



## Teaching Guide

Identifying Data					2023/24
<b>Subject (*)</b>	Digital Twin in Marine System		<b>Code</b>	730542022	
<b>Study programme</b>	Master Universitario Erasmus Mundus en Sostibilidade e Industria 4.0 aplicada ao Sector Marítimo				
Descriptors					
Cycle	Period	Year	Type	Credits	
Official Master's Degree	1st four-month period	Second	Optional	6	
<b>Language</b>	English				
<b>Teaching method</b>	Face-to-face				
<b>Prerequisites</b>					
<b>Department</b>	Enxeñaría Naval e Industrial				
<b>Coordinador</b>	Munín Doce, Alicia	<b>E-mail</b>	a.munin@udc.es		
<b>Lecturers</b>	Ferreño González, Sara Munín Doce, Alicia	<b>E-mail</b>	sara.ferreno@udc.es a.munin@udc.es		
<b>Web</b>					
<b>General description</b>	The objective of this course is to provide students with knowledge in the field of digital twins of marine systems, including the requirements, architecture and components necessary to develop one of these systems.				

## Study programme competences

Code	Study programme competences
B7	CG1 ? To display the adequate intercultural competence to successfully navigating within multicultural learning environments and to implement basic management principles suitable for a multicultural working environment.
B8	CG2 ? To express an attitude of intellectual inquisitiveness and open-mindedness.
B10	CG4 ? To have the capability to think creatively and explore new ideas outside of current boundaries of the field
B11	CG5 ? To have the capability to identify, formulate and solve engineering problems within realistic constraints.
B12	CG6 ? To appreciate the impact of sustainable development goals in maritime transport.
B13	CG7 ? To have the capability to critically analyse, synthesise, interpret and summarise complex scientific processes.
C2	CT2 - Mastering oral and written expression in a foreign language.
C3	CT3 - Using ICT in working contexts and lifelong learning.
C4	CT4 - Acting as a respectful citizen according to democratic cultures and human rights and with a gender perspective.
C6	CT6 - Acquiring skills for healthy lifestyles, and healthy habits and routines.
C7	CT7 -Developing the ability to work in interdisciplinary or transdisciplinary teams in order to offer proposals that can contribute to a sustainable environmental, economic, political and social development.
C8	CT8 -Valuing the importance of research, innovation and technological development for the socioeconomic and cultural progress of society.

## Learning outcomes

Learning outcomes	Study programme competences	
Knowledge of the concept, structure and design constraints of digital twins applicable to the maritime sector.	BC6	CC2
Ability to develop a basic approach to a digital twin	BC7	CC3
	BC9	CC4
	BC10	CC6
	BC11	CC7
	BC12	CC8

## Contents

Topic	Sub-topic



1. Introduction	a. Industry 4.0 overview b. Basic concepts of Digital Twins c. Digital Twin for ships
2. Ship. Ship systems. Sensorization.	a. Ships and ship systems b. Ship sensorization
3. Simulation models	a. Physics based models vs data driven models. b. Modeling of the arquitectura of basic simulations and development of basic simulations models. c. Preparation of models for FMU export. Export types (co-simulación, real time, etc.) and their implications. d. Running the simulation models in the digital twin environment e. Co-simulation of FMUs.
4. Data Analysis	a. Data analytics and machine learning application.
5. Edge solutions and cloud solutions for digital twin	a. Edge solutions b. Cloud solutions
6. Practical use cases	a. Practical use cases

Planning				
Methodologies / tests	Competencies	Ordinary class hours	Student?s personal work hours	Total hours
Guest lecture / keynote speech	B12 C3	20	20	40
ICT practicals	C7	20	40	60
Mixed objective/subjective test	B7 B8 B10 C2 C4 C6	1.5	0	1.5
Supervised projects	B11 B13 C8	1.5	45	46.5
Personalized attention		2	0	2

(\*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
Methodologies	Description
Guest lecture / keynote speech	Oral presentation (using audiovisual material and student interaction) designed to transmit knowledge and encourage learning. Presentations of this type are variously referred to as ?expository method?, ?guest lectures? or ?keynote speeches?. (The term ?keynote? refers only to a type of speech delivered on special occasions, for which the lecture sets the tone or establishes the underlying theme; it is characterised by its distinctive content, structure and purpose, and relies almost exclusively on the spoken word to communicate its ideas.)
ICT practicals	Practice-based learning method for theoretical subject content using ICT resources (demonstrations, simulations, etc.) ICT is an excellent medium for practical knowledge applications and information processing, and a key aid to student learning and skills development.
Mixed objective/subjective test	The mixed objective will consist of an oral presentation about the supervised project.
Supervised projects	Supervised learning process aimed at helping students to work independently in a range of contexts (academic and professional). Focused primarily on learning ?how to do things? and on encouraging students to become responsible for their own learning.  In this course, the supervised project will consist on a group based technical work based on an assignment done by the professors, and dealing about some of the topics of the course.

Personalized attention	
Methodologies	Description



Guest lecture / keynote speech ICT practicals Supervised projects	Students personal attention could be in class or through Teams. The student will be monitored during the completion of the project.
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Assessment			
Methodologies	Competencies	Description	Qualification
Supervised projects	B11 B13 C8	<p>In this course, the supervised project will consist on a group based technical report based on an assignment done by the professors, and dealing about some of the topics of the course.</p> <p>The qualification of the group based technical report will represent a 80 % of the student's final qualification.</p>	80
Mixed objective/subjective test	B7 B8 B10 C2 C4 C6	<p>The mixed objective will consist of an oral presentation about the supervised project.</p> <p>The qualification of the oral presentation will represent a 20 % of the student's final qualification.</p>	20

Assessment comments
<p>According to the degree regulations, the students will have the opportunity to pass this course in two opportunities (first and second opportunity). The evaluation of the total mark will be the same both in the first opportunity and in the second opportunity.</p> <p>General EMJMD Sustainable Ship and Shipping SEAS 4.0 evaluation rules:</p> <ul style="list-style-type: none"> <li>- Students will have only two opportunities to pass a course. If failing to do so, they may be forced to leave the degree.</li> <li>- No part time or lecture attendance exemption are allowed in this degree.</li> </ul>

Sources of information	
<b>Basic</b>	<ul style="list-style-type: none"> <li>- Gopal Chaudhary, Manju Khari, Mohamed Elhoseny (2022). Digital Twin Technology. Taylor &amp; Francis Group</li> <li>- Surjya Kanta Pal, Debasish Mishra, Arpan Pal, Samik Dutta, Debashish Chakravarty, Srikanta Pal (2022). Digital Twin ? Fundamental Concepts to Applications in Advanced Manufacturing. Springer</li> <li>- Nassim Khaled, Bibin Pattel, Affan Siddiqui (2020). Digital Twin Development and Deployment on the Cloud. Elsevier</li> </ul>
<b>Complementary</b>	<ul style="list-style-type: none"> <li>- Shyam Varan Nath, Pieter van Schalkwyk (2021). Building Industrial Digital Twins. Packt Publishing</li> <li>- José L. Risco Martín, Saurabh Mittal, Tuncer Ören (2020). Simulation for Cyber-Physical Systems Engineering. Springer</li> <li>- Saurabh Mittal, Andreas Tolk (2020). Complexity Challenges in Cyber Physical Systems. Using Modeling and Simulation to Support Intelligence, Adaptation and Autonomy. John Wiley &amp; Sons, Inc.</li> </ul>

Recommendations
<b>Subjects that it is recommended to have taken before</b>
Innovative CFD Approaches/730542030
Simulation and Optimization of Shipbuilding Processes/730542024
Introduction to Marine Computational Fluid Dynamics (CFD)/730542011
Industrial Internet of Things (IIoT)/730542015
Statistical Models for Marine Technology Innovation/730542016
<b>Subjects that are recommended to be taken simultaneously</b>
<b>Subjects that continue the syllabus</b>
<b>Other comments</b>



To help in achieving a sustainable environment and to get the objective of number 5 action of the "Ferrol Green Campus Action Plan" (Healthy and environmental and socially sustainable research and teaching): The assignments to be done in this course: - Will be required in digital format. - Will be delivered using Moodle, with no need to print them. In case it is necessary to print them: - Plastics won't be used. - Two side printing will be used. - Recycled paper will be used. - Printing drafts will be avoided. A sustainable use of the resources should be done, together with the prevention of negative impacts on the environment. In this course, an effort will be pursued towards the incorporation of gender inclusion aspects: no sexist language will be allowed, bibliography from authors of both genders will be used, and the participation of students of both gender in class will be promoted. The situations of gender discrimination will be detected, and actions will be implemented to correct them. The full integration of students who for physical, sensorial, psychic, or socio-cultural reasons may have difficulties in their academic life will be promoted.

**(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.**