Seminar Series of the

AFRL/VA and AFOSR

Collaborative Center of Control Science (CCCS)

Closed-Loop Control of Aircraft Cavity Tones

Professor David R. Williams
Illinois Institute of Technology

2:00 PM – 3:00 PM, Friday, November 1, 2002
2027 Robinson Laboratory

A Joint Mechanical Engineering and Collaborative Center of Control Science Seminar

An experimental investigation of acoustic mode noise suppression was conducted with a cavity model at the U.S. Air Force Academy Subsonic Wind Tunnel facility. Flow Mach numbers ranging from 0.25 to 0.55 were studied. The experiments identified two types of resonances, namely single mode and multimode types. In addition to experiments investigating flow physics, closed-loop feedback control experiments were done using analog and digital control systems. The effectiveness of control algorithms ranging from the simple PI-type to adaptive and flow-physics based algorithms were examined. The adaptive controller was comparable to a simpler analog controller in the degree of noise suppression achieved with single modes. Typical noise suppression levels varied from 15 dB to 18 dB. To explore the limitations in controller performance, a new empirical model representing cavity flow physics was developed in collaboration with Professors Tim Colonius (Caltech) and Clancy Rowley (Princeton). The physics based model was successful in suppressing specific modes, and provided a logical framework to improve control models. The experiments showed single-mode resonance at M=0.34 to be self-excited and in a nonlinearly saturated limit-cycle state. In contrast, nonlinear effects do not saturate the multimode resonance states occurring at other Mach numbers. Input disturbance levels from external sources determine the amplitudes of the multimode resonances