Abstract: Nonlinear Aerodynamics Modeling Using Fuzzy Logic

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The objective is to develop nonlinear mathematical model identification techniques for airplane aerodynamics with no prior or otherwise specified model structure using real-world flight data over a large flight envelope.

Advanced modeling techniques using fuzzy logic, and new flight test maneuver approaches have been developed to advance the state-of-the-art in nonlinear aerodynamic modeling in a way that does not require specification of candidate modeling terms. This is a key component in the "Learn-to-Fly" concept, where the intent is to autonomously develop vehicle characterization up through the ability to fly a vehicle with minimum human interaction and time. The ability to rapidly update simulation tools (either aerodynamic models, or flight response models) based on flight test will be improved with successful outcome of the program applicable to both piloted and autonomous vehicles.

To date, we have completed the planned flight testing which consisted of 10 data gathering flights over a large flight envelope – including stall and post-stall flight conditions using an instrumented airplane. Data analysis is being conducted to develop and test fuzzy logic algorithms. Early results show very good model fits to the flight test data – even through post stall gyrations, and these results will be shown in the presentation.

Future work will include further advances in the algorithms to improve execution speed, model development, and error estimation. A goal for eventual self-learning aerospace systems is to be able to accomplish all of these tasks near real-time for vehicles that can "learn to fly".