N95- 23314

Inner Loop Flight Control For The High-Speed Civil Transport

Brett Newman
NASA-ASEE Summer Faculty Fellow
Assistant Professor
Department of Aerospace Engineering
Old Dominion University

High-speed aerospace vehicles which employ high strength, light weight, yet deformable materials may exhibit significant interaction between the rigid-body and vibrational dynamics. Preliminary High-Speed Civil Transport (HSCT) configurations are a prime example. Traditionally, separate control systems have been used to augment the rigid-body and vibrational dynamics. In the HSCT arena, the highly coupled motions may not allow this design freedom. The research activity addresses two specific issues associated with the design and development of an integrated flight control system (FCS) for HSCT configurations, which are discussed next.

The HSCT is expected to have a short period instability at subsonic speeds. Flight vehicles with this characteristic (i.e., F-16, F-22, X-29, Space Shuttle) are stabilized with what is called a superaugmented pitch rate loop. One concern is "Will this stability augmentation logic work for a HSCT?" Studies show that an idealized pitch rate design would be acceptable, but is not realistic. Investigations using a contaminated pitch rate design reveal serious hurdles to overcome in the FCS design. Mounting location for the pitch rate sensor is critical. Results indicate a forward location leads to destabilizing pick-up of aeroelastic modes, while aft locations lead to undesirable coupling of the dominate pitch mode with the 1st aeroelastic mode. Intermediate locations for the sensor may not be acceptable. The source of the problem is the presence of low frequency aeroelastic modes in HSCT configurations, which are not present in vehicles currently using the superaugmented logic. To say the least, a conventional superaugmented pitch rate loop strategy may have undesirable characteristics. An unconventional strategy, which attempts to eliminate the above deficiencies by blending several pitch rate signals, indicates an improvement in the FCS architecture feasibility, but still lacking in some respects.

The HSCT configuration does not have aerodynamic surfaces in the vicinity of the nose (i.e., no canard or vane). A second concern is "Can the fuselage bending/torsion aeroelastic modes be effectively augmented without sufficient control input near the vehicle nose?" The superaugmented FCS results above may be suggesting the necessity of a secondary feedback loop to achieve an acceptable integrated FCS. Preliminary analysis of HSCT aeroelastic mode shapes indicate the use of existing wing leading edge devices as a second control input may be lacking in control authority for the rigid-body attitude and aeroelastic modes. An effort is underway to incorporate generic wing leading edge devices and canards into a generic HSCT model for the purpose of assessing additional control authority and it's use in candidate FCS designs.

A generic HSCT mathematical model was necessary for the studies above. A HSCT category model is available in NASA-CR-172201. This model describes the linear, longitudinal dynamics about the following flight condition: ascent, W = 730,000 lbs, h = 6,500 ft, M = 0.6. The model incorporates the full rigid-body variable set, as well as eighteen aeroelastic modes. Elevator deflection serves as the control input. Modifications to the model include the incorporation of relaxed static stability (i.e., static margin from -7.3% to +10%) and additional control inputs.