Flight Research: X-31A Enhanced Fighter Maneuverability and F-18 High Alpha Research Vehicle

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Overview

Background

F-18 High Alpha Research Vehicle
- High Alpha
- HARV Project
- Thrust Vectoring
  - cold jet
  - hot loads
  - parameter identification

X-31A Enhanced Fighter Maneuverability Demonstrator
- Maneuverability at high angle of attack demonstration
- Post-stall maneuvering
- Close coupled canard and Thrust Vectoring
Background: High Alpha Technology

High Alpha Technology

- Interest in "Ground-To-Flight Correlation" for high angle of attack
- US Department of Defense
- NASA

- 1930s-1940s: Recovery
- 1950s-1960s: Avoidance
- 1970s-1980s: Maneuverability

The Problem

- Reduced Longitudinal Stability & Control
- Lateral-Directional Stability dominated by the forebody
F-18 High Alpha Research Vehicle

HARV: The High Alpha Research Vehicle

F-18 High Alpha Research Vehicle Project
- HARV Project
- HARV Aircraft
  - "840": Ship 6 of F-18 Full Scale Development Program
  - heavily modified to create a research tool
- Electric Back-Up System (avionics & hydraulics)
- Research Flight Control System (RFCS: "brain" that made it work)
- Research Instrumentation (~5000 parameters at up to 2000+ sps)
- Aero Nose Strakes for Enhanced Rolling (ANSEr)
- Spin Recovery Chute (parachute)
- Smoker & PGME Flow Vis System
- LEX Rake
- Thrust Vectoring
- Limited Envelope
- Testbed for advanced control laws
- 396 flights
**F-18 HARV: Aero Research**

- Extensive study of flow

**F-18 HARV: Forebody Vortex**
**HARV: Thrust Vectoring**

**Thrust Vectoring Control System**
- Three Inconel vanes per engine
  - large upper vane
  - small lower and outer vanes
- Removed divergent nozzle
- Attachment constrained by aft fuselage structure
  - odd angle placement of vane
  - used modified aileron actuators

**F-18 HARV: Forebody Controls**

- Use Forebody Strakes to control vortices
F-18 HARV

- Videos
  - High angle of attack aero visualization
  - High yaw rate (spin) maneuver
  - Nose strakes

X-31A EFM

X-31A Enhanced Fighter Maneuverability
X-31A EFM: Maneuverability Demonstrator

X-31A Enhanced Fighter Maneuverability Project
• EFM Project
• EFM Aircraft
  - two airframes
  - custom designed maneuverability aircraft
• Weight growth
• Thrust vectoring
• Three carbon-carbon vanes
• Flight Mechanics Instrumentation
• Close coupled canard
• Spin Recovery Chute (parachute)
• Single engine
• Extensive envelope
• 542 flights

X-31A EFM
• Highly agile, highly maneuverable aircraft
• Herbst Maneuver
• X-31: robust, reliable aircraft
X-31A EFM

- Herbst Maneuver
  - “J-turn”
  - high angle of attack post-stall reversal

1. X-31 enters maneuver at high speed (M 0.5 or greater)
2. X-31 decelerates rapidly while increasing “angle-of-attack”
3. ...exceeds conventional aerodynamic limit (Stall) – needs thrust vectoring for control
4. Angle-of-attack increases to maximum of 70°
5. X-31 rapidly “cones” to new flight direction
6. X-31 lowers nose and accelerates to high speed
7. X-31 now flying in opposite direction
X-31A EFM

• X-31 videos
  - Hebst maneuver
  - Mongoose maneuver
  - Post-stall reversal