The aim of the project is the **development of an Artificial Intelligence (AI) driven diagnostic system for delamination identification in composite laminates** reinforced by carbon fibres. We would like to investigate delaminations because it is one of the most dangerous damage type. However, the methodology proposed in the project is expandable to other types of damage as well. The selection of laminates reinforced by carbon fibres is dictated by the high strength-to-weight ratio and a wide range of applications.

A large number of studies on Lamb wave propagation phenomenon suggest that this type of elastic waves can be applied for damage identification. The anomalies of wave propagation caused by delamination can be observed by the use of specialised equipment. However, due to complex wave propagation patterns, it is difficult to develop universal signal processing methodology capable of robust damage size estimation. It causes that the progress in the field of **Structural Health Monitoring** (SHM) and **Non-destructive testing** (NDT) based on elastic waves is slow. Therefore, the feasibility studies of an alternative approach based on **deep neural network (DNN) architectures** will be conducted.

Deep learning algorithms which employ DNN are classified as a subset of AI. These algorithms can learn from data and make predictions. It means that if we have input and output data, DNN is able to find relations between these two sets. Deep learning has gained recently a tremendous boost in performance and find many applications. It is because of increased computer power which enables to use deeper neural networks which, in turn, leads to better predictions of these networks.

Why AI? We believe that AI-driven approach can be more suitable to the complex problem of analysis of the correlation between elastic wave anomalies and damage than conventional signal processing methods. By the use of conventional signal processing methods, one can detect and localise damage in the structural component. However, estimation of damage size is very difficult to achieve, especially for the case of multiple defects present in analysed structure.

It is expected that AI-driven approach will help to accelerate the progress in the development of robust NDT/SHM systems based on elastic waves. To achieve this, it is necessary to accomplish the following tasks which are proposed in the project:

- implement highly parallel code for solving a problem of elastic wave propagation phenomenon,
- generate a large dataset of examples for supervised training,
- apply DNN for damage identification,
- estimate accuracy of applied DNN.

The most important part of the project is the computation of a **large dataset of elastic wave patterns** interacting with delaminations. The dataset will allow studying various deep neural network architectures, classification and pattern recognition methods for identification of location and size of delamination at an early stage of growth. Nevertheless, it is indispensable to implement a numerical method which will help to generate such datasets in a reasonable time. **We will develop a parallel implementation of the code** which will enable computation on multi-core units in order to speed up computation time.

In this project, **we will propose and evaluate several DNN architectures**. Trained neural networks will be tested on full wavefields measured experimentally on the surface of composite laminates with embedded Teflon inserts simulating delaminations. In this way we will estimate accuracy of applied DNN.

The use of SHM systems will contribute to increasing the safety of operating structures and reducing repair costs.