abstract
Structural health management (SHM) is emerging as a vital methodology to help engineers improve the safety and maintainability of critical structures. SHM systems are designed to reliably monitor and test the health and performance of structures in aerospace, civil, and mechanical engineering applications. SHM combines multidisciplinary technologies including sensing, signal processing, pattern recognition, data mining, high fidelity probabilistic progressive damage models, physics based damage models, and regression analysis. Due to the wide application of carbon fiber reinforced composites and their multiscale failure mechanisms, it is necessary to emphasize the research of SHM on composite structures.

This research develops a comprehensive framework for the damage detection, localization, quantification, and prediction of the remaining useful life of complex composite structures. To interrogate a composite structure, guided wave propagation is applied to thin structures such as beams and plates. Piezoelectric transducers are selected because of their versatility, which allows them to be used as sensors and actuators. Feature extraction from guided wave signals is critical to demonstrate the presence of damage and estimate the damage locations. Advanced signal processing techniques are employed to extract robust features and information. To provide a better estimate of the damage for accurate life estimation, probabilistic regression analysis is used to obtain a prediction model for the prognosis of complex structures subject to fatigue loading. Special efforts have been applied to the extension of SHM techniques on aerospace and spacecraft structures, such as UAV composite wings and deployable composite boom structures. Necessary modifications of the developed SHM techniques were conducted to meet the unique requirements of the aerospace structures. The developed SHM algorithms are able to accurately detect and quantify impact damages as well as matrix cracking introduced.