Title: Nondestructive evaluation and health monitoring of adhesively bonded composite structures

Time: Friday July 14, 2017 at 10:00 AM

Place: Mechanical Engineering Conference Room

Student: William Roth

Advisor: Dr. Victor Giurgiutiu

Committee: Dr. Lingyu Yu
Dr. Michel van Tooren
Dr. Bin Lin
Dr. Paul Ziehl – Civil & Environmental Engineering

Abstract:

As the growth of fiber reinforced composite materials continues in many industries, structural designers will have to look to new methods of joining components. In order to take full advantage of composite materials, such as increased stiffness, decreased weight, tailored material properties and increased fatigue life, mechanical fasteners will need to be replaced by adhesive bonding or welding, when possible. Mechanical fasteners require the drilling of holes, which damages the laminate and becomes the source of further fatigue damage. Also, an increase in laminate thickness or inclusion of other features is required for the material to withstand the bearing stress needed to preload fasteners. Adhesives transfer the load over a large area, do not require additional machining operations, provide increased stiffness through the joint, provide corrosion protection when joining dissimilar materials, and provide vibrational damping. Additionally, the repair of composite structures, which will become a major concern in the near future, will require the use of adhesive bonding for thermoset composites.

In order for adhesives to be used to join primary aerospace structures they must meet certification requirements, which includes proof that the joint can withstand the required ultimate load without structural failure. For most components, nondestructive inspection is used to find critical flaws, which is combined with fracture mechanics to ensure that the structure can meet the requirements. This process works for some of the adhesive flaws, but other critical defects are not easily detected. Weak interface bonding is particularly challenging. This type of defect results in an interphase zone that may be only a dozen microns in thickness. Traditional bulk wave ultrasonic techniques cannot easily distinguish this zone from the interface between adherend and adhesive. This work considers two approaches to help solve this problem.

Guided elastic wave propagation along laminate structures is highly dependent on the boundary conditions at the surface and between plies, especially at high frequencies. This work investigates how interfacial defects can alter the propagation of guided waves through bonded fiber reinforced composite materials. As well as how this information can be used to determine the interface properties and correlate the results with fracture parameters.

The second approach investigates how structural health monitoring can be used to detect the growth of disbonds from service loads. A mode selection technique is proposed for selecting frequency ranges for electromechanical impedance spectroscopy, and a technique for correlating frequency spectrum data to disbond length for guided wave propagation.