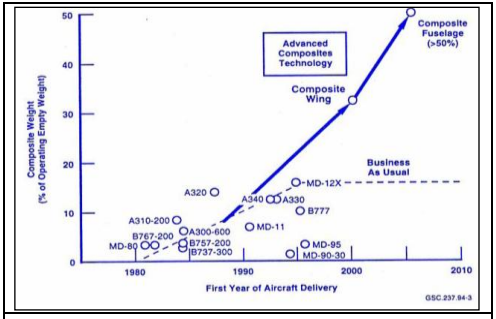
Ultrasonic Guided Waves Based Diagnostic and Finite Element Based Prognostic Structural Health Monitoring

Challenge

In recent years, the use of advance composites has increased significantly in state-of-the-art aircraft and aerospace structures. Despite the advantages, composite structures are highly susceptible to hidden defects and remaining undetected may cause sudden and catastrophic failure of an entire structure. A number of techniques are available for detecting and characterizing damages due to impact event and weak bond lines in aircraft and aerospace structures. These include visual inspection; tap testing, electromagnetics, radiography, thermography, and ultrasonics. However, the systems currently available for detecting such types of anomalies in structural components are cumbersome, time consuming, and costly. Squirter, the off-line ultrasonic (US) scanning system that uses water-jets (e.g., Scanmaster-IRT Model DS-2005, and other systems from Mortec, Olympus NDT, and others) are expensive instruments that require the test structure to be un-mounted and transferred to a defined location where the sample can be scanned. This increases the opportunity for further damage to the component needing additional evaluation. In this case study two key components of the defects are being studied namely damage due to impact and weak bond-lines between the skin and the stiffener.



Composites in Commercial Aircrafts

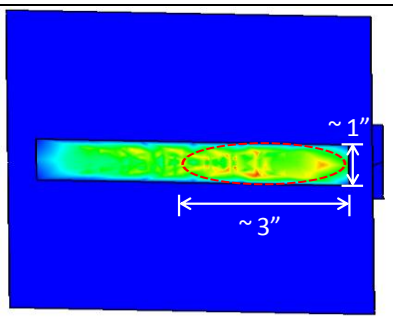
Solution

An ultrasonic based real-time, real time health monitoring of composite stiffened panel is proposed. The waves are launched into the specimen using a PZT patches and are detected by a distributed array of identical sensors located on the surface of the specimen. The guided wave components of the ultrasonic waves are shown to be strongly influenced by the presence of a defect in the composite structure. The experimentally observed results are used to develop an autonomous scheme to locate the defects due to impact and weak bond-line. Multi-Scale progressive failure analysis (MS-PFA) based finite element (FE) approach is also performed to simulate impact test. MS-PFA provides detail break down of when, where and what type of damage is present along with percent contribution of different damage types.

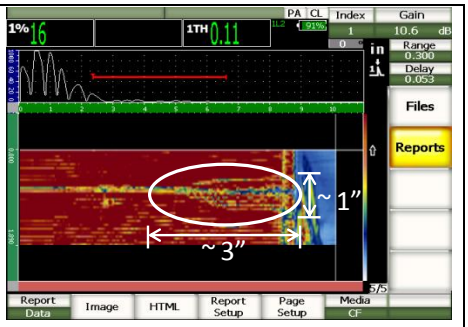
Results & Conclusion

- The overall damage footprint measured using PZT sensor network (diagnostic) shows good comparison to the FE based approach (prognostic).
- The damage foot print predicted from guided wave based approach showed good comparison with commercially used C-Scan techniques.
- The results should be very useful in model-based understanding of ultrasonic data collected during nondestructive inspection and evaluation (NDI/NDE) of advanced aircraft and aerospace structure and in the development of reliable health monitoring systems in the structures.

Key Highlights and Benefits
Product: GENOA SHM, GENOA PFA
Industry: Aerospace
Application: Structural Health Monitoring (SHM)
Benefits: Real Time SHM, Diagnostic Evaluation, Prognostic Assessment of Damage

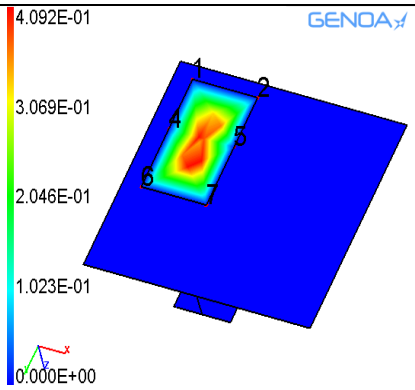


(a)

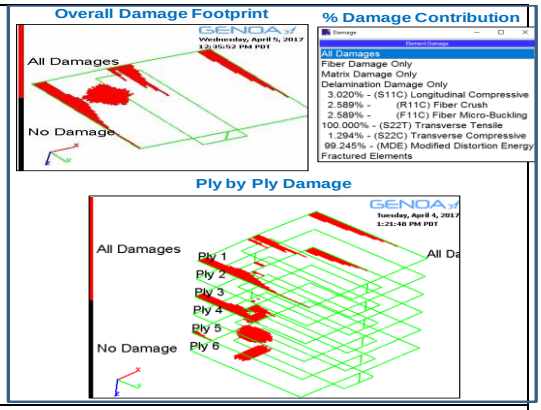


(b)

Weak Bond Line detection (a) PZT Sensor Data Based Diagnostic SHM and (b) C-Scan



Diagnostic: Damage Footprint post impact using PZT Sensor Data



Prognostic: Impact Damage Footprint using Progressive Failure Analysis

Related Publications

1. An Ultrasonic Guided Wave Based Impact and Bond Line SHM of Stiffened Composite Structures. CAMX 2017, Orlando, Florida.
2. Hybrid Fiber Optic/Piezoelectric Based Diagnostic and Finite Element Based Prognostic Structural Health Monitoring. CAMX 2017, Orlando, Florida.