UNIVERSIDADE DA CORUÑA

Teaching Guide

Identifying Data				2022/23
Subject (*)	Digital Twin in Marine System		Code	730542022
Study programme	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

Language	English
Teaching method	Face-to-face
Prerequisites	
Department	Enxeñaría Naval e Industrial
Coordinador	Munín Doce, Alicia
E-mail	a.munin@udc.es

Lecturers		E-mail	
	Ferreño González, Sara		sara.ferreno@udc.es
	Munín Doce, Alicia		a.munin@udc.es

Web	
General description	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 / results	
Code	Study programme competences / results
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 / results	
Knowledge of the concept, structure and design constraints of digital twins applicable to the maritime sector. Ability to develop a basic approach to a digital twin	BC6	CC2
	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 / Results	Teaching hours (in-person & virtual)	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. \n\n In this course, the supervised project will consist on a group based technical work based on an assignment done by the proffessors, and dealing about some of the topics of the course.

Personalized attention	
Methodologies	Description

Guest lecture / keynote speech ICT practicals Supervised projects	Students perssonal attention could be in class or through Teams. The student will be monitored during the completion of the project.

Assessment				
Methodologies	**Competencies / Results**	**Description**		**Qualification**
Supervised projects	B11 B13 C8	In this course, the supervised project will consist on a group based technical report based on an assignment done by the proffessors, and dealing about some of the topics of the course. The qualification of the group based technical report will represent a 80 % of the student´s final qualification.		80
Mixed objective/subjective test	B7 B8 B10 C2 C4 C6	The mixed objective will consist of an oral presentation about the supervised project. The qualification of the oral presentation will represent a 20 % of the student´s final qualification.		20

Assessment comments
According to the degree regulations, the students will have the oportunity to pass this course in two oportunities (first and second oportunity). The evaluation of the total mark will be the same both in the first opportunity and in the second opportunity. General EMJMD Sustainable Ship and Shipping SEAS 4.0 evaluation rules: - Students will have only two oportunities to pass a course. If failing to do so, they may be forced to leave the degree. - No part time or lecture attendance exemption are allowed in this degree.

Sources of information	
Basic	- Gopal Chaudhary, Manju Khari, Mohamed Elhoseny (2022). Digital Twin Technology. Taylor & Francis Group - Surjya Kanta Pal, Debasish Mishra, Arpan Pal, Samik Dutta, Debashish Chakravarty, Srikanta Pal (2022). Digital Twin ? Fundamental Concepts to Applications in Advanced Manufacturing. Springer - Nassim Khaled, Bibin Pattel, Affan Siddiqui (2020). Digital Twin Development and Deployment on the Cloud. Elsevier
Complementary	- Shyam Varan Nath, Pieter van Schalkwyk (2021). Building Industrial Digital Twins. Packt Publishing - José L. Risco Martín, Saurabh Mittal, Tuncer Ören (2020). Simulation for Cyber-Physical Systems Engineering. Springer - Saurabh Mittal, Andreas Tolk (2020). Complexity Challenges in Cyber Physical Systems. Using Modeling and Simulation to Support Intelligence, Adaptation and Autonomy. John Wiley & Sons, Inc.

Recommendations
Subjects that it is recommended to have taken before
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
Subjects that are recommended to be taken simultaneously
Subjects that continue the syllabus

Other comments
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 environmentaly 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.

(*)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.