Composite materials, particularly carbon or glass fiber reinforced polymers, are increasingly used industrially. These materials are widely used in various aerospace structures, automotive and marine industries, among others. Moreover, these materials are widely used in renewable energy for manufacturing wind turbine blades.

The main feature that makes them so attractive for manufacturing structural parts is their high strength-to-weight ratio. However, unexpected damage can occur in composites due to impacts, among other things. Sources of impact can include the fall of a wrench used by aircraft maintenance personnel or a bird striking the fuselage skin. Such an event may result in an invisible defect that may continue to grow until it reaches a critical size that poses a threat to structural integrity. Therefore, it is necessary to use nondestructive testing techniques to check the structural condition of composite components. The use of conventional diagnostic techniques involves the exclusion of the structure from normal operation; moreover, in many cases additional preparation of the structure for testing is required. Also important is the fact that the personnel performing the tests must be highly qualified. In the aviation industry such exclusion of the aircraft from operation generates huge costs. The development of reliable and highly automatic techniques to detect delamination, disbonds and other defects in laminated composites is essential to ensure the safety and functionality of optimally designed composite structures. One such technique is the use of guided waves.

The phenomenon of guided wave propagation can be imagined by analogy to waves propagating in water. A stone thrown into the water causes circularly propagating waves on the surface of the water. If the waves on the surface of the water meet an obstacle, they are reflected, creating an additional circular pattern on the surface of the water. Guided waves behave in much the same way, except that they occur in solids and travel at much higher velocities. These waves occur in thin structures and propagate throughout the volume of the material, not just at the surface.

A special element glued to the structure can excite a waves in a similar way to a stone falling into water. These waves propagate from the point of excitation in all directions, however their behavior (wavelength, velocity, etc.) is closely related to the properties of the material in which they propagate. Additionally, these waves are very sensitive to local changes in the material, and thus also to the damage in which they propagate.

Thanks to very precise measuring devices, such as scanning Doppler laser vibrometer, it is possible to measure this phenomenon in a non-contact manner, on the whole surface of the tested structure. The appearance of a defect in the path of a guided wave leads to its reflection, change of velocity, change of direction, etc. Thus, analyzing the behavior of the guided wave in composite materials can be used to detect, localize and evaluate defects in them. The advantage of this approach is its non-destructive character, the need of access to only one surface and the possibility of application on a working structure.

The result of the project will be the development of a set of diagnostic methods allowing non-destructive evaluation of the technical condition of composite materials with high accuracy, preparation of signal processing techniques allowing to increase the effectiveness of existing diagnostic procedures by using multipoint and broadband excitation of guided waves.

In addition, a repository of data from numerical simulations and experimental studies of the phenomenon under investigation in a variety of composite specimens with damage will be created. This will enable the creation of a reference point for other researchers in the industry and will provide starting points for further work. The project will implement the most important non-destructive techniques of damage localization, which work based on the analysis of propagating guided waves. This will allow direct comparison of the effectiveness of each of them in different damage configurations and materials.