

MASTER IN COMPOSITE MATERIALS, 11º Edition 2021-2022			
Topics	ECTS	Coordinator	Teaching period
1st TERM (160 h)			
Constituents Materials and Characterization	8	R. Avila (Airbus Ops)	04/10/2021 28/10/2021
Manufacturing processes for polymer matrix composites structures	8	Augusto Perez Pastor (FIDAMC)	03/11/2021 30/11/2021
Design of advanced composites structures	5	Joaquin Gallego (Airbus Defense)	01/12/2021 22/12/2021
2nd TERM (h)			
Numerical simulation techniques	4	C. Gonzalez (UPM)	10/01/2022 20/01/2022
Analysis of advanced composites structures	8	J.C. Gomez (Airbus Ops)	24/01/2022 17/02/2022
SEMANA DE HOLGURA CASE STUDY			21 a 24 Feb
Certification of aircraft composites structures	4	J. M. Blanco (AIRBUS OPS)	28/02/2022 09/03/2022
In service behaviour and repairs	4	Ivan Rodriguez (Airbus Ops)	14/03/2022 24/03/2022
Production management: Lean manufacturing	4	F.J. Paramio (Airbus AOSL)	28/03/2022 07/04/2022
SEMANA SANTA			10-17 abril
3RD TERM			
Project management and quality control	4	Rebeca Calvo (Airbus Military)	18/04/2022 28/04/2022
SEMANA CASE STUDIES			3-12 Mayo
Metal matrix composites (MMC), Ceramic matrix composites (CMC)	2	J. Llorca (IMDEA Materiales)	16/05/2022 19/05/2022
Concurrent engineering	2	Francisco Escobar (Airbus Ops)	23/05/2022 26/05/2022
Applications for Space structures	2	Alicia Ayuso (Airbus Space)	30/05/2022 02/06/2022
Nanocomposites and biocomposites. Recycling	2	A Ureña (URJC)	06/06/2022 09/06/2022
Environmental regulations. Health and safety	2	P. Fenoy (Airbus Military)	13/06/2022 16/06/2022
Smart composites	4	A.Güemes (UPM)	20/06/2022 30/06/2022
PROYECTO FIN DE MASTER Master Thesis	26	A.Güemes (UPM) J. M. Blanco (Airbus)	01/07/2022 20/12/2022
TOTAL	90		

El curso comienzan el 4 de Octubre, lunes, a las 17:00 , con entrega de documentacion
El PFM debe ser entregado antes del 15/12/2022, para su calificación dentro del año 2022

Module 1: **CONSTITUENTS MATERIALS AND CHARACTERIZATION**

Coordinator: Rafael Avila (Airbus Operations)

Teaching staff: *J. Sanchez, R. Avila, A. Butragueño, J. Menendez Alberquilla, A. Espada, Ignacio Lopez, Tamara Blanco, Z. Moreno, J. M. Menendez Martin, A. Fernandez, A. Güemes, J.M. Pintado, M.G. Prolongo, C. Arribas, A. R. Pozo Morales.*

Contents:

- 1.1 Polymer Matrix Composites. Types of resins and fibers.
- 1.2 Characterization of reinforcing fibers
- 1.3 Physico- Chemical Characterization of polymer matrix.
- 1.4 Interaction Fiber Matrix. Interfaces.
- 1.5 Physical properties of laminates, prepregs
- 1.6 Physical properties of sandwich structures, foams and honeycombs
- 1.7 Characterization lamina & laminates
- 1.8 Moisture absorption and Adhesives
- 1.9 Statistical Methods. Determination of allowables
- 1.10 NTD methods
- 1.11 Procurement of Composites

- 1.12 Laboratory: chemical tests (DSC, DMTA, FTIR)
- 1.13 Laboratory: mechanical testing (tensile, ILLS)
- 1.14 Laboratory: impact tests and micrographies
- 1.16 Laboratory: non-destructive inspection equipments

Module 2. **MANUFACTURING PROCESSES FOR POLYMER MATRIX COMPOSITES STRUCTURES**

Coordinator: Augusto Perez Pastor (FIDAMC)

Teaching staff: *J. Cuenca, P. Nogueroles, F. Rodriguez Lence, I. J. Marquez, J. M. Santos, Astorga, R. Avila, L. Rubio, J. Galiana, Isabel Martin, T. Busto, David Cano, Enrique Guinaldo, A Perez Pastor*

Contents:

- 2.1 Process of hand molding.
 - 2.2 Autoclave based processes (prepreg)
 - 2.3 Equipments for manufacturing
 - 2.4 Techniques for consolidation and curing of thermosetting resins
 - 2.5 Liquid Molding RTM, RFI, SCRIMP
 - 2.6 Out of autoclave Techniques
 - 2.7 Principles of the processes with thermoplastic matrix
 - 2.8 Tooling for Composites
 - 2.9 Assembly
 - 2.10 Cutting, Machining
 - 2.11. Manufacturing costs. Economic model. Production Orders
 - 2.12 Additive Manufacturing
 - 2.13 Composite industrialization
 - 2.14 Factories 4.0
- Visit to production facilities (FIDAMC)

Module 3. **DESIGN OF COMPOSITE AIRCRAFT STRUCTURES**

Coordinator: Joaquín Gallego Pleite (Airbus Defense)

Teaching staff: Joaquín Gallego Pleite, Enrique Jiménez Gahete, Fernando Cano, David Navarro Martin

Contents:

3.0 INTRODUCTION TO THE MODULE: CONTENTS, EDUCATION PURPOSE AND CASE STUDY EXPLANATION

3.1 INTRODUCTION TO DESIGN OF COMPOSITE AIRCRAFT STRUCTURES

3.2 CHARACTERISTICS OF COMPOSITES

3.3 MANUFACTURING CONSTRAINTS AND DESIGN DRIVERS

3.4 DESIGN REQUIREMENTS AND FEATURES

3.5 DESIGN RULES, STACKING SEQUENCE

3.6 UNION OF LAYERS

3.7 RADIUS DESIGN

3.8 JOGGLES DESIGN

3.9 SANDWICH DESIGN PRACTICES

3.10 TOLERANCES IN COMPOSITE MATERIALS

3.11 REPARABILITY

3.12 CORROSION PROTECTION DESIGN

3.13 ABRASION, EROSION AND BIRD IMPACT PROTECTION

3.14 DESIGN FOR ELECTRICAL STRIKES

3.15 DESIGN FOR ELECTRICAL BONDING

3.16 FIRE DESIGN PROTECTION

3.17 GENERAL DESIGN FOR MECHANICAL JOINTS

Module 4. **NANOCOMPOSITES AND BIOCOSITES. RECYCLING**

Coordinator: Alejandro Ureña Fernandez (Univ Rey Juan Carlos I, Madrid)

Teaching staff: *A. Ureña, M. Sanchez Martinez, Silvia Gonzalez Prolongo, M. Gonzalez Prolongo*

Contents:

- 4.1 Nanotechnology and nanomaterials
- 4.2 Inorganic nanoparticles and other reinforcements
- 4.3 Carbon nanostructures
- 4.4 Thermoplastic nanocomposites
- 4.5 Thermosetting nanocomposites
- 4.6 Multiscale composites
- 4.7 Recycling of composite materials
- 4.8 Natural Composites

Module 5 **NUMERICAL SIMULATION TECHNIQUES**

Coordinator: Carlos González

Teaching staff: Sergio Sádaba, Javier Segurado, Diego Garijo, Carlos González

Contents

- 5.1 Multiscale Modelling of Composite Materials. Revision of Simulation Techniques
- 5.2 Introduction to the Finite Element Method (I). The Boundary Value Problem. Weak Formulation of Boundary Value Problem.
- 5.3 Introduction to the Finite Element Method (II). Spatial and Time Discretization. Implicit and Explicit Integration
- 5.4 Review of Constitutive Equations. Elasticity, Plasticity & Damage
- 5.5 Anisotropic Elasticity. Material Symmetry
- 5.6 Micro-Meso mechanics & RVE generation
- 5.7 Buckling analysis of composite structures.
- 5.8 Failure of composite materials. Failure Modes and Failure Criteria.
- 5.9 Continuum Damage Mechanics.
- 5.10 Cohesive Crack Models & Advanced Techniques (XFEM, DG, VCCT)
- 5.11 In Service Behaviour (I). Temperature & Humidity. Residual Stress
- 5.12 In Service Behaviour (II). Delamination Assessment
- 5.13 In Service Behaviour (III). Low velocity impacts. Debris impacts
- 5.14 In Service Behaviour (II). High velocity impacts. Bird & ice impacts
- 5.15 Processing Simulation.
- 5.16 Computer Lab. Introduction to Abaqus CAE&Standard. Getting Started
- 5.17 Computer Lab. Micromechanics and homogenization
- 5.18 Computer Lab. Stress analysis of the open hole specimen
- 5.19 Computer Lab. Analysis of the impact against composite plate

Module 6 **ANALYSIS OF COMPOSITE STRUCTURES**

Coordinator: José Carlos Gómez López

Teaching staff: *JC Gómez López, Fernando Mancebo Ordóñez, Francisco Fernández Sánchez, Juan Luis de la Gándara, Eduardo Oslé, Agustín González Díaz, Daniel Meizoso Latova, José Antonio Rodríguez Sánchez, Fernando Martín Prieto, Rubén Tejerina Hernanz, Jorge González Rubio, Maria del Carmen Rodriguez, Fernando de Nicolas.*

Contents:

- 6.1 Overview of structural analysis for composites
- 6.2 Design allowables
- 6.3 Environmental effects
- 6.4 Lamina and Laminates analysis
- 6.5 Damage tolerance
- 6.6 Strength Analysis
- 6.7 Hole Analysis
- 6.8 Bolted Joints
- 6.9 Bonded joints
- 6.10 Unfolding
- 6.11 Buckling
- 6.12 Post-buckling
- 6.13 Sandwich Structures
- 6.14 Global FEM Usage:
 - Specific rules for modeling of composite structures
 - Global finite element models
 - Detailed finite element models
 - Non-linear finite element models
- 6.15 Detailed FEM Usage:
 - Detailed finite element models
 - Non-linear finite element models
- 6.16 Reparability
- 6.17 Production defects structural analysis
- 6.18 Structural testing
- 6.19 Practical case: Analysis of structural elements of a torsion box

Module 7 **CERTIFICATION OF AIRCRAFT COMPOSITE STRUCTURES**

Coordinator: Jose Maria Blanco (Airbus Operations).

Teaching staff: J.M. Blanco, Adolfo Avila Gutierrez, Fernando Nicolas, Maria de la Paz Pastor

- *Contents:*

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- 7.1 Aircraft Certification General Overview
- 7.2 Structure Design Certification Requirements.
- 7.3 Composite Structure Design Certification & Manufacturing Interface.
- 7.4 Structure Design Certification & System Instalation Interaction
- 7.5 Proof Of The Structure Design
- 7.6 Structure Certification Test Program
- 7.7 Certification Documentation
- 7.8 Type Design Changes Certification (Modifications)
- 7.9 Continuous Airworthiness
- 7.10 Certification Of Manufacturing And Assembly Deviations (Concessions)

Modulo 8. **IN-SERVICE BEHAVIOUR AND REPAIR**

Coordinator Ivan Rodriguez (Airbus Operations)

Teaching staff: *Ivan Rodriguez, J.L. Dominguez, A. Butragueño, V. Barcelo, L.P. Vicente, J.M. Vizarro, c. Fuentes, N. Fernandez, E. Abad*

- 8.1 Composite Repairs Of Aircraft In-Service
- 8.2 Fatigue & Damage Tolerance Evaluation Of Composite Structures.
- 8.3 Structural Repair Manual. SRM.
- 8.4 Protection Systems For Repairs Of CFRP Elements/Parts
- 8.5 Fatigue & Damage Tolerance Evaluation Of Composite Structures.
- 8.6 Service Bulletins.
- 8.7. Composite Repair Materials & Process In CFRP of In-Service A/C
- 8.8 Analysis Of Damages And Repairs For A/C In-Service

Module 9 **PROJECT AND QUALITY MANAGEMENT**

Coordinator: Rebeca Calvo Aguilar (Airbus Military)

Teaching staff: *Rebeca Calvo Aguilar, Ruben Elvira Herranz, Javier Yagüe Lopez*

- 9.1 Introduction to Project Management
- 9.2 Project product lifecycle phases
- 9.3 Project Management elements
- 9.4 Project initiating
- 9.5 to 9.7 Project planning
- 9.8 Project executing
- 9.9 to 9.11 Project monitoring and controlling
- 9.12 Project closing
- 9.13 Quality Management system. BMS awareness
- 9.14 Quality Management system
 - Evolution of quality, QMS- UNE-EN-9100:2010
 - Top Management aspects of the Standard
 - Resources processes
 - Planning of product realization, customer-related processes
 - Continuous improvement processes
 - Examples
- 9.15 Finance Concepts for Project managers

Modulo 10 **PRODUCTION MANAGEMENT: LEAN MANUFACTURING**

Coordinator : Francisco Jose Paramio

Teaching staff: *F. Paramio, Javier Sanchez, Victor Gonzalez*

- 10.1 Introduction to Lean
- 10.2 The 7 wastes & Kaizen.
- 10.3 Lean principles.
- 10.4 5S - Visual Management.
- 10.5 Andon & Jidoka
- 10.6 TPM (Total Productive maintenance)
- 10.7 Yamzumi-Takt- Equilibrado
- 10.8 Standard Operation
- 10.9 Defect-free Systems Poka Yoke
- 10.10 SMED
- 10.11 Logic flow: kitting, kanban, milk run
- 10.12 Practical Problem Solving
- 10.13 Seven Quality Tools
- 10.14 VSM (Value Stream Mapping)

Modulo 11 **NON CONVENTIONAL COMPOSITES (MMC, CMC)**

Coordinator : Javier Llorca (IMDEA Materiales)

Teaching staff: *J. Llorca, I. Savirov, N. Martin Piris, R. Guzman, J.J. Vilatela*

- 11.1 Introduction
- 11.2 Ceramic matrix composites
- 11.3 Processing and applications of CMC
- 11.4 Carbon/carbon composites
- 11.5 Metal matrix composites
- 11.6 Mechanical properties of MMC
- 11.7 Plastic deformation of MMC
- 11.8 Transport properties and environmental performances of MMC
- 11.9 Fracture and Fatigue of MMC
- 11.10 Nano architectures and Materials design: From nano to macro

Modulo 12 **SMART COMPOSITES**

Coordinator : Alfredo Güemes

Teaching staff: *A. Güemes, A. Fernandez Lopez, J.M. Menendez Martin, I. Gonzalez Requena, J.M. Pintado*

- 12.1 Smart materials & smart structures
- 12.2 Fibre optic sensors for smart structures
- 12.3 Fibre optic sensors for distributed sensing
- 12.4 Morphing Aircrafts. Actuators and shaper sensing
- 12.5 Smart processing
- 12.6 Smart structures. Issues related to the sensor integration in composites
- 12.7 Data driven SHM. Theory of PCA
- 12.8 Data driven SHM. Case Studies
- 12.9 Damage detection by Lamb waves
- 12.10 Design & usage of SHM Systems
 - 1. Probability of detection, decision and risk
 - 2. Methods for damage diagnosis
 - 3. Sensor self-diagnosis of piezoelectric transducers
 - 4. Aspects for design of SHM Systems
 - 5. Identification of unknown structural loads from dynamic measurements
- 12.11 Multifunctional composites
- 12.12 Self-healing materials

Modulo 13. **CONCURRENT ENGINEERING**

Coordinator : Francisco Escobar Benavides

Teaching staff: *F. Escobar, F. Nicolas Lopez*

- 13.1 Overview
 - Definitions& Principles
 - Customer focussed development
 - Design to cost
 - CE organization and Management

- 13.2 Concurrent engineering in composites
 - Overview
 - Certification &CE
 - Design to cost in composites
 - CE strategic vision in composites
 - F1 composite practice

- 13.3 CE case study: Airliner airframe

Modulo 14. **APPLICATIONS IN SPACE**

Coordinator : Alicia Ayuso

Teaching staff: *Alicia Ayuso, Victor Bautista Juzgado*

- 15.1 Composite materials role in space.
- 15.2 Composite materials in space applications. Space market
- 15.3 Space environment characteristics. Effects on composite materials
- 15.4 Material qualification for space
- 15.5 Examples of applications in space projects
 - General overview of EADS Astrium CASA
 - Satellites and payloads
 - Launcher structures
 - Satellite structures
 - Antenna reflectors
 - Engineering and CoC Composites
 - Manufacturing and testing
 - R&D, innovation

Modulo 15 **ENVIRONMENTAL REGULATIONS. HEALTH AND SAFETY**

Coordinator Pedro Fenoy (Airbus Military)

Teaching staff: *P. Fenoy, J.J. Benito*

- 15.1 MA. Introduction, environmental aspects
- 15.2 MA. Environmental Management.
- 15.3 MA. Analysis of the product life cycle
- 15.4 MA. Environmental impacts. regulations
- 15.5 MA. Directives. Ecodesign
- 15.6 SL. General concepts
- 15.7 SL. Industrial Health
- 15.8 SL. Contaminants
- 15.9 SL. Ergonomics and Occupational Health
- 15.10 SL. Pathology at Job