AARD - Autonomous Airborne Refueling Demonstration

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East Coast
SETP Symposium
20 April 2007
DARPA
- Approval of test objectives
- Project funding to primes involved in the demonstration program
- Program Oversight

DFRC
- Responsible Test organization
- Lead system integrator
- Responsible for system airworthiness
- Responsible for flight safety

SNC Development Team
- Overall test leader
- AARD Controller development
- Responsible for mission success
- Responsible for contracting Omega tanker activities.
- Support integration, airworthiness and flight test activities.
Program Goals

- **Primary Objective**
  - To make one **fully automatic** probe-to-drogue engagement using the AARD system.

- **Success Criteria**
  - One successful automatic engagement from the trail position (planned 100 ft from drogue) to basket connection
  - Hold connected to simulate a complete refueling sequence (planned for 5 minutes) then automatically disconnect and return to trail
  - Record on video – (with Pilot’s hands in the air!!)
• The Basket Can Strike Back
System Design

- **Tanker System**
  - GPS Pallet Transmitting Position & Velocity
  - **No** Modifications to Drogue Refuel System

- **F/A-18 System**
  - GPS & Receiver; “Rel-Nav” Solution
  - Optical Tracker; Basket Capture Solution
  - AARD Computer to Replace Pilot Inputs
  - PVI Panel
Passive State

INIT
- initialize peripherals, perform IBT, align IMU, exercise control surfaces upon request from PVI.
- Automatically when GPS/IMU are functional and IMU is aligned.

STANDBY
- GPS/IMU ready, no catalini, no GPS ReNav solution.
- Automatically, when all conditions are met for Ready To Engage: DataLink receiving, GPS ReNav functional, aircraft inside Initiation Box.

READY
- to go to Trail mode.
- Automatically, when aircraft leaves Initiation box or GPS ReNav or dataLink not functional.

Active State

TRAIL
- maintain aircraft at Trail position.
- On plot command (manual) on timeout (automatic).

RETREAT
- return to Trail position.

CLOSURE
- move to Pre-Contact position.
- Automatically upon reaching Pre-Contact position.

PRE-CONTACT 1
- maintain aircraft at Pre-Contact position (w/o following basket motion).
- On plot command (manual) or on timeout (automatic).

PRE-CONTACT 2
- maintain aircraft at Pre-Contact position (following basket motion).
- On plot command (manual) or on timeout (automatic).

FALLBACK
- move to Pre-Contact position.
- On acceptable fault condition, misaligned plug, or plot command.

CAPTURE
- plug the drogue.
- Automatically upon plugging the drogue.

HOLD
- move to Hold position, maintain aircraft at Hold position while plugged.
- On plot command (manual) or on timeout (automatic).

UNPLUG
- unplug and return to Trail position.
- Automatically upon reaching Trail position.
Pictorial View

Modes: Hold  Pre-contact 1&2  Trail

Capture  Closure

Modes:

153 ft  ~70 ft  100 ft

~150 ft  6-20 ft
Rear Cockpit  PVI
PVI Controller

- Eight active push tiles with information

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Front Cockpit

- Canopy bow status lights
- Optical tracker camera
- Video selector
- DDI RFCS control
Validation Flights

- 4 Flights with Sabreliner Surrogate Tanker: 16 – 29 June 2006
- 3 Flights with Sabreliner in second phase: Nov 2006 – Mar 2007
Omega Tanker Flights

- 9 Flights with Omega tanker:
  - 11 July ’06: Optical tracker problems
  - 27 July ’06: Optical tracker problems
  - 17 Aug ’06: Data Link problems, Optical tracker OK
  - 30 Aug ’06: SUCCESS
  - 13 Dec ’07: Plugs
  - 22 Feb ’07: Plugs in a turn
  - 23 Mar ’07: Plugs in turbulence
  - 16 Apr ’07: Plugs in turbulence
  - 17 Apr ’07: Plugs in turns
Turbulence
“Stick” Measurements

[Graph showing stick measurements with different attempts and a manual line]
Lessons Learned

- Early Pilot Involvement
- Computers Remove “Human” Problems
- Shortcuts Seldom Work
- “SHIT” Happens: (*Software / Hardware Induced Trauma*)
Possible Users
Questions???
PSFCC’s
Front Cockpit Glareshield
Receiver States and Modes

Passive State

- INIT
  - initialize peripherals, perform inertial alignment, test control interface upon request from PVI
  - automatically when GPS/IMU are functional and IMU is aligned

- STANDBY
  - GPS/IMU ready, no datalink, no GPS RelNav solution
  - automatically when aircraft leaves initiation box or GPS/IMU not functional

- READY
  - to go to Trail mode
  - automatically when all conditions are met for Ready To Engage: Datalink functioning, GPS/IMU functional, aircraft inside Initiation Box

Active State

- TRAIL
  - maintain aircraft at Trail position
  - on pilot command (manual) on timeout (automatic)

- RETREAT
  - return to Trail position
  - on pilot command

- CLOSURE
  - move to Pre-Contact position
  - automatically upon reaching Pre-Contact position

- PRE-CONTACT 1
  - maintain aircraft at Pre-Contact position
  - on pilot command (manual) or on timeout (automatic)

- PRE-CONTACT 2
  - maintain aircraft at Pre-Contact position (following basket motion)
  - on pilot command (manual) or on timeout (automatic)

- CAPTURE
  - plug the drogue
  - automatically upon plugging the drogue

- HOLD
  - move to Hold position, maintain aircraft at Hold position while plugged
  - on pilot command (manual) or on timeout (automatic)

- UNPLUG
  - unplug and return to Trail position
  - automatically upon reaching Trail position

- MISS
  - move to Pre-Contact position
  - on pilot command (manual) or on timeout (automatic)

- MISS
  - move to Pre-Contact position
  - on pilot command (manual) or on timeout (automatic)

- HOLD
  - move to Hold position, maintain aircraft at Hold position while plugged
  - on pilot command (manual) or on timeout (automatic)

- UNPLUG
  - unplug and return to Trail position
  - automatically upon reaching Trail position

- AARD Receiver States/Modes & Transitions: July 29, 2005
AARD Test Program

- Background
- Participants
- Design
- Simulation and Ground testing
- Test Flights:
  - With surrogate tanker
  - With Omega tanker
    - Optical system problems
    - Rel-Nav problems
- 30 August 2006