NASA Dryden Status

Aerospace Control & Guidance Sub-committee
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Flight Programs with GNC involvement
X-43A

- Ship 2 (Mach 7) April 2004
- Ship 3 (Mach 10) Nov 2004

Active Aeroelastic Wing

- **Objective:**
  - Demonstrate roll capability of
    the AAW at high dynamic
    pressure using only wing
    control surfaces
- **Method:**
  - Modify an F-18 wing to “pre-
    production” stiffness
  - Modify the leading edge flap
    control system
  - Instrument & calibrate the
    wing for loads measurement
  - Utilizing an On-Board
    Excitation System (OBES)
    develop models to be used
    for control system design
  - Design and fly control laws to
    meet the stated objective
AAW Phase II Flight Results

Autonomous Soaring for Improved Endurance of a Small UAV

Michael J Allen, NASA DFRC
AIAA AFM Conference
Reno NV January 13, 2005
Purpose

- Determine the year-round expected benefit of soaring for a small, electric-powered UAV.
- UAV parameters:
  - Aircraft velocity = 12m/s
  - Sink speed = 0.53m/s
  - Nominal endurance = 2hr
- Loiter-only mission was used in this study.
  - Travel to and from target area was not simulated.
- UAV must remain line-of-sight to the target area.
- Upper altitude restrictions are discussed later in this presentation.

Flight Path Visualization

- Day 220 = August 8
- Chosen because it shows all flight modes well.
- Strong lift conditions.
- Peak ground temperature = 97deg
Typical Height Time-Histories

- Winter altitude gain is reduced. Winter days are shorter.
- Summer altitude gain can exceed 2500m.
- Maximum endurance was found to be greater than 14 hours.

Sensitivity Study

- Simulation results remain insensitive to many key parameters.
- Highest sensitivity is with sink velocity. 30% variation causes 8% change in endurance.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Perturbation</th>
<th>Yearly Average endurance</th>
<th>Change in endurance</th>
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</thead>
<tbody>
<tr>
<td>L/D</td>
<td>15.8</td>
<td>-30%</td>
<td>8.63hr</td>
<td>+0.17%</td>
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<tr>
<td>L/D</td>
<td>29.4</td>
<td>+30%</td>
<td>8.54hr</td>
<td>-0.83%</td>
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<tr>
<td>Sink velocity</td>
<td>0.37m/s</td>
<td>-30%</td>
<td>9.27hr</td>
<td>+7.55%</td>
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<tr>
<td>Sink velocity</td>
<td>0.69m/s</td>
<td>+30%</td>
<td>7.91hr</td>
<td>-8.10%</td>
</tr>
<tr>
<td>N</td>
<td>calculated</td>
<td>-30%</td>
<td>8.47hr</td>
<td>-1.69%</td>
</tr>
<tr>
<td>N</td>
<td>calculated</td>
<td>+30%</td>
<td>8.67hr</td>
<td>+0.67%</td>
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<tr>
<td>Updraft lifespan</td>
<td>14min</td>
<td>-30%</td>
<td>8.56hr</td>
<td>-0.61%</td>
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<tr>
<td>Updraft lifespan</td>
<td>26min</td>
<td>+30%</td>
<td>8.63hr</td>
<td>+0.17%</td>
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<tr>
<td>$w_T$</td>
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<td>-30%</td>
<td>7.96hr</td>
<td>-7.62%</td>
</tr>
<tr>
<td>$w_T$</td>
<td>calculated</td>
<td>+30%</td>
<td>8.92hr</td>
<td>+3.60%</td>
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<tr>
<td>$z_l$</td>
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<td>-30%</td>
<td>8.20hr</td>
<td>-4.75%</td>
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<td>+30%</td>
<td>8.92hr</td>
<td>+3.53%</td>
</tr>
</tbody>
</table>
Conclusions

- The use of convective lift in the atmosphere can give a 12hr increase in endurance of a small electric-powered UAV with a nominal endurance of 2hr.

- Performance increases can be obtained during any season of the year and during the majority of daylight hours.

- The overall performance increase has a low sensitivity to many key parameters including: aircraft glide slope, number of updrafts, updraft lifespan, updraft velocity, and altitude upper limit.

Networked UAV Teams

- RSCA-funded Partnership between ARC and DFRC
  - Cooperative Control Flight Demonstration only one part

  - Points of Contact:
    - John Melton, (650) 604-1461, John.E.Melton@nasa.gov (ARC)
    - Curtis Hanson, (661) 276-3866, curtis.hanson@dfrc.nasa.gov (DFRC)

Ground station software was written to allow automated mission plan updates
Waypoint upload / aircraft state download (ARC)
Path planning / 4D navigation (ARC)
Cooperative search / boid waypoint transit (DFRC)
“Boid Path Planning”

Clockwise from left: Flocking behavior, collision avoidance behavior, and heading matching behavior.

Dynamic Search Re-planning – flight data

Clockwise from left: 1. Two aircraft search an area; 2. One aircraft detects a fire; 3. The second aircraft searches the remaining grid points while the first investigates the fire.