Identification and Significance of Innovation

ZONA Technology, Inc (ZONA) and Arizona State University (ASU) developed the ground flutter testing system in place of a wind tunnel (WT), called the Dry Wind Tunnel (DWT) system. The DWT system consists of a ground vibration test (GVT) hardware system and a real-time unsteady aerodynamic force generation software system developed from an aerodynamic reduced order model (ROM). The DWT system can serve as a replacement or complimentary means for flutter/ASE instability testing to a WT. Our Phase II effort has successfully demonstrated the validity of the DWT concept. That is, DWT testing can truly simulate in real time the unsteady aerodynamics through a GVT hardware system, namely the shakers and sensors. Merits of a DWT are many: It can use real full-size aircraft/wing structure including inherent structural nonlinearity and flight controller in-the-loop, instead of a flutter model for WT, hence a cost/time effective test system. It can be carried out with a GVT setup, and because of the simulated aerodynamics the DWT measured data is wall-interference free. The DWT system can be applicable to flutter envelope expansion and flying quality programs of military and civil transport as well as general aviation aircraft.

Expected TRL Range at the end of Contract (1-9):6

Technical Objectives and Work Plan

The technical objective of the Phase II effort was to show the flutter predictive capability of the DWT system on a whole aircraft structure. The merits of the DWT system over the conventional wind tunnel flutter test will be demonstrated to pave the way for a Phase III commercialization. The DWT system has been applied sequentially to a series of structures of increasing complexity:

- the aluminum plate considered in Phase I, for further refinement of the DWT methodology
- a NASA Langley wind-tunnel wing model, for validation of the DWT methodology with wind-tunnel test results
- the ATA Engineering Ironbird, representing a simple full span structure
- Pre-test evaluation for the F-15 horizontal tail flutter was completed. 4 shaker locations and 6 sets of sensor locations on the F-15 horizontal tails were identified and the DWT system was ready for testing.

The outcome of the Phase II effort is guidelines of design, implementation, and execution of the DWT system for complex structures.

NASA and Non-NASA Applications

The DWT system can serve as a time/cost effective replacement or complimentary means for flutter/ASE instability measurement to a wind tunnel system such as TDT. The DWT system can be applicable to flutter envelope expansion and flying quality programs of military and civil transport as well as general aviation aircraft. The potential customers for the DWT system include Air Force, Navy, DARPA, and the aerospace industry. It can be readily adapted to the following programs:

(a) Flying quality and store clearance for the F-22 and F-35 aircraft,
(b) flutter envelope expansion for USAF’s UVA/UCAV, Hilda and joined-wing sensorcraft,
(c) flutter envelope expansion for USAF’s next generation stealth and morphing UAVs designed to deliver directed-energy weapons, and
(d) flutter envelope expansion for DARPA’s new innovative design concepts.
(e) control surface free-play induced limit cycle oscillation,
(f) aeroservoelastic instability measurement.

Firm Contacts

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NON-PROPRIETARY DATA