MASTER IN COMPOSITE MATERIALS, 14º Edition 2024-2025			
Topics	**ECTS**	**Coordinator**	**Teaching period**
1st TERM (160 h)			
Project management and quality control	4	Rebeca Calvo (Airbus D&S)	07/10/2024 17/10/2024
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 Ops.)	18/11/2024 19/12/2024
2nd TERM (180 h)			
Design of advanced composites structures	5	Joaquin Gallego (Airbus D&S)	08/01/2025 22/01/2025
Case Study de Materiales y Fabricacion			23/01/2025
Numerical simulation techniques	4	C. Gonzalez (IMDEA Materiales)	27/01/2025 06/02/2025
Analysis of advanced composites structures	8	J.C. Gomez (Airbus Ops)	10/02/2025 06/03/2025
Certification of aircraft composites structures	4	J. M. Blanco (Airbus Ops)	10/03/2025 20/03/2025
3RD TERM (160 h)			
Applications for Space structures	2	Alicia Ayuso (Airbus D&S)	24/03/2025 27/03/2025
In service behaviour and repairs	4	Ivan Rodriguez (Airbus Ops)	31/03/2025 09/04/2025
Case Study de DISEÑO		Joaquin Gallego (Airbus D&S)	10/04/2025
SEMANA SANTA			14-20 Abril
Concurrent engineering	2	Francisco Escobar (Airbus Ops)	21/04/2025 24/04/2025
Smart composites	4	A.Fernandez (UPM)	28/04/2025 08/05/2025
Case Studies: Reparaciones (13), Analisis (14) Certificacion (16)			12/05/2025 14/05/2025
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 Ureña (URJC)	09/06/2025 12/06/2025
Environmental regulations. Health and safety	2	P. Fenoy (Airbus D&S)	16/06/2025 19/06/2025
PROYECTO FIN DE MASTER Master Thesis	**26**	A Fernandez (UPM) J. M. Blanco (Airbus)	01/07/2025 20/12/2025
TOTAL	**90**		

La sesión inicial del curso tendrá lugar el 7/10/2024, lunes, con la presentación y entrega de documentación, y finaliza el 19/12/24.
El PFM debe ser entregado antes del 15/12/2025, para su calificación dentro del año 2025.
En total son 720 h lectivas, de las que 270 h corresponden a tutoria individualizada sobre el TFM, 150 h son de actividades practicas de laboratorio, talleres interactivos o visitas a empresas, y 300 h a clases teóricas mas expositivas. Este Programa puede sufrir cambios menores durante el curso por circunstancias imprevistas.

Octubre 2024

L	M	X	J	V	S	D		COMENTARIOS
	1	2	3	4	5	6	Presentación, GP	
7	8	9	10	11	12	13	Gestión de Programas	
14	15	16	17	18	19	20	Gestión de Programas.	
21	22	23	24	25	26	27	Constituyentes	
28	29	30	31					

Noviembre 2024

L	M	X	J	V	S	D		
				1	2	3	Constituyentes	
4	5	6	7	8	9	10	Constituyentes	
11	12	13	14	15	16	17	Constituyentes	
18	19	20	21	22	23	24	Fabricación	
25	26	27	28	29	30	1	Fabricación,	

Diciembre 2024

L	M	X	J	V	S	D		
2	3	4	5	6	7	8		
9	10	11	12	13	14	15	Fabricación	
16	17	18	19	20	21	22	Fabricación,	
23	24	25	26	27	28	29		

Enero 2025

L	M	X	J	V	S	D		
30	31	1	2	3	4	5		
6	7	8	9	10	11	12	Diseño	
13	14	15	16	17	18	19	Diseño	
20	21	22	23	24	25	26	Case Study	Constituyentes y Fabricación 24
27	28	29	30	31				

Febrero 2025

L	M	X	J	V	S	D		
					1	2	Simulación	
3	4	5	6	7	8	9	Simulación	
10	11	12	13	14	15	16	Análisis	
17	18	19	20	21	22	23	Análisis	
24	25	26	27	28			Análisis	

Marzo 2025

L	M	X	J	V	S	D		
					1	2		
3	4	5	6	7	8	9	Análisis	
10	11	12	13	14	15	16	Certificación	
17	18	19	20	21	22	23	Certificación	
24	25	26	27	28	29	30	Aplicaciones Espaciales	

Abril 2025

L	M	X	J	V	S	D		
31	1	2	3	4	5	6	Comportamiento. Servicio	
7	8	9	10	11	12	13	Comportamiento. Servicio	
14	15	16	17	18	19	20		
21	22	23	24	25	26	27	Ingenieria Concurrente	
28	29	30					Smart Composites	

Mayo 2025

L	M	X	J	V	S	D		
			1	2	3	4		
5	6	7	8	9	10	11	Smart Composites	
12	13	14	15	16	17	18		Case Study de Analisis, Certificacion, comportamiento en servico y Concurrente
19	20	21	22	23	24	25	LEAN	
26	27	28	29	30	31		LEAN	

Junio 2025

L	M	X	J	V	S	D		
						1		
2	3	4	5	6	7	8	CMC, MMC	
9	10	11	12	13	14	15	Nanocomposites	
16	17	18	19	20	21	22	Medio ambiente, salud laboral	
23	24	25	26	27	28	29	PFM	

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
1.16 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 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 CONSTRAINS AND DESIGN DRIVERS
3.4 DESIGN REQUIREMENTS AND FEATURES
3.5 DESIGN RULES, STACKING SEQUENCE
3.6 UNION OF LAYERS
3.7 RADII 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 BIOCOMPOSITES. 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 Assesment
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 arquitectures 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