Introduction to Aerospace Engineering
A Freshman-level Course in Aircraft Performance and Design
AE 100: Introduction to Aerospace Engineering

• Objective: Introduce incoming freshman students to aspects of aerospace engineering giving them hands-on problem solving design and data collection experience

• Currently: two sections
  – Spacecraft and rocket design
  – Aircraft design
AE 100: Intro to Aerospace Engineering

- History of Aircraft Design
- Case Study of Vehicle Development
- Aircraft/Flight Theory and Design
- Engineering Ethics
- Hands-on Experiences (2 of 3)
  - Discovery Flights
    - Students fly in an aircraft
  - Radio Control Flying and Aircraft Performance
    - Students learn to fly R/C planes and take data from instrumented aircraft
  - R/C Aircraft Design Project
    - Students design a R/C hand launched glider or flying wing
• **Student R/C Flying Experience (CCRCC-AMA)**
  Description: Students have the opportunity to pilot a 4-channel R/C trainer with hobbyists from the local R/C flying club. Students learn about basic flight maneuvers and aircraft control.

• **Instrumented R/C Aircraft Performance**
  Description: Students collected data from instrumented R/C aircraft with on-board imaging data recording and telemetry for class examples and homework problems.
Instrumented R/C Aircraft Flight Testing

Eagle Tree Systems

- GPS
- Altimeter
- Pitot/Static Pressure
- x / y Accelerometer
- Optical RPM
- Engine Temperature
- Current / Voltage
- Telemetry
- Servo Positions
- Angle of Attack

Data Recorder

GPS

Telemetry

Angle of Attack

Pitot/Static Probe
Instrumented R/C Aircraft Flight Testing

Flaps and lift

Airspeed, altitude, and acceleration

- Flaps and lift
- Coefficient of Lift vs. Angle of Attack
- Flaps: Extended, Linear (No Flaps)

- Airspeed, altitude, and acceleration
- GPS
- X/Y Accelerometer
- Pitot/Static Probe
Instrumented R/C Aircraft Flight Testing

Stall and Flow Separation

Tufts

Video Camera

Graphs showing data over time:
- Air Speed (ft/min)
- Engine Speed
- Attitude

University of Illinois at Urbana-Champaign
Department of Aerospace Engineering
Instrumented R/C Aircraft Flight Testing

Flow Separation and Effectiveness of Wingtip Side-Force Generators (SFGs) During Knife-Edge Maneuvers
Instrumented R/C Aircraft Flight Testing

Flow Separation and Effectiveness of Wingtip Side-Force Generators (SFGs) During Knife-Edge Maneuvers

Ground and in-flight video of R/C aircraft with SFG
First with tufts on low-pressure side and then with tufts on high-pressure side of SFGs
Instrumented R/C Aircraft Flight Testing

Flow Separation and Effectiveness of Wingtip Side-Force Generators (SFGs) During Knife-Edge Maneuvers

Viewing low pressure side of SFG
• Tufts on wing indicate no separation
• Tufts indicate flow separation on SFG

Viewing high pressure side of SFG
• Tufts on wing indicate no separation
• Tufts indicate no separation on SFG

Flight Data of Aircraft in Knife-Edge with and without SFGs

<table>
<thead>
<tr>
<th></th>
<th>Airspeed [mph]</th>
<th>Rudder Deflection [Degrees]</th>
<th>Motor Speed [RPM]</th>
</tr>
</thead>
<tbody>
<tr>
<td>No SFGs</td>
<td>59.8</td>
<td>25.7</td>
<td>8841</td>
</tr>
<tr>
<td>With SFGs</td>
<td>59.6</td>
<td>12.6</td>
<td>8789</td>
</tr>
</tbody>
</table>

* For approximately the same aircraft speed the rudder deflection angle (indicating to a first order the yaw angle) is less when using SFGs
R/C Design Project

Description: Students are given a foam wing, battery pack, and flexible servo package which they utilize to design and evaluate the performance of a hand-launched glider or powered flying wing.
R/C Flying Wing Design Project

Initial Measurements and Calculations (weight)

– Wing, Battery, and Servo Package

Flat swept wing
Relatively Low AR
Carbon fiber leading edge

E-flite 300 motor, Propeller, and mount:

Spectrum AR6110e Receiver (Rx)
Servos Spectrum S75 (2)
E-flite 10amp Electronic Speed Controller
R/C Flying Wing Design Project

Conceptual Designs and Evaluation

Motor/Propeller Configuration
- Front Prop
- Pusher Prop

Vertical Stabilizer Configuration and Location
- Rectangle
- Arc /ellipse
- Trapezoid
- Other

Elevon Shape
Design Calculations

- Tail length
- Tail and control surface sizing (TVR)
- Moment, force, and stability calculations
- Component dimensions and lay-out

Aerodynamic Center of the Wing
R/C Flying Wing Design Project
Thank you