Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

Time Delay in the Lift Response to Actuation and Its Effect on Controller Bandwidth[1] DAVID WILLIAMS, Illinois Institute of Technology, TIM COLONIUS, California Institute of Technology, WESLEY KERSTENS, VIEN QUACH, Illinois Institute of Technology — The transient lift responses of two- and three-dimensional wings subjected to pulse-like disturbances are used to obtain a measure of the separated flow system time delay. Data from different investigators (Amitay&Glezer, 2002, Darabi&Wygnanski, 2004, Williams, et al. 2009) using different wing geometries and different actuators are compared, which show that the transient lift measurements share certain common features. All the data scale with the convective time scale, t+=tU/c. An initial reversal in lift occurs immediately after actuation, which is followed by a rapid growth in lift to reach maximum lift at t+=3. A slow relaxation from maximum lift back to the undisturbed separated flow state occurs by t+=15. The initial lift reversal is associated with a time delay in the plant (separated flow system.) The time delay is related to the formation of a leading edge vortex and its convection time. The transient lift time delay limits the bandwidth for a given control architecture, which results in two important implications. First there is a practical upper limit for actuator bandwidth, and second, a different control architecture will be necessary to achieve closed-loop control on the shorter fluid-dynamic time scales.

[1]The support of AFOSR through Grants FA9550-05-1-0369 monitored by Dr. Fariba Fahroo and FA9550-09-1-0189 managed by Dr. Douglas Smith is gratefully acknowledged.

David Williams
Illinois Institute of Technology

Date submitted: 05 Aug 2010 Electronic form version 1.4