MASTER IN COMPOSITE MATERIALS, 13º Edition 2023-2024			
Topics	**ECTS**	**Coordinator**	**Teaching period**
1st TERM (160 h)			
Project management and quality control	4	Rebeca Calvo (Airbus D&S)	05/10/2023 19/10/2023
Constituents Materials and Characterization	8	R. Avila (Airbus Ops.)	23/10/2023 16/11/2023
Manufacturing processes for polymer matrix composites structures	8	I. J. Marquez (Airbus Ops.)	20/11/2023 21/12/2023
2nd TERM (180 h)			
Design of advanced composites structures	5	Joaquin Gallego (Airbus D&S)	08/01/2024 23/01/2024
Case Study de Materiales y Fabricacion			24/01/2024
Numerical simulation techniques	4	C. Gonzalez (IMDEA Materiales)	29/01/2024 08/02/2024
Analysis of advanced composites structures	8	J.C. Gomez (Airbus Ops)	12/02/2024 07/03/2024
Certification of aircraft composites structures	4	J. M. Blanco (Airbus Ops)	11/03/20243 21/03/2024
SEMANA SANTA			25-31 Marzo
3RD TERM (160 h)			
Applications for Space structures	2	Alicia Ayuso (Airbus D&S)	1/04/2024 04/04/2024
In service behaviour and repairs	4	Ivan Rodriguez (Airbus Ops)	08/04/2024 17/04/2024
Case Study de DISEÑO		Joaquin Gallego (Airbus D&S)	18/04/2024
Concurrent engineering	2	Francisco Escobar (Airbus Ops)	22/04/2024 25/04/2024
Smart composites	4	A.Fernandez (UPM)	29/04/2024 09/05/2024
Case Studies: Reparaciones (13), Analisis (14) Certificacion (16)			13/05/2024 16/05/2024
Production management: Lean manufacturing	4	F.J. Paramio (Airbus Ops)	20/05/2024 30/05/2024
Metal matrix composites (MMC), Ceramic matrix composites (CMC)	2	J. Llorca (IMDEA Materiales)	03/06/2024 06/06/2024
Nanocomposites and biocomposites. Recycling	2	A Ureña (URJC)	10/06/2024 13/06/2024
Environmental regulations. Health and safety	2	P. Fenoy (Airbus D&S)	17/06/2024 20/06/2024
PROYECTO FIN DE MASTER Master Thesis	**26**	A Fernandez (UPM) J. M. Blanco (Airbus)	01/07/2024 20/12/2024
TOTAL	**90**		

El curso comienzan el 4/10/2023, lunes, con la presentación y entrega de documentación, y finaliza el 20/12/23.
El PFM debe ser entregado antes del 15/12/2024, para su calificación dentro del año 2024.
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 2023

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

Noviembre 2023

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

Diciembre 2023

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

Enero 2024

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

Febrero 2024

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

Marzo 2024

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

Abril 2024

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

Mayo 2024

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

Junio 2024

L	M	X	J	V	S	D		
					1	2		
3	4	5	6	7	8	9	CMC, MMC	
10	11	12	13	14	15	16	Nanocomposites	
17	18	19	20	21	22	23	Medio ambiente, salud laboral	
24	25	26	27	28	29	30	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:

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:

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