NASA Dryden Status

Aerospace Control & Guidance Sub-committee
Salt Lake City, Utah
March 2-4, 2005

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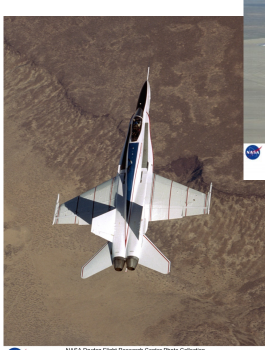
March, 2005

Flight Programs with GNC involvement

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC02-0281-4 Date: December 6, 2002 Photo by: Carla Thomas
This view from a NASA Dryden F-18 chase aircraft shows Dryden's highly modified F-15B, tail number 837, which resumed Intelligent Flight Control System (IFCS) project flights on Dec. 6, 2002.



NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC02-0264-3 Date: November 15, 2002 Photo by: Carla Thomas
The modified F/A-18 being flown in the joint NASA/Air Force Active Aeroelastic Wing research program shows off its colors during its first checkout flight from NASA's Dryden Flight Research Center.

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/Gallery/Photo/index.html
NASA Photo: EC03−0100−2 Date: April 8, 2003 Photo By: Jim Ross

C−20A (Gulfstream III) in flight over the NASA Dryden Flight Research Center.

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X-43A

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

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC01-0182-20 Date: June 2, 2001 Photo by: Jim Ross
Moments after release from NASA's B-52 carrier aircraft, the X-43A/Pegasus "stack" is seen before ignition of the Pegasus rocket motor on.

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC01-0019-20.PSD Date: January 22, 2001 Photo by: Tom Tschida
Head-on view showing the X-43A hypersonic research aircraft after it was mated to its modified Pegasus® booster rocket

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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

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/Gallery/Photo/index.html
NASA Photo: EC04–0361–16 Date: December 15, 2004 Photo By: Carla Thomas

NASA's flexible–wing F/A–18 maneuvers through a test point during the second phase of the NASA/Air Force Active Aeroelastic Wing flight research program.

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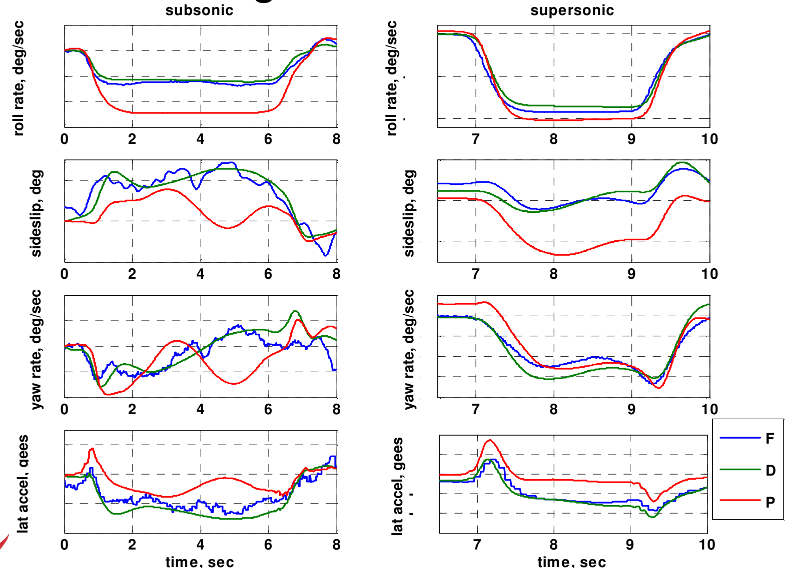
AAW Phase II Flight Results



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Autonomous Soaring for Improved Endurance of a Small UAV

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

March, 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.

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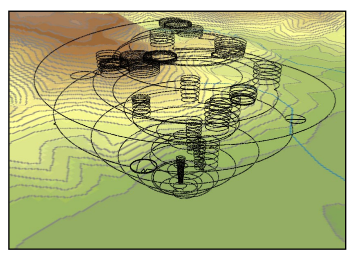
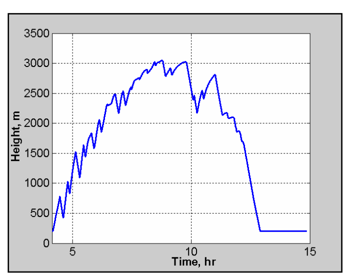
Flight Path Visualization

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





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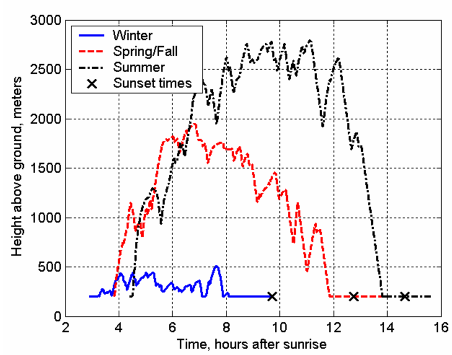
Typical Height Time-Histories

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

Parameter	Value	Pertur-bation	Yearly Average endurance	Change in endurance
L/D	15.8	-30%	8.63hr	+0.17%
L/D	29.4	+30%	8.54hr	-0.83%
Sink velocity	0.37m/s	-30%	9.27hr	+7.58%
Sink velocity	0.69m/s	+30%	7.91hr	-8.10%
N	calculated	-30%	8.47hr	-1.69%
N	calculated	+30%	8.67hr	+0.67%
Updraft lifespan	14min	-30%	8.56hr	-0.61%
Updraft lifespan	26min	+30%	8.63hr	+0.17%
w_T	calculated	-30%	7.96hr	-7.62%
w_T	calculated	+30%	8.92hr	+3.60%
zi	calculated	-30%	8.20hr	-4.75%
zi	calculated	+30%	8.92hr	+3.53%

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.

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Networked UAV Teams

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

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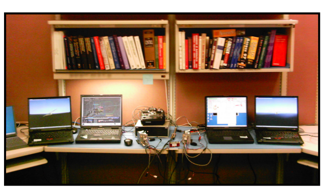

DFRC Networked UAV HILS

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)

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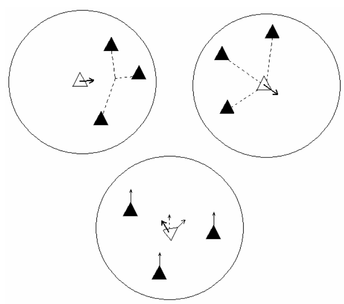
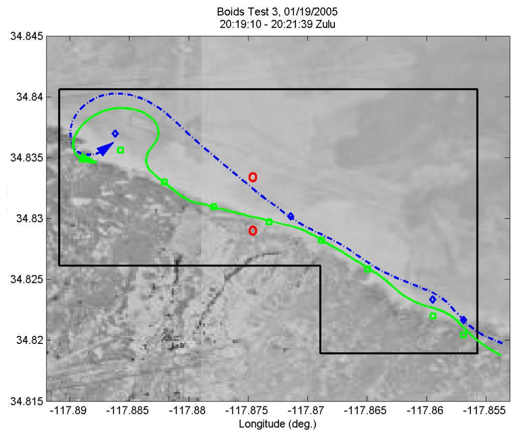
"Boid Path Planning"



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



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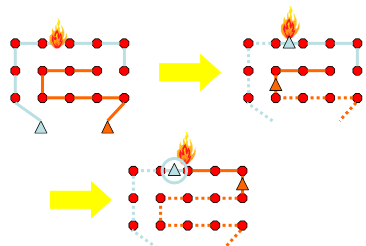
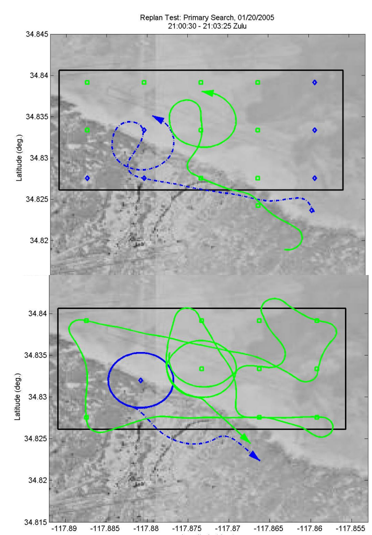
Dynamic Search Re-planning – flight data





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.

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