STRUCTURES, DESIGN AND TEST

Structural dynamics

Structural dynamics saw a great deal of activity this year, particularly in the areas of materials, aeroelastic analyses, and testing of aircraft, rotorcraft, rotating machinery, and spacecraft.

Multifunctional materials are being developed for DARPA at the University of California, San Diego (UCSD). Titanium-titanium trialuminide laminate composites offer outstanding stiffness and strength, and embedded cavities allow the tailoring of properties for damping, smart actuation, heat exchanging, and fiber-optic sensing. Experiments showed that laminates with embedded impact particle dampers produced damping levels 2-10 times greater than solid laminates.

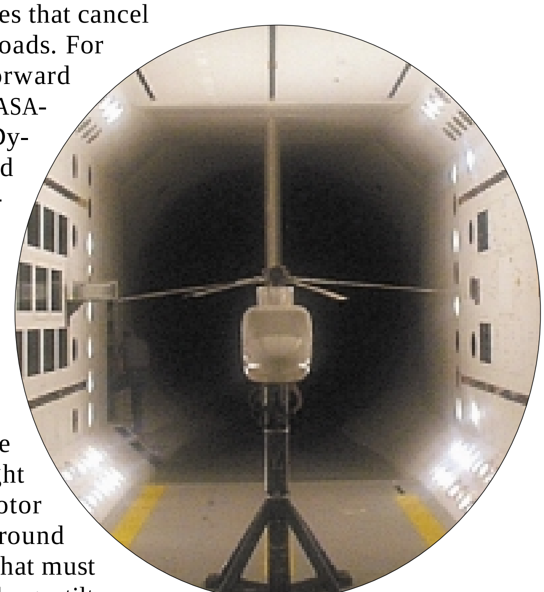
The Air Force Research Laboratory's Computational Sciences Center demonstrated advancements in nonlinear high-fidelity computation of fluid-structure interactions. An Euler flow solver coupled with a linear modal model successfully simulated the F-16 flight-test flutter boundary over multiple flight conditions. Also simulated was a traveling-wave flutter originating from the coupling of transitional boundary layer Tollmein-Schlichting waves with transverse flexible panel motion. Both simulations demonstrate the continuing maturation of computational methodologies for characterizing nonlinear fluid-structure interactions.

UCSD performed an aeroelastic stability investigation on the General Atomics Aeronautical Systems Predator UAV wing. GA engineers developed detailed finite-element models of the graphite/epoxy composite wings, and the models were correlated to experimental ground vibration test results. Results revealed no flutter instabilities below the FAA Federal Aviation Regulation 23 minimum stability speed of 180 kt. Installation of a deice system to the leading edge further improves the mass distribution and removes all potential flutter concerns.

NASA-Dryden has studied flutter instabilities using a test structure mounted on an F-15. Testing during five flights validated the "flutterometer," an online software tool that helps to safely indicate the flutter margin during a flutter clearance flight.

In the area of jet engine blades, UCSD performed a design study to develop an integral passive damping solution for NASA-Glenn's next-generation composite reduced-weight fan blades. The graphite/epoxy blades are designed to have reduced weight and noise, better efficiency, and improved structural dynamics. Damping materials were sized, located, and embedded within the composite to damp primary bending and torsion modes. Specimens will be fabricated and tested next year.

NASA, the Army, and MIT are using active fiber composite actuators to dynamically twist helicopter rotor blades and produce aerodynamic forces that cancel undesirable vibratory loads. For the first time in forward flight, tests in the NASA-Langley Transonic Dynamics Tunnel showed that active twist can reduce vibratory loads between 60% and 100% depending on flight condition.



Using the NASA / ARMY / MIT ATR system in the NASA-Langley Transonic Dynamics Tunnel, the twist of each of the four blades is controlled independently by active fiber composites.

The Army Research Lab, NASA, and Bell Helicopter completed a cooperative test of a reduced-weight soft-inplane hub tilt-rotor model to study hover ground resonance instabilities that must be addressed before large tilt-rotors can take advantage of this innovation. An active swashplate control system using a generalized predictive control algorithm increased the damping in the critical modes of the instability, avoiding ground resonance conditions completely. A modified version of the soft-inplane hub (based on a full-scale design application) will be tested this month.

In the space area, the vibration isolation, steering, and suppression (VISS) system has shown unsurpassed levels of passive vibration isolation performance on orbit. In January, the VISS was successfully commanded to release from its launch locks on the Space Technology Research Vehicle II, a cooperative effort between BMDO and the U.K. Ministry of Defense. Developed by an Air Force Research Laboratory/Honeywell/Trisys/JPL team, the VISS provides unequaled vibration isolation performance, actively suppresses on-board cryocooler disturbances, and steers its optical payload. During on-orbit payload operations, accelerations measured before and after launch lock release show a factor of 80 reduction at 50 Hz.

by **Donald L. Edberg**