Sensor-to-Sensor System Identification for Health Monitoring of Advanced Aircraft

Dr. Sunil L. Kukreja, PI; Prof. Dennis S. Bernstein, Co-PI

Environmental conditions, cyclic loading, and aging contribute to structural wear and degradation, and thus potentially catastrophic events. The challenge of health monitoring technology is to determine incipient changes accurately and efficiently. This project addresses this challenge by developing health monitoring techniques that depend only on sensor measurements. Since actively controlled excitation is not needed, sensor-to-sensor identification (S2SID) provides an in-flight diagnostic tool that exploits ambient excitation to provide advance warning of significant changes. S2SID can subsequently be followed up by ground testing to localize and quantify structural changes.

The conceptual foundation of S2SID is the notion of a pseudo-transfer function, where one sensor is viewed as the pseudo-input and another is viewed as the pseudo-output. This approach is less restrictive than transmissibility identification and operational modal analysis since no assumption is made about the locations of the sensors relative to the excitation.

Since the basic conceptual framework for S2SID was established prior to the start of this project, effort has focused on the analysis of data obtained from the SOFIA aircraft. Significant findings are as follows. First, no appreciable nonlinearity was detected in the pseudo-transfer functions. Second, the pseudo-transfer functions between correlated sensors were most reliably estimated by high-order finite-impulse-response models. Third, the identified models indicate the presence of a significant "noncausal" component of the impulse response. We hypothesize that this noncausal portion is due to either multiple transmission paths or multiple independent excitations. These findings suggest the benefit of employing three or more sensors in close proximity in order to maximize the accuracy of the identified models.