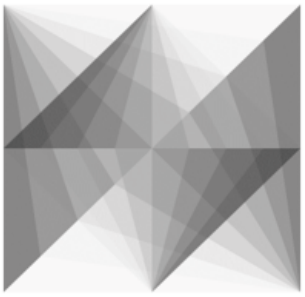

ENHAnCE

Featuring Engineering

D 7.2 Report on open meeting points and visits to local school

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Internally Approved: Coordinator	**Date:** 27/06/2022

1 Introduction

Deliverable D.7.2 is one of many ways of dissemination of works during the ENHAnCE project. We aim to present the project and our research to public. The ESR3 was in charge of a local school visit. At the same time, the ESR7 presented their work during the British Science Week. The University of Nottingham and Nottingham Trent University hosted a popular science event, named Science in the Park. A range of fun and interactive science exhibits were aimed at all ages of visitors. The cover of the Science exhibitor brochure is shown in Figure 1. Each ESRs will provide more details regarding the process of their event in a dedicated part of this report.

Figure 1: Science exhibitor brochure

2 ESR3: Visit of local school students

2.1 Context of the visit

Due to the pandemic, getting appointments at a local school in France was challenging. However, at ENSTA Paris, we have the opportunity to lead the visit of 75 students. The students were divided into three groups. The event was scheduled as follows per group of students:

- 15 mins of presentation
- 15 mins of visit in the labs with posters presentation.

The presentation were done by:

- **Amond ALLOUKO, ESR3**, PhD candidate at ENSTA Paris/ CEA
- **Clara LEPAROUX**, PhD candidate at ENSTA Paris/ONERA
- **Laura BAGUR**, PhD candidate at ENSTA Paris/ ENS Paris

The labs visit were driven by:

- **Jean-François FRITSCH**, PhD candidate at ENSTA Paris/CEA
- **Quentin** , PhD candidate at ENSTA Paris/ ENS
- **Aurore MAZURE**, internship student at ENSTA Paris.

The teenager average age was 14 years. The challenge is to explain the use of mathematics in our current work to people who do not know the derivation of a linear function. The visit aims to show them that ordinary people can use mathematics. We do not need to look like Einstein for it. This exercise was interesting and helpful by forcing us to use adequate words as much as possible in a few minutes.

2.2 Presentations

■ **Clara LEPAROUX**, PhD candidate at ENSTA Paris/ONERA

Clara is currently working on the reusability of a rocket launcher. A rocket comprises many parts, the launcher and the container (Satellites, humans, etc.). Only the American company SpaceX can return its launcher to a predetermined area after the dislocation of the rocker once the container is in orbit. Generally, European rockets are used once for one mission, making the rocket costly. The new objective is to build a new generation of reusable rockets (Ariane 6 program). Clara's job is to find the optimum trajectory with the optimum parameters (engine power, weight, wind speed, etc.) that should follow the launcher to land out at the right place.

Figure 2: Clara presentation

■ **Laura BAGUR**, PhD candidate at ENSTA Paris/ ENS Paris

Laura is developing models for simulating strategies for earthquake control. An earthquake results from the sudden release of energy accumulated by the stresses exerted on the tectonic plates. The earthquakes measured are not only due to natural phenomena. The gas and petrol exploitation produces an earthquake of lower amplitudes than the ones produced naturally. To extract petrol, one injects from on side fluids (mud or water vapor) to chase petrol which is taking off on the other side. With the same principle, by monitoring the flow of mud or fluids between both sides of the tectonics plates, Laura wants to vanish the accumulating energy.

Figure 3: Laura presentation

■ **Amond ALLOUKO, ESR3**, PhD candidate at ENSTA Paris/ CEA

In charge of this event, my primary role is explaining the notion of acoustical waves. From natural phenomena like the water waves, observed when a stone hits the surface of a lake, to the waves used by bats to find the location of food at night, the waves lie around us. How can mathematics be used to describe these phenomena? Can we use the waves for real daily applications thanks to mathematics?

Figure 4: Amond presentation

And the answer is yes. A numerical simulation of waves produced by a point source was presented. This simulation is the case that fits with the stone hitting water surface. Since the ESR3 is working on the hybrid modal approach that uses elastic waves for the SHM of composites plates with finite element methods, we introduced ultrasonic acoustic techniques in aeronautics. That was the opportunity to talk about the ENHAnCE project and the various projects funded by the European Commission to train the next generation of worldwide experts in the PHM of composites materials.

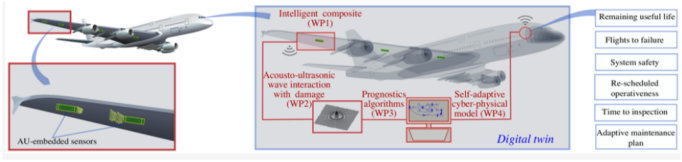

Figure: PHM for 4.0 Aircraft monitoring

Figure 5: ENHAnCE presentation

2.3 Photos showing the public

The following pictures show the students during the presentation and posters sessions. The feedback was good because they appreciate the simplification we have done in order to make the speech accessible to them.

Figure 6: Attendance

3 ESR7: Dissemination during British Science Week

3.1 Preparation for the exhibitions

■ **Poster**

A poster was prepared in order to present the research topic in a detailed and logic way, as shown in Figure 7. The title of the poster is "Digital World Signals Show Everything". We are living in a digital world. Sensors are

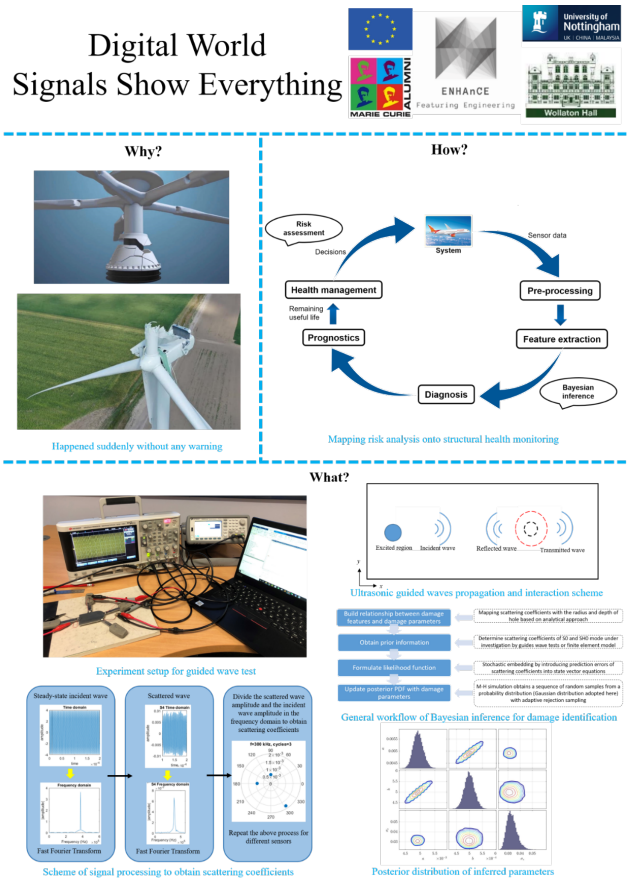

Figure 7: The poster consists of three parts, Why, How and What?

common in our daily life. Although we may not know how they works, but their use is quite familiar to us. For example, we use a thermometer to measure the temperature, this is one of the simplest sensors to transfer the temperature into a number which can be understood easily. The heart rate detection in hospital describes the physical condition by a number that can be analysed by doctors. Lots of equipment and systems are related to sensors in different areas within various ways of expression and complexity. In some areas sensors are used to monitor the condition of equipment and devices. For example, in this research, signals from sensors are used to interpret the health of machinery, such as wind turbines and aeroplanes. The three parts of the poster, Why, How and What, are descibed below.

1. Why

   - ❖ Avoiding risks. The first picture in the poster is a propeller of the helicopter. An accident was caused due to a crack in the propeller. With the pressure in the high altitude and plenty of other factors, the crack expanded and affected the flight. If signs of an early crack could have been identified using sensors, the accident could have been prevented.
   - ❖ Reducing costs. The wind power generation has to be interrupted if there is damage on wind turbine blades. Sometimes the damage can happen suddenly without any warning, so we need sensors as a tool to monitor blade condition. As a result, we can then consider follow-up decisions, such as whether maintenance or replacement is needed, etc. As such, costs are likely to be reduced.

2. How

   - ❖ First of all, the collected data by the sensors will be pre-processed, identifying some damage characteristics or features; secondly, the damage features will be used to derive the location and size of damages by applying Bayesian inference; then experts will make a prognosis for the remaining useful life of the system. Finally, they will decide whether any actions are necessary and use some data as feedback for the next prediction.

3. What

   - ❖ Physical models are developed to simulate the wave damage interaction in order to derive damage features numerically; a physics-based framework using Bayesian inference is presented to infer the size of damage.

■ Interactive experiments

In this section, an experimental presentation of an aluminium joint with defects based on Lamb wave monitoring is given. The joint is attached to four rectangles to represent waveguides. There are four piezoelectric sensors (PZT) located at the end of the four rectangles near the centre. The leftmost PZT has been used to generate an input waveform, and the rest of the PZT sensors receive the reflected and scattered signals. The overall experimental setup is shown in Figure 8. A Keysight 33512B arbitrary waveform generator was used to generate a steady-state sinusoidal waveform in a specific frequency, and a DSOX2014A oscilloscope was used to digitize the signals using a sampling frequency of 9.6 MHz and averaging 32 measurements to increase the signal-to-noise ratio. A laptop was used to remotely control the waveform generator and oscilloscope.

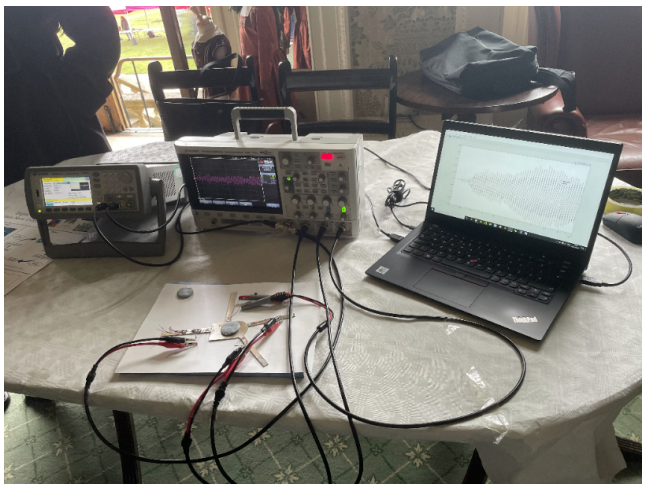

Figure 8: Experiment setup used comprising of a laptop, an arbitrary waveform generator and an oscilloscope connected to the PZT transducers attached to the aluminium joint

To make the experiments and presentation more interesting, an interactive process was introduced. As shown in Figure 9, a piece of blu-tack is placed in the centre of the specimen to simulate the real damage. If the size of blu-tack is changed, the signal received by the sensors will change, shown in Figure 10. It can be seen that with the increase of blu-tack size, the steady amplitude is going up. The steady amplitude could be used as an indicator of the size of the damage. During the event, visitors are invited to place a different size of blu-tack to see effects in signals caused by it.

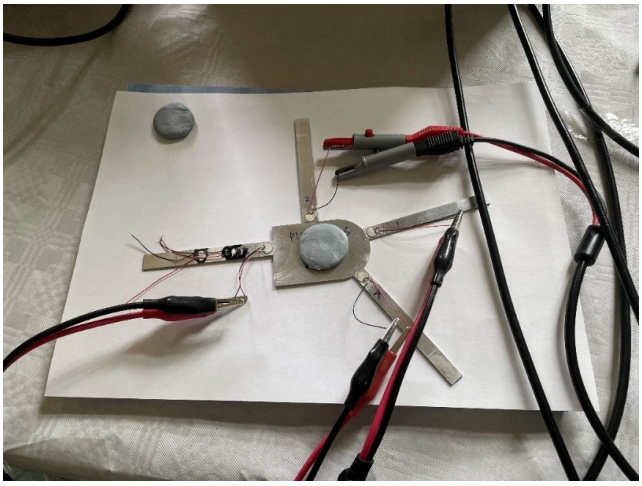

Figure 9: The aluminium joint with surface mount transducers and surface attached blu-tack that is used to simulate damage; there are four transducers in total

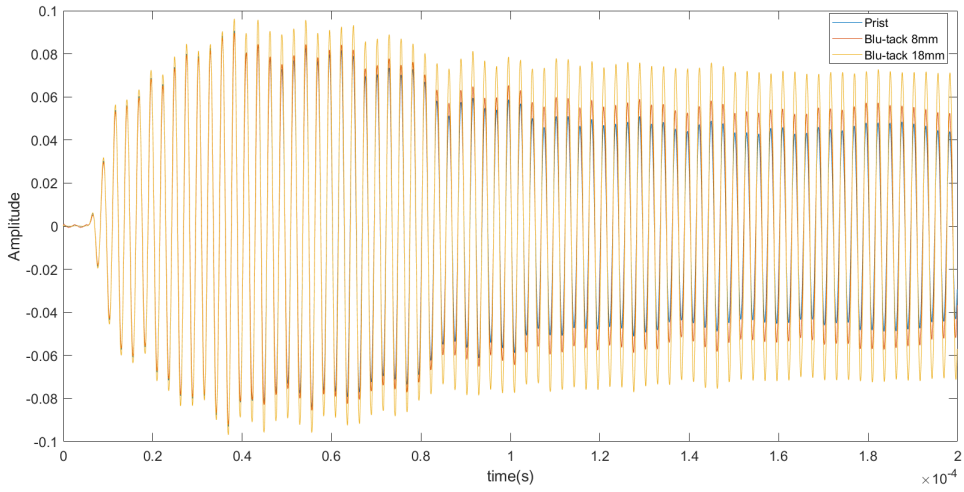

Figure 10: Time domain signal of pristine and different damage state. The difference in amplitude between different states is demonstrated clearly

3.2 Exhibition

The whole exhibition was such an interesting and impressive event. Different people, including children, adults and engineering enthusiasts, were interested in this research. This is my first time presenting the research to the public. Unlike presenting my research to colleagues, presenting it to someone who has never heard of it is a fantastic and unique experience. I had to use easy-to-understand words and examples of everyday use, not specialized words. Some kids asked very interesting questions. There were even scholars who were willing to collaborate with me in the future.

■ Some photos of the demonstration

In this section, some photos are added to show some memorable moments. Details are given under each photo.

Figure 11: Photo one: Parents bring their children to see my research experiments, and while I am explaining the demonstrations, Dad is excitedly adding explanations of some scientific phenomena for his children!

Figure 12: Photo two: Talking to an old engineer about an interesting engineering problem.

Figure 13: Photo three: Some peers who were not doing the same research as I was, but they were interested in my research mission, and they thought it was a great demonstration

■ Reflection about the exhibition

First of all, I especially enjoyed communicating my research to public and different people. I got a lot of interesting suggestions and some positive feedback. Sometimes some advice from a non-researcher can open up

a new perspective for me. In this process, it improves my reflection and review on my own research. Secondly, it is not easy to introduce your own research to others. During the introduction, I constantly had to update my words and expressions. This, of course, also has something to do with English not being my native language. But as the day went, I got better at introducing my work and things went a lot smoother. From the audience point of view, they will have gained a certain understanding of some cutting-edge science. This has the potential to improve children's scientific literacy. In particular, when people changed the size of the defect (blu-tack) themselves, they saw the effect of this on the signal. They were very happy and engaged.
This event and similar popular science events provide us with an opportunity to improve our communication skills. This is very important for researchers. And positive feedback from the public increases the enthusiasm and passion of researchers. Furthermore, such events may encourage the next generation of teenagers to engage in science activities.

4 Conclusion

This deliverable allows both ESR3 and ESR7 to improve their transferable skills. On one hand, during the local visit, one tried to simplify some technical notions as much as possible to make them more accessible. On the other hand, the dissemination during British Science Week was not only very interesting, but it also facilitated reflection about research and improved presentation and communication skills. We hope to participate in similar activities in the future and we hope to contribute to fostering scientific interests in teenagers.