Perspective of Structural Health Monitoring for military aviation in Poland.

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About 40 years have passed from introducing non-destructive testing inspections (NDI) as an inherent component of *damage tolerant* approach in order to ensure structural integrity of aircrafts. Over the years, non-destructive testing (NDT) methods became very accurate and reliable in damage detection and assessment, allowing to achieve very high level of safety in the aerospace. However, still there are some issues of this aircraft design paradigm which need to be addressed in the future. First, NDI are scheduled based on assumed or statistically represented loads spectrum, which doesn't necessarily fit to the way which a given aircraft is operated. This jeopardize the safety, but also is connected with not scheduled inspections, whose costs are much higher than regular ones. In fact, the fraction of unexpected NDI prevail over scheduled inspections. Furthermore, application of new lightweight materials, e.g. composites, introduces new damage evolution pathways, making it difficult to use low cost NDT techniques like visual testing, which account for about 60% of overall NDI. Therefore, there is a strong need from the industry sector to introduce Structural Health Monitoring (SHM) and Operational Load Monitoring (OLM) systems, based on sensors permanently integrated with the aircraft structure. Application of such systems would definitely increase safety, especially when considering hardly accessible 'hot-spots', but it could also save up to 50% of necessary inspections time depending on the aircraft type. Furthermore, possessing the knowledge about the current state of an aircraft as well as the way it is used, would allow to predict its further performance and determine the optimal time for its overhauls. Clearly, damage detection and damage assessment capabilities of SHM systems, e.g. expressed in terms of PoD curves, are the most important ones. However, from the cost analysis perspective, also a very important property of SHM systems is their false calls ratio. Damage indication by SHM system will be verified with classical NDT methods, at least at their early stage of development, which would increase the number of unplanned NDI and could rise aircraft maintenance costs, if there would be too much false positive findings. Both, the improvement of damage detection capabilities as well as the reduction of false calls ratio of SHM systems, are as much important for their applicability.

Providing reliable and universal Structural Health Monitoring (SHM) system allowing for direct aircraft inspections and maintenance costs reduction is one of the major issues in the aerospace industry. The installation of SHM sensors in composite structures for structural health monitoring requires care selection of a proper techniques to guarantee its reliability and lack of affecting structure durability. There are several SHM technologies which are exist based on the principles of the Non Destructive Evaluation Technology. Among them we may differentiate: techniques based on guided Lamb waves, acoustic emission, strain monitoring based on Fiber Optic Sensing.

In the paper an approach for the implementation to military aerospace structures damage growth monitoring and early damage detection of the structural elements is presented based on selected SHM techniques. Advantages and limitations of adressed technologies are presented. Experience of the authors with described technologies to composite structures are highlighted. In particular some issues concerning the mathematical algorithms inferring about damage from the impact damage presence and its growth are discussed. Further perspective of the SHM implementation on military aerial platforms based on lessons learned will be also delivered.

Keywords:
Structural Health Monitoring, Damage detection, Non Destructive Testing, Composites, Signal processing, Sensors.

LSP solution	Manufacturing technology	Costs of LSP	Effectiveness of LSP
Highly conductive metal coatings	Simple (metallized paints or sprays)	Low	Low
CFRP structure	Standard manufacturing process	Low	Very low
CNT-reinforced composite	Simple (possible difficulties with dispersion of CNTs)	Very high	Excellent
Composite with metallized fibre or immersed metallic meshes/foils	Complicated (fibre metallization, metal-polymer adhesion)	High	Fine
ICP-based composite	Simple (possible difficulties with dispersion of CNTs)	Medium	Fine

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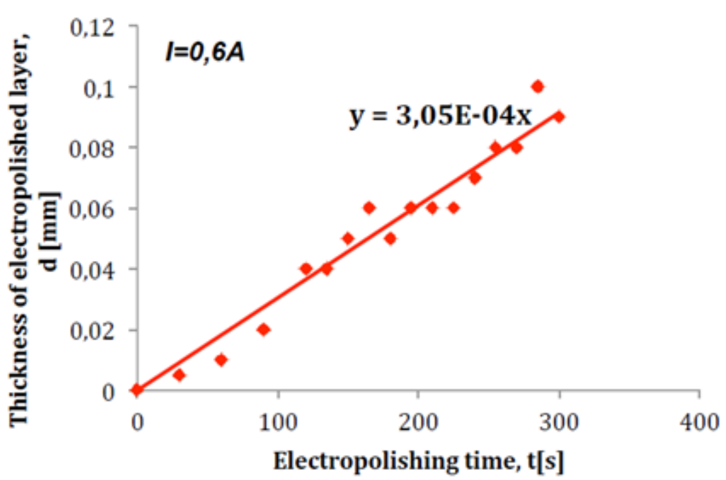

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Figure 1. Figure captions should be placed under the figures. <Times 10, italics>

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