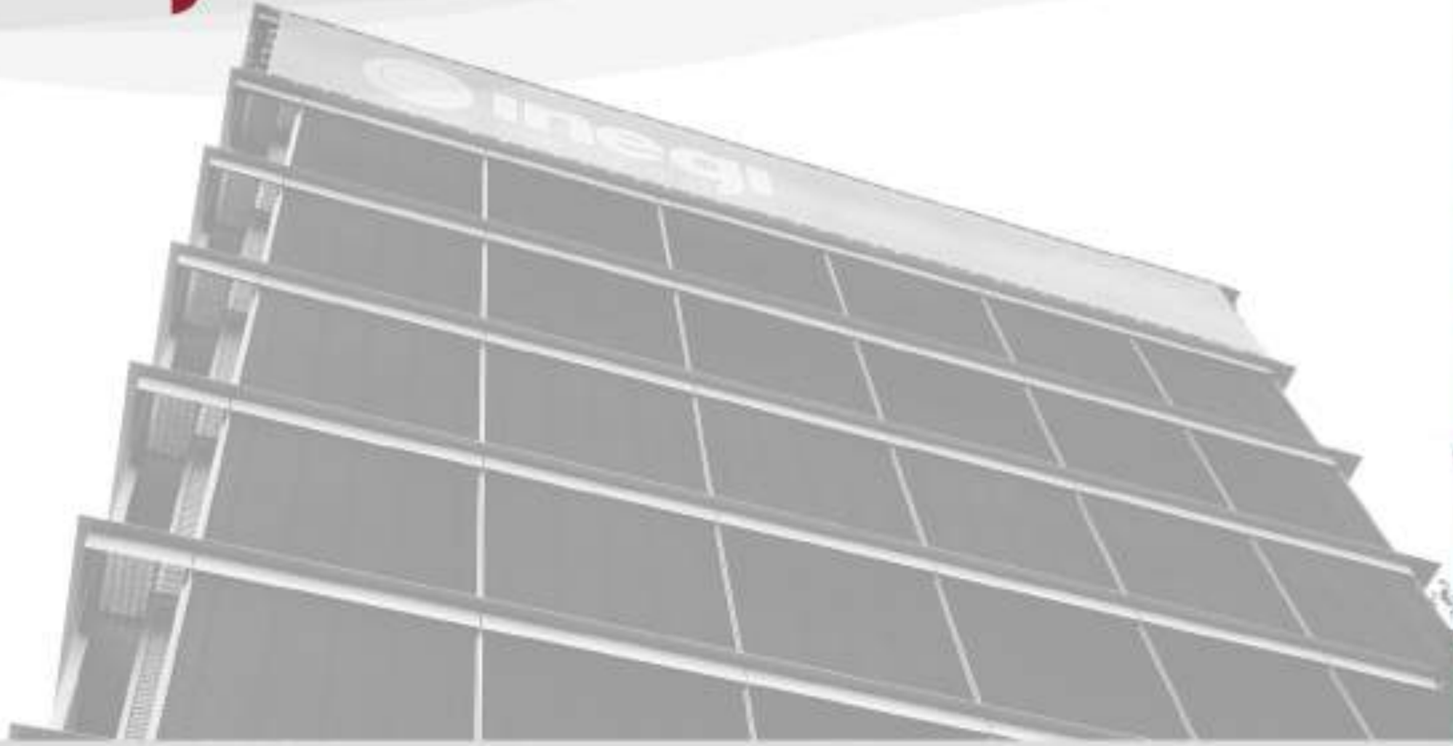


RESEARCH ON COMPOSITE MATERIALS AT INEGI

NUNO CORREIA

SEPTEMBER 27, 2017, Nottingham

INDEX

1. ON INEGI

U.PORTO

31,000	Students
24,364	1st Cycle / Degree (BSc) and Integrated Masters (BSc + MSc) Students
3,845	2nd Cycle / Masters (MSc) Students
2,049	3rd Cycle / Doctorate (PhD) Students
742	Post-Doctoral Researchers
2,200	Teachers

U.PORTO

FEUP FACULTY OF ENGINEERING OF THE UNIVERSTY OF PORTO

Undergraduate Students	4966
Msc Students	408
Phd Students	395
Teaching Staff	443
Teaching Staff (With Doctorate)	327
Non-teaching Staff	304

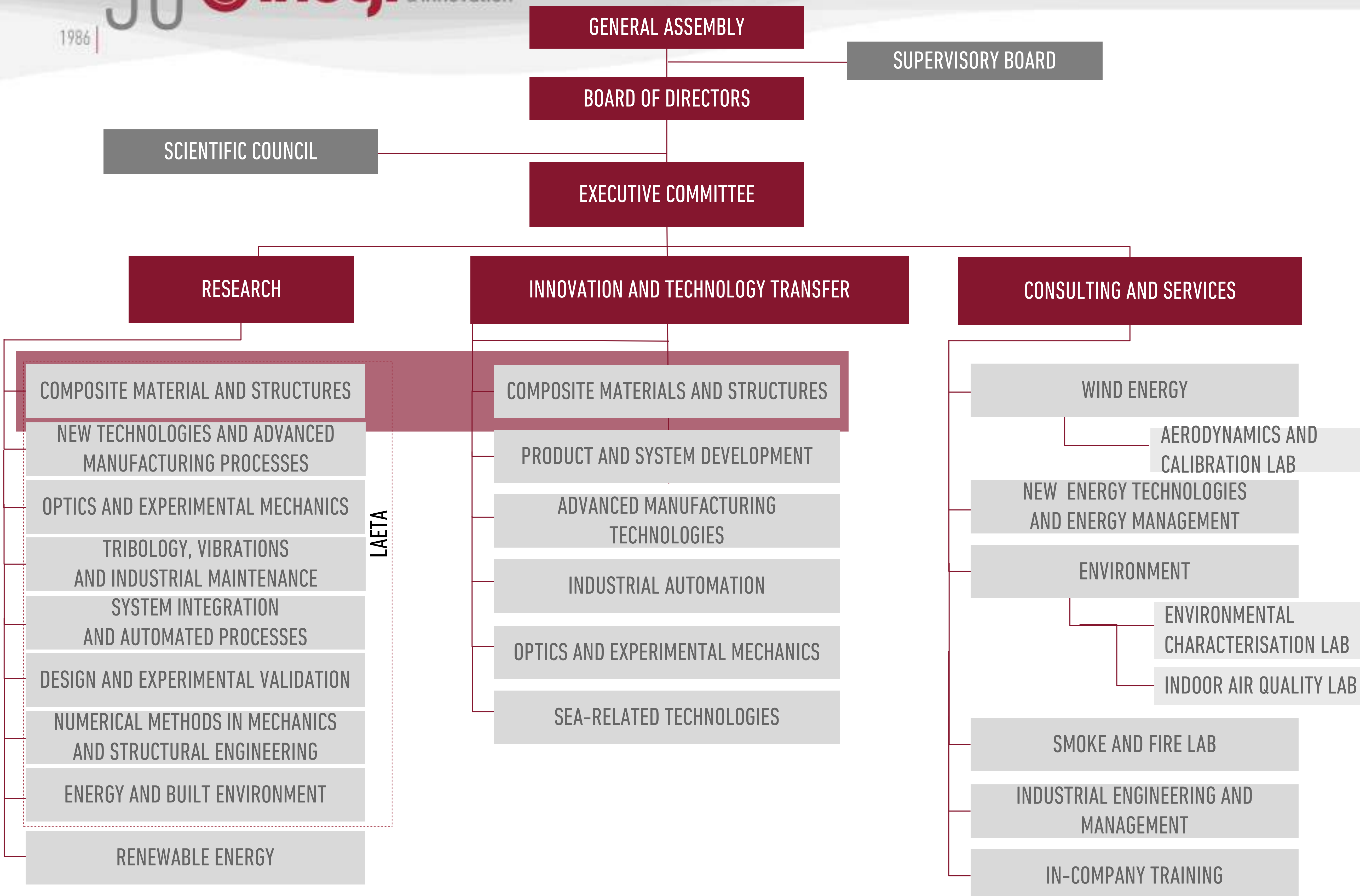
INSTITUTE FOR SCIENCE AND INNOVATION IN MECHANICAL AND INDUSTRIAL ENGINEERING

- NON-PROFIT PRIVATE ORGANIZATION
- RESEARCH INSTITUTE CREATED IN 1986 IN PORTO (PORTUGAL) AS AN INTERFACE BETWEEN UNIVERSITY AND INDUSTRY
- RESULTS FROM THE MERGING OF TWO INSTITUTES OF THE UNIVERSITY OF PORTO AND IS THE LARGEST MECHANICAL ENGINEERING INSTITUTE IN PORTUGAL

inegi INSTITUTE FOR SCIENCE AND INNOVATION IN MECHANICAL AND INDUSTRIAL ENGINEERING

KEY NUMBERS OF 2016

- 2016 **209** Employees
- 2016 **83** Associated Companies
- 2016 **593** Customers
- M EUR **7,1** Turnover in 2016
- 2016 **54%** Turnover from contracts with industry
- 2016 **137** Integrated PhD Researchers
- 2016 **32** Completed Doctoral Theses
- 2016 **224** International Partners
- 2016 **94** R&I Projects
- 2016 **329** ISI Publications
- **7** SPIN-OFFS in the market

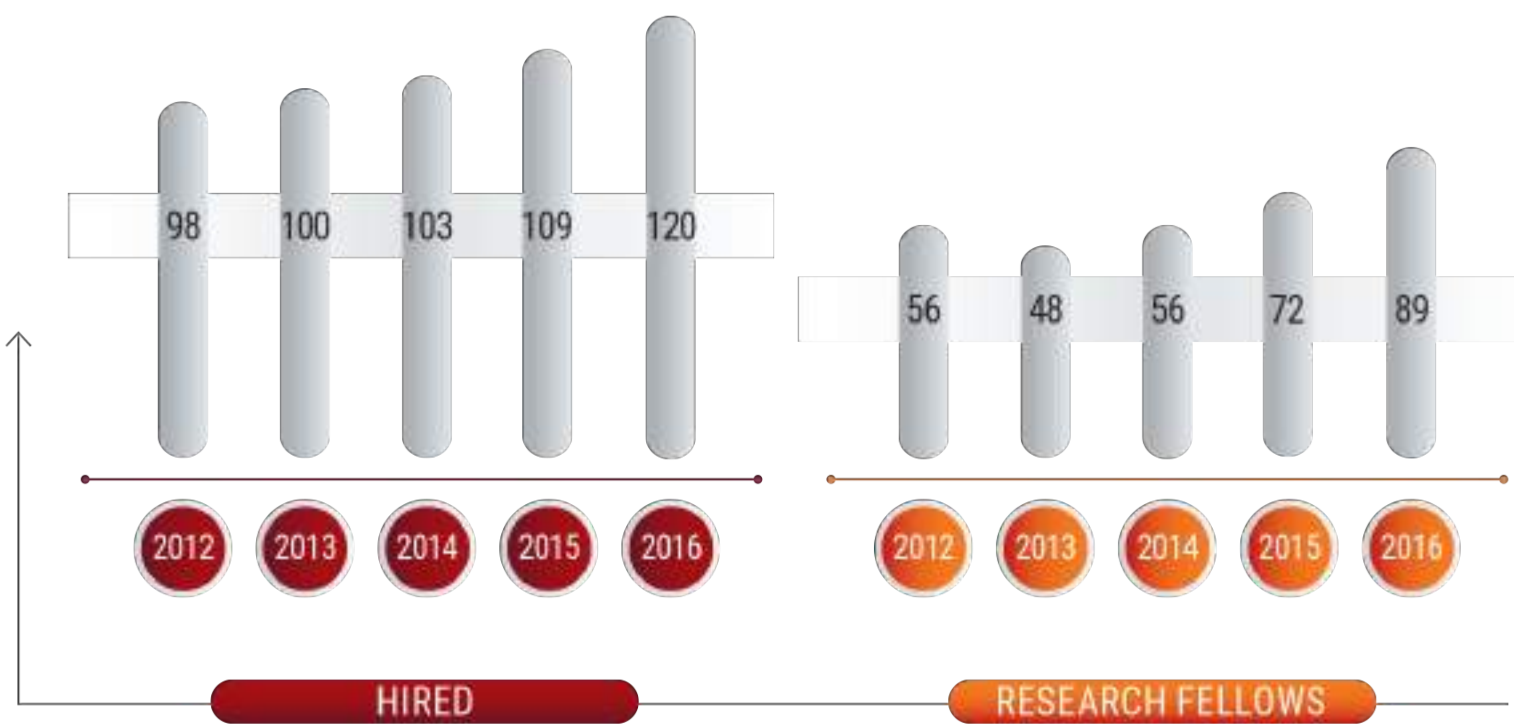

GENERAL ASSEMBLY
SUPERVISORY BOARD
BOARD OF DIRECTORS
SCIENTIFIC COUNCIL
EXECUTIVE COMMITTEE
RESEARCH
INNOVATION AND TECHNOLOGY TRANSFER
CONSULTING AND SERVICES
COMPOSITE MATERIAL AND STRUCTURES
NEW TECHNOLOGIES AND ADVANCED MANUFACTURING PROCESSES
OPTICS AND EXPERIMENTAL MECHANICS
TRIBOLOGY, VIBRATIONS AND INDUSTRIAL MAINTENANCE
SYSTEM INTEGRATION AND AUTOMATED PROCESSES
DESIGN AND EXPERIMENTAL VALIDATION
NUMERICAL METHODS IN MECHANICS AND STRUCTURAL ENGINEERING
ENERGY AND BUILT ENVIRONMENT
RENEWABLE ENERGY
LAETA
COMPOSITE MATERIALS AND STRUCTURES
PRODUCT AND SYSTEM DEVELOPMENT
ADVANCED MANUFACTURING TECHNOLOGIES
INDUSTRIAL AUTOMATION
OPTICS AND EXPERIMENTAL MECHANICS
SEA-RELATED TECHNOLOGIES
WIND ENERGY
AERODYNAMICS AND CALIBRATION LAB
NEW ENERGY TECHNOLOGIES AND ENERGY MANAGEMENT
ENVIRONMENT
ENVIRONMENTAL CHARACTERISATION LAB
INDOOR AIR QUALITY LAB
SMOKE AND FIRE LAB
INDUSTRIAL ENGINEERING AND MANAGEMENT
IN-COMPANY TRAINING

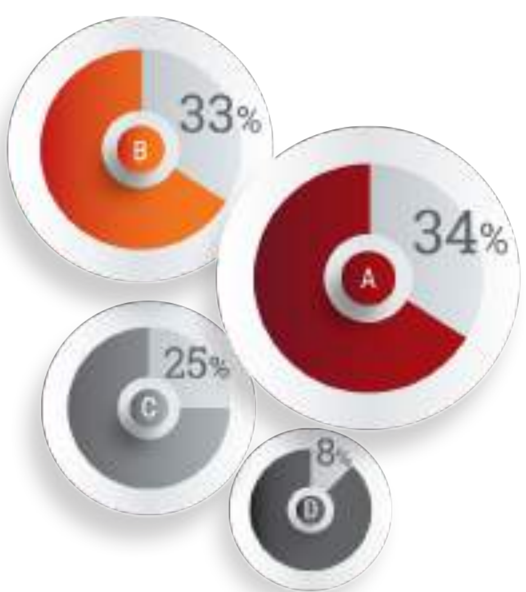
PEOPLE

(31st December 2016)

Hired	120
Research Fellows	89
Total of Own Staff	**209**
Affiliated Academics	125
FCT Research Fellows hosted at INEGI	28

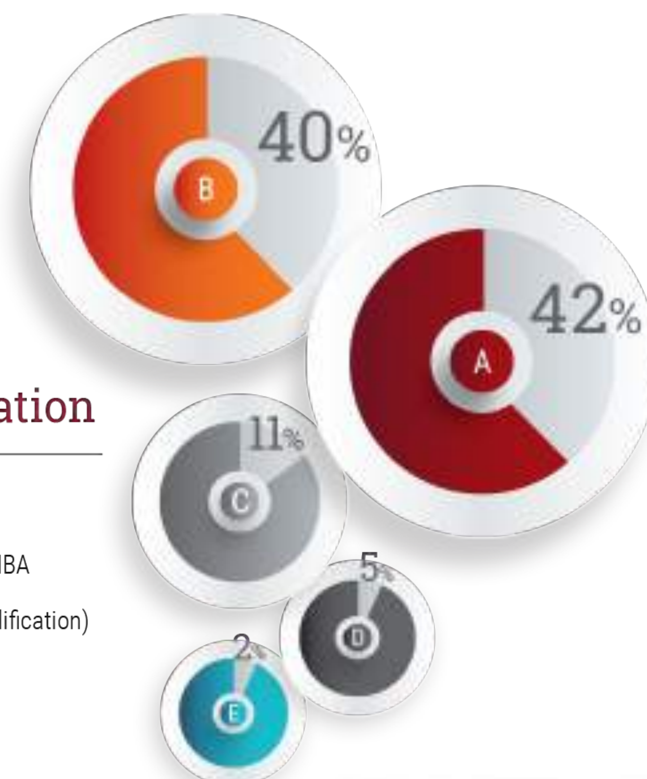
Trend in the number of Employees





Type of Bond

- A Hired
- B Affiliated Academics
- C Research Fellows
- D FCT Research Fellows hosted at INEGI



Academic Qualification

- A PhD
- B Master's/Postgraduate Studies/MBA
- C Bachelor's Degree (first cycle qualification)
- D 12th Grade + Level IV
- E Below the 12th Grade

SCIENTIFIC OUTPUT

Average/researcher:

- 2,4 ISI articles
- 34 citations
- 1 PhD thesis

Main Areas:

- Computational Mechanics
- Experimental Mechanics
- Composite Materials

Application sectors:

- Transport
- Health & Wellness

Scientific Output 2016

329
ISI Results
241 in Journal + **72** in Conference
34 Book Chapters

119
Reviews in more than 119 Journals
35 Editors + **75** Members
of Editorial Teams

140
PhD theses
32 completed + **108** underway

17
FCT/ON2 Projects
7 R&D + **6** HR + **4** Structuring
Over EUR 1.5 m executed

55
Workshops, Seminars/Symposia & Thematic Sessions

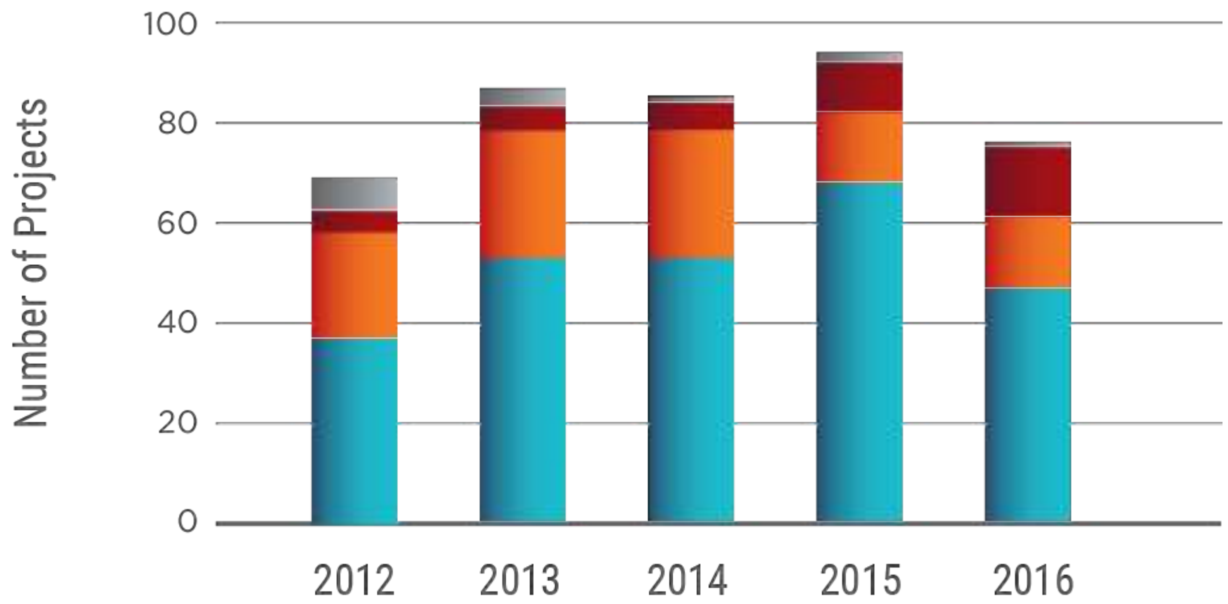
4382
Citations of ISI Articles
(self-citations excluded)

42
(Co)Organisation of 42 Conferences and other events
Participation in the Scientific Committee
of another **70** Conferences and Events

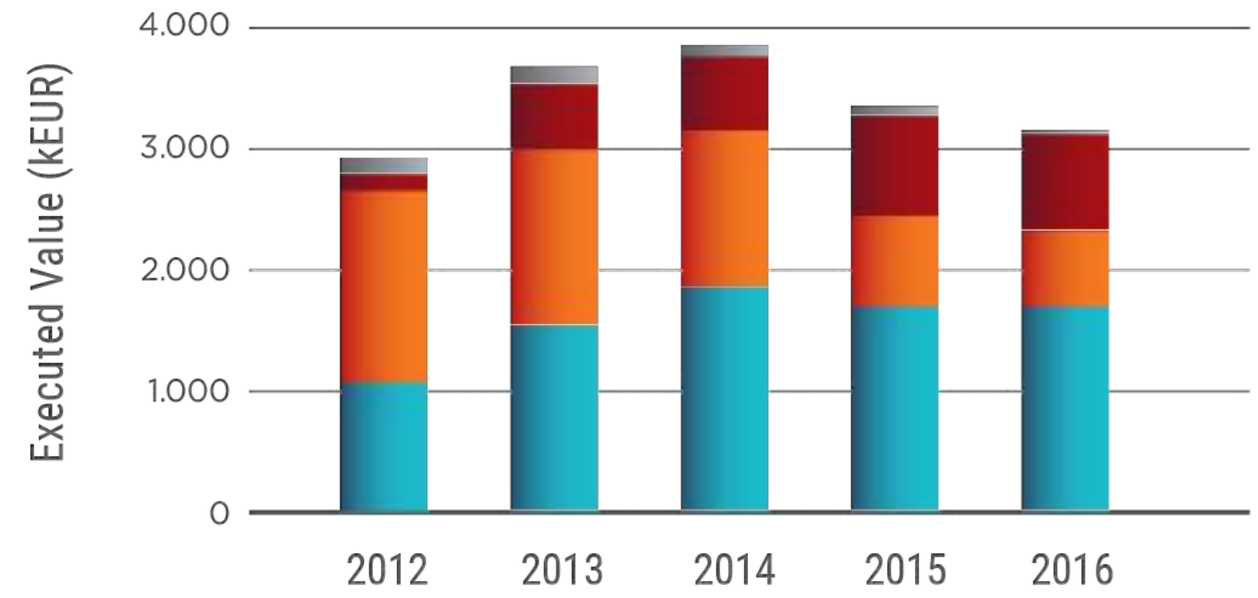
8
Patent Requests
+ 1 Patent Granted

R&I PROJECTS

R&I Projects - Number of Projects



R&I Projects - Executed Value



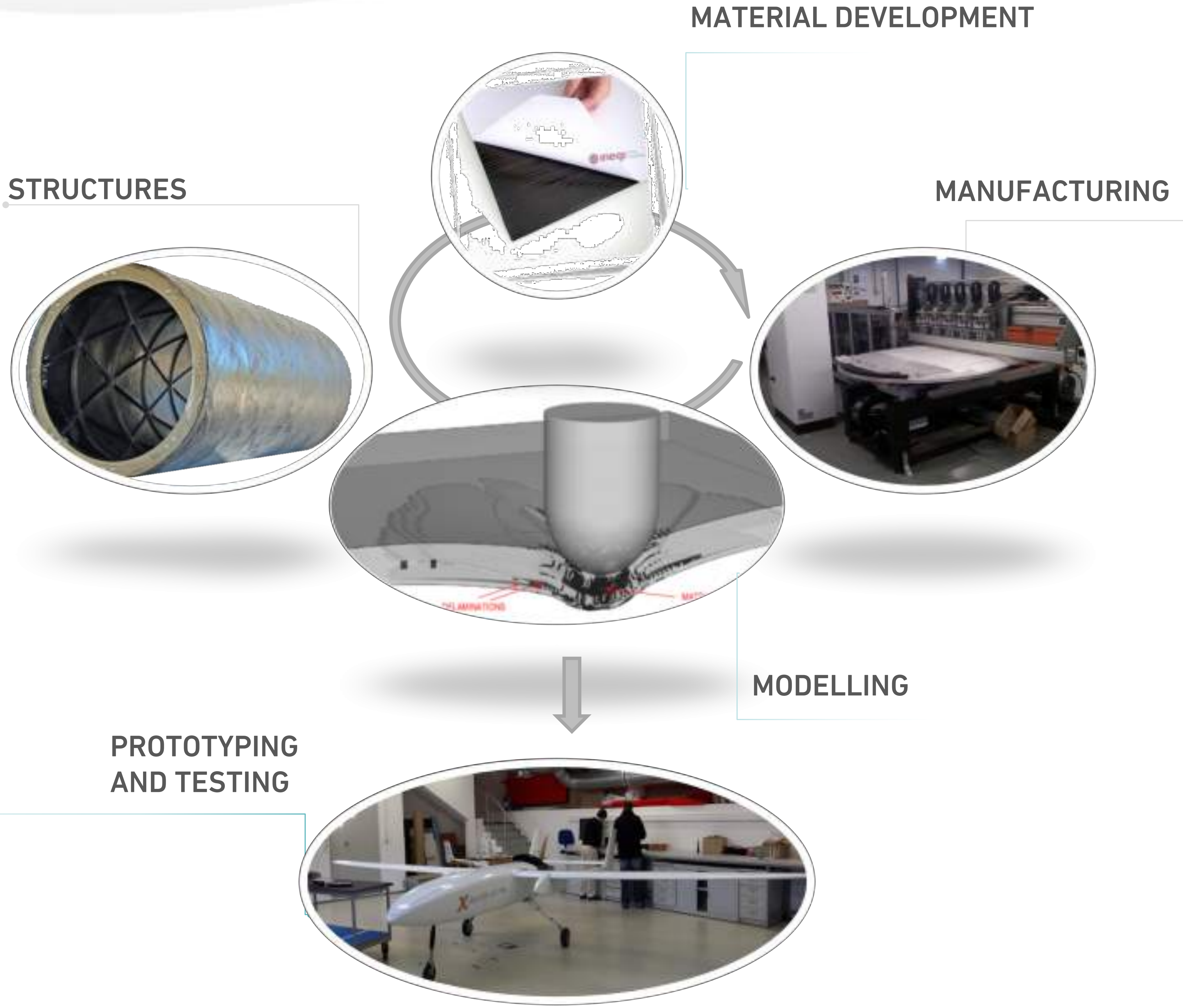
- Projects co-financed by Other Programmes
- Projects co-financed by the European Commission
- Projects co-financed by QREN/P2020
- ITT Projects contracted by Companies*

*Budget over EUR 5 k

2. ON THE COMPOSITES GROUP OF INEGI

INEGI COMPOSITES January 2017

SCOPE OF ACTIVITIES



MANUFACTURING TECHNOLOGIES

THERMOPLASTIC COMPOSITE AUTOMATED HOT STAMPING CELL

6 AXIS CNC FILAMENT WINDING MACHINE

FILAMENT WINDING IMPREGNATION WITH SPOOL SUPPORT

PULTRUSION

THERMOPLASTIC LAYUP

HP RTM

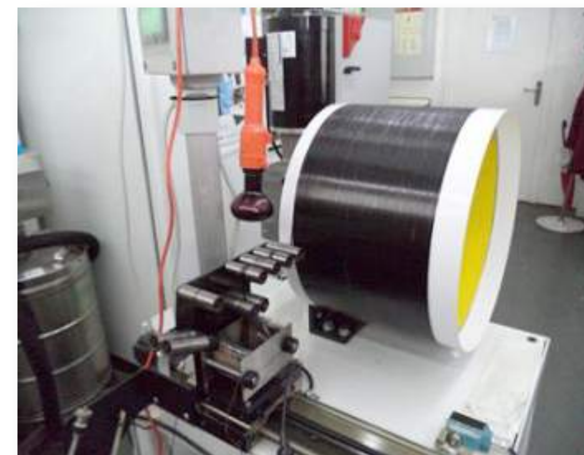
AUTOCLAVE

CLASS 10K CLEAN ROOM

MATERIALS DEVELOPMENT AND TESTING

GRAPHITIZATION OVEN (UHM CARBON FIBRE AT FISIPE / SGL)

NANO MODIFICATION OF RESINS

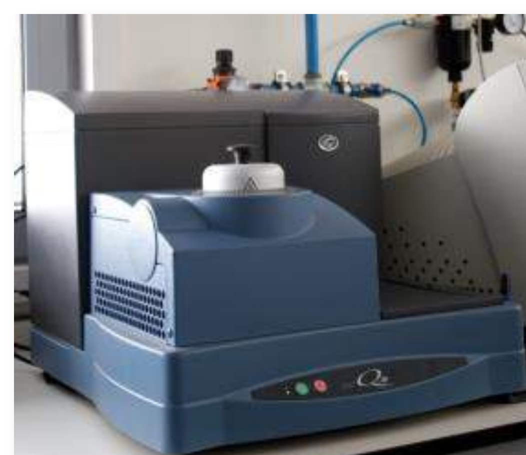


PRE-IMPREGNATION

PRE-PREGS

DYNAMIC MECHANICAL ANALYSIS

THERMOGRAVIMETRIC ANALYSIS



DIFFERENTIAL SCANNING CALORIMETER

RHEOMETER

FUME HOOD

3. CURRENT RESEARCH TOPICS

OUR RESEARCH ON COMPOSITES

Reasonable concerns for research in the field of composites

1. Reducing manufacturing costs and improving quality.
2. Improving the understanding of the material's potential (and limitations) for use.
3. Developing new materials or new material combinations that create new or improved uses.

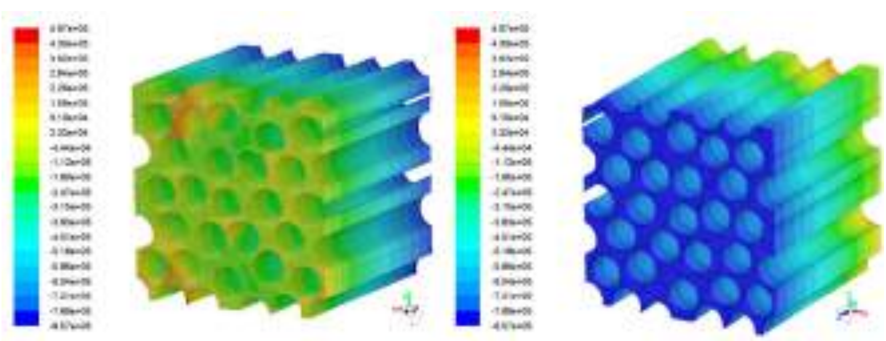
Manufacturing cost reduction, better **understanding of performance and properties** and **material innovation** can be relevant classes of drivers for materials research.

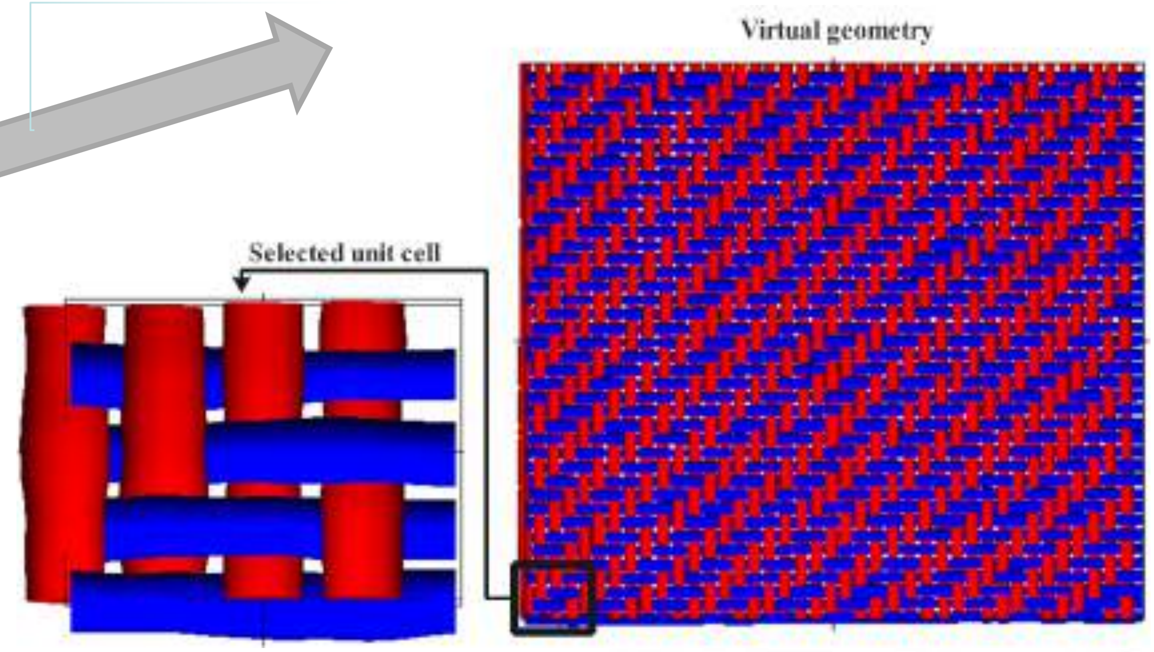
1. MANUFACTURING COSTS ARE LINKED TO: QUALITY; SCRAP; LABOUR; ENERGY; AND INTERMEDIATE PROCESS/SEMI-PRODUCT PREPARATION.

Manufacturing cost reduction leads to automation and advanced out-of-autoclave technologies, including thermoset and thermoplastic processes. But, along with process development, understanding manufacturing is understanding a multiscale phenomenon.

Modelling processes
Modelling properties
Virtualizing testing

Problems at different scales. Possibly multiscale problems: Micro-meso-macro



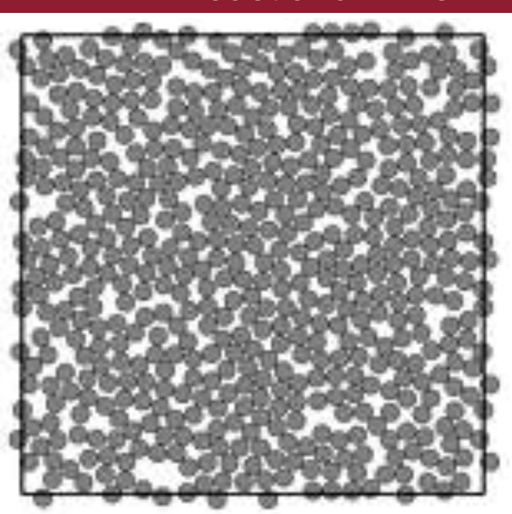


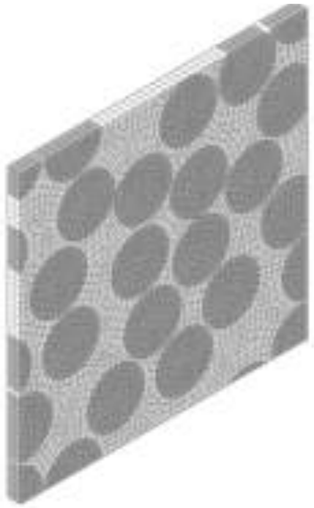
2. PERFORMANCE AS A FUNCTION OF: MANUFACTURING; MATRIX SELECTION; AND FIBRE ARCHITECTURE (INCL. HYBRIDIZATION).

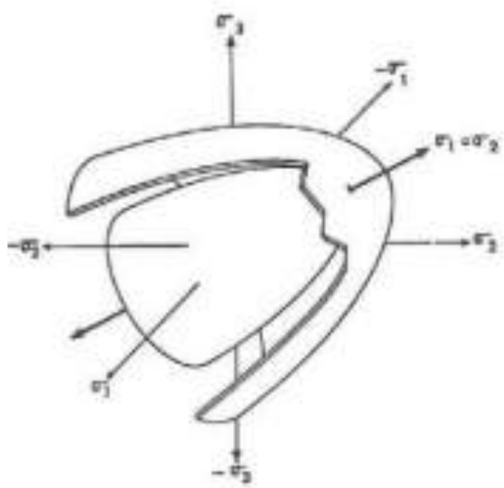
Understanding and improving material performance leads to understanding and improving the material solutions themselves.

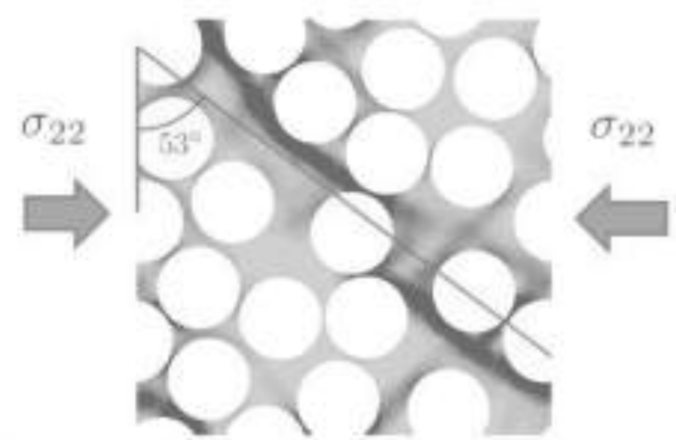
In composites, understanding performance is to understanding a **structural multiscale phenomenon, starting at the micro-scale.**

Automatic generation of the FE model and RVEs → Constitutive models for the constituents → Analysis → Microscale analysis



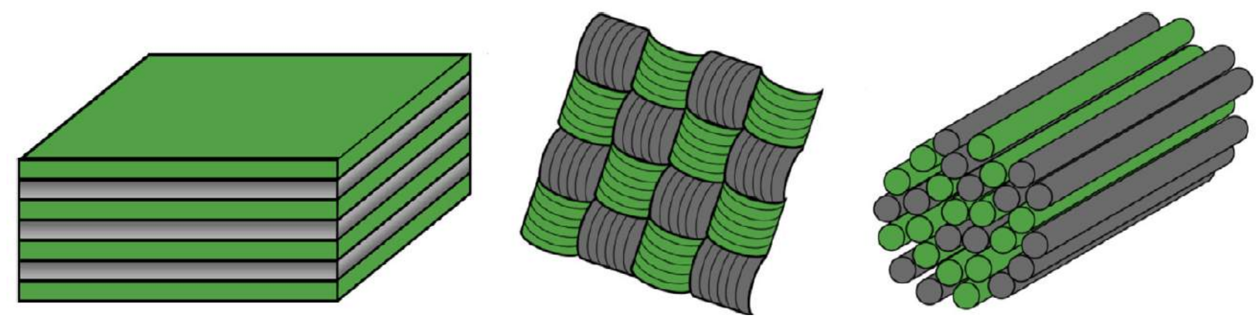






3. NEW MATERIALS AND NEW PROPERTIES OPENING UP NEW OPPORTUNITIES.

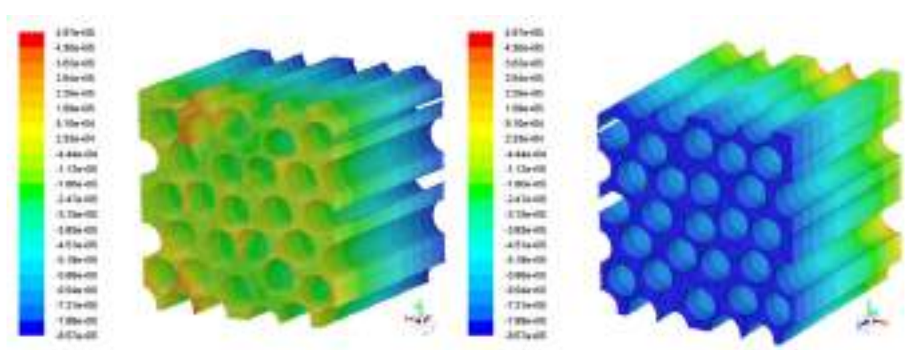
New materials and new properties open up new opportunities. Obvious avenues for development lie not only in the fields of **nano-modification of resins but also on hybridization**. Along side this one could add new or improved fibres and sizing.



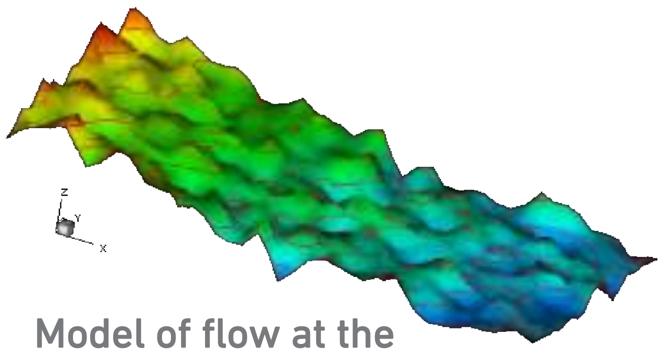
1.1. MULTISCALE FLOW MODELLING

The idea behind this work is to create a basis for a fundamental understanding of permeability scatter –where the scatter comes from, what the implications are, and how it can be reduced.

In this sense, this is an important topic and effort to put forward an appropriate distribution model for simulation of its variability is systematic.

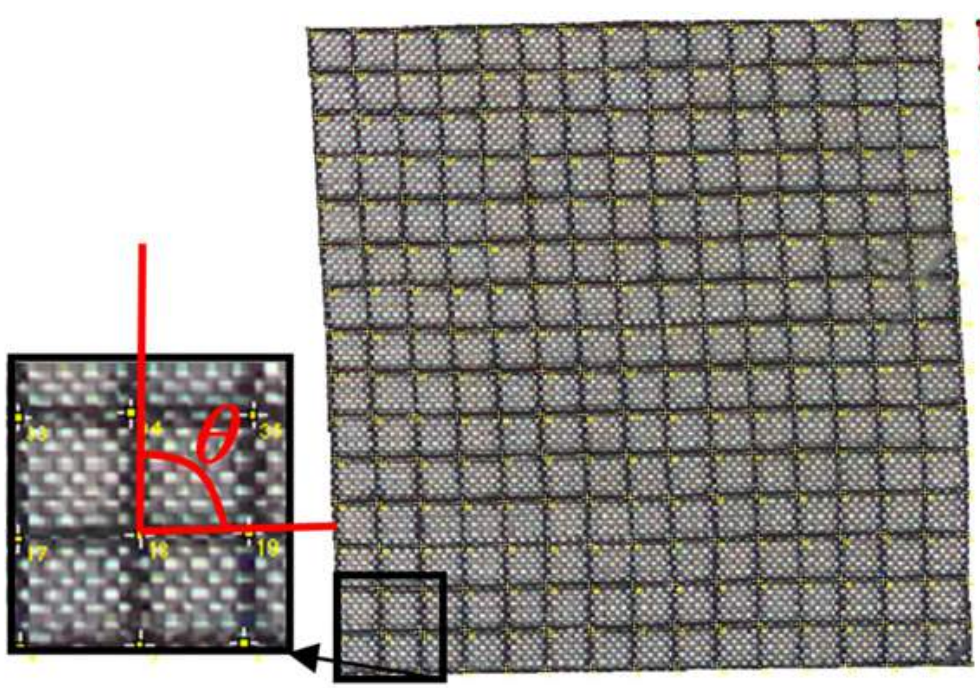


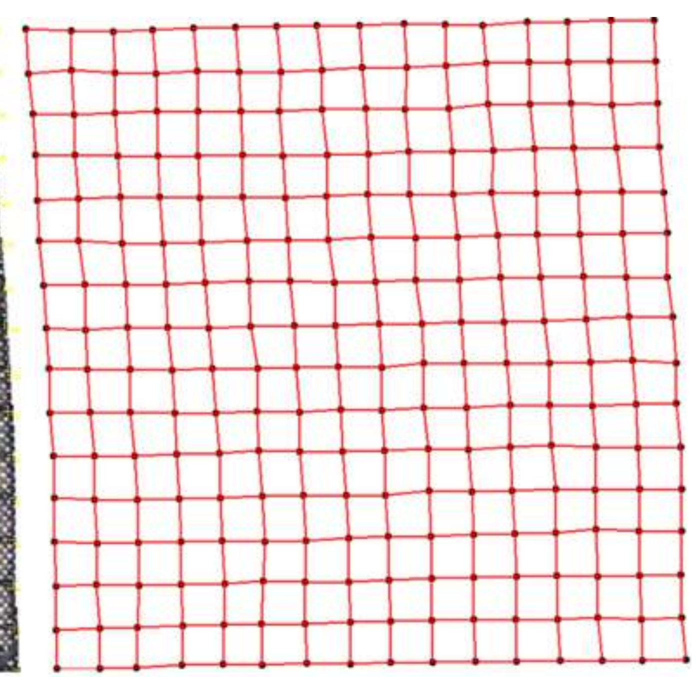
Modelling of permeability on the micro-scale

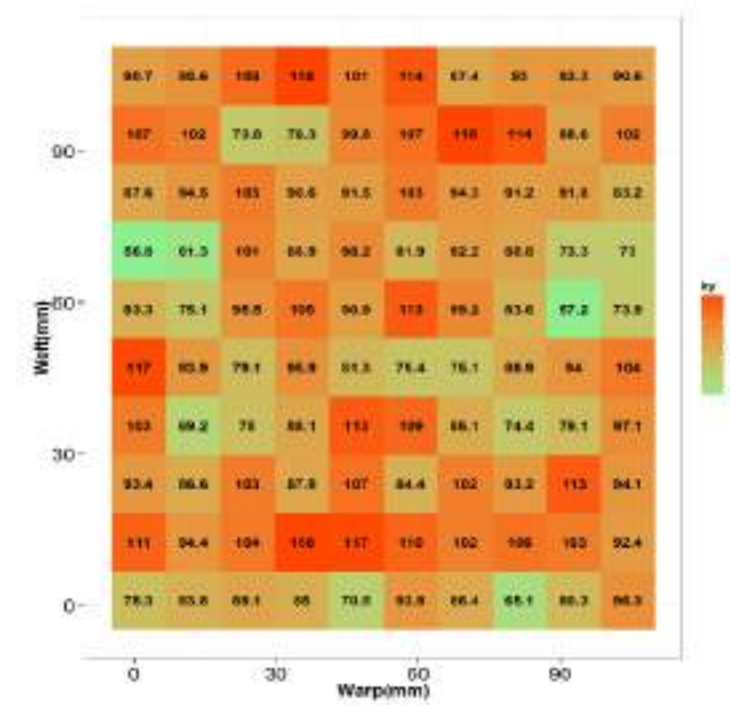


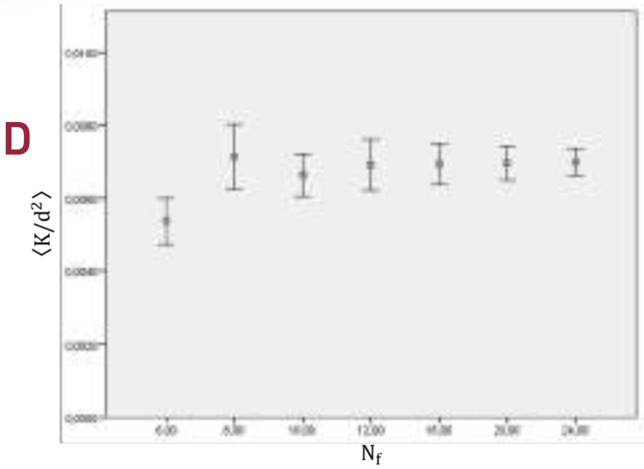
Model of flow at the macro-scale (Nottingham 2004)

A difference in K_x and K_y of one specific unit cell was observed which is attributed to the difference in warp and weft yarn width, confirming that a wider inter-yarn gap leads to higher permeability in that direction.

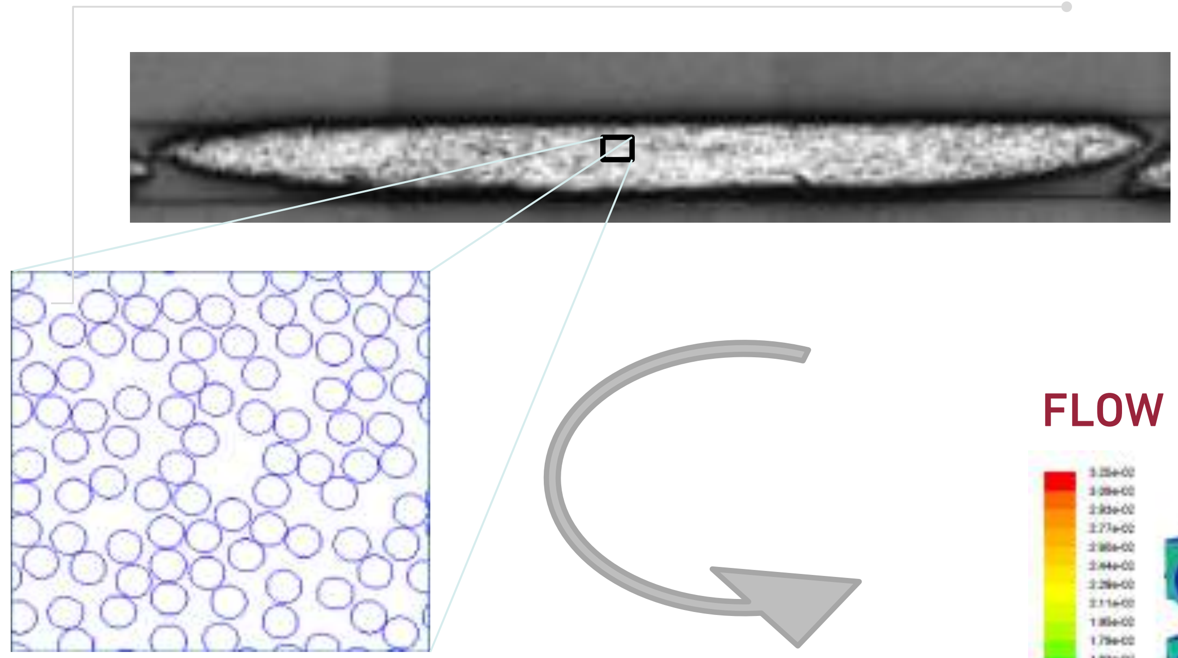




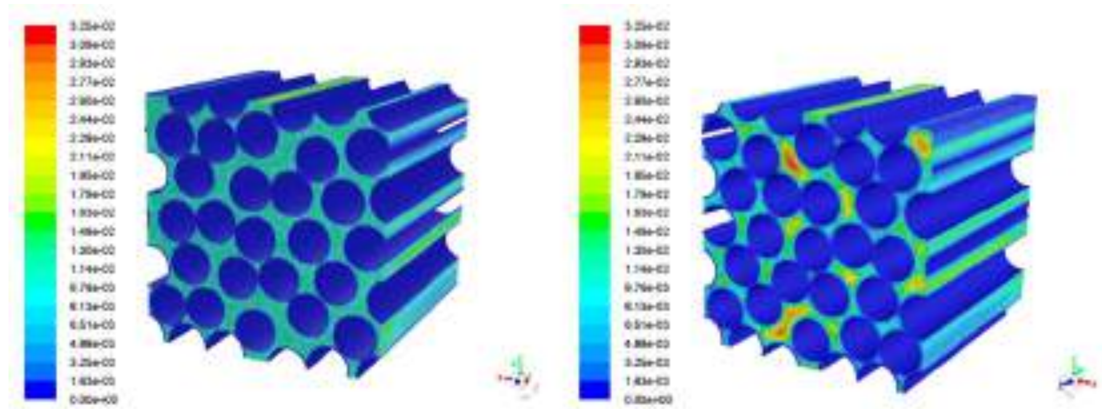




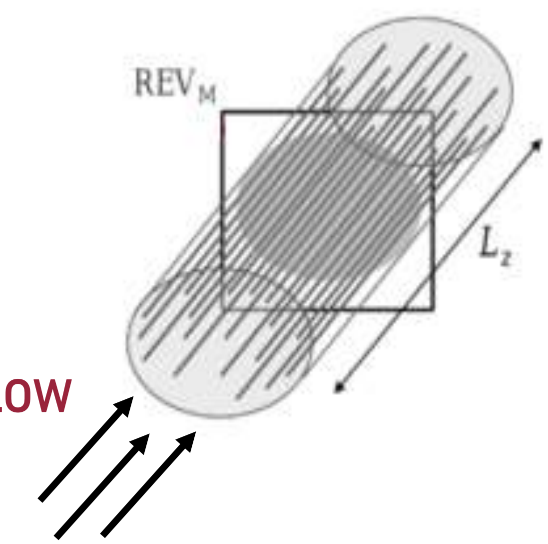
AUTOMATICALLY GENERATED CROSS SECTION RVE



FLOW RATE – LONGITUDINAL FLOW



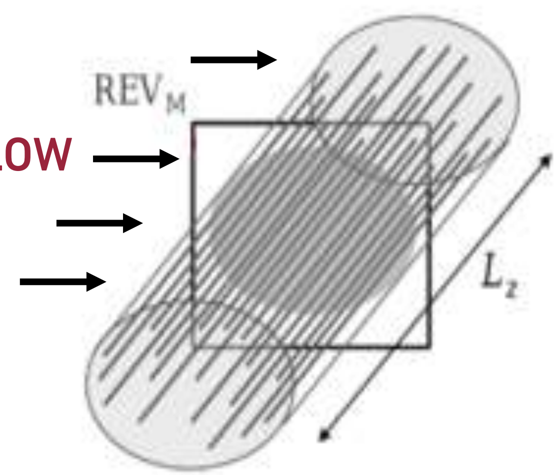
LONGITUDINAL FLOW



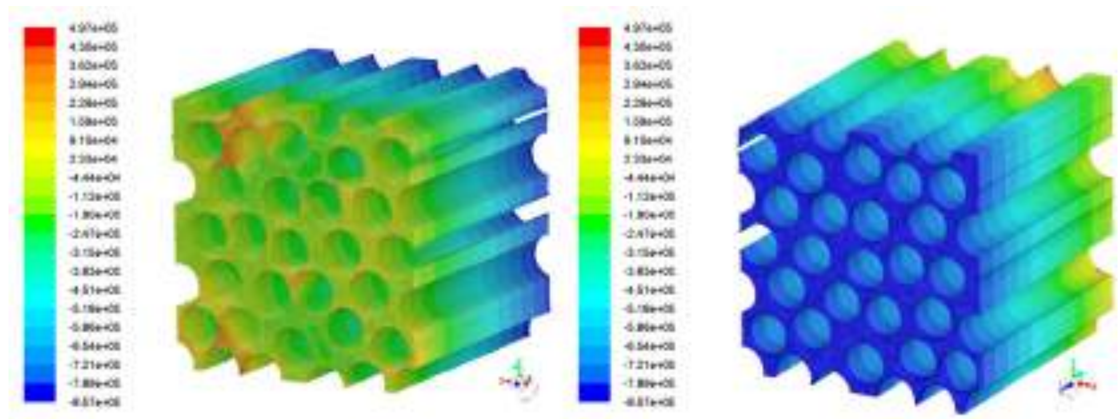
FLOW

TRANSVERSE FLOW

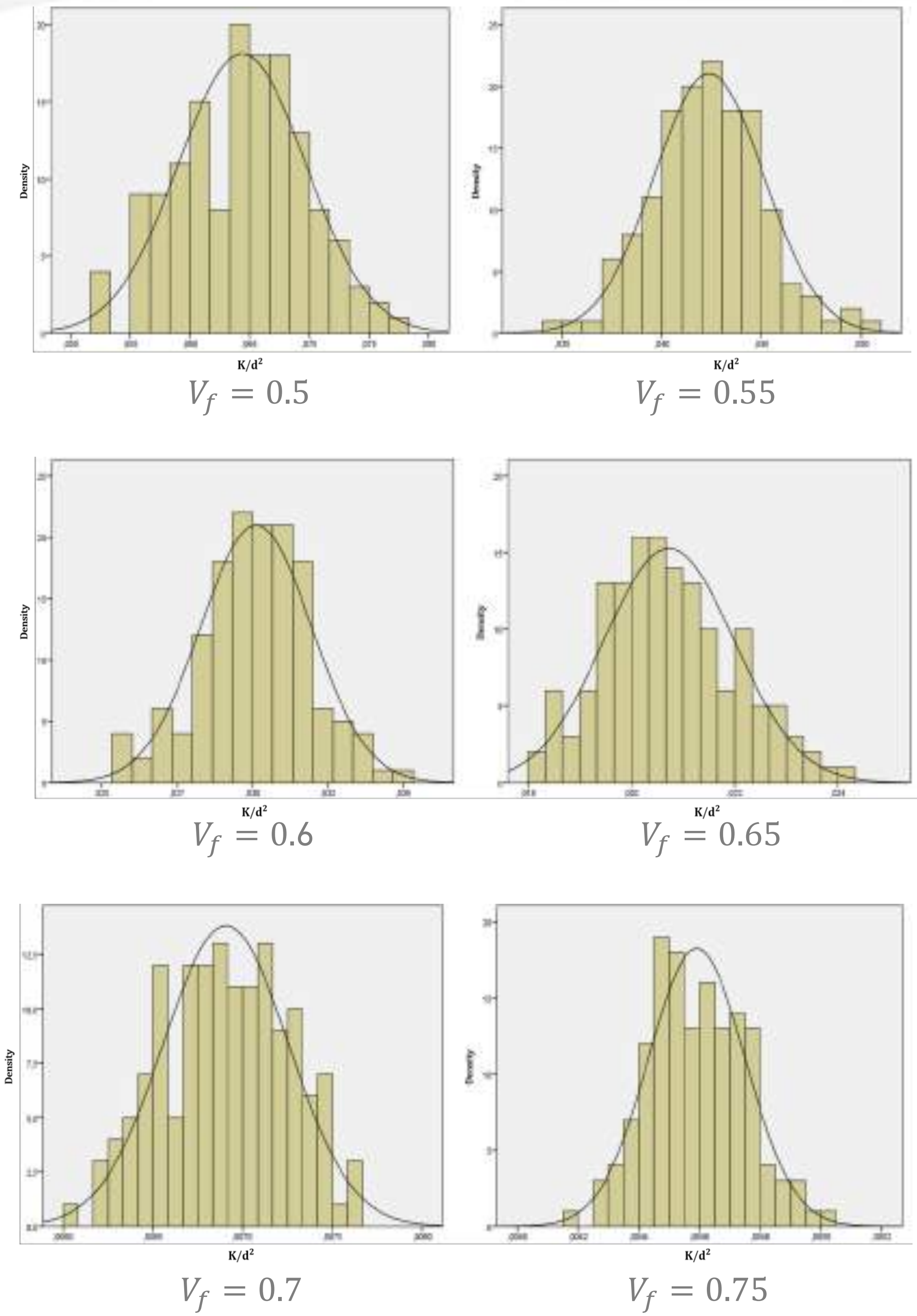
FLOW

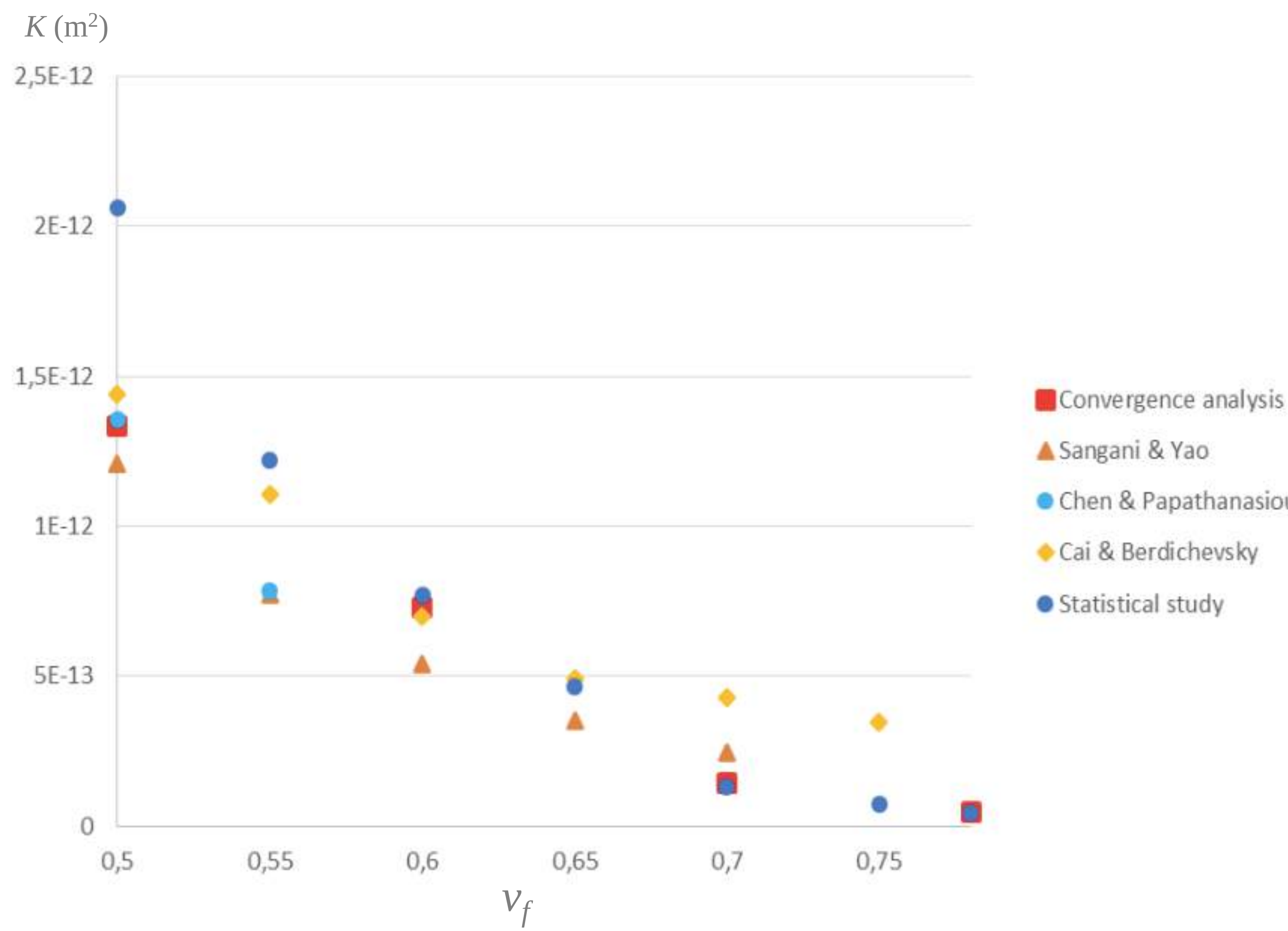


PRESSURE – LONGITUDINAL FLOW



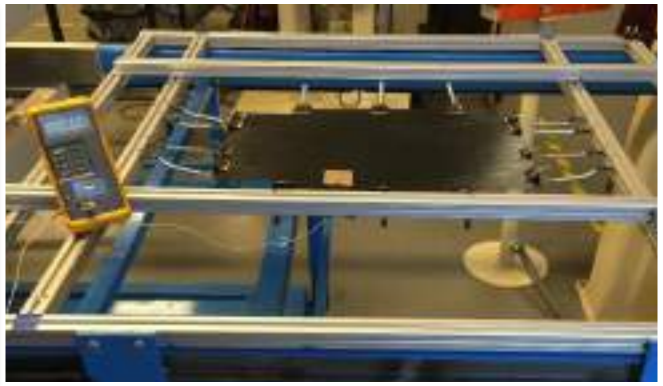
Ability to model, from the fundamental physics of the process, both the permeability at multiple scales and its statistical properties.

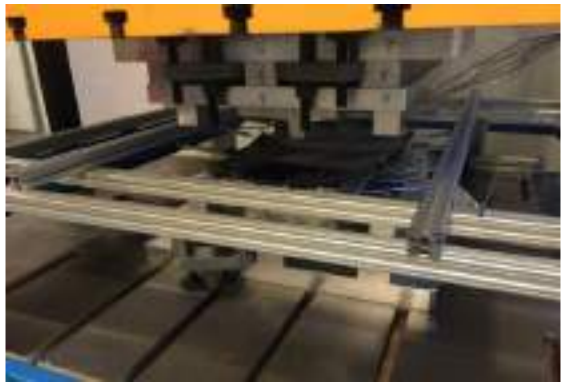




1.2. MULTISCALE MODELLING IN HOT FORMING

We have been involved in modelling hot forming (with a collaboration with UoGlasgow). An interesting avenue for research (which we are just starting to explore) is to begin modelling the mechanical tests that are currently run to provide data for complex forming simulations (cantilever bending, rheology, ply-ply friction, variability, etc). Ultimately this would form a framework that would enable reduced testing.

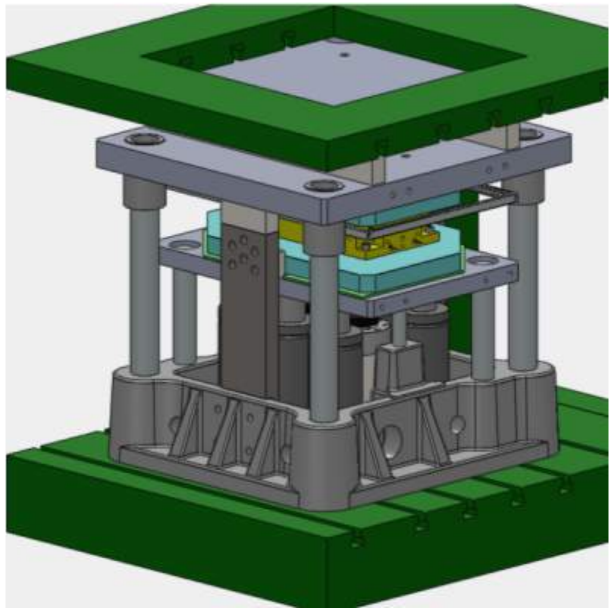




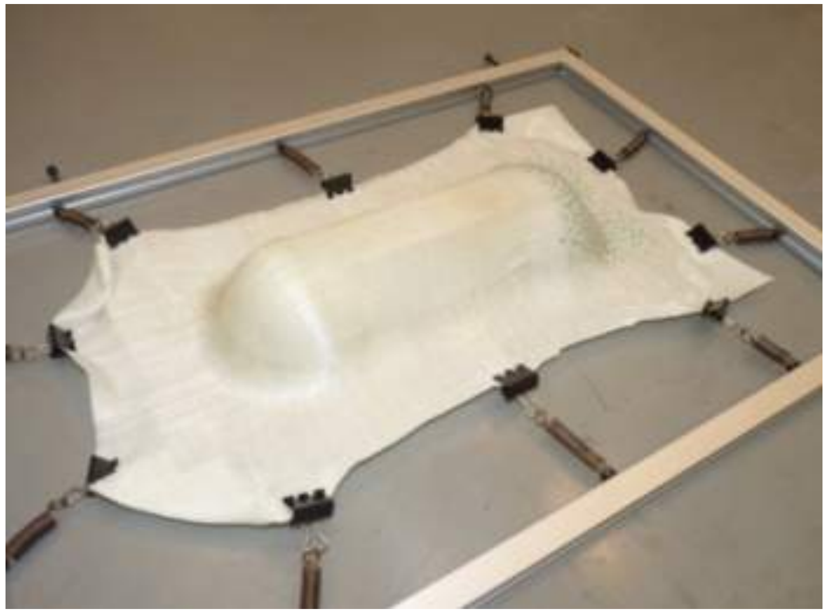
Advanced Processing of Thermoplastic Matrix Composites

INEGI integrates a capability in the implementation of advanced processing of thermoplastic matrix composites and has ongoing collaborations in this activity.

Process implementation



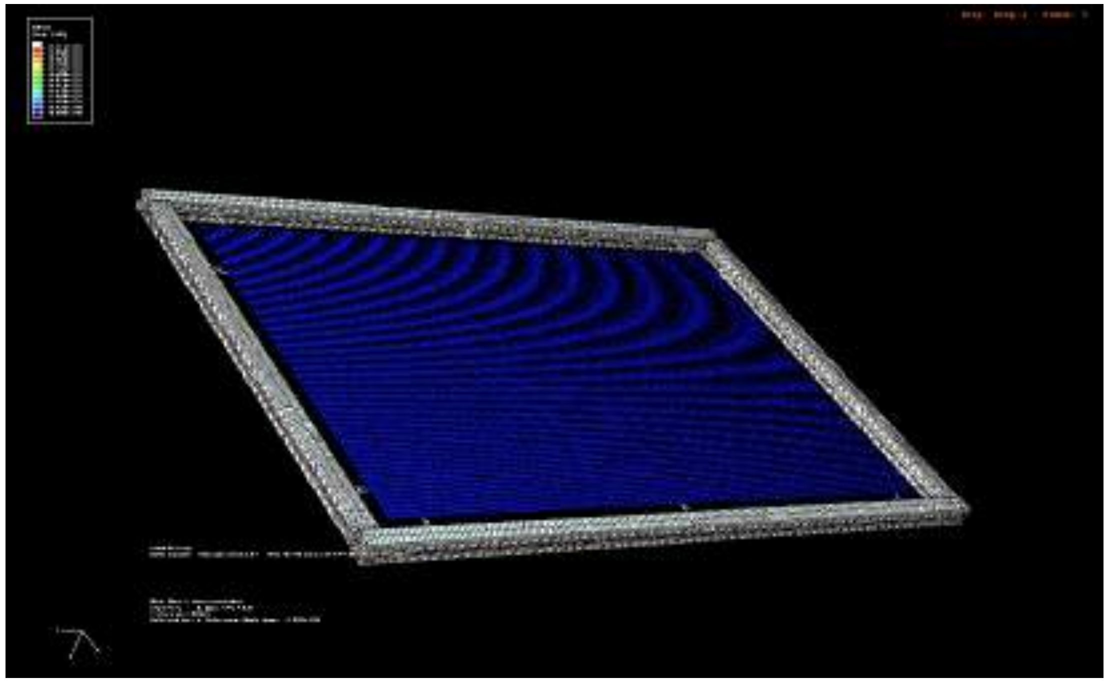
Mould engineering

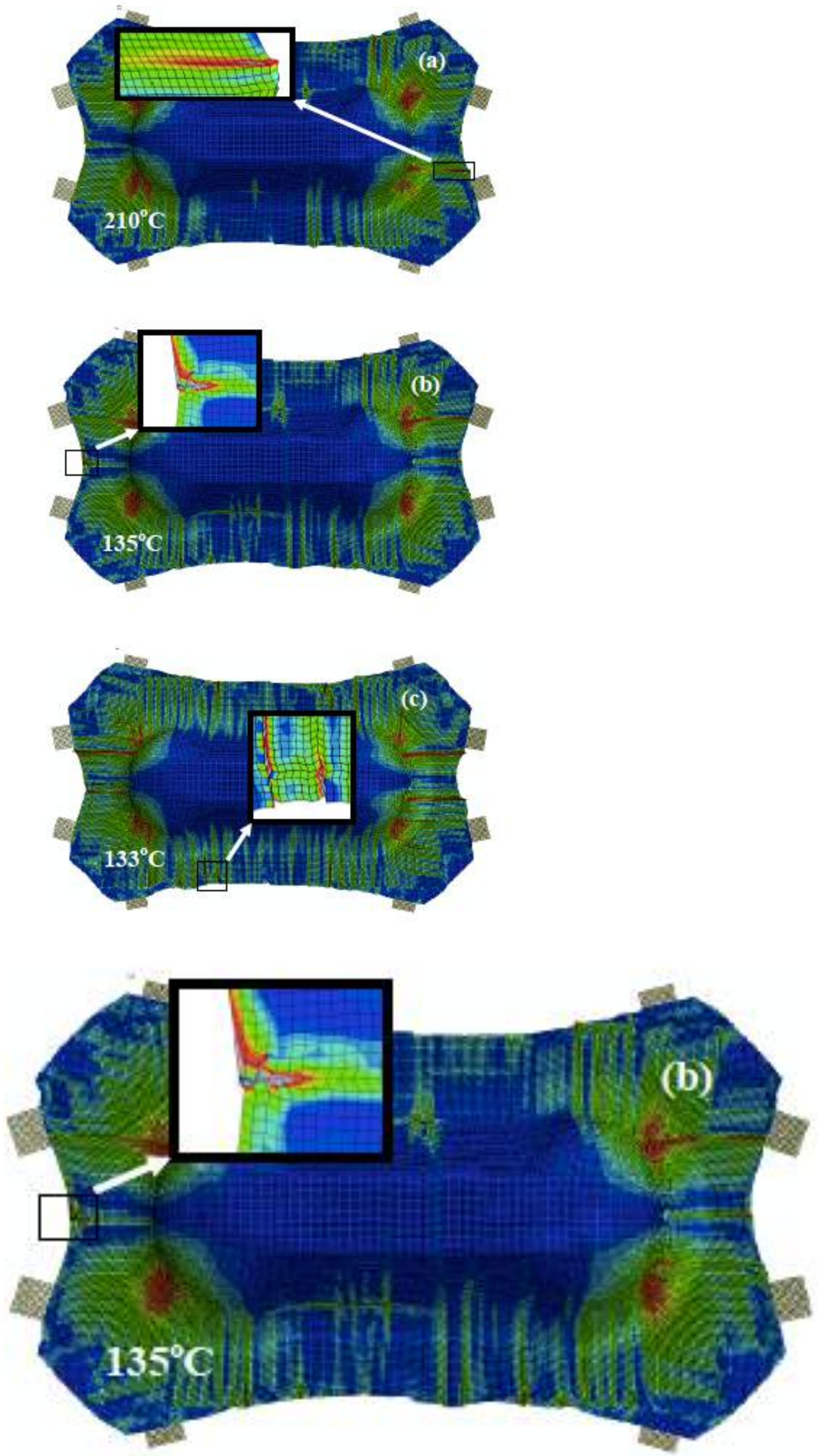


Prototyping

Modelling hot forming of thermoplastic matrix composites, including variability

Long term collaboration with Prof. Phillip Harrison – University of Glasgow.

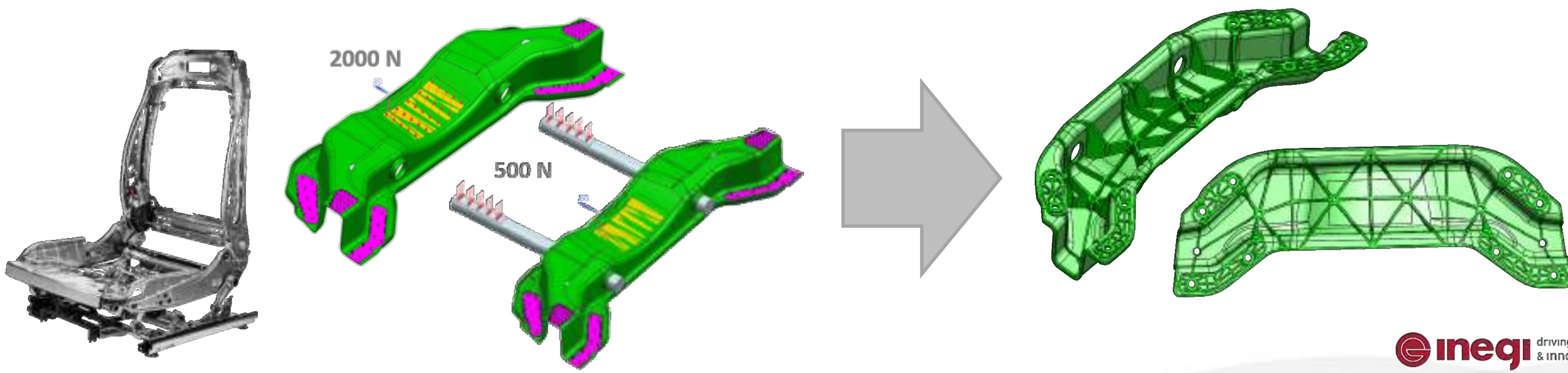




LaTCh: "Lightweight Thermoplastic Composites" (2014-2015)

Objective:

- Develop and integrate new composite materials of thermoplastic matrix of unidirectional continuous fibre and of its manufacturing technologies
- Replace steel with thermoplastic composites in an automotive seat upper cross member



Ongoing vision for forming

Modelling scale	Numerical strategy	To-scale	Result integration
Macro-scale	Calibration with experimental data	To micro-scale	
Multi-scale	Calibration / validation with experimental data	To meso-scale model	
Validation	Calibration / validation with experimental data	To macro-scale model	Validation; numerical results; benchmarks; forming process

Ongoing vision for forming

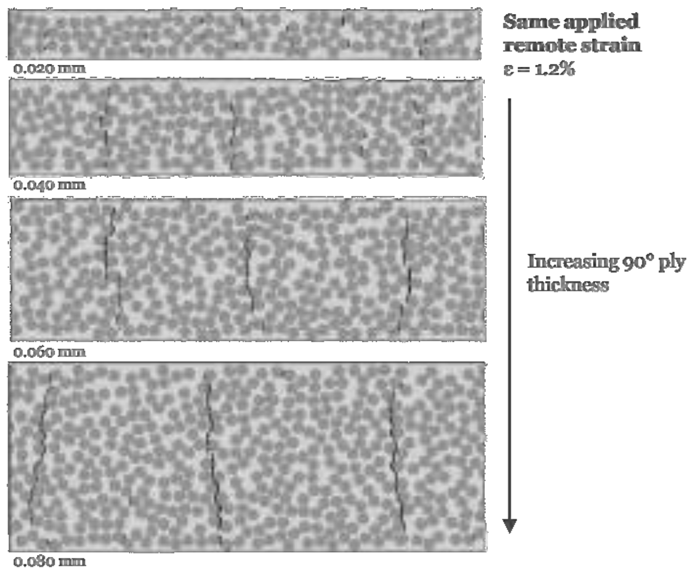
Modelling scale	Numerical strategy
Continuous	*A-priori* computation: Numerical homogenization, Definition of the material properties
Semi-discrete	*A-priori* computation Computation of specific FE behaviour Main behaviours of the representative unit cell
Multiscale FE Modelling	At each time step Computation of specific FE Behaviour; Full behaviour of the representative unit cell; Contact conditions; Matrix behaviour; Pressure; Thickness of the FE.

Ongoing vision for forming

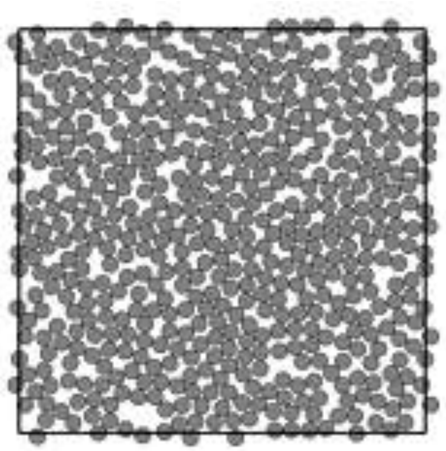
Modelling scale	Numerical strategy
Other advanced FE techniques	● FE^2 method – Continuous approach – Stress/Strain at the Gauss points – FE model of RVE ● Arbitrary Lagrangian Eulerian formulation – Sliding: fibre/fibre – ply/ply – Fluxes of viscoplastic matrix – 1 element over the thickness

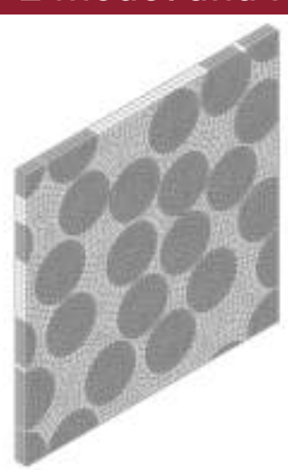
2.1. MULTISCALE 1: PLY MATERIALS

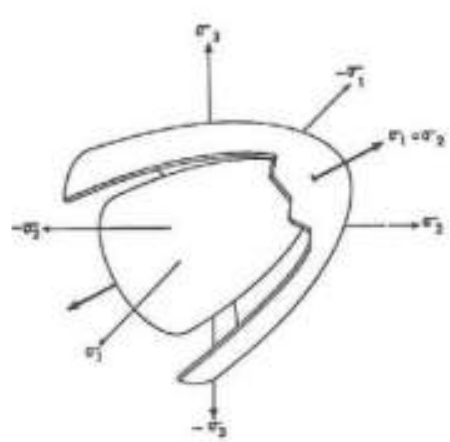
This is the most advanced framework in place for using a multiscale approach to the understanding of composite materials. In this case RVEs were developed to work, with natural variability, at the micro-scale and fundamentally understand notch sensitivity, compressive strength and fatigue properties in thin laminates.

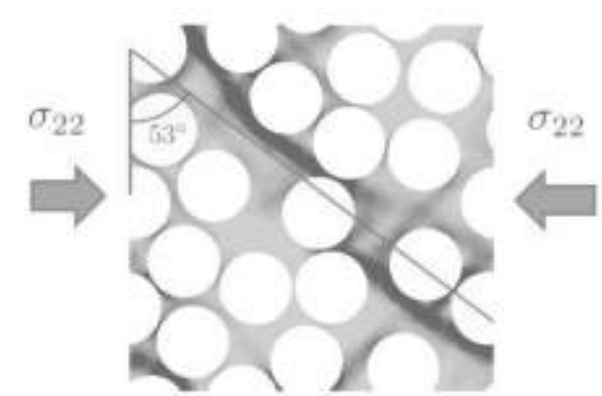


Matlab® code for the generation of random RVEs → Automatic generation of the FE model and PBCs → Constitutive models for the constituents → Application of PBCs and analysis

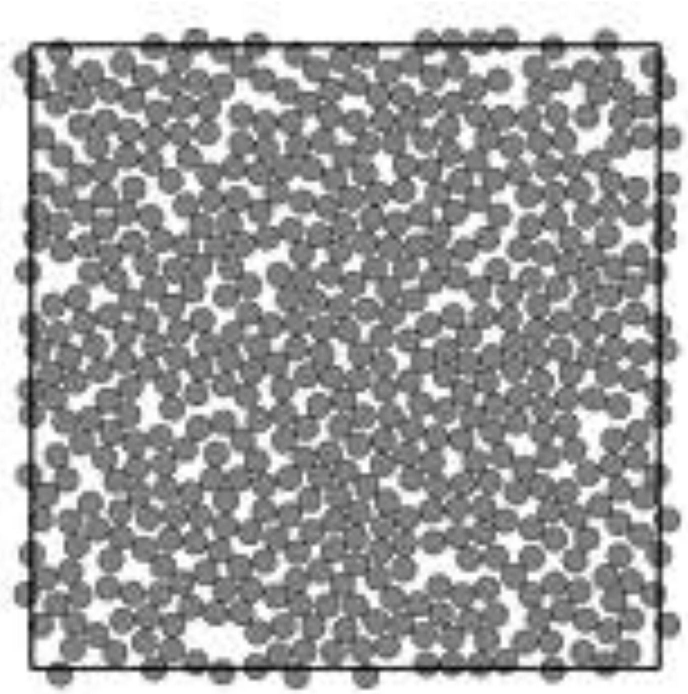








MICRO-SCALE MODELS: RANDOM FIBRE POSITIONING RVE

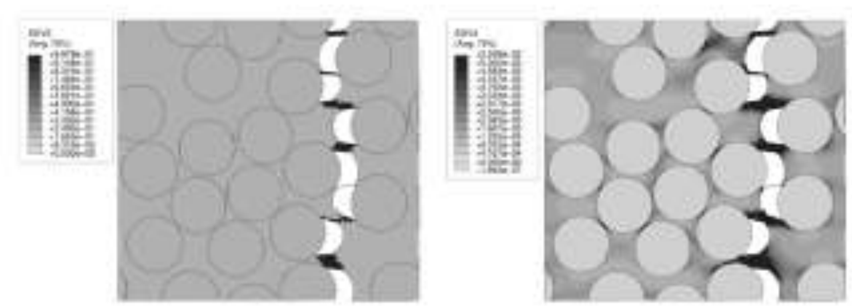


Matlab generated RVE (allowing fibre arrangement variability).

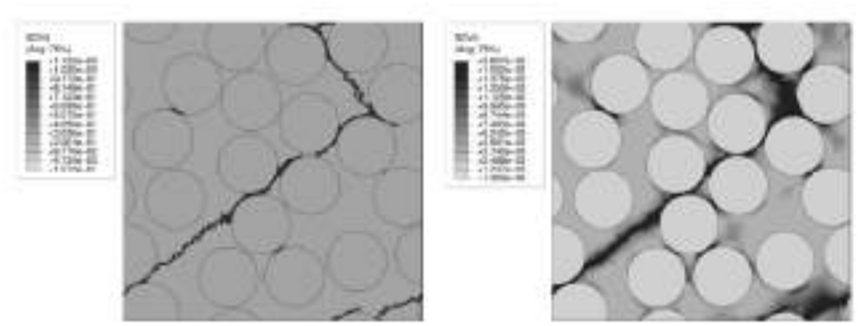
Automated procedure for the generation of RVEs.

On the generation of rve-based models of composites reinforced with long fibres or spherical particles
Compos Struct., 138 (2016), pp. 84-95, 10.1016/j.compstruct.2015.11.039

Modelling of specific phenomena like Damage (left) and equivalent plastic strain (right) fields in transverse tension.

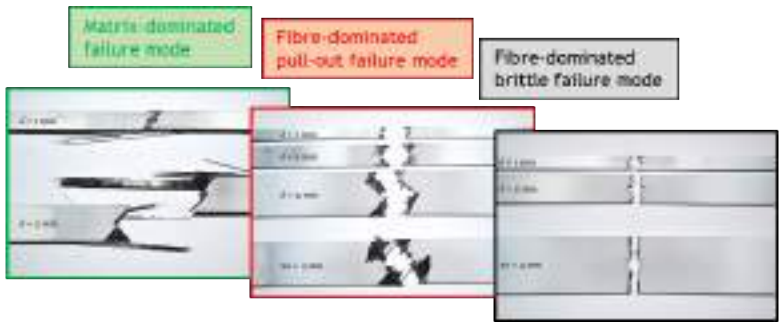


To damage (left) and equivalent plastic strain (right) fields in transverse compression.

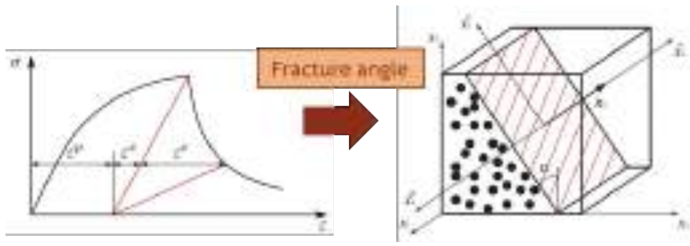


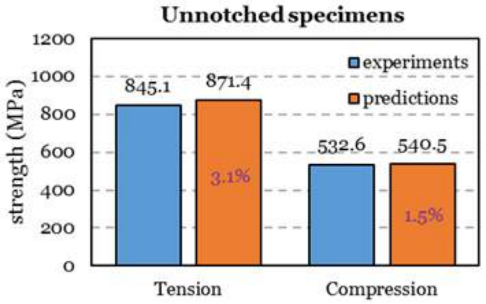
STRUCTURAL MECHANICS OF THIN-PLY LAMINATED COMPOSITES

Experimental testing and characterisation

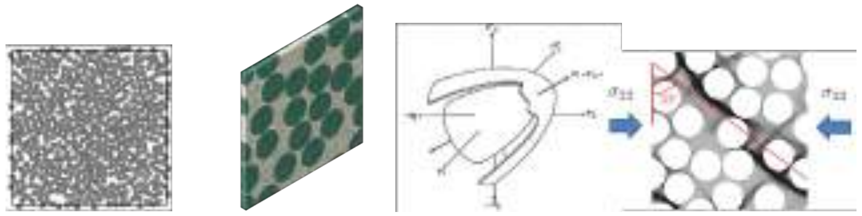


Smeared crack model



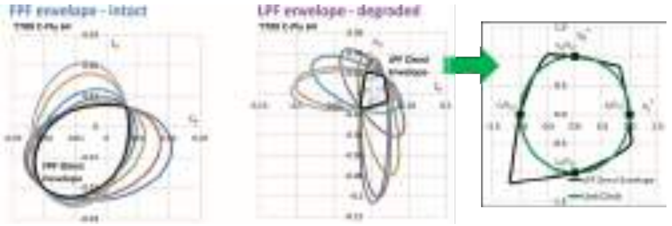


Computational micro-mechanics

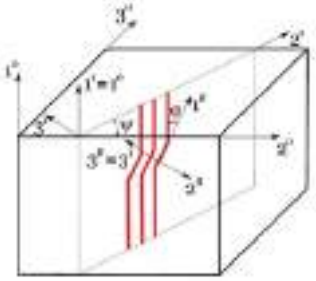


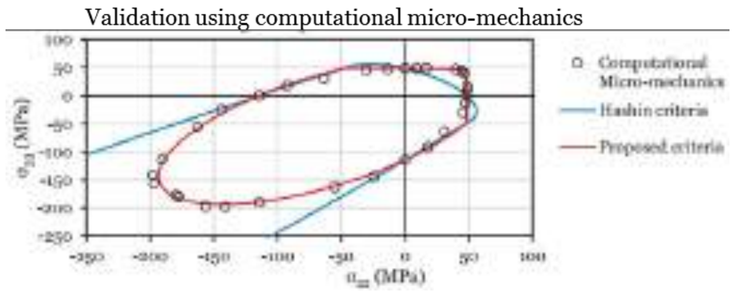
Invariant-based approach to laminate design based on Trace

	E_x / Tr	E_y / Tr	G_{xy} / Tr	ν_{xy}
Universal [0]	0.880	0.052	0.031	0.320
[0/90]	0.468	0.468	0.031	0.036
[π/4]	0.336	0.336	0.129	0.308
[0_7/±45/90]	0.662	0.175	0.070	0.310

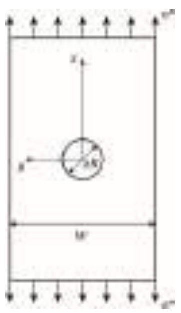


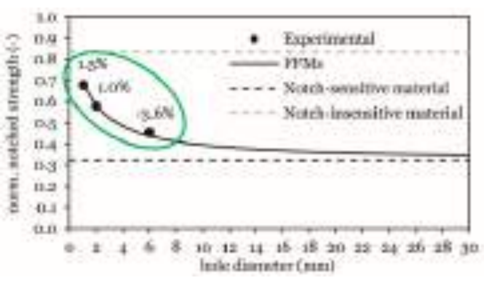
3D failure criteria



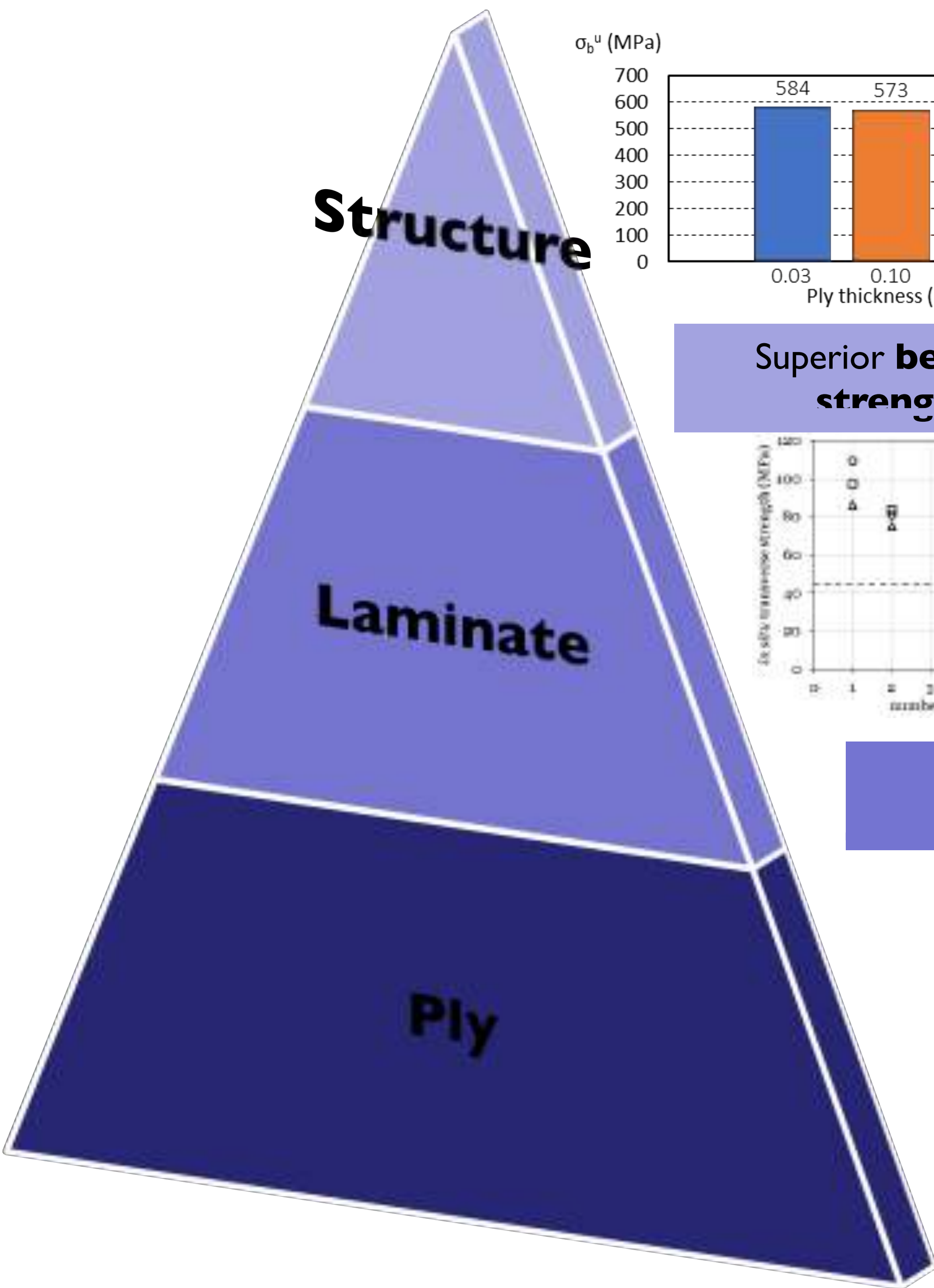


Failure prediction of notched laminates

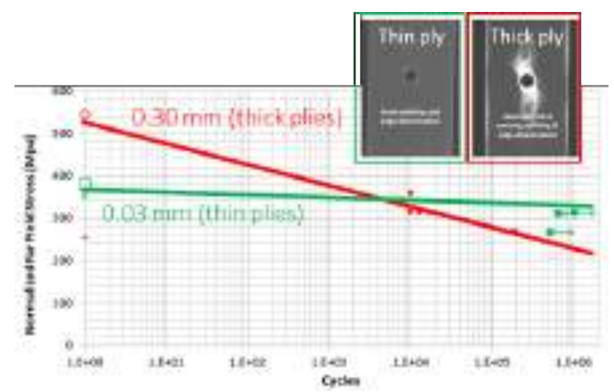




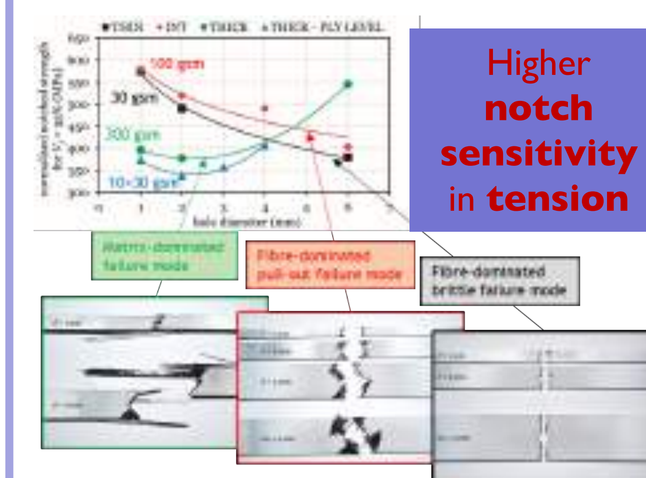
SPREAD-TOW THIN-PLY LAMINATES



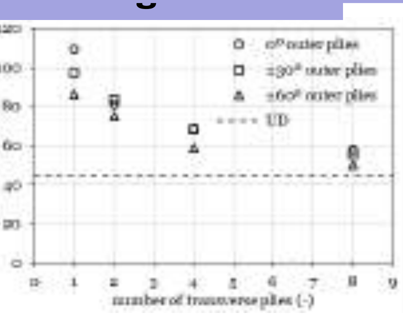
Superior **bearing strength**

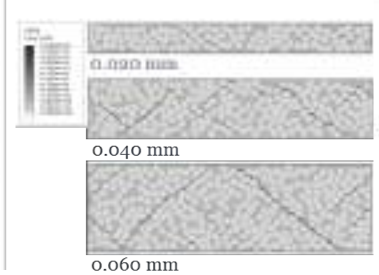


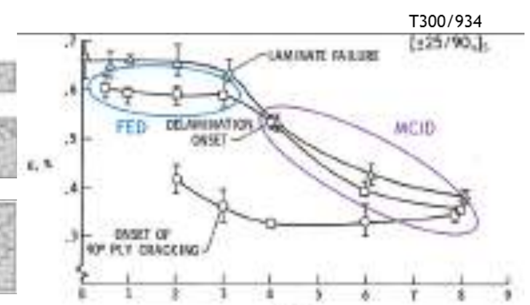
High **fatigue resistance**



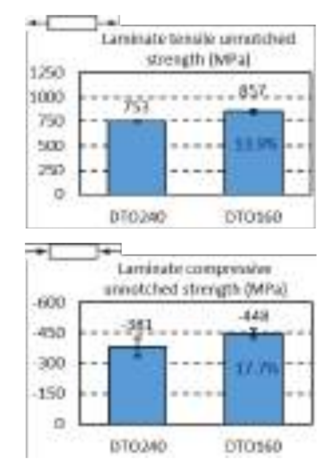
Higher **notch sensitivity** in **tension**



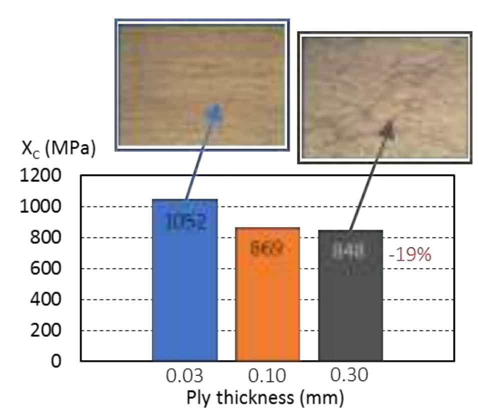


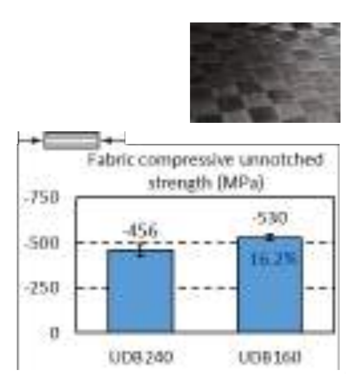


Higher resistance to **matrix cracking** (*in situ* effect) and **delamination**



Superior **laminate strength** in **tension** and in **compression**

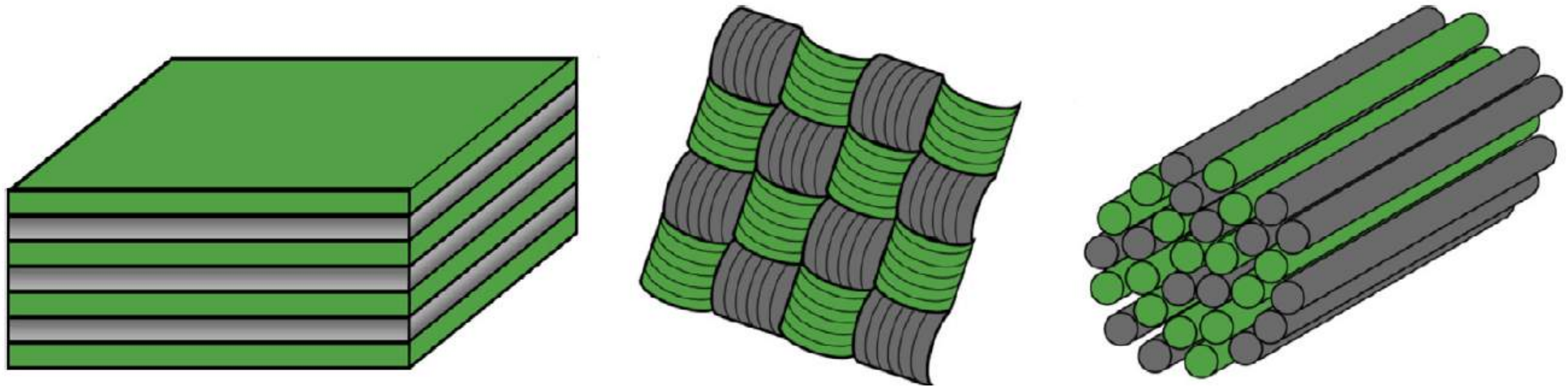




Improved **longitudinal compressive strength** in **UD** and **woven** reinforcements

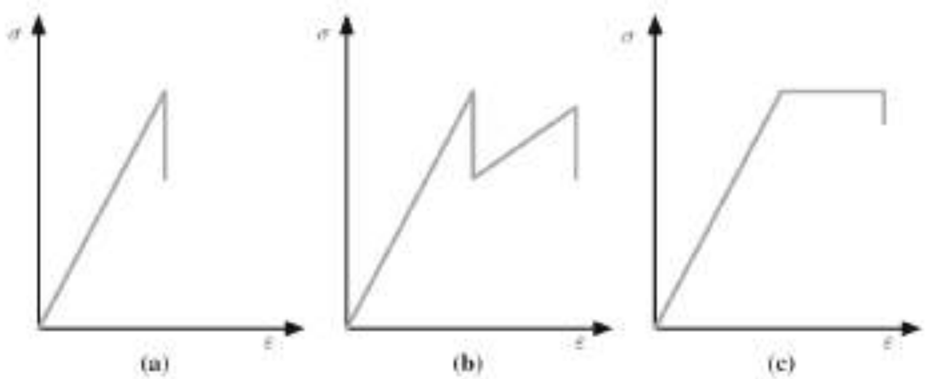
2.2. MULTISCALE 2: HYBRIDS

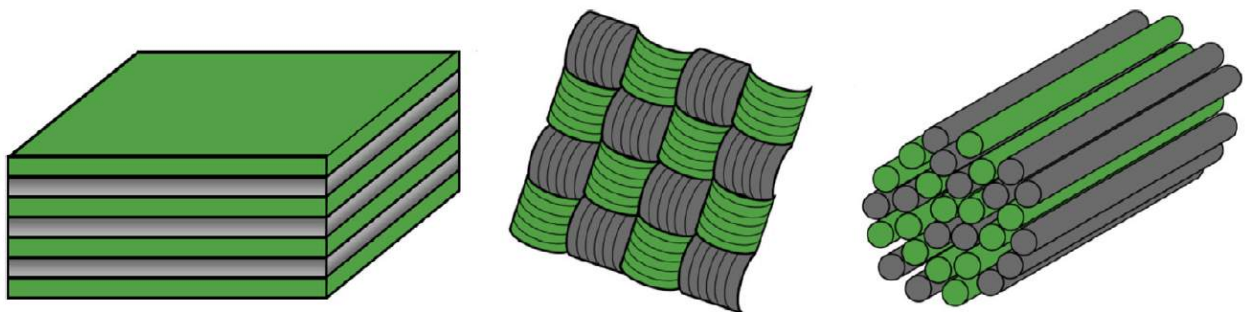
The previous work was extended to using different types of fibres in order to understand failure of these hybrid materials. Analysis are run considering hybridization in three different forms, at the lamina, at the tow level or within the tow. Ultimately we aim to design the failure of these composites to induce pseudo-ductility.



2.2. Hybrid Composites

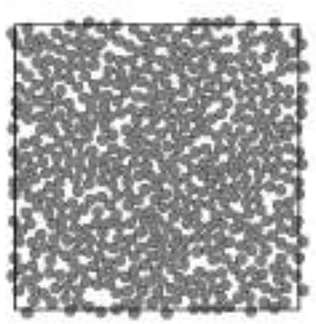
Fibre hybridization changes not only the properties of the composite material but also the failure mechanisms and can be used to achieve a non-catastrophic failure of the material.





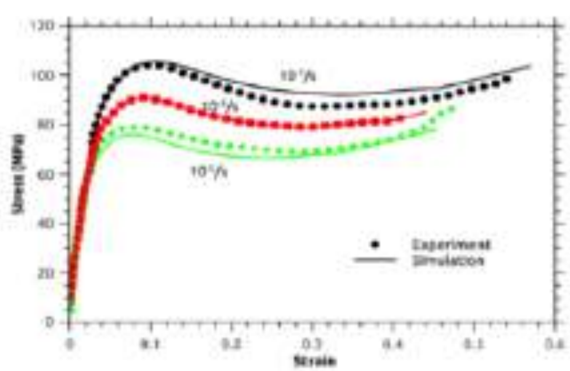
Modelling strategies:

1. Fibre tow model
2. Continuous damage model
3. Spring element Model
4. 3D Micromechanical model

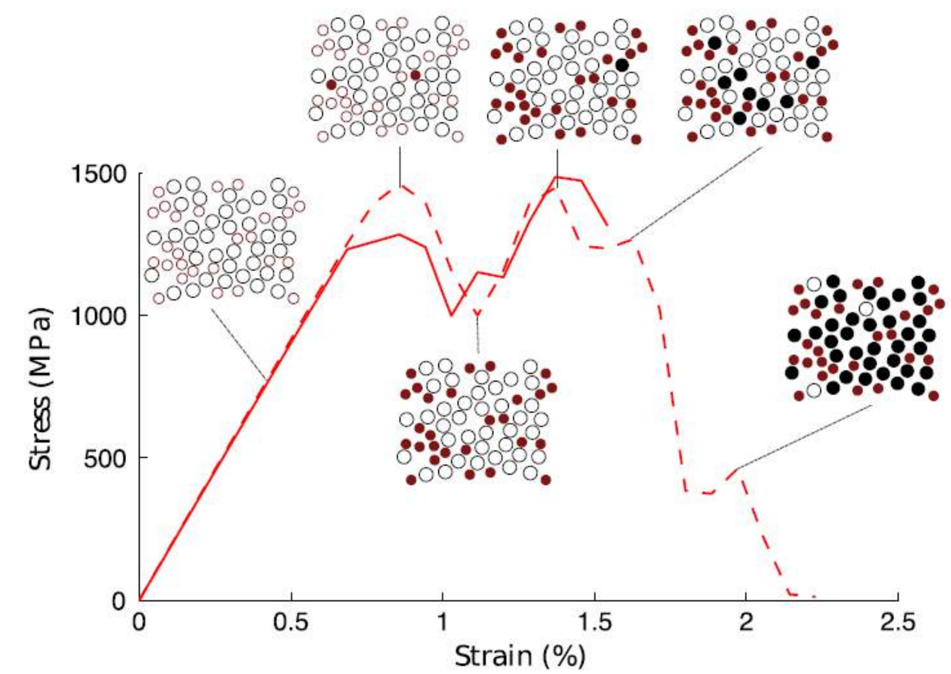


Random distribution of fibres

RVE and mesh generation



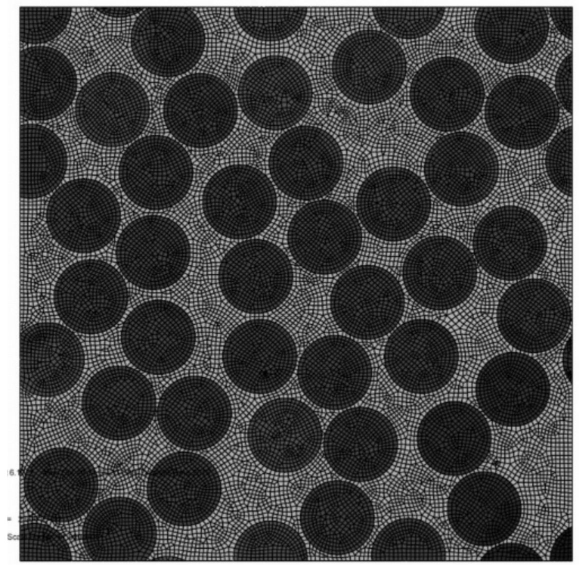
Fibre Matrix and fibre-matrix constitutive modelling



2.2. Hybrid Composites – micromechanical model

Finite Element Model (FEM)

- Real 3D microscopic representation
- All physical phenomena



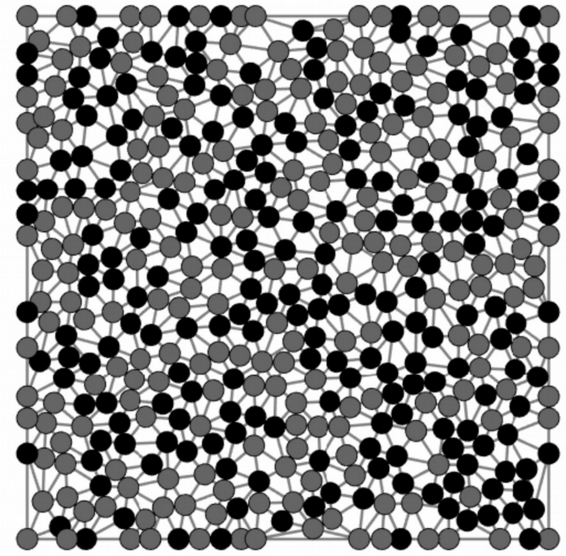
- Computationally extremely expensive

50 Fibres, 3.10^6 elements

few days

Spring Element Model (SEM)*

- Simplified 1D microscopic representation
- The main physical phenomena for longitudinal failure
- Computationally efficient



500-100 Fibres, 5.10^5 elements

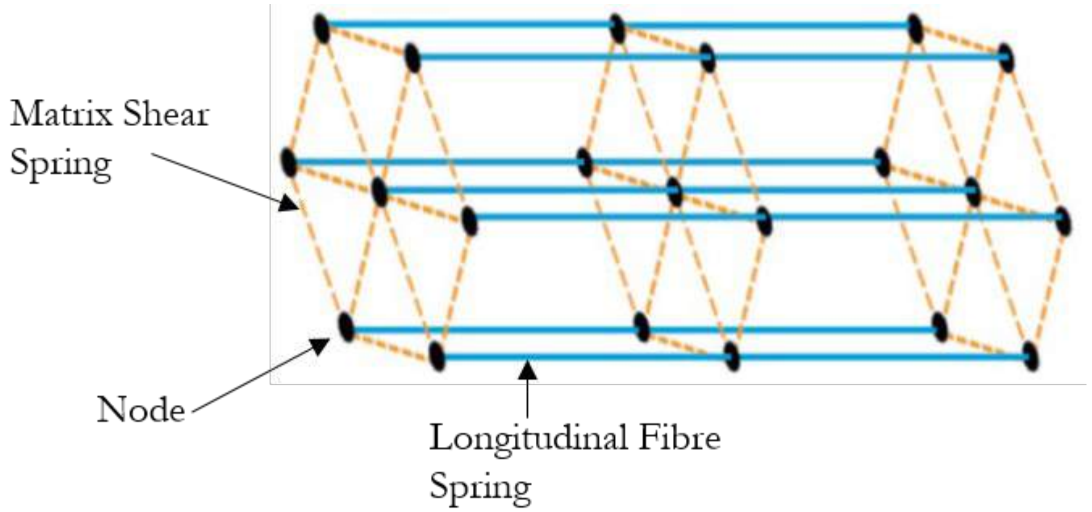
few hours

* R. P. Tavares, F. Otero, A. Turon & P. P. Camanho, ***Effective simulation of longitudinal failure of unidirectional polymer composites***, *International Journal of Fracture* (Submitted)

2.2. Hybrid Composites – 1D model

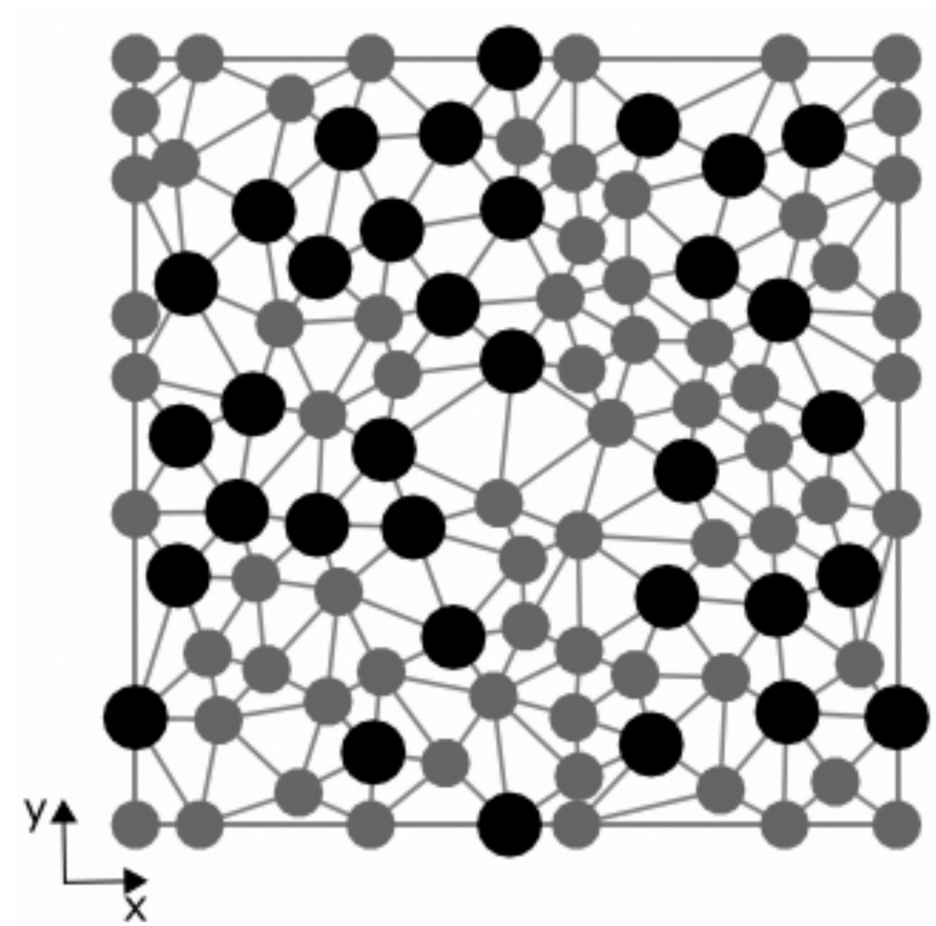
Fibre = longitudinal spring element

Matrix = transverse spring element



3D Represent Volume Element (RVE)

- Random fibre distribution (2D mesh)
  - Extrusion of 2D triangular mesh
- Fibre elements = connecting sections



Failure criteria

- Fibre failure

$$\frac{\sigma_f}{X_T^e} - 1 < 0 \quad \text{if} \quad \sigma_f > 0$$

stress

tensile strength

  – Each fibre = random strength
- Matrix damage
  – Shear stress = maximum G

$$G_{i+1} = \frac{G_i}{\alpha}$$

shear stiffness

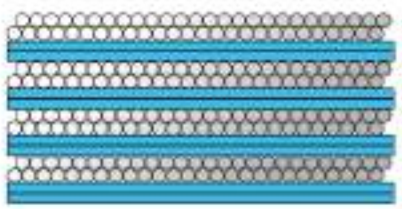
2.3. MULTISCALE 1: NANO-REINFORCED MATERIALS

We are working on nano-reinforcement in two parallel tracks, at the matrix modification level and at the computational mechanical levels. At the computational mechanical concepts work is using existing models and experimenting with different constitutive models to attempt to replicate the modifications.

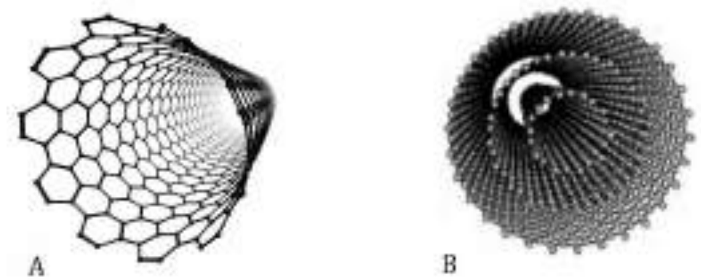
Interesting work could also take place at a sub micro level (atomistic/molecular modelling) which we are not doing.

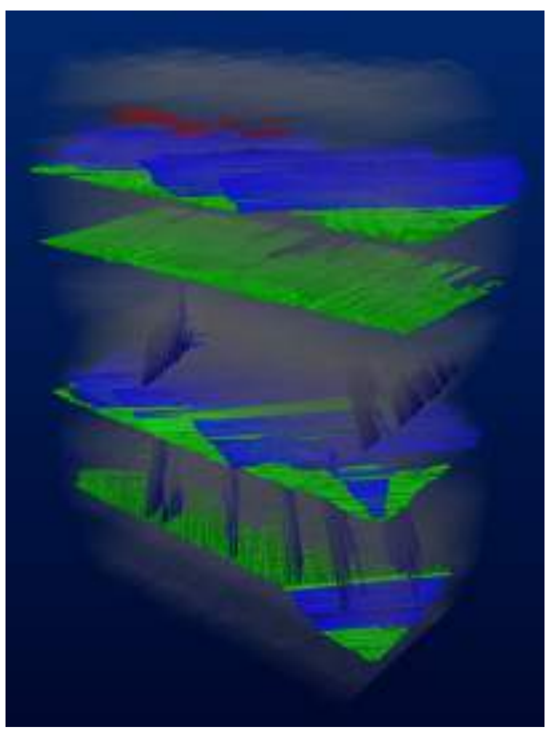
2.3 Nano-reinforced thin ply laminates

Ultra-thin ply laminates



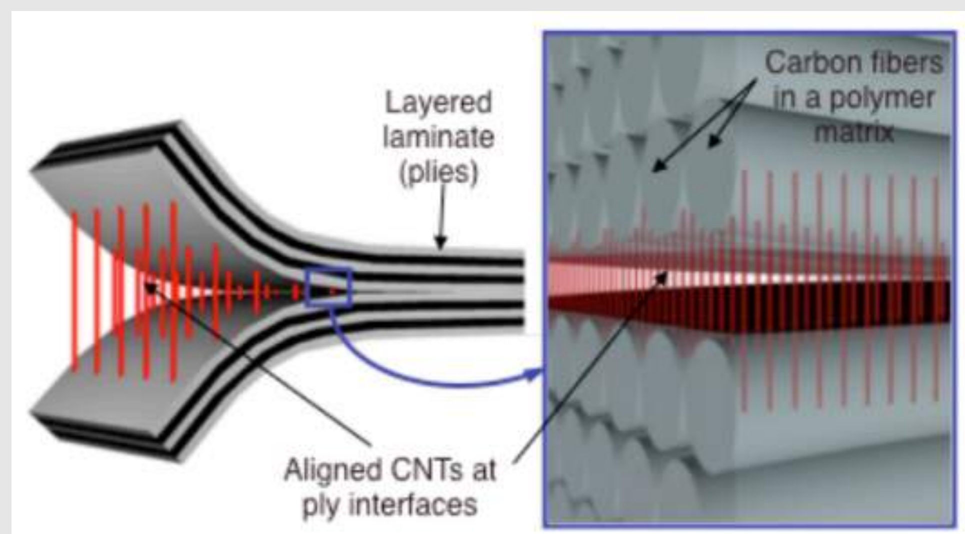
Nanostructured materials



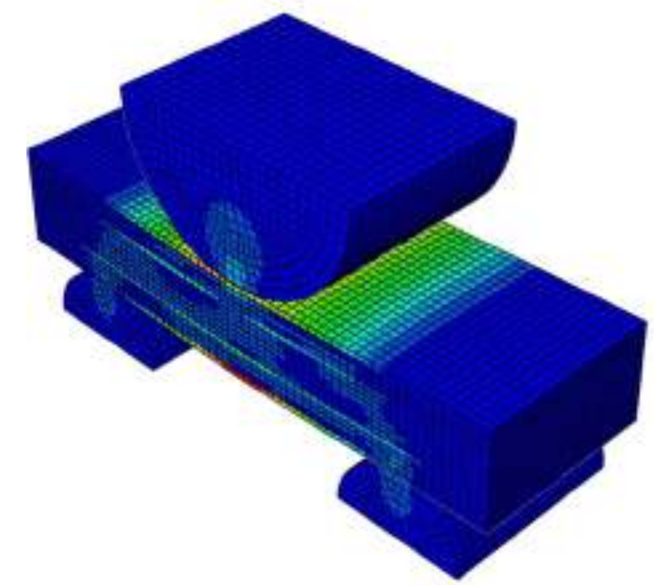


Experimental work

Nano-reinforced thin ply laminates



Concept

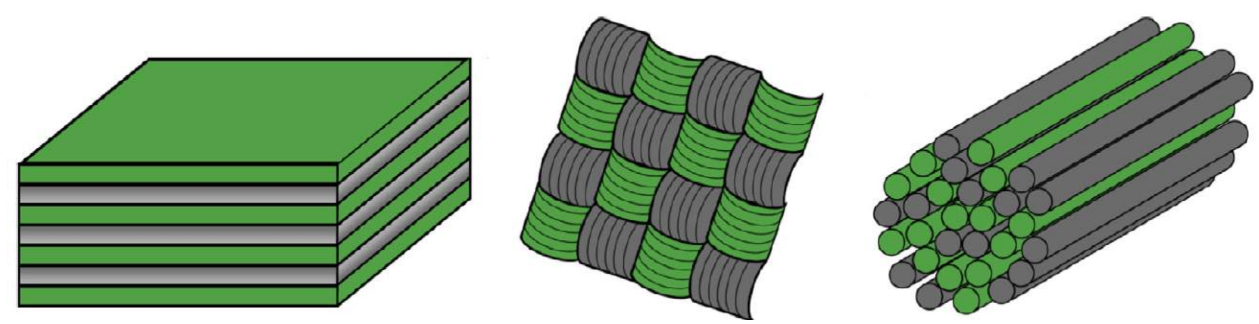


Simulation

What are the improvements of nano-reinforced thin-ply laminates over standard grade composite materials?

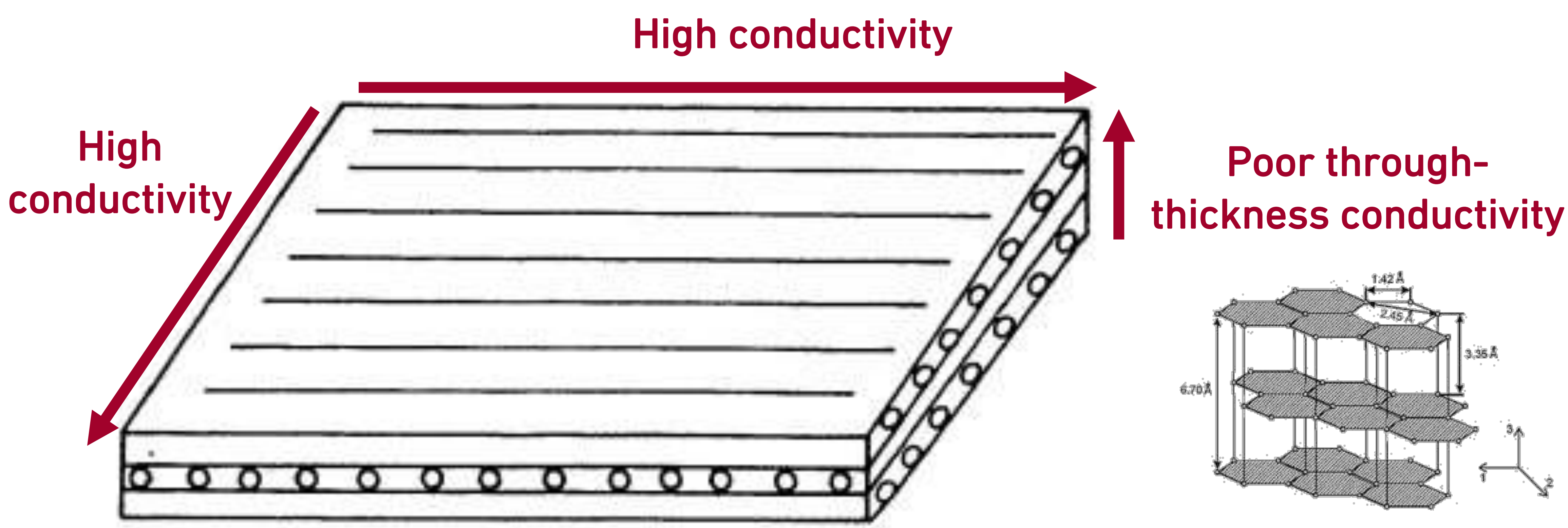
3. NEW MATERIALS AND NEW PROPERTIES OPENING UP NEW OPPORTUNITIES.

New materials and new properties open up new opportunities. Obvious avenues for development lie not only in the fields of nano-modification of resins but also on hybridization. Along side this one could add new or improved fibres and sizing.



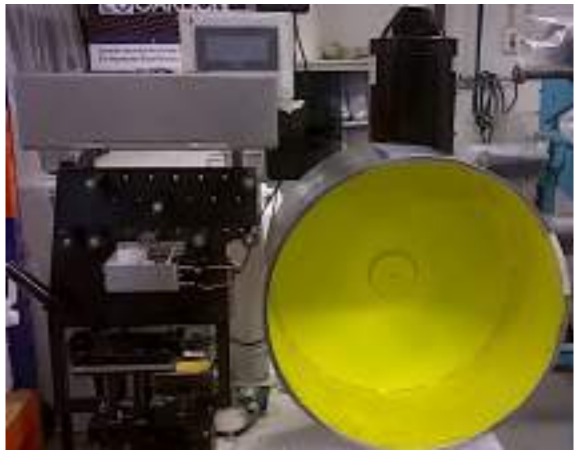
Relevance of MultiFunctionality in CFRP

- When compared to metals, due to their anisotropic characteristics, CFRP do not provide thermal and electrical **conductivity in the through-thickness direction**, currently limiting their use in structural applications where it is required to dissipate heat and electric charges (ex: electronic boxes and aircraft structures for lightning-strike protection).



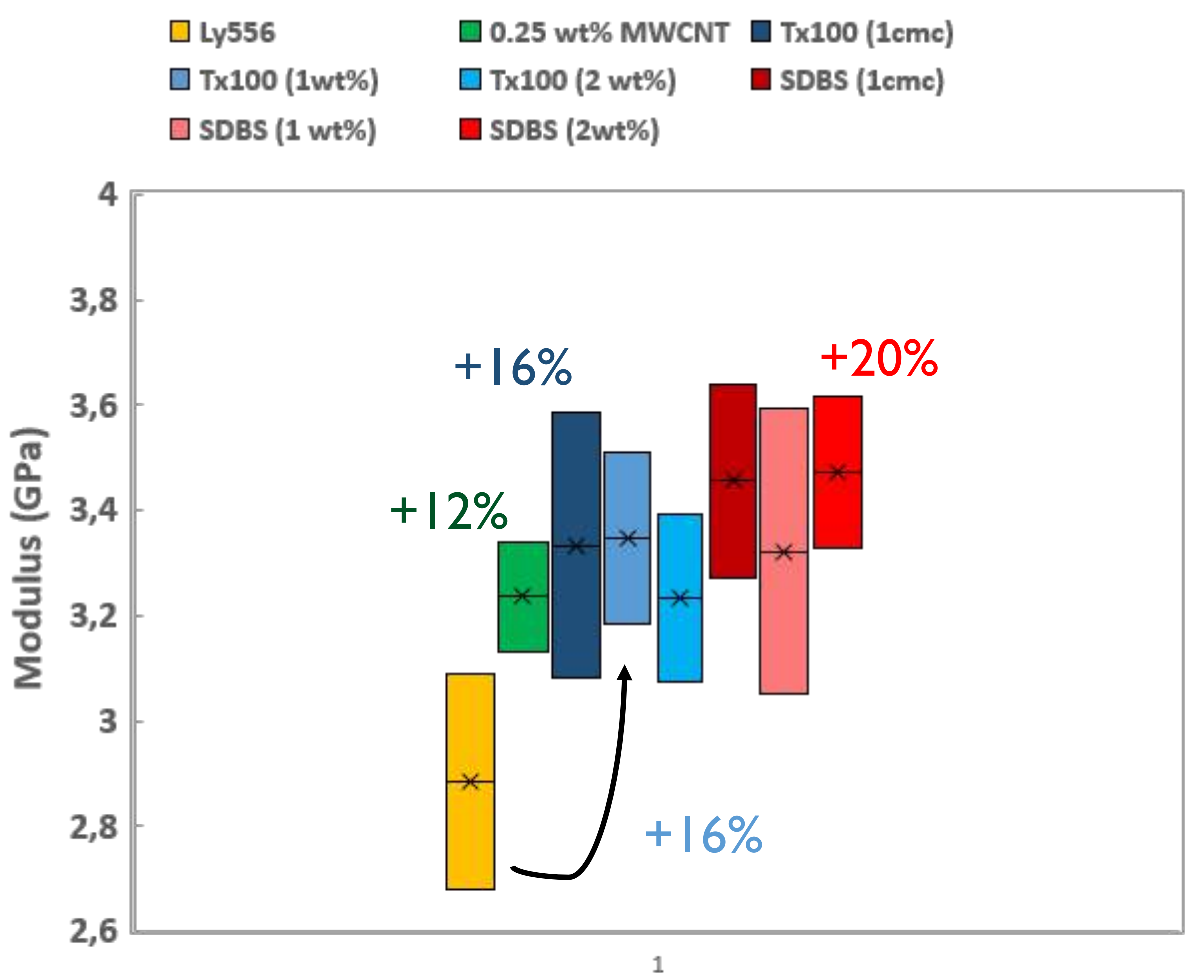
3.1. CARBON NANOTUBE AND GRAPHENE MODIFIED MATRICES

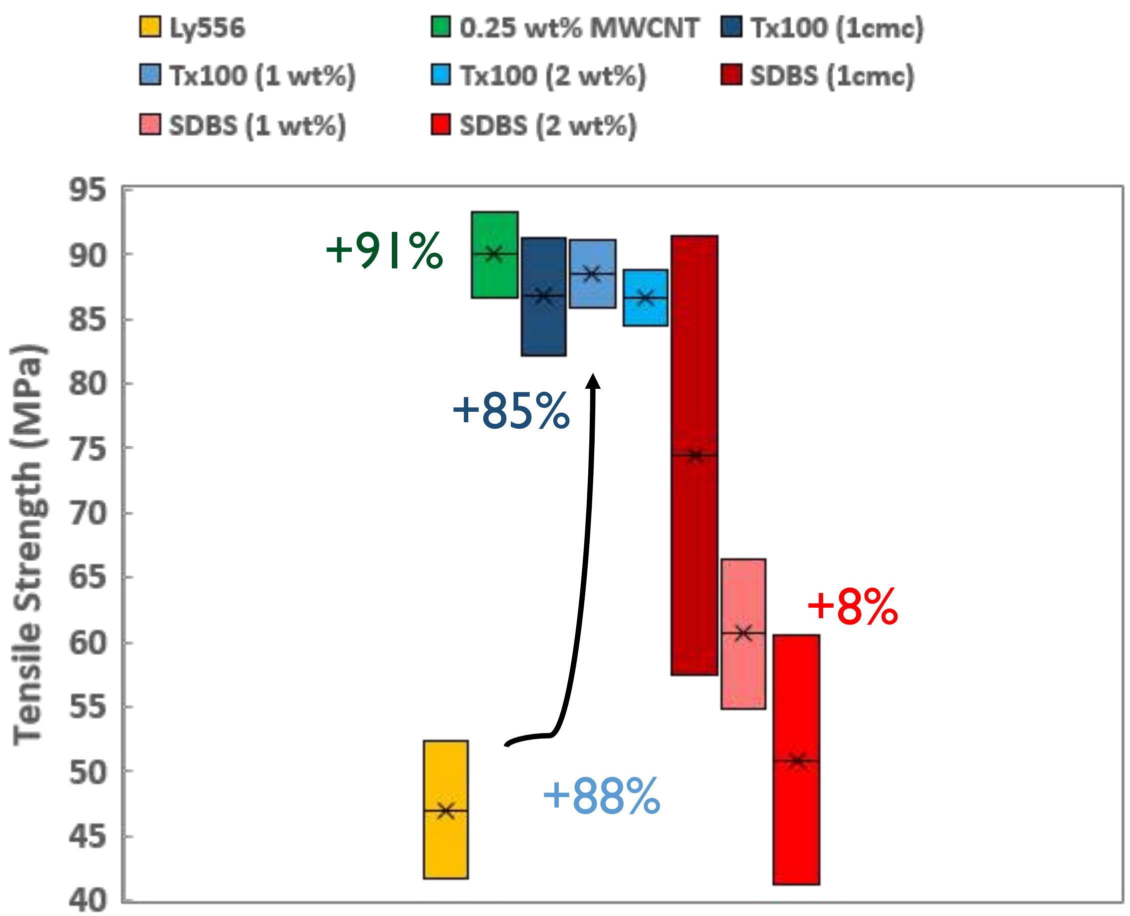
The approach that is being followed is to modify epoxy matrices with the inclusion of CNTs and graphene (including the development of dispersing agents) and to include these new matrices in bespoke prepreg materials (which are then used to demonstrate macroscale, structural, impact of the modifications.



Our approach & Results

The influence of different surfactants on Mechanical Properties





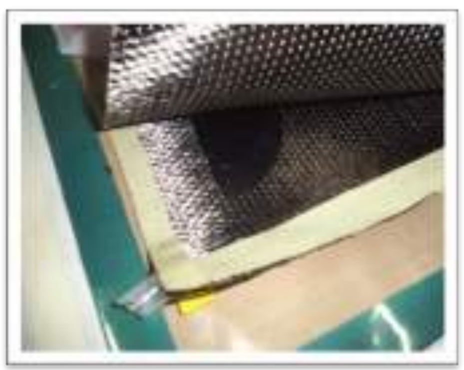
The addition (0,2wt%) of CNTs normally improves the elastic modulus (~34%) and reduces the tensile strength (10%)

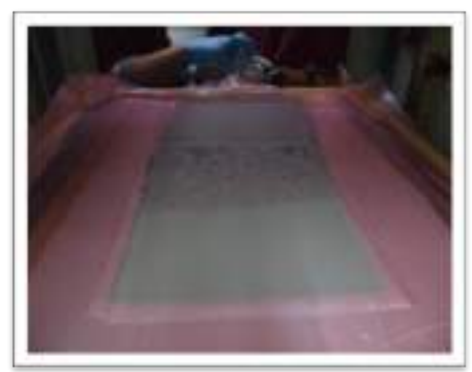
Ghorabi et al., Iran Polym J (2012)

Use of carbon nano tubes and graphene for high thermal conductivity

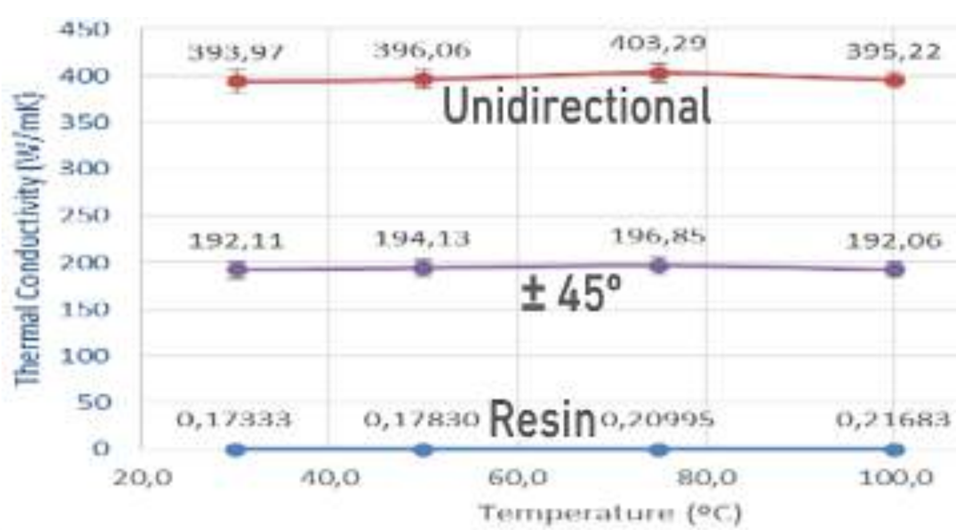
Materials development

CFRP preparation based on thermally conductive pitch-based carbon fibres.
Evaluation of processing variables.

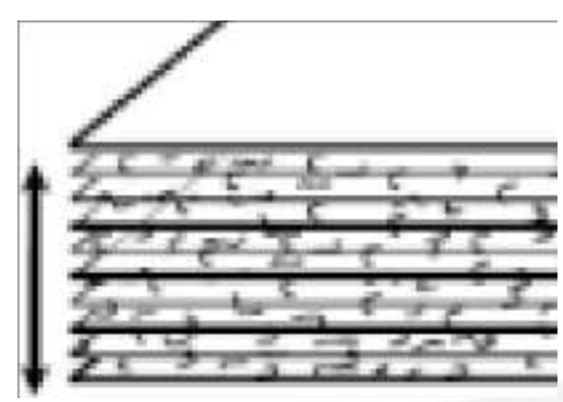


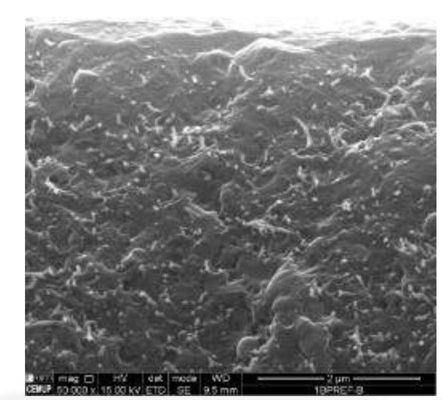


Very high in-plane conductivity is an advantage for systems thermal design



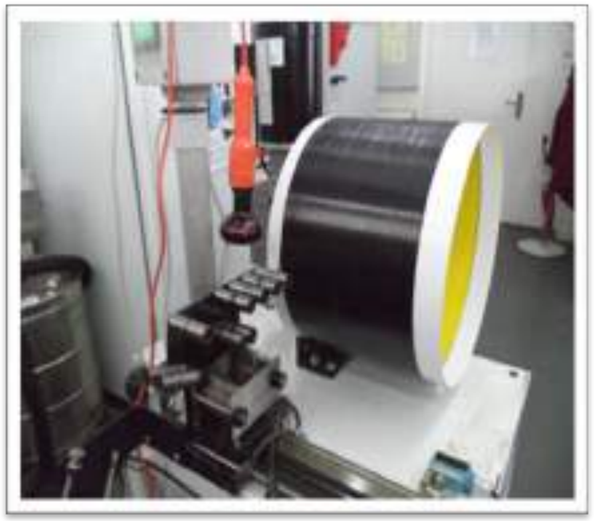
Alternative approaches based on carbon nanotubes doping for increased through thickness conductivity

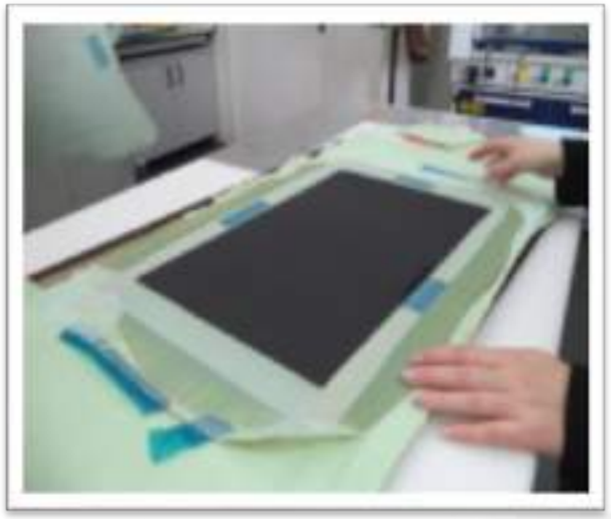




3.2. NEW FIBRE MATERIALS

Our work on the development of fibres extends from the development of composite demonstrators for high modulus (>350 GPa) PAN based carbon fibres working with FISIPE (now SGL) on the development of the precursor, graphitization and pre-impregnation steps to currently working on a number of follow-on projects (MODCOMP, SPACE CARBON and others) which aim to stabilize this knowledge and bring it to the market. We are also starting work on thermoplastic comingling (CF/PPS) on a 4 year project.





4. EXAMPLES OF PROJECTS

European Space-Qualified Carbon Fibres and Pre-Impregnated Based Materials

Partners: INEGI (PT), Fisipe (PT), Airbus Defence and Space (SP), and CTL (IR).
Client: EC – European Comission

EUCARBON (2011-2015): the main objective was to develop European carbon fibers and pre-impregnated materials for satellite sub-systems applications. It was further objective to improve electrical and thermal conductivity of these materials using CNT doped resins approach.

inegi driving science & innovation · FISIPE YOUR CREATIVE PARTNER IN ACRYLIC FIBERS · AIRBUS DEFENCE & SPACE EADS CASA ESPACIO · Composites Testing Laboratory CTL Tástáil Teo.

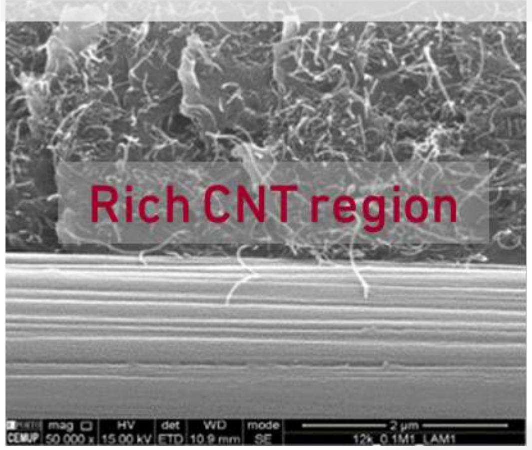
Pre-Impregnation with resin system modified with carbon nanotubes

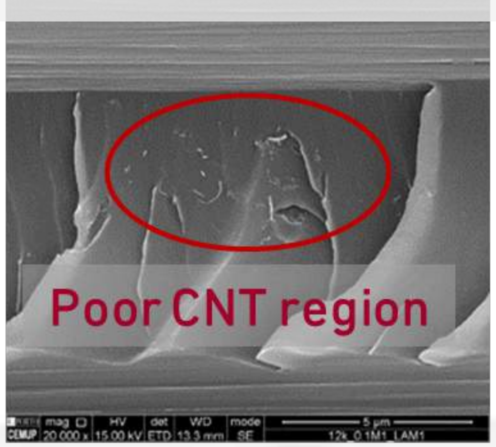
- High fibres stiffness and further increase of epoxy resin system viscosity makes this process very challenging
- CNT contents up to 1.5% (wt. in epoxy) where achieved using intermediate modulus fibres (IMS60)

- Strength decreased for only 0.1% loadings

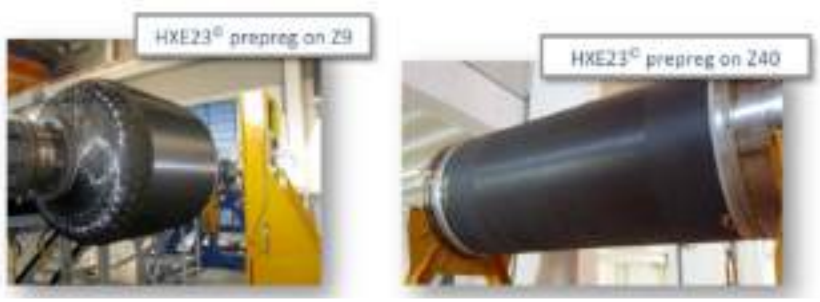
Sample	HM	HM + 0.1%wt.CNT
Fibre Volume Fraction	52% (Reference: 60%)	47% (Reference: 60%)
Voids content (%)	0.77 (Acceptance: <2)	0.21 (Accept: <2)
ILSS (MPa)	70 ± 1.3 (Nom: 81; Accept: 80)	69 ± 0.9 (Nom: 89; Accept: 80)
0° Tensile Strength (MPa)	1700 ± 97 (Nom: 2000; Accept: 2000)	1340 ± 98 (Nom: 1700; Accept: 2000)
0° Tensile Modulus (GPa)	182 ± 8.0 (Nom: 210; Accept: 195)	162 ± 2.3 (Nom: 206; Accept: 195)

- Poor dispersion in the matrix





SPACECARBON Project | European Carbon Fibres and Pre-Impregnated Materials for Space Applications



- Develop intermediate and high modus carbon fibres for launchers and satellite sub-components.
- Develop pre-impregnation process for Space Qualified Prepregs
- Novel prepreg formulations for future Spacecraft structural composites

CO-FUNDING

European Commission | Horizon 2020 European Union funding for Research & Innovation

HORIZON 2020

PARTNERS

FISIPE YOUR CREATIVE PARTNER IN ACRYLIC FIBERS

AIRBUS DEFENCE & SPACE

AVIO

AAC

National Technical University of Athens

ECO-COMPASS Project | Ecological and multifunctional composite materials for application in aircraft

› Development and evaluation of multifunctional and ecologically improved composite materials using bio-fibres and bio-resins for application in the aviation sector.

CO-FUNDING

European Commission | Horizon 2020 European Union funding for Research & Innovation

PARTNERS

Deutsches Zentrum für Luft- und Raumfahrt e.V. | Airbus Group Innovations France University of Manchester | Centre Internacional de Mètodes Numèrics a l'Enginyeria LEITAT Technological Centre | University of PATRAS | L-UP China Aviation Industry Corporation | Beijing Institute of Aeronautical Materials | China Aviation Industry Corporation | Hefei Hangtai Electrophysics Co, Ltd. | Avic Xi'an Aircraft Industry Company Ltd. | Ningbo Institute of Materials Technology and Engineering, CAS | Tongji University | Shandong University | Harbin Institute of Technology | Shanghai Aircraft Manufacturing CO, Ltd. | China Aviation Industry Corporation General | Aircraft Co, Ltd.

PASSARO Project | Design of multifunctional structures using intelligent technologies

› Produce more efficient aircraft in relation to cost and weight, using the incorporation of composite materials.

› Demonstrate, through representative prototypes, the applicability of technologies for design, manufacturing and ground testing, including full-scale physical demonstrators on the ground (a cockpit structure, external wing and aileron).

CUSTOMER

AIRBUS DEFENCE & SPACE

CO-FUNDING

European Commission | Horizon 2020 European Union funding for Research & Innovation

Clean Sky 2

PARTNERS

CAETANO AERONAUTIC GRUPO SALVADOR CAETANO

aertec solutions aerospace & aviation

iSQ

alma DESIGN

CRITICAL MATERIALS

EDISOFT DEFENCE & AEROSPACE TECHNOLOGIES

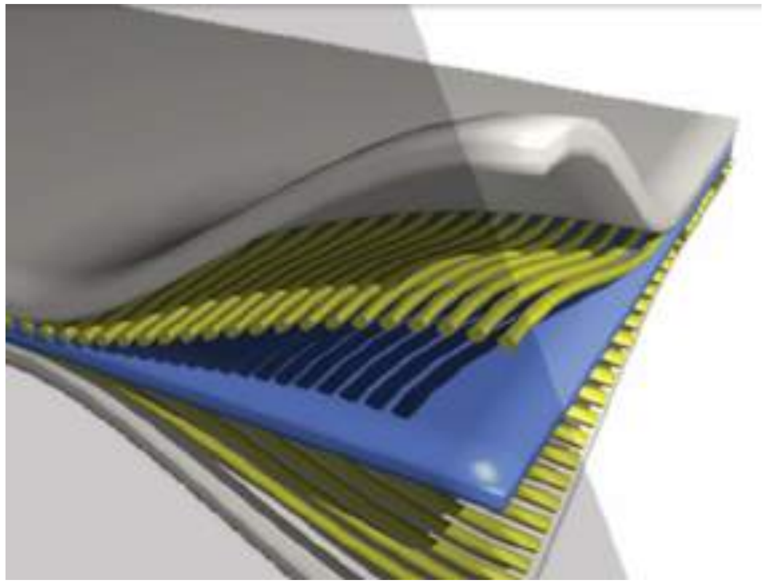
gmv INNOVATING SOLUTIONS

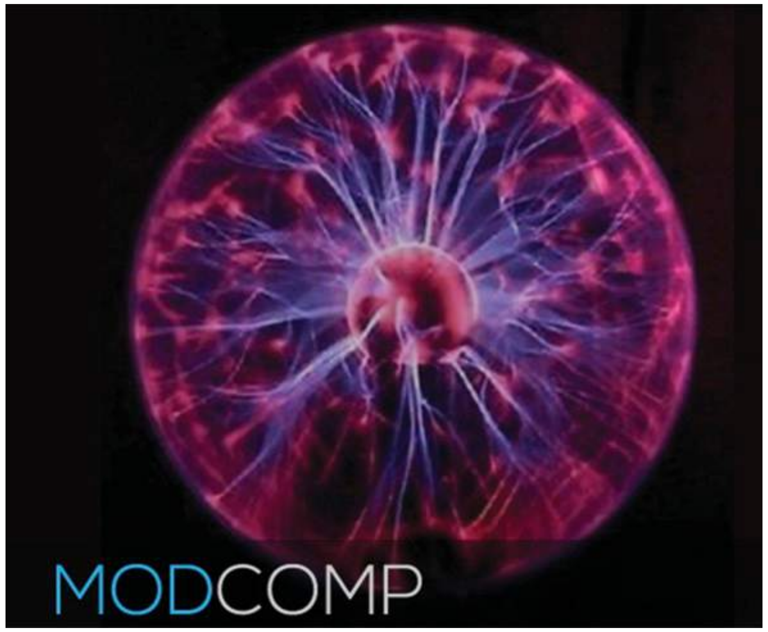
OPTIMAL STRUCTURAL SOLUTIONS

CEiiA

tekever

MODCOMP Project | New structural solutions based on carbon fibres





› Development of new structural solutions for technical products with high added value and high performance, through new fibre modification strategies.

› Design of demonstrators capable of satisfying levels for future industrialisation, having as end users several industrial sectors, namely automobile and transport, aeronautics and space, construction, leisure and electronics.

CO-FUNDING

European Commission | Horizon 2020

PARTNERS

National Technical University of Athens | The Welding Institute | University of Birmingham | Thales Research & Technology | ITAINNOVA - Instituto Tecnológico de Aragón | GlobalSafeGuard Ltd | Anthony, Patrick & Murta Exportação | NCC Operations Ltd | Open Source Management Ltd. OSM United Kingdom SME | Innovation in Research & Engineering Solutions | IRES Belgium SME | Politecnico di Torino POLITO Italy RTO | Swerea SICOMP AB SICOMP Sweden RTO | Aernnova Engineering Division S.A. AERN Spain IND | Freni Brembo SpA BREMBO Italy IND | Yuzhnoye State Design Office YUZ Ukraine IND | Euromobilita S.R.O. EUMO Czech Republic SME

ENLIGHT Project | Car door prototype made of carbon fibre reinforced polymer

› Development of viable and sustainable solutions for the production of electric vehicles.

CO-FUNDING

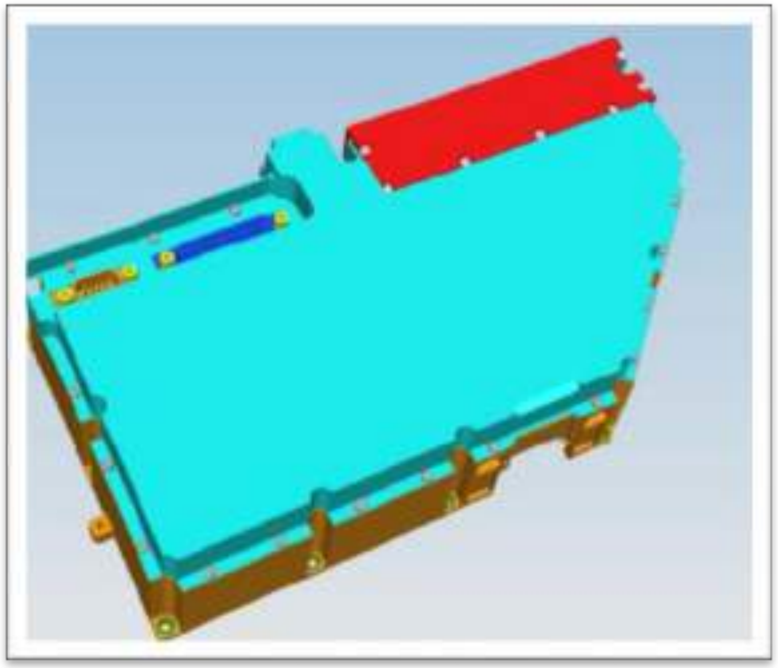
PARTNERS

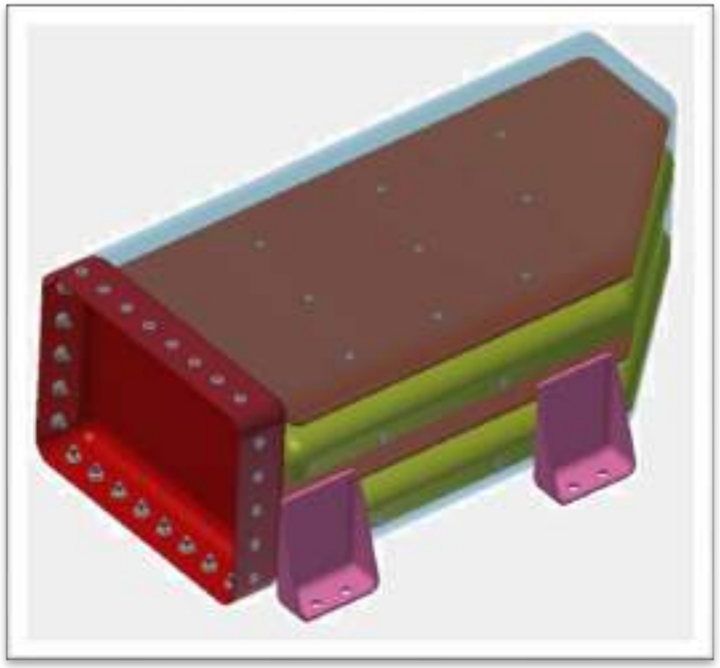
Fraunhofer LBF | AIT Austrian Institute of Technology - LKR GmbH | Airborne Technology Center B.V. | Bax & Willems S.L. | Benteler Automobiltechnik GmbH |CENTRO RICERCHE FIAT SCPA | DSM Engineering Plastics | Institut für Kraftfahrzeuge - RWTH Aachen | Jaguar Cars & Land Rover | Katholieke Universiteit Leuven | MAGNETI MARELLI S.P.A. | Oxeon AB | RENAULT | Sistemas y Procesos Avanzados S.L. | Swerea SICOMP AB | Tecnaro GmbH | Università degli Studi di Firenze | Volvo Technology Corporation | VOLKSWAGEN AG | The University of Warwick

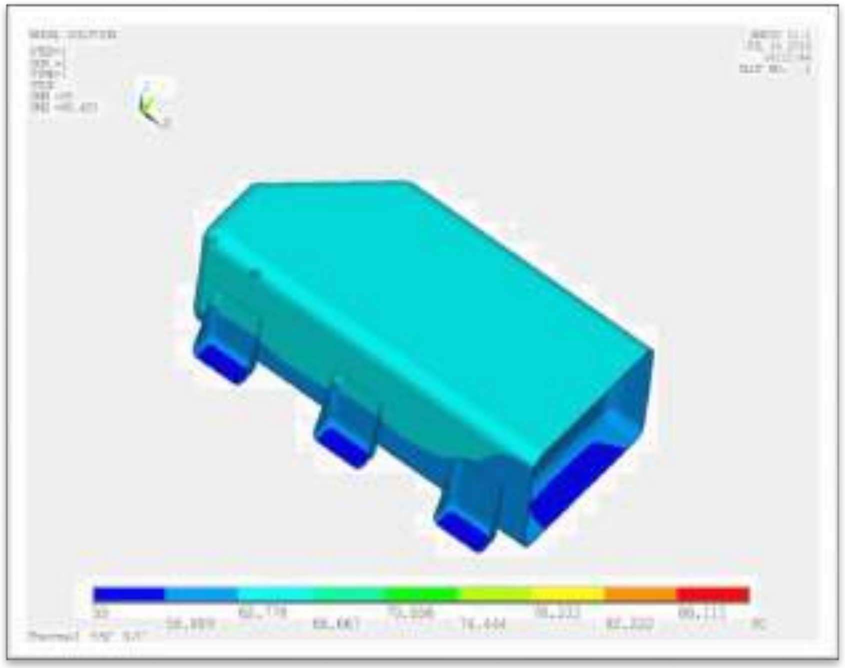
RTM EBOX: "Thermally Conductive RTM CFRP" (2013-2015)

Objective: Manufacturing of a thermally conductive electronic box based on Resin Transfer Moulding (RTM) process.

Increased interest in out-of-autoclave processes and thermally conductive CFRP.



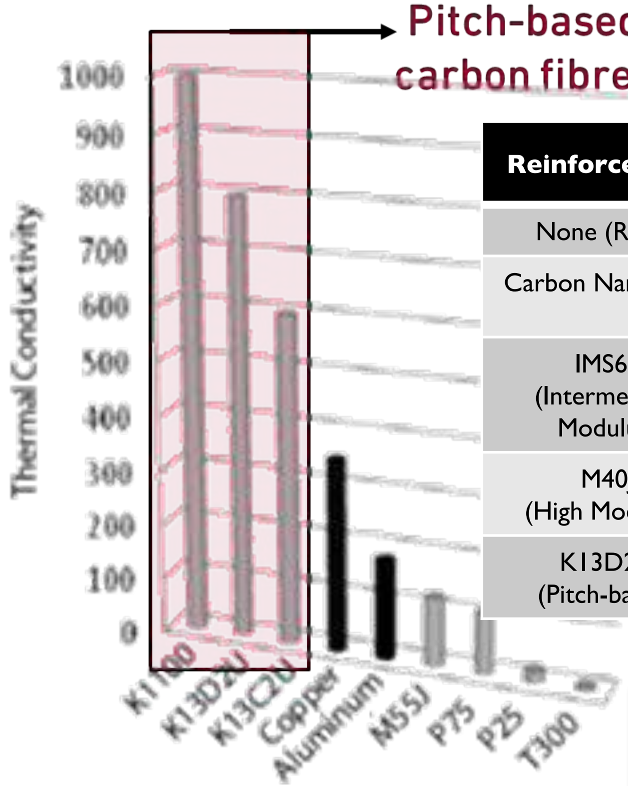




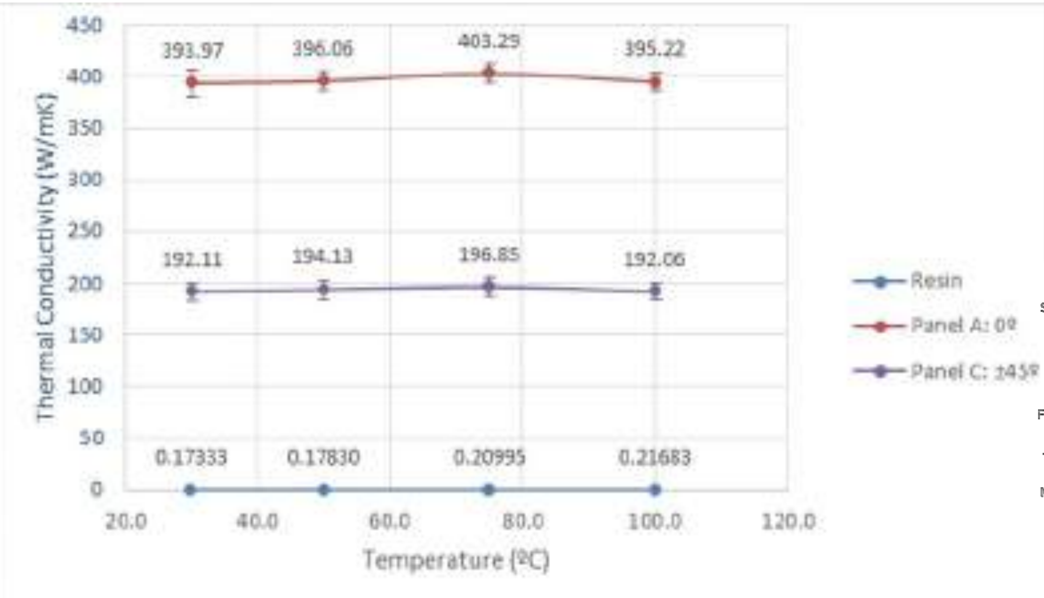
Thermally Conductive CFRP manufactured by Resin Transfer Moulding

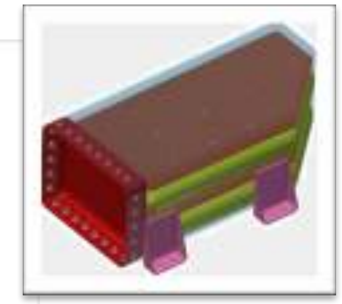
Partners: INEGI (PT), HPS (DE), and Evoleo (PT).
Client: ESA – European Space Agency

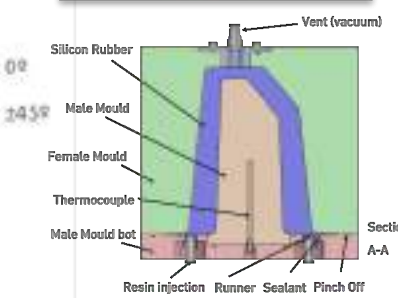
RTM E-BOX (2013-2015): the main objective was to develop a thermally conductive composite material for electronic box space applications, manufactured through an out-of-autoclave process (Resin Transfer Moulding).



Reinforcement	Volume Fraction	Thermal conductivity
None (Resin)	-	0.2 W/mK
Carbon Nanotubes	1%	0.3 W/mK
IMS60 (Intermediate Modulus)	45%	0.6 W/mK
M40J (High Modulus)	50%	0.8 W/mK
K13D2U (Pitch-based)	60%	2.0 W/K



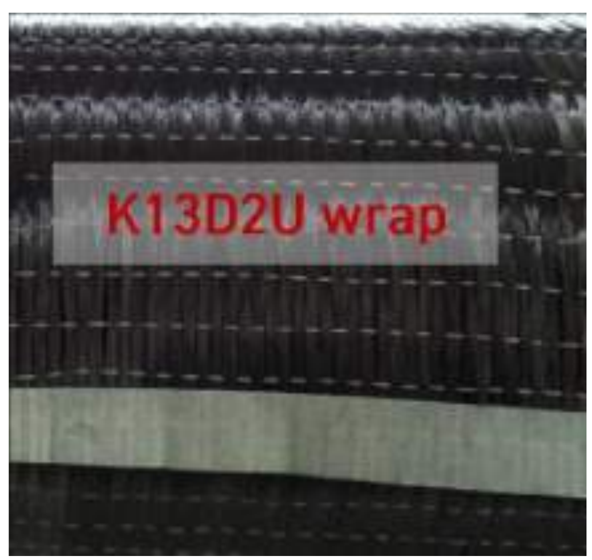




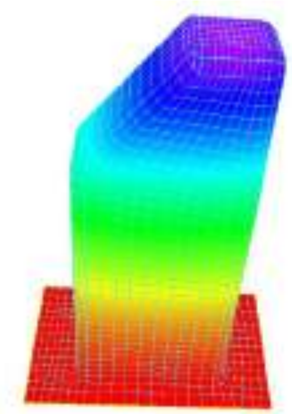
inegi driving science & innovation HPS EVOLEO

RTM EBOX: “Thermally Conductive RTM CFRP” (2013-2015)

Alternative approaches based on carbon nanotubesdoping for increased through thickness conductivity

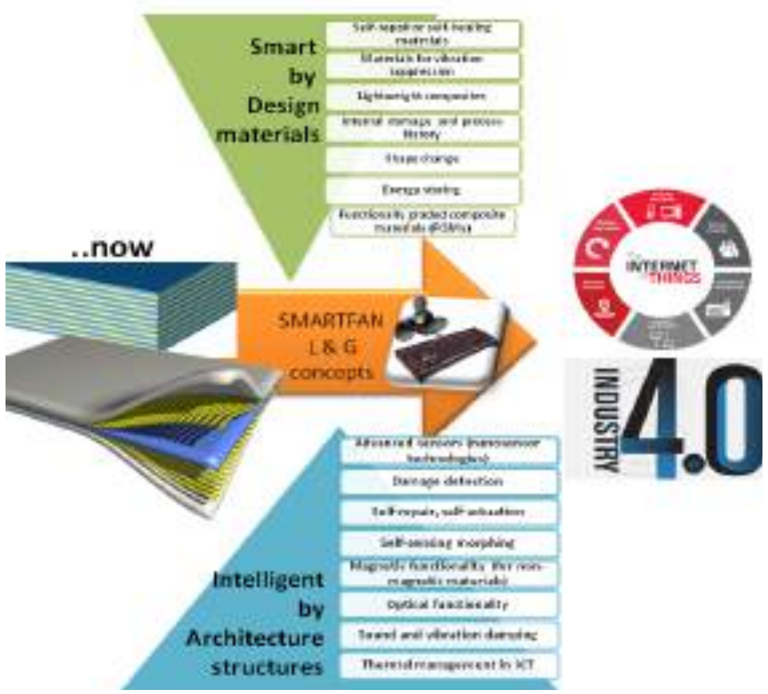


RTM process modelling



In-house RTM manufacturing facilities

SMARTFAN Project | Smart by Design and Intelligent by Architecture for turbine blade fan and structural components systems



SmartFAN

› Develop “smart” composite materials, from raw-materials to novel architectures, with integrated functionalities that will interact with surrounding environmental (focus on self-sensing, actuating and damage repair)

› Demonstration through prototypes of turbine blade fans and structural component systems, requiring materials and process development to integrate smart behaviour on final composites

CO-FUNDING

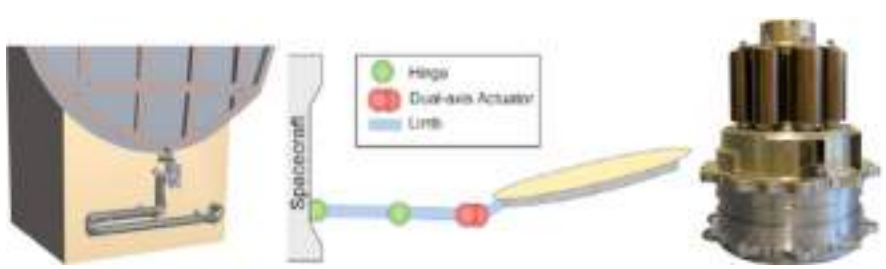
European Commission | Horizon 2020 European Union funding for Research & Innovation

HORIZON 2020

PARTNERS

National Technical University of Athens | Warrant Group| Canoe Platform - Adera | Dallara Automobili | Thales Research & Technology | ITAINNOVA - Instituto Tecnológico de Aragón | Elica | Foundation for Research and Technology- Hellas | Techedge Group | University of Rome - Tor Vergata | Innovation in Research & Engineering Solutions | IRES Belgium SME | Politecnico di Torino POLITO Italy RTO University of Birmingham | BioGen3D - 3D New Technologies | Open Source Management Critical Materials | Lavrion Technology Culture Park

COMETH Project | Composite Elastic Hinge For Antenna Deployment Structures



› Current technology: deployment arms by articulation of one or multiple limbs through mechanical hinges.

› Objective: develop an ultra-light and low-cost composite arm for deployable antennas based on elastic hinges.

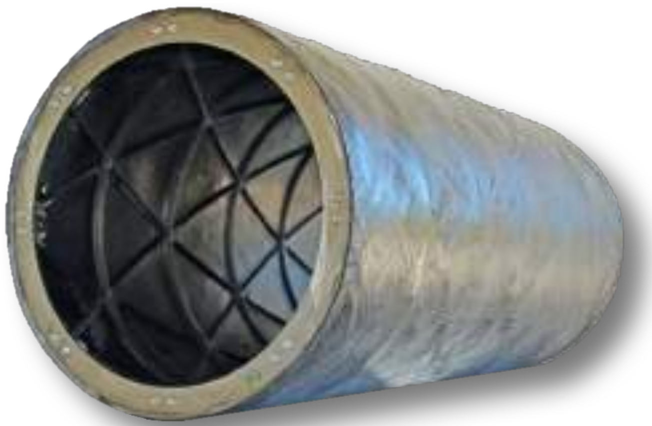
CUSTOMER

esa

PARTNERS

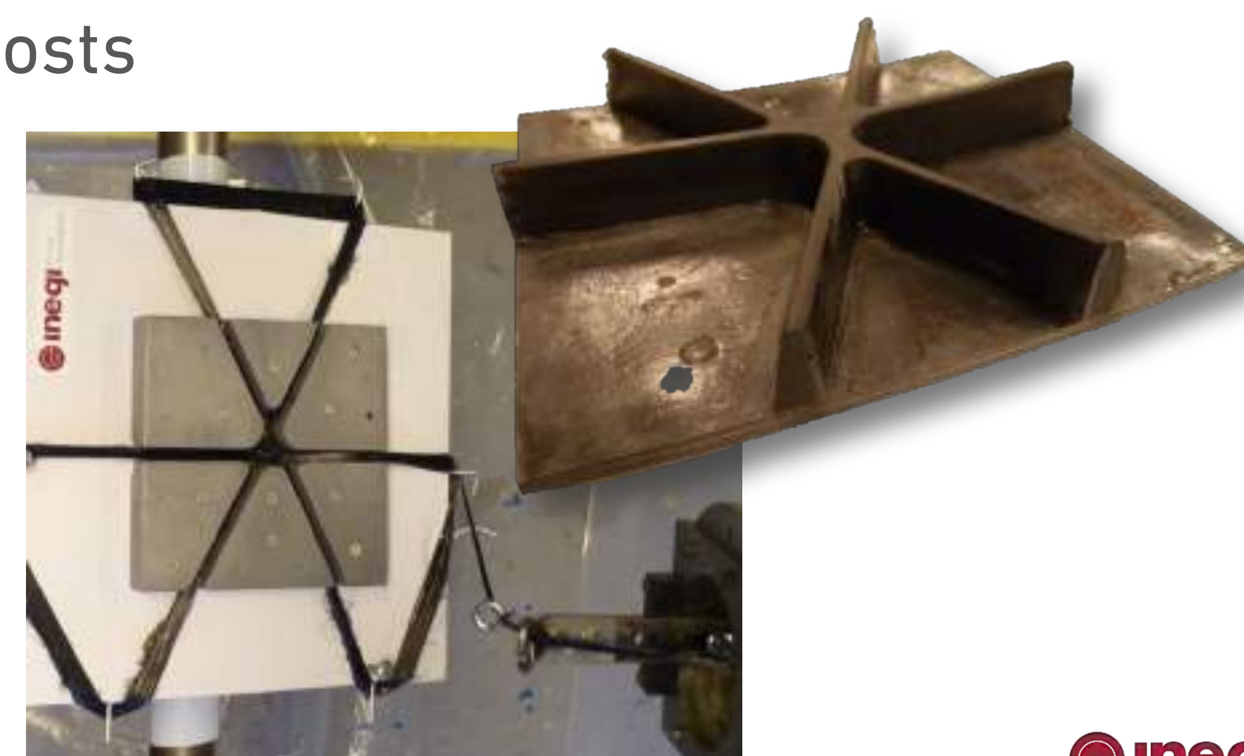
sonaca GROUP

WASIS: “Wafer desing Approach for Safety Increasing in worst case Situations and joints minimizing” (2011-2014)

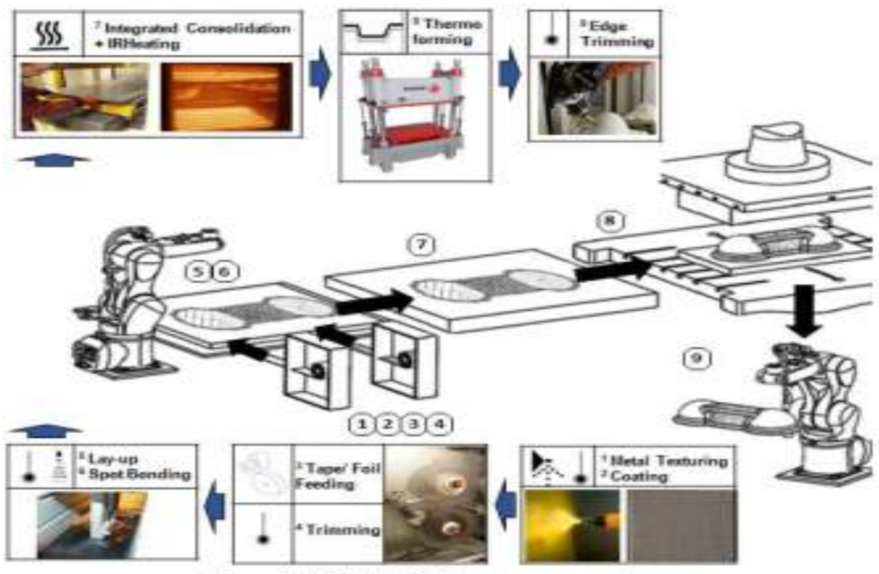


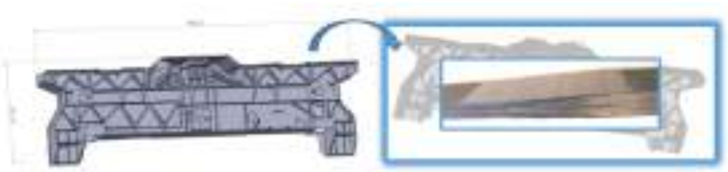
Objective:

- Reduce composite fuselage section weight
- Reduce aircraft fuselage weight
- Raise fuselage section safety in worst case situations
- Reduce aircraft manufacturing costs



LAY2FORM Project | Efficient Material Hybridization by Unconventional Lay-up and Forming of Metals and Composites for Fabrication of Multifunctional Structures





LAY2FORM

› Develop a new advanced and highly integrated manufacturing process for forming of layered metal / thermoplastic-matrix composites hybrid materials

› Suitable to highly dynamic and competitive manufacturing environments, such as those of the automotive sector

CO-FUNDING

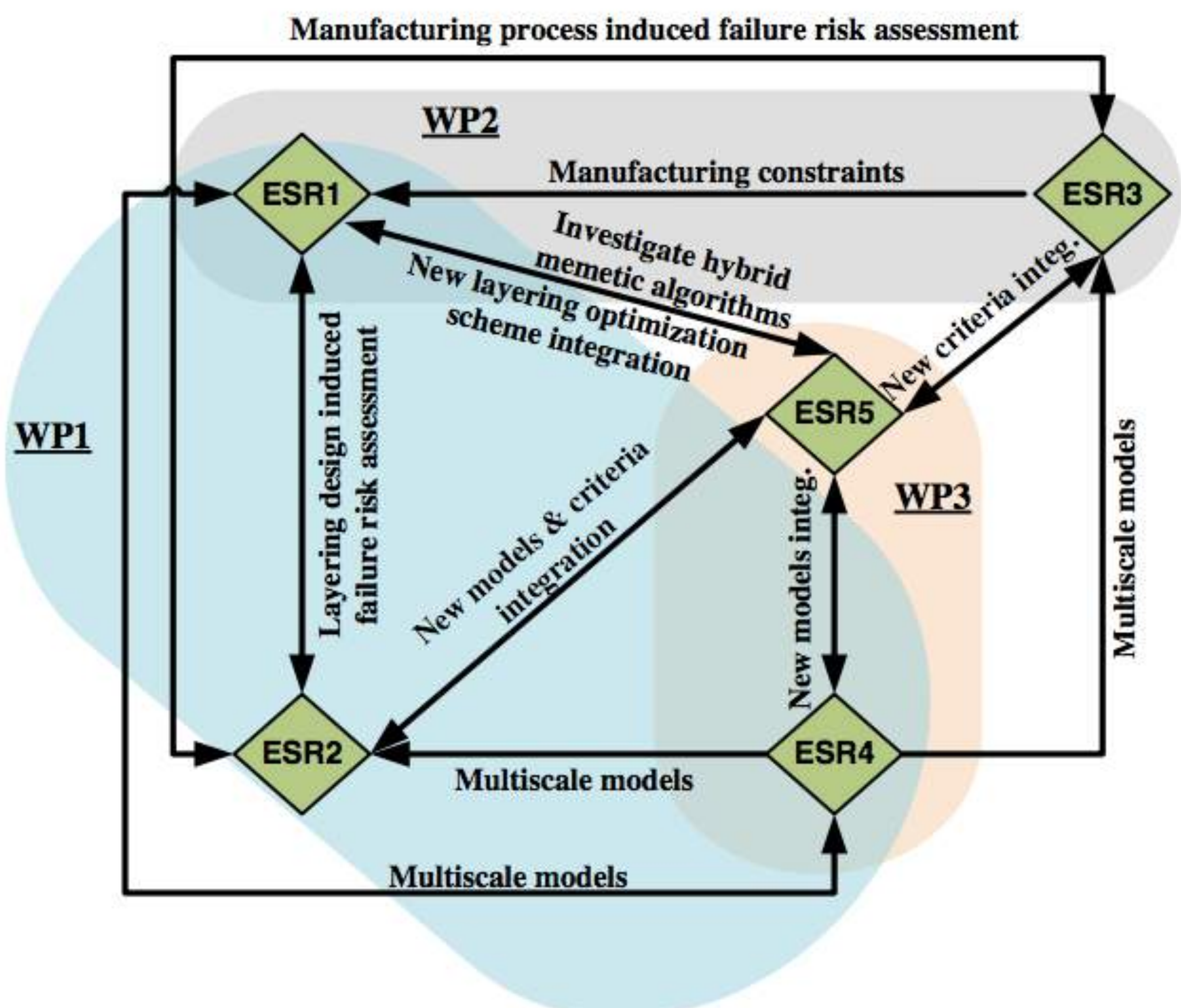
European Commission | Horizon 2020 European Union funding for Research & Innovation

HORIZON 2020

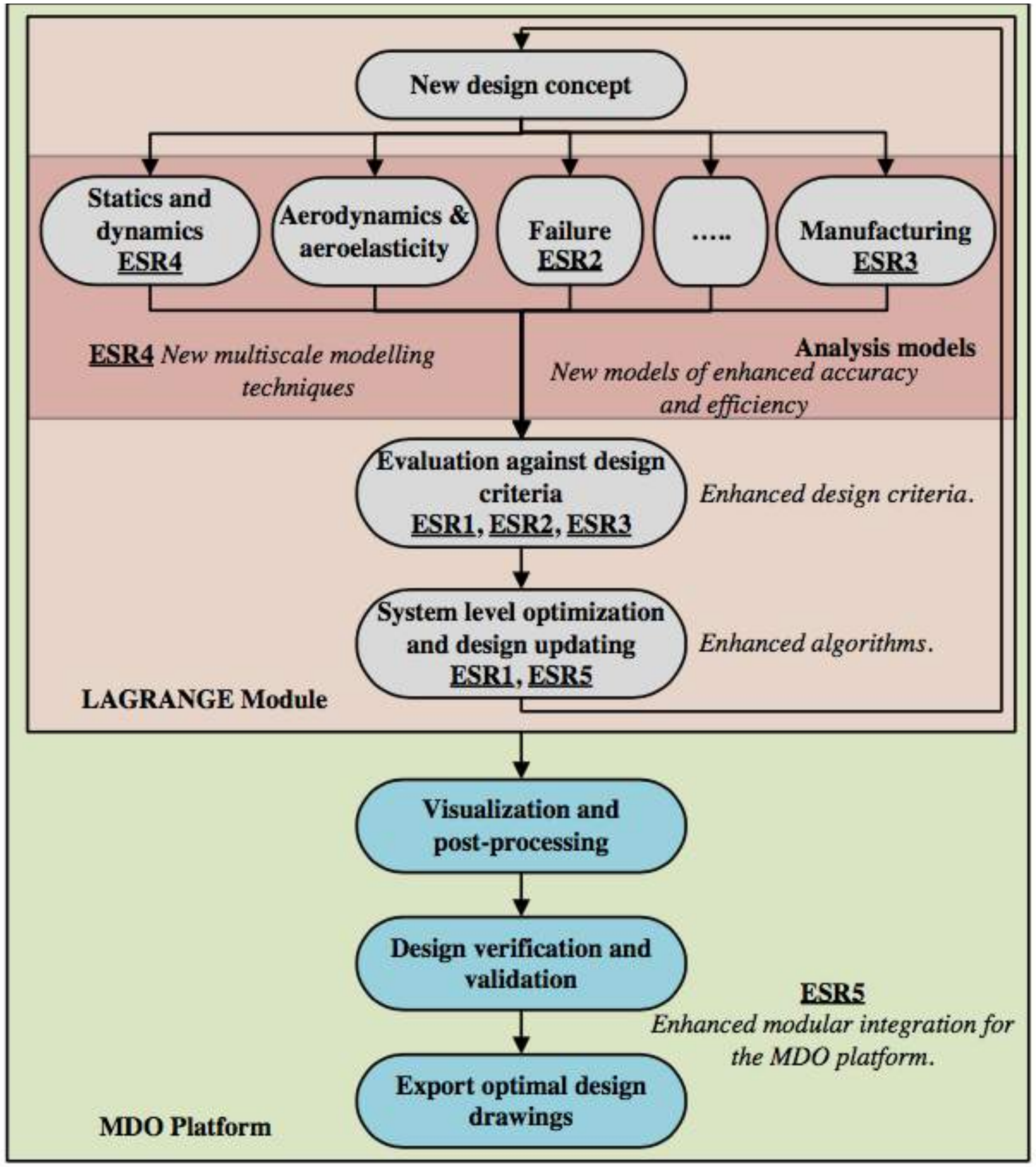
PARTNERS

FAGOR | AIMEN | RESCOLL | ESI | MASSGE | V2I | INAPAL | TREELOGIC | MECASONIC

OPTIMACS



Manufacturing process induced failure risk assessment
WP2
ESR1
Manufacturing constraints
ESR3
Investigate hybrid memetic algorithms
New layering optimization scheme integration
New criteria integ.
ESR5
WP1
Layering design induced failure risk assessment
New models & criteria integration
New models integ.
WP3
Multiscale models
ESR2
Multiscale models
ESR4
Multiscale models



New design concept
Statics and dynamics ESR4
Aerodynamics & aeroelasticity
Failure ESR2
.....
Manufacturing ESR3
ESR4 New multiscale modelling techniques
Analysis models
New models of enhanced accuracy and efficiency
Evaluation against design criteria ESR1, ESR2, ESR3
Enhanced design criteria.
System level optimization and design updating ESR1, ESR5
Enhanced algorithms.
LAGRANGE Module
Visualization and post-processing
Design verification and validation
ESR5
Enhanced modular integration for the MDO platform.
Export optimal design drawings
MDO Platform

X Aero Structures: “Manufacturing of a large wingspan UAV” (2012-2015)

Objective:

- Develop a new concept of operation for a UAV,
- Design specifically for a target-market that is characterized by missions of a pre-determined nature
- Develop new manufacturing methodologies for aerostructures, supported by new materials to be employed
- Develop new test and validation methodologies for the aerostructure, that are conducive to its certification for civilian applications

I-SEAT- RESEARCH AND DEVELOPMENT OF INTEGRATED COMPONENTS FOR RAILWAY SEATS

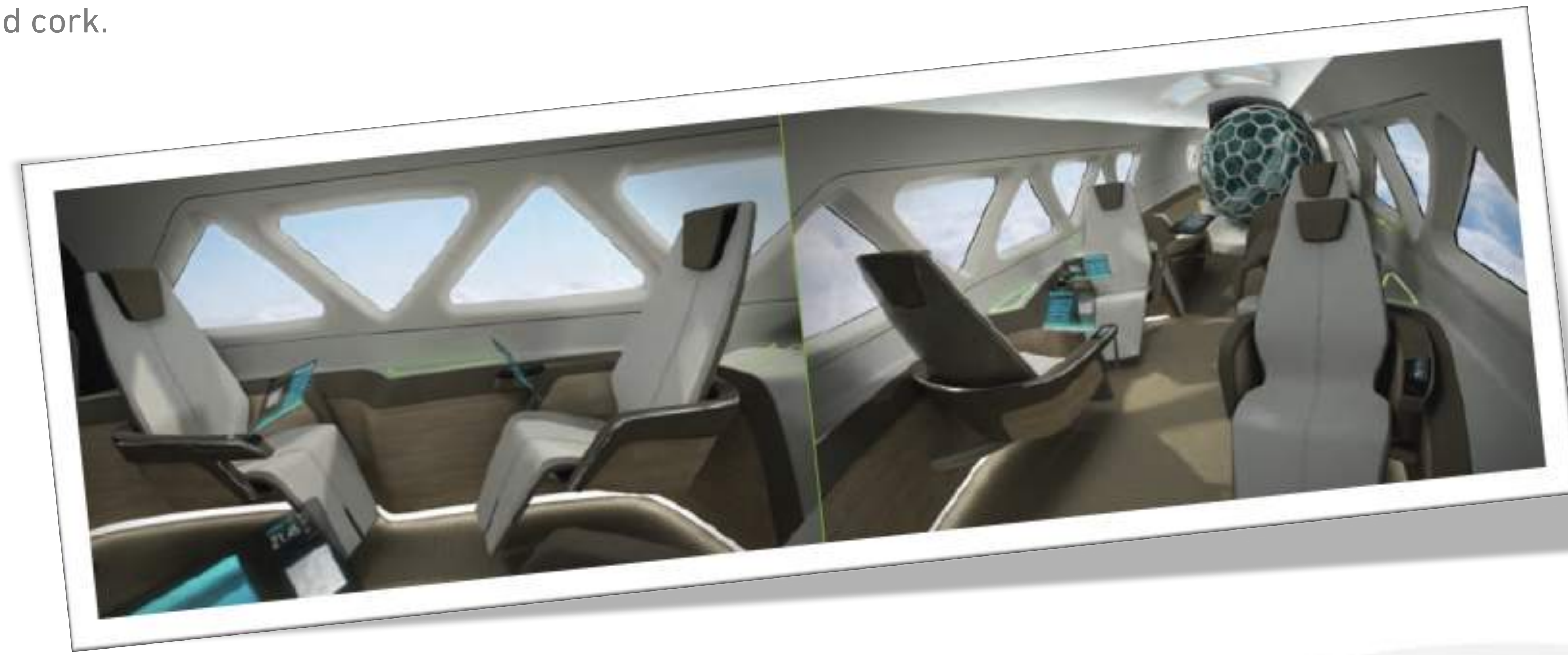
Consórcio: Amorim Cork Composites, Caetano Components, Couro Azul, INEGI
Colaboração: Almadesign e ALSTOM | Cofinanciamento: QREN / COMPETE

The projects purpose is to create skills for design, development and industrialization of functional and technical solutions, for eco-efficient, lighter, more comfortable and innovative railway seats in high-speed trains.

L.I.F.E. - LIGHTER, INTEGRATED, FRIENDLY AND ECO-EFFICIENT

Partners: Amorim Cork Composites, Couro Azul, SET;
Colaboration: Embraer e a Almadesign | Co-financing: QREN / COMPETE

The project L.I.F.E. is a vision for aviation in the future resulting in the conception of the private jet inside within a few years, combining solutions and technology with natural and sustainable materials like leather and cork.



I-BUS - COMPONENTS DEVELOPMENT FOR INTERIOR AND EXTERIOR TOURISM BUS

Partners: Amorim Cork Composites, Caetano Components, Couro Azul, SET
Colaboration: Almadesugn | Co-financing: QREN / COMPETE

This project integrates expertise from different areas of technology to build an innovative "mock-up", reflecting the technological capabilities and the group synergies, applied to the interiors of buses which become lighter, more eco-efficient, comfortable and integrated.

ENROLFILAM - COMET - PLUMA

Client: AMTROL-ALFA | Parceiros: INEGI, PIEP, Saint Gobain Vetrotex
Co-financing: QREN

Development of medium/high pressure composite tanks. INEGI's participation covers the development of the filament winding process, testing of the tank's behaviour to pressure and steaming tests.

Thank you for your attention