



**ENHAnCE**

Featuring Engineering

## LECTURE SYNTHESIS OF TWS 7 TO 11

<b>Project Acronym:</b> ENHAnCE	
<b>Project full title:</b> European training Network in intelligent prognostics and Health mAnagement in Composite structurEs	
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# 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 improvement of the ESRs' potential 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 have attend formal thematic training weeks (TWs) arranged as Network-wide Schools around a specific ENHAnCE's topic, which have been made available not only for the ESRs but also for other participants within the scientific community. TWs are organised and hosted by the partner beneficiaries and have brought all the ENHAnCE's researchers together for a one week-event at several host institutions. 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 of research products. Table shows the list of TWs, and their schedule as initially planned in the project.

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

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 (TU Delft)	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	Dept. Mechanical Engineering (POLIMI)	30



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Module title		Summary of content	Lead Institution	Project Month
		prognostics fusion with Artificial Intelligence methods, post-prognostics methodologies, Open-Access prognostics implementation, etc.		
9	Asset management and Maintenance modelling	This module deploys useful tools for the asset management and maintenance of systems such as rails.	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

The already submitted deliverable D 6.4 presented the training events that took place from the beginning of the project (M1) to the end of the second year (M24). The current deliverable 6.5 comprises the remaining training weeks from month M25 until the end of the project, providing details of the organization and a description of the contents. Some modifications have been introduced due to several circumstances (including the pandemic irruption in March 2020, M3) regarding modality (on-line instead of in-person) and dates, even joining compatible modules, to run the schedule on time as far as possible. All modifications were previously discussed at SB level and communicated to the REA. Because of this fact, the final amount of TW have been 9, instead of 11 since two of them have been celebrated jointly between two beneficiaries, as indicated in the table below:

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

Module title		Summary of content	Lead Institution	Initially scheduled Project Month	Re-scheduled 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	23	Held in person in FIDAMC facilities (Madrid, Spain),. Celebrated jointly between FIDAMC and DLR to avoid further delays in the schedule
	Latest trends in manufacturing of intelligent composites (TW7)	Manufacturing engineering of composite parts with embedded sensors, monitoring of manufacturing quality.	R&D Department (FIDAMC)	27		
4	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 (TUDelft)	21	27	Held in person at TUDelft (Delft, Netherlands)
5	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 List)	18	30	Held jointly with the H2020 -MSCA project GW4SHM-ITN in Paris, France



Module title		Summary of content	Lead Institution	Initially scheduled Project Month	Re-scheduled date	Notes
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	34	Held in person at Cenaero (Charleroi, Belgium)
7	Latest trends in prognostics algorithm architecture	Up-to-date advances in algorithmic methods for computing prognostics signatures, like prognostics fusion with Artificial Intelligence methods, postprognostics methodologies, Open-Access prognostics implementation, etc.	Dept. Mechanical Engineering (POLIMI)	30	37	Held in person at POLIMI (Milano, Italy)
8	Asset management and Maintenance modelling	This module deploys useful tools for the asset management and maintenance of systems such as rails.	Dept. Aerospace Engineering (UNOT)	33	39	Held in person at the University of Nottingham (United Kingdom). Celebrated jointly between UNOTT and STRATH.
	Turbine blades design and technology	Foundations of design, analysis and blade manufacturing techniques. Monitoring techniques. Assembly technology and maintenance.	Dept. Naval, Ocean & Marine Engineering (STRATH)	36		
9	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.	University of Granada (UGR)	42	41	Held in person at the University of Granada (Spain)

## 2. Training weeks

### 2.1. General structure of the Training Weeks

The TWs have been

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 are complemented by 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. Organization of the training weeks celebrated during the second and third years of the project***

A total of six Training Weeks have taken place during the second half of the project ENHAnCE with great enthusiasm and commitment from supervisors, lecturers and researchers. With these sessions, the project ENHAnCE reaches the successful completion of the intensive training for the researchers involved, who were equipped with the necessary skills, knowledge, and expertise to excel in their respective fields.

The training program was meticulously designed to cover a wide range of critical areas, including cutting-edge research methodologies, advanced data analysis techniques, interdisciplinary collaboration, and innovation management. Throughout these six weeks, the researchers had the opportunity to engage in workshops, seminars, hands-on exercises, and interactive sessions facilitated by renowned experts and industry leaders. The design of the training programmes were based on the local organizers, in liaison with the PI and Coordinator of the project, Prof. Manuel Chiachío, who supervised the agenda, contents and procedures.

The training not only focused on enhancing technical proficiency but also emphasized the development of essential transferable skills. Effective communication, project management, teamwork, and leadership skills were fostered, enabling our researchers to effectively disseminate their findings, forge collaborations, and drive impactful outcomes.

The commitment of the ESRs to acquiring new knowledge and pushing the boundaries of the state of art in their fields was truly commendable. The acquired expertise and insights gained during these weeks will undoubtedly contribute to the advancement of cutting-edge research and innovation within the H2020 projects. It is also remarkable the labour of the trainers, mentors, and all those involved in organizing this enriching training program.

This milestone marks not only the culmination of an intense training period but also the beginning of an exciting phase where the researchers will apply their newfound skills and knowledge to further drive the success of the ENHAnCE project.

Hereafter is described the content of each Training Week, which is illustrated with some data and pictures. The detailed programme can be consulted in the Appendixes.



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### **2.2.1. 4<sup>th</sup> Training week, TUDelft (Delft, Netherlands)**

The fourth training week was delivered at the Department of Mechanical and Aeronautical Engineering of TUDelft, Netherlands, from the 28th of February to the 4th of March 2022. The title was “Understanding the fatigue damage in engineering materials” and numerous laboratory sessions at the Delft Aerospace Structures and Materials Laboratory (DASML) were undertaken, along with the corresponding lectures regarding the subject of fatigue in composites like: how to test and what to measure in composites; theory and practicalities about guided waves and wavelet methods applied to the Finite Element Method; and a vision and path to Intelligent Manufacturing, to cite but any.

The Training Week also included a visit to the Smart Advanced Manufacturing XL (SAM|XL) and a social activity in Rotterdam visiting the port, one of its museums and a following dinner.



**Figure 1. Lectures and laboratory sessions at TUDelft (Netherlands)**



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### **2.2.2. 5<sup>th</sup> Training week, CEA List (Paris, France)**

The fifth training week was held at CEA Saclay (Paris, France), a research centre from CEA List, from the 20<sup>th</sup> to the 24<sup>th</sup> of June, 2022. CEA List (Commissariat à l'énergie atomique et aux énergies alternatives), is a French research organization devoted to the development and promotion of sustainable energy technologies, nuclear energy, and defence applications, and is one of the largest technological research organizations in Europe.

The title of the Training Week was “Guided Wave (GW) Structural Health Monitoring (SHM): from modelling to applications” and the foundations of simulation and study of GWs interaction with composite damage, as well as a mixture of monitoring techniques between Guided Waves (GWs) and Acoustic Emission (AE) were taught to the researchers. The training program was thoughtfully designed to cover a wide range of topics, including advanced modelling techniques, signal processing methodologies, sensor technologies, and practical applications.

This Training Week was celebrated jointly with the H2020 -MSCA ITN project GW4SHM (<https://www.bam.de/GW4SHM/EN/Navigation/Home/the-project.html>), dedicated to transforming SHM research into practical applications to assess the integrity of structures and create ready-to-use tools for the industry and other SHM users. The remarkable collaboration between the two projects allowed us to combine expertise, knowledge, and resources in the fields of guided waves and structural health monitoring, fostering groundbreaking advancements and innovation.



**Figure 2. Lectures and social dinner in CEA, Paris, France**





This was a unique opportunity for participants to gain a comprehensive understanding of GW and AE principles, methodologies, and potential applications. Through interactive workshops, hands-on experiments, and engaging discussions, the participants were able to deepen their knowledge and develop practical skills that will greatly contribute to their ongoing research and future endeavours. The collaborative nature of this training week played a pivotal role in fostering interdisciplinary collaboration and knowledge exchange.

Researchers and professionals from different backgrounds and fields had the opportunity to network, establish fruitful connections, and lay the groundwork for future collaborative projects. The synergy generated by the convergence of expertise from ENHAnCE and GW4SHM projects has set the stage for groundbreaking research and innovation in the field. The knowledge gained and the collaborative networks established during this training week will undoubtedly pave the way for new breakthroughs and innovative solutions in the field.

### ***2.2.3. 6<sup>th</sup> Training week, CENAERO (Charleroi, Belgium)***

The following training week was held at CENAERO's office in Charleroi, Belgium, from the 10th to the 14th of October 2022. CENAERO (Centre for Numerical Methods and Engineering Optimization) is a non-profit research center specialized in the development and application of advanced numerical methods for engineering and industrial sectors. The center collaborates with industry partners and academic institutions to address various engineering challenges and provide innovative solutions in the fields of computational mechanics, fluid dynamics, and multidisciplinary optimization.

The title of the Training Week was "Numerical Methods for virtual laboratory engineering" and a virtual laboratory simulation was presented to the researchers, along with lecturers based on cyber-physical systems for the optimisation of manufacturing processes, visiting the Manufacturing Laboratory and the Supercomputer centre. There was also a Career Session from the Tutor Mentor of ENHAnCE, Dr. Rafael Muñoz, who talked about the next steps the researchers can take through their careers.

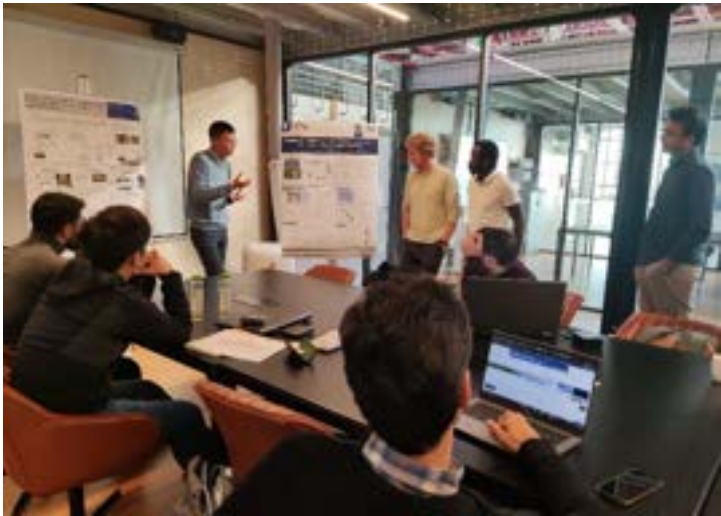
The training week counted with a tour along SONACA facilities (SONACA is Partner Organization of the ENHAnCE project), a Belgian aerospace company that specializes in the design, development, and manufacturing of advanced aerostructures and related systems for the aerospace industry. There the ESRs had the opportunity of presenting their PhD topics and the course of their research over a Poster Session, sharing with other researchers, industry professionals and experts their ideas and best practices, and enhancing their skills in the cutting-edge domain of numeric simulation.

Additionally, the Coordinator launched an initiative to foster collaboration between the ESRs to build the ENHAnCE demonstrators. This initiative have boosted the demonstrator's development.

The social activities were held in Charleroi and Brussels with great enthusiasm from the researchers and other participants.



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**Figure 3. Lectures, visits and social activities in Belgium**



#### **2.2.4. 7<sup>th</sup> Training week, Politecnico di Milano (Milano, Italy)**

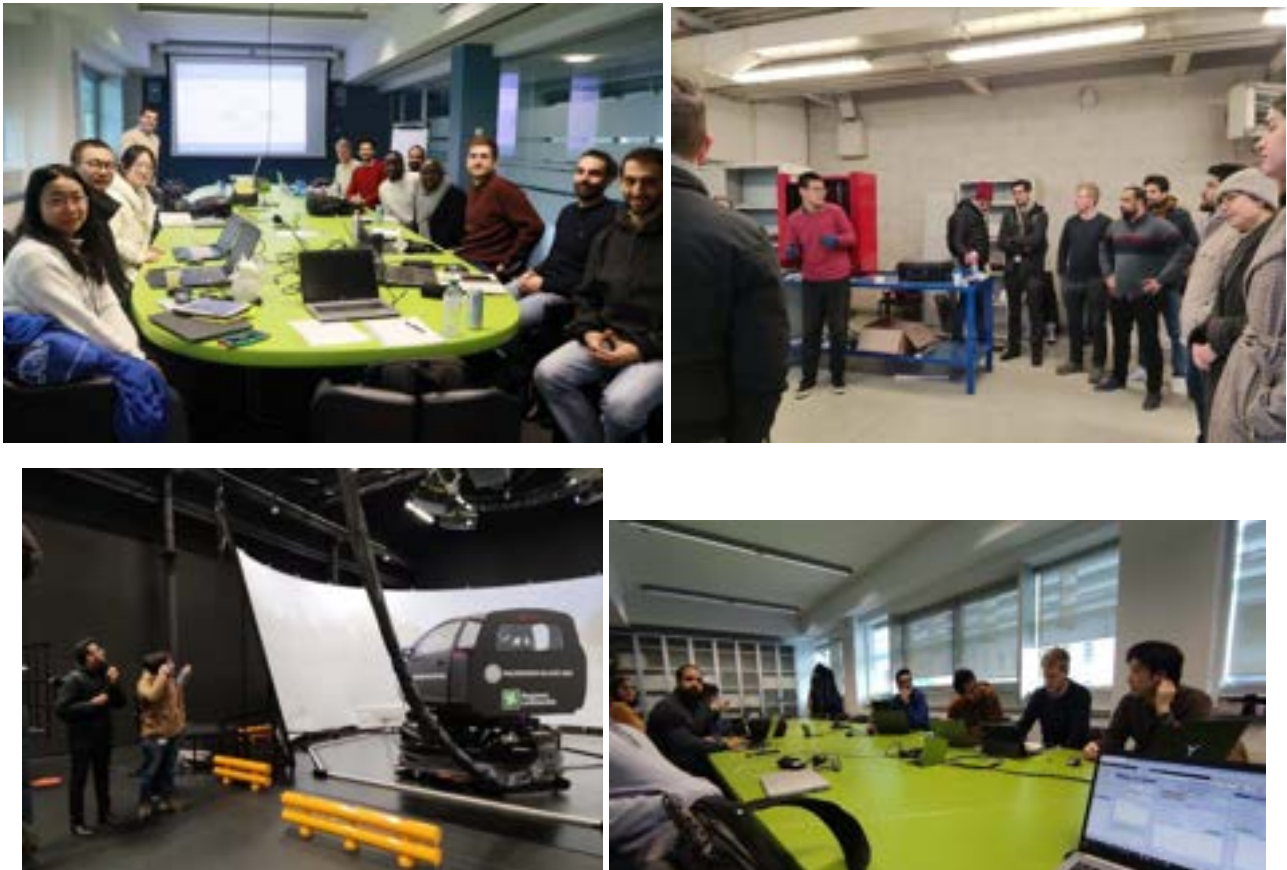
The seventh training week was delivered at the Department of Mechanical Engineering of the Politecnico di Milano (POLIMI), Milano, Italy, from the 23rd to the 27th of January 2023. The topic of this TW was “Latest trends in prognostics algorithm architecture”, and covered aspects such as the Bayesian Inference, Montecarlo Sampling and Particle Filters, equipping participants with the necessary tools to apply these techniques in their research and enabling them to tackle challenging mathematical problems that arise in prognostic algorithm architecture.

Other significant sessions were focused on Artificial Neural Networks (ANNs) and their role in condition monitoring and prognosis algorithm architecture. Participants were introduced to the fundamentals of ANNs, including different network architectures: Convolutional neural networks, Recurrent neural networks and Physics informed neural networks. The session provided practical examples and case studies to demonstrate the effectiveness of ANNs in prognostic applications.

The training week fostered a collaborative environment, allowing participants to engage in discussions, exchange ideas, and establish valuable connections. The interactive nature of the sessions encouraged knowledge sharing and facilitated a deeper understanding of the latest trends in prognostics algorithm architecture.

Several interesting visits took place, such as the one to the Mechanical Engineering Polimi Laboratories where experimental activities were undertaken regarding the use of acquisition systems, baseline acquisition, impacts, post-impact acquisition and post-processing.

The social activity was fully enjoyable at the Duomo cathedral in Milano and the following dinner.



**Figure 4. Lectures and laboratory activities in POLIMI**



**Figure 5. Social activities in Milano, Italy**

### ***2.2.5. 8<sup>th</sup> Training week, University of Nottingham (Nottingham, U.K.)***

The following TW was held at the University of Nottingham, from the 27th to the 31st of March 2023, with the title “Asset Management and Maintenance Modelling, with Applications to Wind Turbines and Rails”. As indicated previously, this TW was jointly celebrated between the University of Strathclyde and the University of Nottingham, to avoid delays in the training schedule. Both institutions delivered a comprehensive overview of asset management and maintenance applied to railways and wind turbines.

Lectures about Petri Nets as a mathematical representation of processes involving the flow of resources in systems and its importance in asset management were accompanied by Material’s lectures focused on Composites. A quite interesting visit to the University’s laboratory, showing the researchers their cutting-edge facilities regarding the study of composites, took place during the training week.

The application of the maintenance policies to rails and wind turbines was fully developed by the lecturers and enjoyed by the researchers, along with the sessions dedicated to Communication Skills and Preparation for an interview.

The social activities brought the researchers to know the city and the caves in Nottingham, followed by a wonderful dinner.



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Figure 6. Lectures, visits and social activities in Nottingham, U.K.

### 2.2.6. 9<sup>th</sup> Training week, University of Granada (Granada, Spain)

The last training week took place at the University of Granada, Spain, hosted by the project coordinator, Dr. Manuel Chiachío, and the rest of local supervisory team: Dr. Juan Chiachío, Dr. Rafael Muñoz and Ms. María Megía. Spanning from May 22nd to May 26th, 2023, the training week was titled "Pathways to Commercial End-Product Impact and Final ENHAnCE Results". This training week aimed to provide a global view of the ENHAnCE findings, along with foundations and pathways to promote end-user product development, business & entrepreneurial skills, and leadership on the ENHAnCE researchers, showing their results across several workshops.

The sessions commenced with an overview of the project's accomplishments thus far, presented by the Coordinator Dr. Manuel Chiachio. Next, several tutorials were conducted, covering topics such as doctoral European programs and research opportunities within the Horizon Europe context, along with tutorials for thesis preparation, and dissertation. Additionally, an engaging 3-Minute Thesis Contest was held, recognizing the outstanding contributions of the ESRs and presenting them with well-deserved prizes.

The Tutor mentor Dr. Rafael Muñoz delivered a series of informative talks on leadership, transitioning PhD work into the market, and the preparation of a business plan. Throughout the week, the ESRs actively worked on developing their business plans and presented them as part of team activities.



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Simultaneously, they also focused on finalizing the submission of project demonstrators. In addition to the core program, several lecturers conducted thought-provoking "Thinking out-of-the-box" sessions. These sessions covered topics such as explosions in structures, industry trends, market opportunities in the asset management field, and digital twin technologies.

This TW particularly counted with external recognized experts from industry and academia like: Dr. Alfredo Arnedo (fellow Principal Engineer, SENER SA), Dr. Carlos Ureña (Executive Asset Manager of Hewlett Packard, Spain), Dr. Aidan Hughes (University of Sheffield), and Dr. Sergio Cantero (University of Bristol).

The training week concluded with various cultural and social activities, providing an opportunity to showcase the city to the visitors and allowing all participants, including researchers, supervisors, and attendees, to create memorable moments together. These activities aimed to foster a sense of network and create a positive, inclusive environment for everyone involved in the project.



**Figure 7. Lectures, visits and social activities in Granada, Spain**



## Appendixes

### A1. Programme of the Training Week “ Understanding the fatigue damage in engineering materials “ at TUDelft, Netherlands

ENHANCE TRAINING WEEK, 28th February to 4th of March 2022, TUDelft (Netherlands)

PROGRAMME:

DAY	TIME	LECTURE / ACTIVITY
Monday 28-Feb-22	10:00 – 10:30	Welcome
	10:30 – 12:30	Dr. John-Alan Pascoe: Fatigue of composites: what we do know and what we don't (Lecture room C)
	12:30 – 13:30	Lunch and meet the lecturer session
	13:30 – 15:00	Tour at the Delft Aerospace Structures and Materials Laboratory (DASML)
	15:00 – 16:30	Dr. Dimitrios Zarouchas: Fatigue of composites: How to test and what to measure (Lecture room C)
Tuesday 01-March-22	10:00 – 12:00	Dr. Nan Yue: Practicalities of guided wave based SHM for aircraft composite structures: Part I: Instrumentation, environmental effects and upscaling Part II: Uncertainty quantification, diagnosis and prognosis (Computer room 7)
	12:00 – 13:00	Lunch
	13:00 – 16:00	Delft Aerospace Structures and Materials Laboratory (DASML);Task I
	16:00 – 17:00	Supervisory board meeting
Wednesday 02-March-22	10:00 – 12:00	Nathan Eskue:“The Vision and Path to Intelligent Manufacturing” (Fellowship instruction room 8)
	12:00 – 13:00	Lunch and meet the lecturer session
	13:00 – 14:00	Tour at SAM(XL)(Smart Advanced Manufacturing XL)
	14:00 – 16:30	Delft Aerospace Structures and Materials Laboratory (DASML);Task II
Thursday 03-March-22	10:00 – 12:00	Dr. Christos Nastos:A wavelet domain numerical method for the simulation of wave propagation in composite structures (Lecture room E)
	12:00 – 13:00	Lunch
	13:00 – 18:30	Leisure activity in Rotterdam
Friday 03-March-22	10:00 – 12:00	Delft Aerospace Structures and Materials Laboratory (DASML);Task III
	12:00 – 13:00	Lunch
	13:00 – 15:00	Delft Aerospace Structures and Materials Laboratory (DASML);Task IV



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## A2. Programme of the Training Week “SHM methods using GWs and AE in composites“ at CEA List, France

At CEA Saclay (France), from 20<sup>th</sup> June 2022 to 24<sup>th</sup> June 2022

When?	Mon. 20th June	Tues. 21st June	Weds. 22nd June	Thur. 23rd June	Fri. 24th June
Where?	Nano-Innov			Digitéo	Digitéo
08:30	Coffee	Coffee			Coffee
09:00	Install posters		Coffee		
09:30	M. Hafez (CEA) - Welcome and introduction	B. Chapuis & O. Meani (CEA) - Rail monitoring and its environmental impact	J. Mull (Goethe Univ.) - The influence of EDC on GW-based SHM systems	Coffee	F. Le Bourdais (CEA) - Additive manufacturing monitoring
10:00	N. Manzini (Sibas) - SHM for civil engineering applications and projects		A. Lemery (CEA) - Uses of reciprocity principle in the development of hybrid models for NDE/SHM	A. Imperiale (CEA) - Behind CIVA SHM	
10:30		ESR Session 2			Break
11:00	Break		Break	Break	F. Monzéou (PRIMA) - Inverse problems using observers for wave like problems
11:30	A. Rezaoui (CEA) - Passive tomography and applications with optical fibers	Poster 2	J-S Sommer-Ben Dhia (INSTA) - An overview of numerical methods for elastic wave modeling	A. Rezaoui (CEA) - CIVA SHM applications	P. Calmon (CEA) - Conclusion
12:00					
12:30	Lunch				
13:00					
13:30					
14:00	R. Micarelli (CEA) - Towards artificial intelligence in SHM	P. Calmon (CEA) - Reliability assessment, POD and MAPOD	V. Beronius (CEA) - Modeling tools for the inspection of waveguide structures in harmonic regime	F. Foucher (Extende) - CIVA SHM	End
14:30					
15:00	ESR Session 1	ESR Session 3	J. Mull (Goethe Univ.) - Cyclic Guided Waves: Benchmark Datasets for Guided Wave Inspections		Centre d'Intégration Nano-INNOV 2 Boulevard Thomas Gobert 91120 PALAISEAU Tel : + 33 (0)1 69 08 05 14 GPS   N 48.712608°   E 02.194447°
15:30	Poster 1	Poster 3	Remove posters	Break	CEA SACLAY DIGITEO LABS Bât. 565 91101 Gif-sur-Yvette Cedex Tel : +33 (0)1 69 08 06 00 GPS   N 48.727849°   E 02.150158°
16:00			Bus		
17:00	End	End		CEA lab tour (starts 16:15)	
17:30		Music festival	Social event		
Evening				End	





## **A3. Programme of the Training Week “Numerical Methods for virtual laboratory engineering” at CENAERO, Belgium**

**ENHANCE TRAINING WEEK, 10th to 14th of October 2022, Charleroi (Belgium)**

**PROGRAMME:**

DAY	TIME	LECTURE / ACTIVITY
Monday 10-Oct-22	12:00 – 13:00	Check-in
	13:00 – 14:00	Lunch
	14:00 – 14:30	Welcome and Introduction. David Dumas
	14:30 – 15:30	Virtual laboratories for engineering. David Dumas
	15:30 – 16:30	Composite process. Olivier Pierard.
	16:30 – 17:30	ESR Session - 1
Tuesday 11-Oct-22	9:00 – 10:00	Morfeo, Thermo-mechanical kernel. Olivier Pierard.
	10:00 – 11:00	ESR Session - 2
	11:00 – 12:00	Opti-Minamo theory, Surrogate – assisted optimization and data mining. Charlotte Beauthier
	12:00 – 13:00	Lunch
	13:00 – 14:00	Opti-Structural applications. David Dumas
	14:00 – 16:00	Practical session / workshop
Wednesday 12-Oct-22	16:00 – 19:00	Evening in Brussels
	9:00 – 10:00	Visit to the Supercomputer in A6K
	10:00 – 11:00	Modelisation of cure-induced deformations in Thermoset resin-based composite parts. Arnaud Parmentier.
	11:00 – 12:00	Metallic manufacturing process modelling and simulation. Arnaud Francoise.
	12:00 – 13:00	Lunch
	13:00 – 17:00	Visit to SONACA
Thursday 13-Oct-22	9:00 – 10:30	Virtual Laboratory on the Application of GW for SHM, Theoretical session. Mohammad Ali Fakh.
	10:30 – 12:00	Virtual Laboratory on the Application of GW for SHM, Practical session-1. Mohammad Ali Fakh.
	12:00 – 13:00	Lunch
	13:00 – 14:30	Career talk: Are you ready for the next steps in your career? Ratael Muñoz, Tutor Mentor.
	14:30 – 16:00	Aero-mechanical optimization. Lieven Baert.
	16:00 – 17:00	Deliverables think-tank
Friday 14-Oct-22	9:00 – 10:00	Advanced CFD in relation with experimental aerodynamics. Thomas Toulorge.
	10:00 – 12:00	Supervisory board meeting
	12:00 – 13:00	Lunch
	13:00	End



## A4. Programme of the Training Week “Latest trends in prognostics algorithm architecture” at the Politecnico di Milano, Italy

ENHANCE TRAINING WEEK, 23<sup>rd</sup> to 27<sup>th</sup> of January 2023, Milano  
(Italy)

**PROGRAMME:**

DAY	TIME	LECTURE / ACTIVITY
Monday 23-Jan-2023	9:15 – 10:15	Intro + Bayesian Inference – Prof. Claudio Sbarufatti
	10:15 – 11:15	Bayesian Inference – Prof. Claudio Sbarufatti
	11:15 – 11:30	Break
	11:30 – 12:15	Bayesian Inference – Prof. Claudio Sbarufatti
	12:15 – 13:15	Lunch
	13:15 – 14:15	Monte Carlo sampling for definite integrals – Prof. Claudio Sbarufatti
	14:15 – 15:15	Monte Carlo sampling for definite integrals – Prof. Claudio Sbarufatti
	15:15 – 16:15	Self Practice (ESRs)
Tuesday 24-Jan-2023	9:15 – 10:15	Particle filters - Prof. Francesco Cadini
	10:15 – 11:15	Particle filters - Prof. Francesco Cadini
	11:15 – 11:30	Break
	11:30 – 12:15	Particle filters - Prof. Francesco Cadini
	12:15 – 13:15	Lunch
	13:15 – 14:15	Artificial neural networks for regression - Prof. Francesco Cadini
	14:15 – 15:15	Artificial neural networks for regression - Prof. Francesco Cadini
	15:15 – 16:15	Self Practice (ESRs)
Wednesday 25-Jan-2023	9:15 – 10:15	Experimental activities: Intro on impacts on composites – Prof. Andrea Manes
	10:15 – 11:15	Deep Learning for SHMPHM: Convolutional neural networks – Luca Lomazzi
	11:15 – 11:30	Break
	11:30 – 12:15	Deep Learning for SHMPHM: Physics informed neural networks – Luca Lomazzi
	12:15 – 13:15	Lunch
	13:15 – 14:15	Deep Learning for SHMPHM: Recurrent neural networks – Dario Poloni
	14:15 – 15:15	Deep Learning for SHMPHM: Recurrent neural networks – Dario Poloni
	15:15 – 19:00	Social event: Visit to the Duomo cathedral (Milano)
Thursday 26-Jan-2023	9:15 – 10:15	Experimental activities: acquisition systems
	10:15 – 11:15	Experimental activities: acquisition systems
	11:15 – 11:30	Break
	11:30 – 12:15	Experimental activities: acquisition systems
	12:15 – 13:15	Lunch
	13:15 – 14:15	Experimental activities: baseline acquisition, impacts, post-impact acquisition, etc.
	14:15 – 15:15	Experimental activities: baseline acquisition, impacts, post-impact acquisition, etc.
	15:15 – 16:15	Experimental activities: baseline acquisition, impacts, post-impact acquisition, etc.
	16:15 – 19:00	Experimental activities: baseline acquisition, impacts, post-impact acquisition, etc.
	19:30	Social Dinner
Friday 27-Jan-2023	9:15 – 10:15	Acquired signals post-processing - Luca Lomazzi + Dario Poloni
	10:15 – 11:15	Acquired signals post-processing - Luca Lomazzi + Dario Poloni
	11:15 – 11:30	Break
	11:30 – 12:15	Visit to MeccEng Polimi Laboratories
	12:15 – 13:15	Lunch
	13:15	End



## A5. Programme of the Training Week “Aerospace Structural Materials” & “Turbine blades design and technology” at the University of Nottingham, U.K.

ENHANCE TRAINING WEEK, 27<sup>th</sup> to 31<sup>st</sup> of March 2023, Nottingham (UK)

**PROGRAMME:**

DAY	TIME	LECTURE / ACTIVITY
	12.00 – 14.00	Lunch
	14.00 – 15.00	Introduction to asset management and maintenance modelling (I) - Dr Rasa Remenyte-Prescott and Dr Darren Prescott, University of Nottingham
	15.00 – 15.30	Break
	15.30 – 17.00	Introduction to asset management and maintenance modelling (II) - Dr Rasa Remenyte-Prescott and Dr Darren Prescott, University of Nottingham
Tuesday 28- March -2023	9.00 – 10.30	Petri net modelling in maintenance (I) - Dr Darren Prescott and Prof John Andrews, University of Nottingham
	10.30 – 11.00	Break
	11.00 – 12.00	Petri net modelling in maintenance (II) - Dr Darren Prescott and Prof John Andrews, University of Nottingham
	12.00 – 14.00	Lunch
	14.00 – 15.00	Inspection and maintenance of wind turbines (I) - Prof Athanasios Kolios, University of Strathclyde
	15.00 – 15.30	Break
Wednesday 29- March - 2023	15.30 – 17.00	Inspection and maintenance of wind turbines (II) - Prof Athanasios Kolios, University of Strathclyde
	9.00 – 10.30	Composites (I) - Prof Nick Warrior, University of Nottingham
	10.30 – 11.00	Break
	11.00 – 12.00	Composites (II) - Prof Nick Warrior, University of Nottingham
	12.00 – 14.00	Lunch
	14.00 – 15.00	ESR networking
Thursday 30- March - 2023	15.00 – 15.30	Break
	15.30 – 17.00	Social activity and dinner
	9.00 – 10.30	Inspection and maintenance of wind turbines (III) - Prof Athanasios Kolios, University of Strathclyde
	10.30 – 11.00	Break
	11.00 – 12.00	Inspection and maintenance of wind turbines (IV) - Prof Athanasios Kolios, University of Strathclyde
	12.00 – 14.00	Lunch
Friday 31- March -2023	14.00 – 15.00	Communication skills session - Andy Smith, Careers Consultant, University of Nottingham
	15.00 – 15.30	Break
	15.30 – 17.00	Preparing for an interview - Andy Smith, Careers Consultant, University of Nottingham
	9.00 – 10.30	Strategic life cycle modelling to maximise value for Network Rail's stakeholders - Dr Gareth Calvert, Whole Lifecycle Costing Manager, Network Rail
	10.30 – 11.00	Break
	11.00 – 12.00	Generalising analytic methods to real-world scenarios in wind turbine health assessment - Joshua Greenslade, Machine Learning Engineer, Onyx Insight
	12.00 – 14.00	Lunch



## A6. Programme of the Training Week “Pathways to Commercial End-Product Impact and Final ENHAnCE Results” at the University of Granada. Spain.

ENHANCE TRAINING WEEK, 22<sup>nd</sup> to 26<sup>th</sup> of May 2023, Granada (Spain)

**PROGRAMME:**

DAY	TIME	LECTURE / ACTIVITY
Monday 22nd- May -2023	9:30 - 10:30	Enhance Global view and results (MCR)
	10:30 - 11:00	Enhance: past, present and future within the European program (JCR)
	11:00 - 12:00	Break
	12:00 - 12:45	Thesis preparation and dissertation tutorial (MCR)
	12:45 - 13:30	Lunch
	13:30 - 15:00	Deploying leadership (RMB)
	15:00 - 15:30	Break
	15:30 - 17:00	3 Minutes Thesis contest
	17:00	Cultural activities
Tuesday 23th- May -2023	9:30 - 10:30	Thinking out-of-the-box (I): Bayesian model updating of complex structures (JCR)
	10:30 - 11:00	Break
	11:00 - 12:00	Thinking out-of-the-box (II): Structures subjected to explosions (AAP)
	12:00 - 12:45	(Tutorial) Pathways to commercial end-product: how to create a bussines plan (RMB)
	12:45 - 13:30	Lunch
	13:30 - 15:00	Workshop about ENHAnCE Demonstrator I (ESRs)
	15:00 - 15:30	Break
	15:30 - 17:00	Workshop about ENHAnCE Demonstrator II (ESRs)
	17:00	Cultural activities
Wednesday 24th- May - 2023	9:30 - 10:30	Machine Learning: Basics and Applications to Ultrasonic NDE (SCC)
	10:30 - 11:00	Break
	11:00 - 12:00	Thinking out-of-the-box (III): Practicing ML/DL for multiple SHM/NDT applications and sensing techniques (MAF)
	12:00 - 12:45	Industry tendencies and market oportunities in the Asset Management (CUN)
	12:45 - 13:30	Lunch
	13:30 - 14:30	Sandpit I: PhD work to the market (ESRs assisted by CUN, RBM)
	14:30 - 15:00	Break
	15:00 - 16:00	Sandpit II: PhD work to the market (ESRs assisted by CUN, RBM)
	16:00	Cultural activities
Thursday 25th- May - 2023	9:30 - 10:30	Digital twin technology in structural engineering (MMC)
	10:30 - 11:00	Break
	11:00 - 12:00	Active Learning for decision-making in Structural Digital Twins (AH)
	12:00 - 12:45	From data classification to data generation in SHM (ED)
	12:45 - 13:30	Lunch
	13:30 - 15:00	Sandpit continuation: PhD work to the market (ESRs)
	15:00 - 15:30	Break
	15:30 - 17:00	Sandpit continuation: PhD work to the market (ESRs)
	17:00	Cultural activities
Friday 31- March -2023	9:30 - 10:30	Showcase and discussion of ENHAnCE Bussiness plan WP 1 & 2 (ESRs)
	10:30 - 11:00	Break
	11:00 - 12:00	Showcase and discussion of ENHAnCE Bussiness plan WP 3 & 4 (ESRs)
	12:00 - 12:45	Showcase of ENHAnCE Demonstrator (ESRs)
	12:45 - 13:30	Lunch
	13:30 - 15:00	ENHAnCE conclusions and final message (MCR)
	17:00	Cultural activities