



**ENHAnCE**

Featuring Engineering

## **END OF YEAR 1 PROGRESS REPORT & PERSPECTIVE**

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# 1. Introduction

The ENHAnCE project is oriented to train the next generation of scientists targeting a paradigm shift on the health management of composite structures by fusing ad-hoc sensing technologies and prognostics engineering within the structural system leading to a new concept of intelligent structures understood as cyber-physical systems (CPS). Since its beginning on 1<sup>st</sup> January 2020, 10 Early Stage Researchers (ESR) have been recruited and started their training, accomplishing all milestones and deliverables overcoming the difficulties arising from the pandemic situation suffered all over the world since March 2020. As described below, the project has successfully completed its objectives for its first year, with minor delays that do not significantly alter the course of the research.

## 2. General progress of the action

### 2.1. Deliverables and Milestones

As the main tool to quantify the progress of the action, the deliverables and milestones during the first year of the project are listed below:

**Table 1. Milestones of ENHAnCE**

MILESTONE #	DATE	STATUS	MILESTONE TITLE	MEANS OF VERIFICATION	WORK PACKAGE (WP)
MS1	February 2020	Accomplished on time	Kick-off meeting and 1st General Assembly (GA) successfully concluded – ENHAnCE has started	Beneficiaries met in Brussels, discussed and agreed on the adopted research, training and dissemination strategy	WP8 - Management
MS2	July 2020	Accomplished on time	Internet webpage and social media are running	Project webspace and social media operational	WP7 - Dissemination and Outreach
MS3	October 2020	Accomplished in January 2021, 3 months of delay due to the global pandemic	End of the recruitment process	All ESRs engaged and working on their individual projects	WP8 - Management
MS4	November 2020	Accomplished on time	Training Weeks started	The engaged ESRs have presented their Personal Career Development Plan	WP6 - ESR Training

The formal recruitment process ended in December 2020 so the milestone *MS3. End of the recruitment process*, which was initially set at month 10 (October 2020), was finally moved to month 13 (January 2021) due to the global pandemic situation. At that date, the 10 ESRs were fully designated, with contracts signed and Research Declarations submitted in the Participant's Portal.



The ESR 2 started his contract with a minor delay of 4 days in January 2021. This was due to adverse circumstances as the previous candidate resigned from this position (without having started) for unforeseen personal reasons. This issue also affected the submission of the deliverable *D2.1.Review of integrated monitoring technology*, with a delay due to the late entry of the current ESR 2 in charge of this submission.

**Table 2. Overview of Deliverables of ENHAnCE**

<b>DELIVERABLE #</b>	<b>DELIVERABLE TITLE</b>	<b>DESCRIPTION</b>	<b>SCHEDULED DATE</b>	<b>STATUS</b>	<b>WORK PACKAGE (WP)</b>
D8.1	Consortium Agreement	Consortium Agreement document	February 2020	Submitted on time	WP8 - Management
D8.2	Supervisory Board of the network	Report of the kick-off meeting and supervisory board constitution of the network	February 2020	Submitted on time	WP8 - Management
D8.3	Evaluation Guidelines for ERS recruitment	Evaluation Guidelines for ERS recruitment	May 2020	Submitted on time	WP8 - Management
D8.4	Data Management Plan	Data Management Plan	June 2020	Submitted on time	WP8 - Management
D7.1	Dissemination and Outreach plan	Dissemination and Outreach plan, including website, media interfaces and App	June 2020	Submitted on time	WP7 - Dissemination and Outreach
D6.1	Training overview and monitoring methodology	Report on training overview and monitoring methodology of the project	July 2020	Submitted on time	WP6 - ESR Training
D4.1	Damage evolution models for PHM in composites	Report on damage evolution models for prognostics and health management in composites	September 2020	Submitted on time	WP4 - Real-time, self-adaptive prognostics algorithms
D2.1	Review of integrated monitoring technology	Literature review and technology review of current technology in integrated, onboard, built-in structural health monitoring.	September 2020	Submitted in March 2021, with 6 months of delay due to the late incorporation of the ESR2	WP2 - Technology development of intelligent composite components
D6.2	Researchers Declarations on Conformity	Report about Researchers Declarations on Conformity	October 2020	Submitted on time	WP6 - ESR Training
D5.1	Integration post-prognostics information for decision making	Technical report on integration post-prognostics information for decision making	December 2020	Submitted on time	WP5 - Development of a CPS Information System
D1.1	Ethics - NEC - Requirement No. 1	In case activities undertaken in non-EU countries raise ethical issues, the applicants must ensure that the research conducted is legal	December 2020	Submitted on time	WP1 - Ethics requirements



DELIVERABLE #	DELIVERABLE TITLE	DESCRIPTION	SCHEDULED DATE	STATUS	WORK PACKAGE (WP)
D1.2	Ethics - EPQ - Requirement No. 2	Further information about the possible harm to the environment caused by the research should be presented	December 2020	Submitted on time	WP1 - Ethics requirements
D1.3	Ethics - DU - Requirement No. 3	Details on the dual-use items in the sense of Regulation (EC) 428/2009 should be presented	December 2020	Submitted on time	WP1 - Ethics requirements
D6.3	Personal Career Development Plans	Report on Personal Career Development Plans	December 2020	Submitted on time	WP6 - ESR Training
D8.5	Planned recruitments completed	Report about ESR recruitment	December 2020	Submitted on time	WP8 - Management

In total, 15 deliverables have been produced and submitted to the REA. From them, only one has been delayed with respect to the initial scheduled date due to the late recruitment of the involved ESR (ESR2), caused by the pandemic situation.

## ***2.2. Scientific progress***

### ***2.2.1. Work Package 2: Technology development of intelligent composite components***

The WP2 seeks a new technology for smart structural components of composites by manufacturing-based integration of an engineered SHM and communications skin. This WP also involves the development of numerical tools for optimisation of the manufacturing process with embedded Acousto-Ultrasonic (AU) sensors, which will be miniaturized and connected to an array of microprocessors providing a first signal analysis and filtering. This work explores a cost-effective production, design and operation of smart composite components by measuring the dielectric properties of the curing process of the structural component.

The ESRs 1, 2, and 4 are collaborating on this WP and have submitted the deliverable *D 2.1. Review of integrated monitoring technology*.

### ***2.2.2. Work Package 3: Modelling AU-based wave propagation and interaction with damage***

The WP3 focuses on modelling guided waves (GW) propagation and interaction with damage in composite structures. The methodology involves identifying an efficient approach with brittle failure modes at the microscale (fibre fracture, debonding, delamination and brittle cracking), and also dissipation using a phase-field simulation approach. Proper multiscale FE approaches are examined to communicate the microstructural information at a coarser computational scale through benchmark tests of escalating complexity along with the development of surrogate models.

The ESRs 3 and 8 are working on this WP, and are preparing the deliverable *D 3.1. Report of Guided Waves models*, to be submitted by end of April 2021.



### **2.2.3. Work Package 4: Real-time, self-adaptive prognostics algorithms**

WP4 investigates fast and efficient filtering-based prognostics algorithms to predict the Remaining Useful Life (RUL) of composite materials under damage conditions using on-line data from onboard SHM sensors. The surrogate models of SHM-damage interaction developed in WP3 are to be encoded within Bayesian filtering algorithms to provide multistep ahead predictions of failure scenarios with quantified uncertainty.

The ESRs 5 and 6 are working on this WP and have submitted the deliverable *D 4.1. Damage evolution models for PHM in composites*.

### **2.2.4. Work Package 5: Development of a CPS Information System**

In the WP5 the focus is on the development of an integrated expert system to allow adaptive, yet autonomous, decision-making from post-prognostics information. The resulting expert-system will shift the burden of managing a composite structure from maintenance engineers to an autonomous system that acts under the guidance of monitoring data and maintenance policies implemented as rules. This WP is firstly facing the integration of the predicted information from component level (from WPs 3 & 4) to a system-level, which encompasses a significant research challenge due to the heterogeneity of operational information when applied to the level of an engineering system. Novel methodological frameworks like Plausible Petri nets (PPNs) are being investigated to efficiently incorporate monitoring data, expert knowledge, and/or data-based and model-based prognostics algorithms within the expert system.

The ESRs 7, 9 and 10 are developing this WP and have submitted the deliverable *D 5.1. Integration of post-prognostics information for decision making*.

## **3. Recruitment**

### **3.1. ESR positions**

The ENHAnCE project has recruited the ESRs who best fit the 10 positions of the ENHAnCE programme, looking not only for the academic merits but also for open-minded and team-spirited PhD candidates showing the capacity and enthusiasm to undertake the opportunity of developing a cutting-edge state-of-the-art research on intelligent prognostics and health management in composite structures.

As commented previously, due to the global pandemic situation making difficult travels and visa arrangements, the end of the recruitment process has been delayed from the expected date of October 2020 to January 2021. Either way, the Research Declarations from the 10 ESRs were submitted on due time to the EU participant's portal and their profiles were published on the web page of the project <https://h2020-enhanceitn.eu/esrs/> with full access to the Intranet, in order to share their results and communicate within the ENHAnCE network.

The delays in the recruitment of up to 6 months are considered not significant and will not impede the future course of the project. The periods for secondment of the ESRs are flexible and can be



adapted according to each fellow's career development plan. Also, the training activities and deliverables to be submitted can partially be adapted to the delays in the recruitment for those particular cases. Late recruited fellows have the opportunity to catch up with the course work. The ESRs that have been selected but not yet recruited due to the global situation of the pandemic at the time of the first training activity were attending this event, thus boosting their integration within the project.

All ESRs were/are in the process to be enrolled in doctoral programmes, depending on the administrative date of each Academic Institution for the formal registration. The ESR's positions and their related institutions are the following:

**Table 3. ESR positions of the project ENHAnCE**

ESR	NAME	THESIS TITLE	HOST INSTITUTION	REGISTRATION IN DOCTORAL DEGREE	CONTRACT DATE
ESR 1	Shankar Galiana	Reliable sensor networks for Structural Health Monitoring (SHM) systems in highly loaded composite structures.	German Aerospace Center (DLR) Germany	Clausthal University of Technology (TUC)	01/12/2020
ESR 2	Aravind Balaji	Virtual Laboratory for Modelling and Optimisation of Manufacturing of Composites Structures with embedded structural health monitoring systems	Cenaero (CEN) Belgium	Politecnico di Milano (POLIMI)	04/01/2021
ESR 3	Amond Sarr Allouko	Computing Platform Based on Novel High-Order Numerical Methods for Smart FRP Composite Structures with Embedded AU-SHM sensors.	List CEA Tech (CEA) France	University of Paris-Saclay (UPS)	07/10/2020
ESR 4	Tasdeeq Sofi	Novel procedure for designing, manufacturing and assembling smart composite wind turbine blades with embedded AU-SHM sensors	Fidamc (FID) Spain	Clausthal University of Technology (TUC)	04/11/2020
ESR 5	Morteza Moradi	Prognostic signatures based on data-fusion techniques from Lamb-wave and acoustic emission in real-world FRP laminates subjected to random fatigue damage	Delft University of Technology (TUDELFF) Netherlands	Delft University of Technology (TUDELFF)	01/09/2020
ESR 6	Tianzi-Li	Development of super-fast Bayesian algorithms for real-time prognostics in composite structures using structural health monitoring.	Politecnico di Milano (POLIMI) Italy	Politecnico di Milano (POLIMI)	01/06/2020
ESR 7	Javier Contreras	Development of a System-Level Post-Prognostics Reasoner for FRP turbine blades using on-board SHM.	University of Strathclyde (STRATH) UK	University of Strathclyde (STRATH)	21/09/2020
ESR 8	Wen Wu	Modelling risk of failure using guided wave propagation and interaction with damage in complex composite structures.	University of Nottingham (UNOTT), UK	University of Nottingham (UNOTT)	02/09/2020
ESR 9	Juan Fernández	Paradigm-Shift Research for System-Level Real-Time Prognostics of Cyber-Physical Assets using Deep Learning approaches.	Universidad de Granada (UGR) Spain	Universidad de Granada (UGR)	14/07/2020



ESR	NAME	THESIS TITLE	HOST INSTITUTION	REGISTRATION IN DOCTORAL DEGREE	CONTRACT DATE
ESR 10	Ali Saleh	Development of a prognostics-based self-adaptive Expert System for smart Composite Structures.	Universidad de Granada (UGR) Spain	Universidad de Granada (UGR)	30/09/2020

### 3.2. Recruitment strategy

The recruitment strategy strictly followed the European Charter for Researchers (The Code of Conduct for Recruitment of Researchers) guaranteeing worldwide access and a fair and competitive selection of fellows by the host institutions in accordance with gender equality and minority rights. It involved an intensive advertisement national and international through different channels available to the members of the consortium to get as many qualified applicants as possible. These channels included EURAXESS (<https://euraxess.ec.europa.eu/jobs/471470>), web and social media, and academic and professional associations, among others.

The course of the recruitment and the timing has been as follows:

**-Advertisement:** The promotion was made internationally visible in online portals as EURAXESS (<https://euraxess.ec.europa.eu/jobs/471470>), also using the Science for Refugees option, research communities and mailing lists. Additionally, the partners used local channels for announcing the ESR positions. This period began on the 10<sup>th</sup> of December 2019 and was active until March 2020 at the first stage, then until the end of May 2020, in a second stage.

**-Deadline:** The initial deadline for application, which was the end of March 2020, was extended 2 extra months due to the global pandemic circumstances until the end of May 2020, to better ensure the offer was available globally. The ESR 2 position had to be reallocated due to the renounce of the candidate for personal circumstances. A new advertisement process had to be opened and the position was covered again by a suitable candidate, which started in January 2021.

**-Central Reception of Applications and Marie-Curie eligibility check** (ESR status and the Mobility Rule): The reception of applications was arranged centrally at the Coordinator level. All the applications were received by email as posted in the advertisements, containing the required documents: a detailed Curriculum Vitae, a letter of motivation, a research declaration, meaningful certificates, a list of MSc courses and grades, reference letters, and any other relevant documents or information. Those that did not accredit the program's conditions were discarded after the senders did not respond to the warnings.

**-First Review of Applications:** A first screening of the applications were carried out by the Coordinator to classify them into the different positions offered. Some of them include an order of preference for different positions. Those including no preferences were categorized on the base of the academic background, country of origin to accomplish the mobility rule and experience. Once categorized, all the applications were sent to the beneficiaries to freely have the choice to select their own candidate. Also, a first eligibility check of the application was carried out at the Coordinator level. The first review of applications, including the eligibility check, was done by early April 2020.

**-Selection Committee meeting:** On the 15<sup>th</sup> of April, and after a first screening of the applications was done, a meeting of the Selection Committee (based on the supervisors of each beneficiary, the Coordinator and the Equal Opportunity officer) was held to share the evaluation guidelines (please





refer to Deliverable D8.3/D31 “Evaluation Guidelines”), to agree on the timeline and methodology for interviews, deadline for a first output, and data sharing management.

**-Second Review of Applications:** Each beneficiary received all the applications classified for easier scrutiny, with the freedom to choose one candidate not initially classified as optimum for their position. Irrespectively, each institution had also the opportunity to include their own choices in the process being monitored by the Coordinator, ensuring the same opportunity for each candidate.

**-Shortlisting and interview:** Each beneficiary made a shortlist for the interviews with at least 3 candidates. The interviews were held online by the academic and/or the industrial supervisor(s) during June, July and September 2020. One extra set of interviews was held to reallocate the position ESR 2 during November and December 2020.

**-Selection at the beneficiary level:** Finally the 10 candidates were selected, fulfilling all the requirements and selected as the most suitable to perform each position. After this, all candidates received a confirmation of the outcome of the recruitment process by the Coordinator. The contracts have been signed and the research declarations submitted to the EU portal from July 2020 to January 2021.

The recruitment process was coordinated centrally to ensure global equality in the assessment, opportunities, and that method followed the MSCA rules and the Code of Conduct for Recruitment (<https://euraxess.ec.europa.eu/jobs/charter/code>). However, each beneficiary had the freedom to make their choice according to their preferences, adequacy to their individual projects, and in compliance with their internal quality requirements codes and regional/national requirements.

### ***3.3. Some statistics about the applications***

The consortium received a total of 65 applications from 20 different countries worldwide for the 10 ESR positions, with 15% being from women. Up to 22 different academic backgrounds applied, from aeronautical/aerospace to transports, materials, artificial intelligence, robotics, energy, industrial, mechanical and civil engineering, to cite some of them.

In total, beneficiaries shortlisted and invited 30 candidates for interviews. The 3 most demanded positions were: ESR1 (21%), ESR 4 (20%) and ESR 6 (20%), whereas the least demanded were ESR 3 and ESR8 (3% each).

## **4. Career Development plan for each researcher**

The Career Development Plan of every Early Stage Researcher (ESR) is part of the action implementation in line with the European Charter for Researchers. These plans aim to achieve a realistic and well-defined set of objectives in terms of career advancement for the ESRs to develop and widen the competences of the researchers, particularly in terms of multi/interdisciplinary expertise, inter-sectoral experience and transferable skills.

Each ESR has produced a PCDP at the start of their research fellowship, which is composed of an individual training plan and a plan for the research objectives.

The ESRs have written their PCPD in agreement with their main supervisor and shared this document with the consortium to ensure coherence within the network and with the training needs of both



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industry and academia. The ESRs will revise their PCDP once a year based on the progress made, the changing needs of the research and the suggestions from their supervisors and mentoring bodies.

## 5. Training

The first training week was held on-line due to the pandemic circumstances from the 26th to the 30th of October 2020. It 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, Spain); 4) Practice of research dissemination, conducted by Dr. Juan Chiachío (University of Granada, Spain); and 5) practice of Open Science/Open Data, developed by Dr. Manuel Chiachío.

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”.

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.

## 6. Dissemination, communication and outreach

A Dissemination and Outreach Plan was launched in the first semester and will be updated during the implementation, with a final version to be handed at the end of the project. This plan comprises the strategy and actions related to the protection, dissemination and exploitation of the project results, which are conceived to be consistent and proportionate to the impact expected from the action. The target group comprises both the researchers and the scientific community, fully in line with the purposes and nature of the Marie Skłodowska-Curie Actions programme.

Besides, a website has been launched along with a social media presence to maximize the outreach of the project. The website is the core instrument of the project's communication achieving multiple objectives, not only sharing information within the project participants working as an operational platform but also offering a window to the general audience, deploying the main concepts related to the project along with links for the main social media (Twitter and Facebook) and contact via email.

The ENHAnCE website has been developed specifically for the project, with a public side fully accessible and a private part (intranet) only for beneficiaries and associated partners, and can be easily accessible through the following link <http://h2020-enhanceitn.eu/>.

To be connected to the general public and the scientific community, the project is linked to the main social media channels, as Twitter and Facebook with the accounts: [@ENHANCEITN1](#) for both (Twitter and Facebook), and LinkedIn with the account: [@ENHANCE-ITN-MSCA](#).



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In addition to all of this, short videos showing the development of the project (ESRs in action, conferences and other events, short classes from the training weeks, etc.) will be uploaded on the ENHAnCE web and also on YouTube.

The brand communication developed a specific logo for the project, representing the transmission and reflection of a wave through the multi-layer picture of a composite layer. The wave refers to the signals that the ENHAnCE SHM sensors will produce and the colour was chosen on grayscale, simulating the black and white (when fibres like glass are used) colours of composite materials.

The EU and Marie Skłodowska Curie Action (MSCA) logos will also appear in all the outreach activities as well as on the web and all the media channels. The European Commission policy on visual identity will be followed to correctly place and refer to the acknowledgements and logos in every item.

Communication activities are planned strategically identifying clear objectives, pursuing a creative and innovative way of communication, with all the beneficiaries involved in the outreach. These activities started at the beginning of the project with its presentation and the publication of the recruitment process on social media, reaching a specialised audience.

The advances of ENHAnCE will potentially have a significant impact in increasing social awareness on modern monitoring and maintenance technologies as well as inspiring the new generation of European and global technologists and engineers. The following actions have been adopted in order to ensure that the developments will be successfully communicated to the public:

- Communication skills were trained in the ESRs through specifically designed sessions (monthly sessions), and will be promoted at the Communication Days where the ESRs will be invited to present their work to consortium members, local authorities and industry partners. This way the ESRs will be conscious of the importance of showing the role of the EU in promoting research at top level and the funding impact on society, economy, environment and policy making.
- Boosting the social media channels (Twitter, Facebook and LinkedIn) to contribute to outreach the news about ENHAnCE, being constantly updated with ESRs project progress, training events, etc. This not only accelerates their research impact and aid their profile for being 'spotted' by potential future employers, but also increases the project visibility widely.

ENHAnCE will adopt an exploitation strategy to maximize valorisation of the achieved research and training outcomes, promoting their use for commercial purposes or in public policymaking. Besides, the work developed in ENHAnCE project is the result of the contribution of the whole consortium and as such, depending on the content, some usage rights need to be complied with. Specific Intellectual Property Rights (IPR) issues related to the exploitation of ENHAnCE are discussed in detail in the Grant Agreement.

## **7. Data management**

ENHAnCE will investigate and contribute to the prognostics and health management of composite structures, hence health/damage data about composite testing, manufacturing data, SHM sensor, numerical simulations, and software codes are expected outputs during the lifetime of the project. This information will become available as datasets to support the project results dissemination through the scientific community, including not only raw data but also pictures, computer simulations, videos, software codes, and technical reports. These sets of data will be discoverable, accessible,



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intelligible, assessable and reusable, and will constitute a useful source of information for PHM researchers, practitioners, data-science researchers and the entire composite industry (manufacturing and engineering).

The Data Management Plan was delivered at the beginning of the project and covers accessibility, interoperability, licensing, allocation of resources, data security and ethical aspects.

The ENHAnCE project respects the spirit of publicly funded research and endorses the Open Science movement by openly publishing non-confidential data that can be valuable to future researchers. Because of this, subject-specific descriptive metadata will be used to help researchers. To ensure data visibility, the metadata system used for the description of the materials hosted in the University of Granada (UGR) repository DIGIBUG, which is Dublin Core Qualified. This is a metadata initiative adopted by the European repository OpenAIRE. DIGIBUG assigns a unique identifier (handle) to each document and/or dataset, which allows the identification and citation of electronic documents.

ENHAnCE data will be shared through the DIGIBUG repository under Creative Commons license which will help to promote our data to be freely available and downloadable from the internet. The data produced during the project lifetime will be updated as soon as available except when an embargo period is requested by any consortium member and agreed upon at the Supervisory Board level.

## **8. Ethics**

The three mandatory deliverables about the Ethics Work Package of ENHAnCE were submitted on time with the related documentation supporting the ethical purposes of the project.

The Ethic Work package was proposed by the Commission after the evaluation of the project to act as an Ethics clearance for demonstrating that the investigated technologies are not going to be used in the military and defence sector, neither in the UE nor outside the EU (as the University of Basilea is a Partner Organization from a Non-EU Member country).

## **9. Research**

To get closer to the developments of the ESRs and promote their communication skills along with their commitment, monthly meetings are held on-line since December 2020. In these meetings, the ESRs are encouraged to present their work during 10-15 minutes, showing their progress and manifesting any doubt or problem they might have to find a solution with the cooperation of all participants. Needs and gives are welcome in these sessions, making the most of sharing to get ways of collaborations between researchers. Supervisors, co-supervisors and other members of the project committees are invited to these meetings.