

<b>MASTER IN COMPOSITE MATERIALS, 14° Edition 2024-2025</b>			
<b>Topics</b>	<b>ECTS</b>	<b>Coordinator</b>	<b>Teaching period</b>
<b>MMtC Welcome</b>			<b>03/10/2024</b>
<b>1st TERM (160 h)</b>			
Project management and quality control	4	Rebeca Calvo (Airbus D&S)	07/10/2024 16/10/2024
Case Study de Project Management			11/12/2024
Constituents Materials and Characterization	8	R. Avila (Airbus Ops.)	21/10/2024 14/11/2024
Manufacturing processes for polymer matrix composites structures	8	I. J. Marquez (Airbus D&S)	18/11/2024 19/12/2024
Case Study de Materiales y Fabricación			27/01/2025
<b>2nd TERM (180 h)</b>			
Design of advanced composites structures	5	Joaquin Gallego (Airbus D&S)	07/01/2025 21/01/2025
Case Study de Diseño			27/03/2025
Numerical simulation techniques	4	C. Gonzalez (IMDEA Materiales)	22/01/2025 06/02/2025
Analysis of advanced composites structures	8	J.C. Gomez (Airbus Ops)	10/02/2025 05/03/2025
Case Study de Análisis			24/04/2025
Applications for Space structures	2	Alicia Ayuso (Airbus D&S)	10/03/2025 13/03/2025
<b>3RD TERM (160 h)</b>			
Certification of aircraft composites structures	4	J. M. Blanco (Airbus Ops)	17/03/2025 26/03/2025
Case Study de Certificación			13/05/2025
In service behaviour and repairs	4	Ivan Rodriguez (Airbus Ops)	31/03/2025 9/04/2025
Case Study de Reparaciones			12/05/2025
<b>SEMANA SANTA</b>			<b>14-18 Abril 2025</b>
Concurrent engineering	2	Francisco Escobar (Airbus Ops)	21/04/2025 23/04/2025
Case Study de ingeniería Concurrente			14/05/2025
Smart composites	4	A.Fernandez (UPM)	28/04/2025 08/05/2025
Production management: Lean manufacturing	4	F.J. Paramio (Airbus Ops)	19/05/2025 29/05/2025
Metal matrix composites (MMC), Ceramic matrix composites (CMC)	2	J. Llorca (IMDEA Materiales)	02/06/2025 05/06/2025
Nanocomposites and biocomposites. Recycling	2	A Urefia (URJC)	09/06/2025 12/06/2025
Environmental regulations. Health and safety	2	P. Fenoy (Airbus D&S)	16/06/2025 19/06/2025
<b>PROYECTO FIN DE MASTER</b>			
<b>Master Thesis</b>	<b>27</b>	A Fernandez (UPM) J. M. Blanco (Airbus)	01/07/2025 20/12/2025
<b>TOTAL</b>	<b>90</b>		

Octubre 2024						
Lu.	Ma.	Mi.	Ju.	Vi.	Sá.	Do.
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Noviembre 2024						
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- Inicio del Curso: 3/10/2024
- S1 S2 S3 S4 Gestión de programas (4)
- Gestión de programas (3) y otras actividades formativas
- Materiales Constituyentes (4)
- Materiales Constituyentes (4)
- S5 Materiales Constituyentes (4)
- S6 Materiales Constituyentes (4)
- S7 Fabricación (4)
- S8 Fabricación (4)

Diciembre 2024						
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- S9 Fabricación (3) y Otras actividades formativas
- S10 Presentaciones de Caso de Estudio de Gestión de Programas. Fabricación (1)
- S11 Fabricación (4)
- NAVIDAD
- NAVIDAD

Enero 2025						
Lu.	Ma.	Mi.	Ju.	Vi.	Sá.	Do.
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- NAVIDAD
- S12 Diseño (3)
- S13 Diseño (3)
- S14 Diseño (2). Simulación (2)
- S15 Presentaciones Caso de Estudio de M&P y Fabricación. Simulación (2)

Febrero 2025						
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- S16 Simulación (4)
- S17 Análisis (4)
- S18 Análisis (4)
- S19 Análisis (4)

Marzo 2025						
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- S20 Análisis (4)
- S21 Aplicaciones Espaciales (4)
- S22 Certificación (4)
- S23 Certificación (3). Presentación Caso de Estudio de diseño
- S24 Comportamiento en Servicio (4)

Abril 2025						
Lu.	Ma.	Mi.	Ju.	Vi.	Sá.	Do.
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- S24 Comportamiento en Servicio (4)
- S25 Comportamiento en Servicio (3). Otras actividades formativas
- SEMANA SANTA
- S26 Diseño Concurrente (3). Presentación Caso de Estudio de Análisis
- S27 Smart Composites y Data Management & Processing for SHM (3)

Mayo 2025						
Lu.	Ma.	Mi.	Ju.	Vi.	Sá.	Do.
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- S28 Smart Composites y Data Management & Processing for SHM (4)
- S29 Presentación Caso de Estudio de Comportamiento en servicio. Presentación caso de estudio Certificación. Presentación Caso de Estudio de diseño Concurrente.
- S30 LEAN (4)
- S31 LEAN (4)

Junio 2025						
Lu.	Ma.	Mi.	Ju.	Vi.	Sá.	Do.
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- S32 CMC,MMC (4)
- S33 Nanocomposites (4)
- S34 Medio ambiente, sostenibilidad y salud laboral (4)
- Fiesta fin de máster

## Module 1: **CONSTITUENTS MATERIALS AND CHARACTERIZATION**

Coordinator: Rafael Avila (Airbus Operations)

Teaching staff: *R. Avila, A. Butragueño, A. Espada, Ignacio Lopez, Tamara Blanco, Z. Martin Moreno, Gloria Santacruz Rodríguez, Elena del Puerto, José Ignacio López Reina, J. M. Menendez Martin, A. Fernandez, J.M. Pintado, M.G. Prolongo, C. Arribas, A. Amate*

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
- 1.15 Laboratory: non-destructive inspection equipments

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

Coordinator: I. J. Marquez (Airbus Operations)

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

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 D&S)

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

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 BIOCOSCOMPOSITES. RECYCLING**

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

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 (IMDEA Materiales)

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 (Airbus Operations)

Teaching staff:

*José Carlos Gómez López, Fernando Mancebo Ordóñez, Francisco Javier Martin Garcia, Juan Luis de la Gándara Verano, Eduardo Osle Dorremochea, Rubén Tejerina Herránz, Jorge González Rubio, Pablo Arrieta Carretero, José Antonio Rodríguez Sánchez, Daniel Meizoso Latova, María del Carmen Rodríguez Gómez, Fernando de Nicolás López*

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 estructures 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:*

- 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 In-service repair embodiment
- 8.2 Composite repairs and engineering solutions for in-service A/Cs
- 8.3 Repair Materials and processes
- 8.4 Sealing application on composite repairs
- 8.5 Individual Repair Approval. Exercises
- 8.6 Fatigue and Damage tolerance of Composite structures
- 8.7 Structural repair manual (SRM)
- 8.8 Analysis of damages and repairs for in-service A/Cs
- 8.9 Spares management for composite serial and repair parts

## Module 9 **PROJECT AND QUALITY MANAGEMENT**

Coordinator: Rebeca Calvo Aguilar (Airbus D&S)

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*

- 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 : Antonio Fernández (UPM)

Teaching staff: *A. Güemes, A. Fernandez Lopez, J.M. Menendez Martin, I. Gonzalez Requena, J.M. Pintado, D. del Río Velilla, A. Pedraza, L. E. Mujica*

- 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 (Airbus Operations)

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 (Airbus D&S)

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 D&S)

Teaching staff: *P. Fenoy, Gema Maria Plaza Muñoz*

- 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