospace products including A220 Wing, A320 NEO Thrust Reverser, Global Express HStabs, Fuselages and Nacelles and Thrust Reversers

2.3 Osvaldo Querin – University of Leeds

Topology optimization techniques and their application for the design of composite fuselage structures

Osvaldo Querin

University of Leeds

O.M.Querin@leeds.ac.uk https://engineering.leeds.ac.uk/staff/248/dr_ozz_querin

Structural optimization, in the last decades, has qualified as a crucial tool for engineers to design efficient lightweight structures by minimizing the stresses weight or compliance for given boundary conditions.

Structural optimization is the process of determining the best material distribution within a physical volume domain, to safety transmit or support the applied lading conditions. It can be grouped in size optimization, shape optimization or structural optimization.

Within the last group, topology optimization plays a leading role in designing phase of aeronautic structures by the use of different analytical and numerical methods such as optimality criteria methods and heuristic or intuitive methods.

The presentation provides a comprehensive introduction of the Sequential Element Rejection and Admission (SERA), framable within the heuristic methods, accompanied by a set of practical application of a numerical tool.

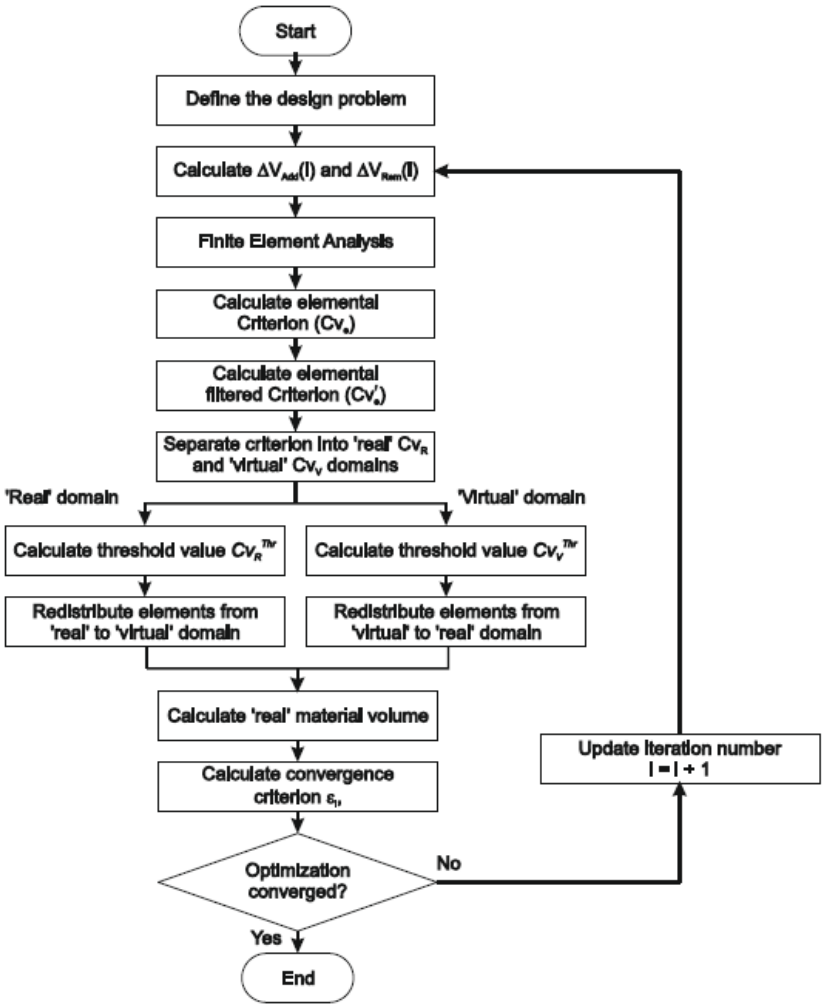

Figure 1 - Sequential Element Rejection and Admission (SERA) - Flowchart

About Osvaldo Querin

Osvaldo Querin (Master of Engineering, University Sydney, 1994) received his PhD from the University of Sydney 1998 is Associate Professor at the University of Leed.

Osvaldo's research interests lie in four different areas: Structural Optimisation, Finite Element Analysis (FEA), Computer-Based Learning and Helicopter aerodynamics & dynamics.

In particular, Structural Optimisation is the core of his research activities ranging from Evolutionary Structural Optimisation (ESO), to Shape and topology optimisation using Genetic Algorithms (GA), optimisation of a bicycle frame.

With +130 published scientific works, +3000 citations and an h-index of 24, Prof Osvaldo Querin is Senior Member American Institute of Aeronautics and Astronautics (AIAA) and a fellow of the Royal Aeronautical Society.

2.4 Eoin Hinchy – University of Limerick

Joining large-scale, light-weight composite structures using Digital Twin Technology

Eoin Hinchy

University of Limerick

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The Confirm Centre is a €47m SFI funded Smart Manufacturing research centre in Ireland. One of the key Smart Manufacturing research is Cyber-Physical Production Systems (CPPS). CPPSs have traditional physical production systems, as well as identical cyber counterparts, referred to as digital twins. These digital twins are high-fidelity digital counterparts of the manufacturing systems, which can be used to optimise business performance. One key research area of the Confirm centre is the development of digital twins for joining large-scale composite structures. The key joining techniques of interest are mechanical fastening (drilling) and fusion joining (ultrasonic welding). A digital twin of a robotic, high-TRL drilling suite will be used to monitor and optimise process performance. Live process data is fed to the digital twin, where data analytics are used to gain insights into the process. These insights can then be used to update the process to optimise performance. Additionally, a high-fidelity digital twin of an ultrasonic joining process is being developed, which uses a collaborative robot to weld CFRP specimens, which then tests the strength of the joints. A machine learning algorithm is will be used to assess the digital twin to compare process parameters to joint strength, identifying critical parameters and optimising joint strength.

About Eoin Hinchy

Dr Eoin P. Hinchy obtained his honours Bachelor of Engineering (Mechanical) from University College Dublin, before winning an Irish Research Council PhD Scholarship in 2011. Eoin commenced his PhD at the University of Limerick in 2012, where his research was focused on the repair process of nickel superalloy gas-turbine components with Lufthansa Technik Turbine Shannon (LTTS). Eoin presented at both national and international conferences during his PhD, winning an award for best poster presentation at MSI annual symposium 2015. After completing his PhD, Eoin worked with LTTS, Rolls-Royce and Johnson and Johnson on metal additive manufacturing and advanced manufacturing processes. In July 2018, Eoin commenced research in the Confirm Smart Manufacturing Research Centre in the area of Digital twin and Smart Manufacturing.

2.6 Julian Schäfer – Daimler

FlexCAR – A Technology Platform Concept for the Future Cyberphysical Vehicle at the Research Campus ARENA2036

Julian Schäfer

Daimler

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Future mobility is undergoing rapid change, which is already evident today in terms of the growing number of mobility service providers and the growing number of vehicle variants, and which will accelerate even further in the coming years. Novel mobility concepts, autonomous driving and alternative drive concepts lead to fundamental changes in the use of the automobile as well as its development and production up to the supply chain. At the same time, the trend in user behaviour is moving away from the personal property towards on-demand, intuitive and individual mobility. The dominant hardware issues in the past are losing more and more importance and mingling with software issues. The system concept of vehicle development and use is becoming more and more important.

As part of the lecture, the joint project FlexCAR will be presented, which will be edited by the members of the research campus ARENA2036. The focus of the joint project FlexCAR is on the development of an open vehicle platform for the cyber-physical mobility of the future. The focus is on the upgrade and update capability of hardware and software components. Today's trades and module structures are called into question and possibly redefined. The involvement of startups will create an opportunity to integrate innovations for the electrically-autonomous vehicle of tomorrow.

In addition to the successful handling of individual technology topics such as sensor integration and 3D printing, it shows how researchers, suppliers and OEMs can work together in a new kind of development environment.

About Julian Schäfer

10/2010 – 07/2014	Bachelor Studies: Mechanical Engineering University of Applied Science Ulm
09/2014 – 08/2017	Master Studies: Systems Engineering and Management for Mechanical Engineering
	Scientific Assistant, Institute of Design and CAx Methods
	University of Applied Science Ulm
Since 09/2017	PhD Student, Topic: Automated Design Process for Sensor Systems of Autonomous Driving based on Graph-based Design Languages
	Daimler AG and the University of Stuttgart, Institute of Aircraft Design, Dr.-Ing. habil. Stephan Rudolph
	Research Campus ARENA2036, Public Funded Project FlexCAR

3. Transferable skills

IPR and technology transfer

Stefan Burauer

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Intellectual property rights (IPR) enable researchers and companies to claim benefits for their creative efforts.

It is crucial understanding the implication of the dissemination activities and the differences occurring between a scientific achievement (i.e., a scientific publication) and a patent application to avoid huge economic losses and irreparably damage the company activities in the contest of the global market.

With the aim to give a fundamental basis to start a patenting process, a comprehensive overview is given presenting the product classes that can be protected by IPR. Starting from the experience of DLR, the patenting procedures are described highlighting the patent levels (i.e., National, European, and International).

The consequences of publishing before filing are underlined explaining the importance of the “novelty” concept.

4. DLR Augsburg

Center for Lightweight Production Technology - GroFi Platform

Today's production of large scale parts out of CFRP is dominated by the use of prepreg material. Machining development has reached a high level of maturity for this purpose, but the existing single layup systems cannot meet the demand for high productivity needed for aircraft production in high quantities. Due to this, a multi layup approach is done within the ZLP to demonstrate high productivity on an industrial scale.

The project covers the development of production processes for large scale, highly integrated components made of composite materials in automated fibre layup technologies. In this regard, a research facility is developed on the basis of several coordinated, robot-based layup units that can be moved on a rail system. The rail system is split into a manufacturing loop, that allows a circumferential movement around a double-sided moulding tool and a connected maintenance loop. In addition, the robot units are equipped with fibre placement or tape laying heads that can be used simultaneously and enables high flexibility of the manufacturing process. The aim of the project is the development of a production technology that allows a layup rate of more than 150 kilograms per hour of prepreg material

The Center for Lightweight-Production-Technology (ZLP) aligns within the programmatic research approach of the German Aerospace Center (DLR) with its core disciplines in aeronautics, space, transport and energy. ZLP seeks to enhance aeronautical research by taking production technology into account, which complements the interdisciplinary approach of DLR in research on the air transport system. Thus, fundamental assessment capabilities beginning with materials up to maintenance, repair, overhaul (MRO) will be researched. The ZLP in Stade is integrated into the building complex of CFK Nord. It covers part related technologies for fuselage production, wing production, the empennage, rotor blades as well as the automated RTM process as it will be used for both automotive application or the frame production of aircraft.

Source: https://www.dlr.de/fa/en/desktopdefault.aspx/tabid-10599/#gallery/25907