

# **ENHANCE** Featuring Engineering

# **LECTURE SYNTHESIS OF TWS 1 TO 6**

Project Acronym: ENHAnCE		
Project full title: European training Network in intelligent prognostics and Health mAnagement		
in Composite structurEs		
Call: H2020-MSCA-ITN-2019		
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(UGR)		
Internally Revised: Ms. María Megía (UGR)/OFPI Date: 24/12/2021		
Internally Approved: Dr. Manuel Chiachío (UGR)	Date: 26/12/2021	



## 1. Introduction

The ENHAnCE programme is designed to provide technical and professional skills training to ten Early Stage Researchers (ESRs) fully in line with the purposes and nature of the Marie Skłodowska-Curie Actions programme. The training pursues the purpose of improving the potential of the researchers to enhance their career and advance their research based on opportunities of acquisition and transfer of new knowledge. A dedicated Training and Tutoring Committee (TTC), chaired by the Senior Training Mentor (STM) along with an industrial co-chair, ensures the efficient implementation of the training programme and will discuss training needs during the lifetime of the project.

ENHAnCE sets up a structured training program to ensure that all ESRs will obtain multidisciplinary, international and advanced oriented translational knowledge so that they have the capacity, mindset and experience to successfully bring ENHAnCE to the market. Moreover, we realise that acting at the forefront of innovation is highly demanding and requires strong leadership skills. Hence, this will be complemented by network-wide training on transferrable skills to meet the objectives identified through each ESRs Personal Career Development Plan (PCDP) through specific social and economic training modules, along with the technical ones, whose purpose is to prepare the ESR for high-level positions in the public or private sector and industry.

The ESRs attend formal thematic training weeks (TWs) arranged as Network-wide Schools around a specific ENHAnCE's topic, which will have a public character and are available to attend for all the interested scientific community. TWs are organised and hosted by the partner beneficiaries and bring all the ENHAnCE's researchers together for a one week-event at each host institution. The main aim of the TWs is to provide ESRs with advanced theoretical backgrounds from European experts as well as methods and tools to carry out their own research projects and to perform appropriate exploitation and dissemination on research products.

	Module title	Summary of content	Lead Institution	Project Month
1	Introductory Week	Basic training in research methods, scientific- writing, literature review, programming, laboratory methods, Project Management and conflict resolution.	Dept. Structural Mechanics and Hydraulics Engineering (UGR)	9
2	Introduction to Composite Science and Technology	An introduction to key composite design technologies including understanding of the principles mechanical behaviour, testing & characterisation, and manufacturing.	Institute of Composite Structures and Adaptive Systems (DLR)	12
3	Foundations on Prognostics and Health Management	Prognostics foundations, metrics for prognostics and Bayesian methods used for prognostics.	Dept. Structural Mechanics and Hydraulics Engineering (UGR)	15
4	SHM methods using GWs and AE in composites	Foundations about simulation and study of GWs interaction with composite damage, as well as mixture monitoring techniques between GWs and AE.	List Institute research on Non Destructive Testing (CEA)	18
5	Understanding the fatigue damage in engineering materials	Fatigue quantification methods, training about laboratory experiments, design and calculation methods, latest trends for fatigue damage mitigation.	Dept. Mechanical and Aeronautical Engineering (TUDelf)	21
6	Numerical methods for virtual laboratory engineering	Virtual laboratory simulation and cyber-physical systems for optimisation of manufacturing processes.	Polymer Processes and Composites Lab. Cenaero (CEN)	24
7	Latest trends in manufacturing of intelligent composites	Manufacturing engineering of composite parts with embedded sensors, monitoring of manufacturing quality.	R&D Department of FIDAMC	27
8	Latest trends in prognostics algorithm architecture	Up-to-date advances in algorithmic methods for computing prognostics signatures, like prognostics fusion with Artificial Intelligence methods, post-prognostics methodologies, Open- Access prognostics implementation, etc.	Dept. Mechanical Engineering (POLIMI)	30

Table 1. Complete thematic training weeks (TWs) as initially scheduled in the ENHAnCE proposal



	Module title	Summary of content	Lead Institution	Project Month
9	Aerospace Structural Materials	This module considers the materials used in, the history of the development of these materials and potential materials for the future.	Dept. Aerospace Engineering (UNOTT)	33
10	Wind Engineering technology	Foundations of design, analysis of wind turbines. Monitoring techniques. Assembly technology and maintenance.	Dept. Naval, Ocean & Marine Engineering (STRATH)	36
11	Pathways to commercial end- product impact and final ENHAnCE results	Global view, foundations and pathways to allow end-user product development, business & entrepreneurial skills, and leadership. ENHAnCE results workshops.	Institute of Data Science and Computational Intelligent (UGR)	42

This deliverable presents the training events that took place from the beginning of the project (M1) to the end of the second year (M24), providing details of the organization and a description of the contents. Some modifications have been introduced due to the pandemic irruption (since March 2020, M3) regarding modality (on-line instead of in-person) and dates, even joining compatible modules, to run the scheduled on time as far as possible. All modifications were previously discussed at SB level and communicated to the REA. Because of this fact, no 6 but 3 TWs have been held until the date, and details about the first six TWs are provided in the table below.

	Module title	Summary of content	Lead Institution	Initially scheduled Project Month	Re- schedu led date	Notes
1	Introductory Week (TW1)	Basic training in research methods, scientific- writing, literature review, programming, laboratory methods, Project Management and conflict resolution.	Dept. Structural Mechanics and Hydraulics Engineering (UGR)	9	10	Held on-line
2	Foundations on Prognostics and Health Management (TW2)	Prognostics foundations, metrics for prognostics and Bayesian methods used for prognostics.	Dept. Structural Mechanics and Hydraulics Engineering (UGR)	15	16	Held on-line
3	Introduction to Composite Science and Technology (TW3)	An introduction to key composite design technologies including understanding of the principles mechanical behaviour, testing & characterisation, and manufacturing.	Institute of Composite Structures and Adaptive Systems (DLR)	12 / 27	22	Held in person in FIDAMC facilities. Joint
	Latest trends in manufacturing of intelligent composites (TW7)	Manufacturing engineering of composite parts with embedded sensors, monitoring of manufacturing quality.	R&D Department (FIDAMC)		23	TWs to avoid further delayes in the schedule
4	SHM methods using GWs and AE in composites (TW4)	Foundations about simulation and study of GWs interaction with composite damage, as well as mixture monitoring techniques between GWs and AE.	List Institute research on Non Destructive Testing (CEA)	18	27	To be hold jointly with the H2020 -MSCA project GW4SHM-ITN
5	Understanding the fatigue damage in engineering materials (TW5)	Fatigue quantification methods, training about laboratory experiments, design and calculation methods, latest trends for fatigue damage mitigation.	Dept. Mechanical and Aeronautical Engineering (TUDelf)	21	25	To be hold. In preparation currently, but with uncertainties about in-person celebration due to the unforeseen Omicron variant.

Table 2. Re-scheduled training weeks (TWs) from M1 to M24



## 2. Training weeks

### 2.1. General structure of the Training Weeks

The TWs are intended to be structured over three main elements: a Core Module (Day 1 to 3 of the week), a Communication Day (Day 4 of the week) and an Industry day (Day 5). This organisation allows several achievements: concentrating scientific training in the first three days of core modules; receiving visiting scientists and practitioners; concentrating the involvement of most of the consortium members, local authorities and industry partners in the last two days, therefore maximising the chance of exposure of the fellows and the presence of partners within the Supervisory Board (SB) meeting.

The Communication day includes a mandatory module about communication skills (2 hours), designed to equip ESRs with the ability to maximize their impact. Sessions were specifically designed to promote communication, creativity and entrepreneurial skills in academic researchers (including grant proposal writing). The rest of the communication day is devoted to dissemination and outreach for ESRs to present their ongoing research projects to all other participants of the TW and beyond. It should be noted that the training on transferable skills will be complemented by the several presentations that the ESRs will perform at their monthly meetings and during participation at international conferences.

The Industry Day contains contributions from experts employed by the private sector partners of each participant country, and consists of 3 sessions: (a) Industry seminars (2 hours), delivered by partners from industry as well as leading local industry specialists; (b) R&D Management workshops (4 hours), delivered by visiting R&D Directors to provide practical guidelines on how to manage the development and transfer of intellectual assets to the Knowledge Economy, as well as key business feasibility questions concerning technical and market assessment, business plans and preparation for a company spin-out; (c) face-to-face meetings (2 hours), whereby ESRs and industry specialists come together to discuss recruitment, activities of potential transfer of research, entrepreneurship and exploitation of their results.

### 2.2. First Training Week (TW1)

The Introductory Week was held once all ESRs were recruited, with a small delay (1 month) due to the COVID-19 pandemia effects. This training was finally decided to be delivered online from 26th to 30th October 2020 and a streaming link was provided to the general public to follow the sessions in real-time. The attendance varied between 40 to 70 participants, per daily session.

Researchers from the DASCI Institute were specially invited, as this is an institution focused on Data Science, Computational Intelligence and Artificial Intelligent-based with technological applications in the engineering field, area in which is developed the project ENHAnCE.

The first training week consisted of 5 modules: 1) the Introduction to the ENHAnCE Technology, developed by the Coordinator Dr. Manuel Chiachío; 2) Practice of Latex & Beamer, conducted by Dr. Sergio Cantero (University of Bristol, UK); 3) Practice of scientific writing, presented by Prof. Francisco Herrera (University of Granada, UGR, head of the DASCI Institute); 4) Practice of research dissemination, conducted by Dr. Juan Chiachío (University of Granada), and 5) practice of Open Science/Open Data, developed by Dr. Manuel Chiachío. The detailed schedule is included in Annex A1.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 859957.



Figure 1. Screenshot of the Introduction to the First TW, by Dr. Manuel Chiachío (coordinator)



Figure 2. Screenshot of the Practice of Latex & Beamer, by Dr. Sergio Cantero (Univ. of Bristol, UK)



Figure 3. Screenshot of the Practice of scientific writing, by Prof. Francisco Herrera (UGR)



In addition to this, two thematic workshops were held: the Communication day, with an info session given by Ms. María Megía (Research Communication), Project Manager of ENHance, and the Industry day, with two conferences carried out by Prof. Guillermo Rus, Founder & CEO of Innitius, S.L. with a talk named "from research to industry: pathways to entrepreneurship", and Dr María Ros (expert of the H2020 and Horizon 2030 programmes, University of Granada), who gave a talk named "European research opportunities after H2020".



Figure 4. Screenshot of the Practice of scientific writing, by Prof. Francisco Herrera (UGR)

To put in practice the theory learned, two challenges were launched: *the latex challenge* and *the communication challenge*, both with a symbolic economic price for the winner and a successful number of the participants. The communication challenge gave as a result the promotion of the ENHAnCE project and the MSCA-ITN network among the student's community, in original and creative ways of exposition.



Figure 5. Some of the communication challenge participant's promotion posts



### 2.3. Second Training Week (TW2)

The second training week was held online due to the pandemic situation which impended us travelling and meetings. The TW was open to all the scientific and engineering community by registration. It was focused on the Foundations of the Prognostics and Health Management (PHM) technology and included Master Classes, Keynotes and specialized Seminars with worldwide leaders of the PHM technology, such as:

-Dr. Kai Goebel (Principal Scientist at Palo Alto Research Center (PARC), USA),

-Dr. Matteo Corbeta (Research Scientist. NASA, Ames Research Center, USA),

-Dr. Shankar Sankararaman (Staff Data Scientist. Intuit, Inc., USA),

-Prof. Marcos Orchard (Department of Electrical Engineering Faculty of Physical and Mathematical Sciences, Universidad de Chile, Santiago, Chile)

-Dr. David Acuña (Assistant Professor. Pontificia Universidad Católica de Chile)

-Prof. Enrico Zio (Full Professor Politecnico di Milano, Italy),

-Dr. Francesco Cadini (Associate Professor-Co-Investigator of ENHAnCE project. Politecnico di Milano, Italy)

-Dr. Claudio Sbarufatti (Associate Professor-Co-Investigator of ENHAnCE project. Politecnico di Milano, Italy)

The attendance varied between 20 to 30 participants and the detailed schedule is included in Annex A2. The link of the recorded sessions are given in the following link: https://u.pcloud.link/publink/show?code=xEvitalK



Figure 6. Screenshot of the Masterclass on "Introduction to PHM, origins, and research vision", by Prof. Marcos Orchard (University of Santiago, Chile)





Figure 7. Screenshot of the Masterclass on "Fundamentals of PHM: Methods and algorithms", by Dr. David Acuña (University of Santiago, Chile)



Figure 8. Screenshot of the Masterclass on "The path from PHM to decision making ", by Enrico Zio (Politecnico di Milano, Italy)



Figure 9. Screenshot of the Masterclass on "Towards The True Hybrid PHM: Overview of Physics-Informed Trainable Models for Prognostics and Health Management", by Dr. Matteo Corbeta



### 2.4. Third Training Week (TW3 and TW7)

The training weeks "Introduction to Composite Science and Technology (TW3)" and "Latest trends in manufacturing of intelligent composites (TW7)" were combined in one Training Week organised by DLR and FIDAMC and held in person at the facilities of FIDAMC in Madrid (Spain) on 15<sup>th</sup> to 19<sup>th</sup> November 2021. This fusion conferred a richer and wider view about composite structures, gathering a first introductory perspective with a more advanced view as a journey across the development of this material.

Due to the reserved character of the facilities and the pandemic circumstances, the attendance was restricted to the ESRs. The Advanced Materials Training Center in FIDAMC has more than 500 m2 of spaces focused on training, which includes classrooms, a trimming workshop and a training workshop, where each participant made a piece of composite with embedded sensors, detecting induced disturbances. The detailed schedule is included in Annex 3.



Figure 10. Session "Smart materials and structures" by Prof. Peter Wierach, DLR



Figure 11. Session "Industrial lecture - Aeronautical composites: where we are and where we go", Tamara Blanco (Airbus)





Figure 12. Workshop: "Practical session: Thermoset composite panel manufacturing (hand lay-up)" by Dr. María Rodriguez, FIDAMC



Figure 13. Workshop: "Practical session: Bonding, wiring and connections on the embedded sensors at the composite", by Dr. Maria Moix-Bonet (DLR)



Figure 14. The ENHAnCE team at FIDAMC facilities (Madrid, Spain)



### 2.5. Upcoming Training Weeks (TW4 and TW5)

The TW "SHM methods using GWs and AE in composites" is intended to be organized as a joint event with the GW4SHM ITN network https://cordis.europa.eu/project/id/860104, (whose coordinator already expressed his willingness to collaborate for arranging joint-training weeks) and also might be joined to the ReMap project <u>https://h2020-remap.eu/</u>, which share many common research and training topics (guide-wave modelling, SHM, maintenance modelling, structural integrity, etc.). This would imply changing someway the schedule of some other training weeks since their contents might have been already covered through the join event. Changes will be discussed at SB level and communicated in advance to the REA. A tentative date for the event is discussed to be on September 2022.

The TW "Understanding the fatigue damage in engineering materials" to be organized by TU-Delft is foreseen to M25 (January 2022) and arrangements in this direction have already taken place.



## Appendix

## A1. Programme of the first Training Week



ORGANIZERS Dr. Manuel Chiachio (General Chair) Prof. Francisco Herrera (DaSCI) Dr. Juan Chiachío (Co-Chair) Ms. María Megía (Chair of Secretariat)

LECTURERS

Dr. Manuel Chiachío (Univ. of Granada, Spain) Prof. Francisco Herrera (Univ. of Granada, Spain) Dr. Manuel Chiachío (Univ. of Granada, Spain) Dr. Sergio Cantero (Univ. of Bristol, UK) Prof. Guillermo Rus (Univ. of Granada, Spain) Dr. María Ros (Univ. of Granada, Spain)

#### SCIENTIFIC COMMITTEE

Dr. Manuel Chiachío (Coordinator, Spain) Prof. Peter Weirach (DLR, Germany) Dr. Daniel Smidth (DLR, Germany) Mr. Ir. David Dumas (Cenaero, Belgium) Dr. Ingrid Lepot (Cenaero, Belgium) Prof. Alain Lhemery (CEA List, France) Dr. Vahan Baronian (CEA List, France) Dr. María Rodríguez (FIDAMC, Spain) Dr. Diego Sáez del Castillo (FIDAMC, Spain) Dr. Dimitrios Zarouchas (TUDELFT, Netherlands) Prof. Rinze Benedictus (TUDELFT, Netherlands) Dr. Claudio Sbarufatti (Polictecnico di Milano, Italy) Dr. Franceso Cadini (Polictecnico di Milano, Italy) Prof. Athanasios Kolios (Univ. of Strathclyde, Scotland) Prof. Fearnal Breenan (Univ. of Strathclyde, Scotland) Dr. Dimitrios Chronopoulos (Univ. of Nottingham, UK) Prof. John Andrews (Univ. of Nottingham, UK) Dr. Juan Chiachío Ruano (Univ. of Granada, Spain)

Prof. Francisco Herrera (Univ. of Granada, Spain)







ENHANCE Featuring Engineering

#### ENHAnCE TRAINING WEEK

26th to 30th of October, 2020 (On-line event. Follow us on streaming) https://stream.meet.google.com/stream/0392c7bb-09dd-4aa5-89be-0fa9cdd00e56

#### INTRODUCTION TO RESEARCH PRACTICE

#### PROGRAM

#### MODULES

**[MD1]** Opening, Introduction to the ENHAnCE Research project (Dr. Manuel Chiachío, Assistant Prof. University of Granada. Coordinator of ENHAnCE Consortium)

[MD2] PhD Practice I: Introduction to LaTeX & Beamer (Dr. Sergio Cantero, University of Bristol. Former Marie Curie Fellow of SAFE-FLY ITN project)

[MD3] PhD Practice I: Introduction to Scientific Writing (Prof. Francisco Herrera, Royal Academy Professor of Computer Science and Chief Editor of Information Fusion [Elsevier])

[MD4] PhD Practice II: Research Communication (Dr. Juan Chiachío, Assistant Prof. & Deputy Director of Internationalisation, Faculty of Engineering, University of Granada, Spain)

[MD5] PhD Practice III: Open Science/Open Data (Dr. Manuel Chiachio, Assistant Prof. University of Granada. Coordinator of ENHAnCE Consortium)

#### COMMUNICATION DAY

[COD1] Research Dissemination: ENHAnCE public website and Social Media (Mr. María Megía, University of Granada. Project Manager of the ENHAnCE Consortium)

#### INDUSTRY DAY

**[IND1]** From research to industry: Pathways to entrepreneurship. Prof. Guillermo Rus, Spain. Founder and Co-Founder of 3 university-based Start-Ups (Oritia & Boreas, INNITIUS, & REGEMAT 3D)

**[IND2]** After the PhD: European Research Opportunities. Dr. María Ros, H2020/Horizon Europe International Project Manager, International Project Office, University of Granada, Spain).



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## A2. Programme of the second Training Week

Please visit the dedicated website created to the Training Week:

https://www.granadacongresos.com/enhance



### **#PROGRAM**

Time (UTC+2)	Session	Lecturer
Monday, 19th April		
11:00-12:00	[MASTER CLASS] The PHM challenge of the ENHAnCE European project	Dr. Manuel Chiachío
12:00-15:00	(SEMINARS) ENHANCE individual projects presentation	
Tuesday, 20th April		
16:00-18:00	[MASTER CLASS] Introduction to PHM, origins, and research vision	Prof. Marcos Orchard
19:00-21:00	(KEYNOTE) Fundamentals of PHM: Methods and algorithms	Dr. David Acuña
Wednesday, 21st April		
11:00-14:00	[MASTER CLASS] The path from PHM to decision making	Prof. Enrico Zio
18:00-20:00	[KEYNOTE] PHM/AI in Industry 1: Intuit, Inc.	Dr. Shankar Sankararaman
Thursday, 22nd April		
11:00-12:00	[KEYNOTE] PHM on the railway industry. Track degradation case study	Dr. Juan Chiachío
18:00-20:00	[KEYNOTE] Towards The True Hybrid PHM: Overview of Physics- Informed Trainable Models for Prognostics and Health Management	Dr. Matteo Corbeta
Friday, 23rd April		
16:00-18:00	[TUTORIAL] 3 hours tutorial conducted by Dr. Juan Chiachio, Dr. Claudio Sbarufatti, and Dr. Franscesco Cadini	Dr. Juan Chiachio, Dr. Claudio Sbarufatti, and Dr. Franscesco Cadini
19:00-20:00	[MASTER CLASS] PHM/AI in Industry 2: Palo Alto Research Center, Inc. The future of PHM	Dr. Kai Goebel



## A3. Programme of the third Training Week



ENHANCE Featuring Engineering ENHAnCE TRAINING WEEK 15<sup>th</sup> to 19<sup>th</sup> November, 2021



Introduction to Composite Science and Technology Latest trends in manufacturing of intelligent composites

Venue: FIDAMC facilities, Av. Rita Levi Montalcini, 29, Getafe, Madrid

#### Monday 15/11

11:00 - 11:30	Welcome
11:30 - 12:30	Introduction to composite Materials Álvaro Calero (FIDAMC)
12:30 - 13:30	Thermoset composites: manufacturing and properties TBD (FIDAMC)
13:30 - 14:30	Lunch
14:30 - 15:30	Thermoplastic composites: manufacturing and properties Isabel Martín (FIDAMC)
15:30 - 16:30	Coffee break
16:30 - 17:30	Industrial lecture - Aeronautical composites: where we are and where we go Tamara Blanco (Airbus)
Tuesday 16/11	
09:00 - 11:00	Smart materials and structures: session 1 Peter Wierach (DLR)

- 11:00 11:30 Coffee break
- 11:30 13:00 Smart materials and structures: session 2 Peter Wierach (DLR)
- 13:00-14:00 Lunch
- 14:00 15:00 Smart materials in action Peter Wierach (DLR)
- 15:00 16:00 Visit to FIDAMC facilities
- 16:00 17:30 ESRs: Networking Supervisors: Supervisory board meeting
- 20:45 Supervisory Dinner at the restaurant "Fismuler", C/ Sagasta, 29, Madrid.



#### Wednesday 17/11

09.00 - 11.00	Practical session 1 - part I: Thermoset composite papel manufacturing (hand law up)			
05.00 11.00	FIGURE Session 1 part is merinoset composite parer manufacturing (nand ray-up)			
	FIDAMIC			
11:00 - 11:30	Coffee break			
11:30 - 13:00	Practical session 1 – part II: Vacuum bag preparation			
	FIDAMC			
13:00 - 14:00	Lunch			
14:00 - 15:00	Characterization of composite materials			
	María Rodríguez (FIDAMC)			
15:00 - 17:00	Networking/ Video interviews/Pictures			
Thursday 19/1	1			
Thursday 18/11				
09:00 - 11:00	Practical session 2 – part I: Bonding, wiring and connections			
	Maria Moix-Bonet (DLR)			
11:00 - 11:30	Coffee break			
11:30 - 13:00	Practical session 2 – part II: Damage evaluation			
	Maria Moix-Bonet (DLR)			
13:00 - 14:00	Lunch			
14:00 - 15:00	Poster session			

15:00 - 17:00 Networking

#### Friday 19/11

- 09:00 13:00 Leisure activity: Visit to Museo del Prado, Madrid
- 13:00 15:00 Closing lunch