Mission Specification for
A&AE 451 Aircraft Design, Fall 2001

Design of a Small Remotely-Piloted Aircraft with Pitch Rate Feedback

Background: Feedback control is often employed to improve the dynamic response of aircraft and guide the trajectory of autonomous aircraft. An aircraft that uses feedback control and has easy-to-modify feedback gains is called a variable stability aircraft. The stability of the aircraft motion depends on the easy-to-modify feedback gains.

A variable stability small aircraft would be a useful tool for teaching students about dynamic stability and feedback control. Courses at Purdue University that would benefit from such an airplane include AAE 364 Control Systems Analysis, AAE 421 Flight Dynamics and Control, and AAE 490A Flight Testing.

The Design Challenge: The remotely piloted aircraft to be designed must use feedback to modify the dynamic response of the aircraft. The vehicle must use a pitch rate gyro to measure pitch angular rate and generate a feedback signal to the elevator. The system must have two feedback gains (off and nominal) that are selectable from the remote pilot. In addition the feedback system must be stable when the normally stabilizing feedback gain has its sign reversed. The sign of the feedback gain can be determined from the ground only.

Students must analytically predict the dynamic motion of the aircraft with and without pitch rate feedback with both stabilizing sign and de-stabilizing sign. The short period approximation may be used.

The variable stability aircraft is intended to be marketed to existing companies who sell and manufacture model aircraft and to be used in other coursework at Purdue and other universities.

Design Constraints: Flight of the variable stability aircraft must be safely demonstrated within the Mollenkopf Athletic Center. The vehicle should be stable under all flight conditions and nominal feedback gains. It must be robust to crashes, easy to fly (i.e., have exceptional flying qualities), and easily transportable in a compact automobile. In all aspects of design and construction, cost must be minimized. The cost to build the fixed-wing aircraft must not exceed $200 (excluding radio-control gear, electric motor, speed controller, and rate gyro). Because the aircraft will be flown in an enclosed space, the powerplant must be electric (battery powered). Following a conventional rolling take-off, the aircraft must have an endurance of 6 minutes. Take-off rate-of-climb must be sufficient for satisfactory flight in the Mollenkopf Athletic Center. The aircraft should be as small and light as practical.

Rate gyroscopes are compatible with our radio control electronics are available from Futaba (see http://www.futaba-rc.com/radioaccys/futm0501.html).

Any deviation from the design constraints must be formally requested in writing to Professor Andrisani and justified using sound engineering and business logic.