Simulation of Ultrasonic Wave Propagation Phenomena for the Optimal Design of Multi-Sensoric Monitoring Systems

Maintenance costs have a big share of the total life cycle cost of a modern aircraft in addition to manufacturing and fuel cost. In this context, structure-health-monitoring systems (SHM-systems) have been integrated into aircrafts to detect early damage and to monitor efficiently the health of the structure.

These systems can reduce the maintenance time and costs by increasing the inspection intervals and can also contribute to an even higher safety level. Moreover, a carefully controlled structure can lead to an increased implementation of modern light weight concepts, making a lighter design of aircrafts possible. A reduction in weight of the aircraft is directly related to lower fuel consumption. Therefore, modern SHM-systems contribute to reduction of CO^2 emissions.

Within recent years, several approaches utilizing ultrasonic waves have been developed. In case of thin-walled structures, guided waves that are excited and sensed by surface-bonded or integrated piezoelectric elements (PZTs) have shown a high potential. Permanently installed PZTs enable a continuous monitoring. To setup an optimal SHM-system many parameters have to be selected. Especially, the position and shape of the actuators and sensors, excitation signals, the signal analysis method, the localization method and so on are one of the factors which have to be determined in many costs and time consuming experiments.

In cooperation with (EADS), an efficient numerical method for modeling of wave propagation processes in thin-walled shell structures based on so-called spectral element is developed. Here, the electro-mechanical coupling of piezoelectric sensors and actuators is taken into. On the one hand, the simulation tool helps to understand the complex wave propagation and scattering phenomena. On the other hand, the simulation tool supports the design process of SHM-systems according to the optimal sensor configuration and distribution, the excitation signals and the optimal signal analysis method to setup an optimal multi-sensoric monitoring system.

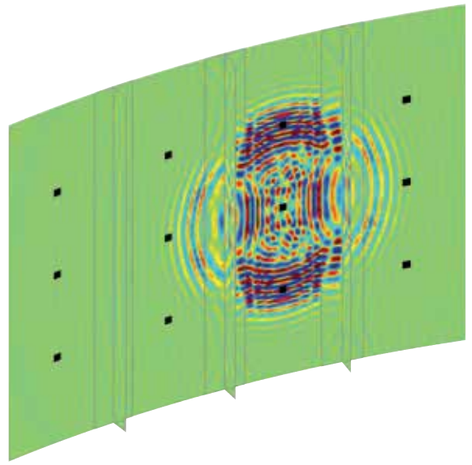

Illustration above
Wave propagation in a stiffened trunk shell, where especially the reflections by the stiffening ribs are visible.

Illustration below
Vision of an aircraft, similar to the human nervous system, completely equipped with sensors.
Source: EADS

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