Flight Research

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

16 July 15

Al Bowers

Flight Research

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

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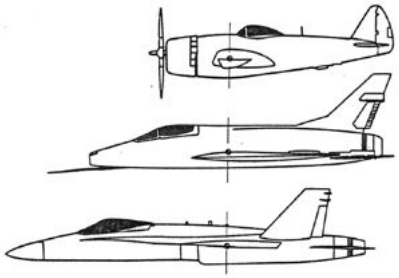
Background: High Alpha Technology

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



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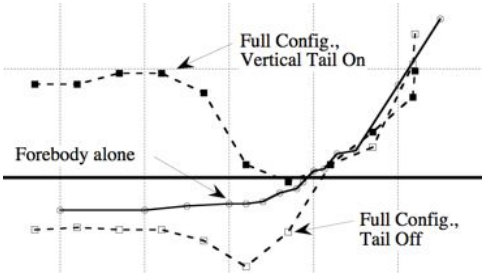
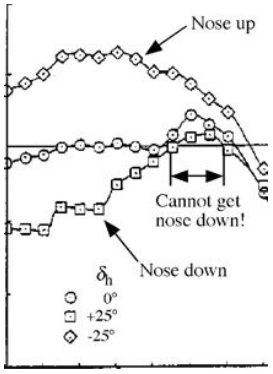
The Problem

- Reduced Longitudinal Stability & Control
- Lateral-Directional Stability dominated by the forebody





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F-18 HARV

F-18 High Alpha Research Vehicle

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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

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F-18 HARV: Aero Research

- Extensive study of flow

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F-18 HARV: Forebody Vortex

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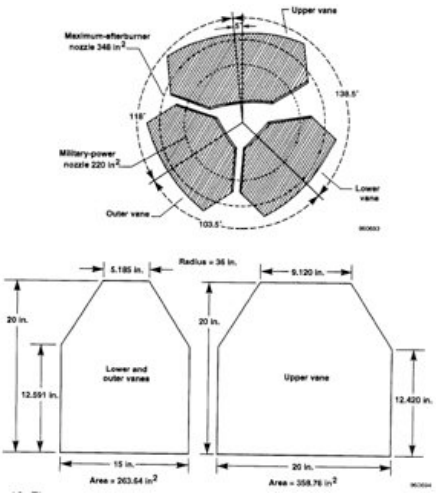
HARV: Thrust Vectoring

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



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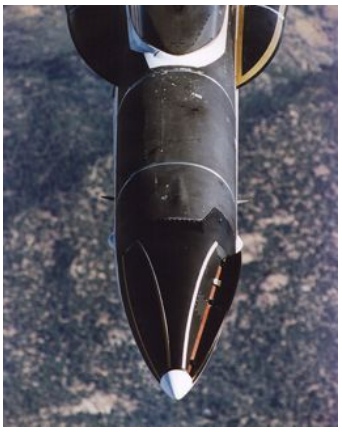
F-18 HARV: Forebody Controls

- Use Forebody Strakes to control vortices



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F-18 HARV

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

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X-31A EFM

X-31A Enhanced Fighter Maneuverability

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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

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X-31A EFM

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

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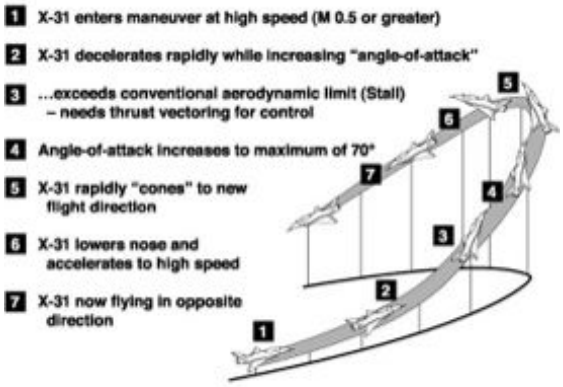
X-31A EFM

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



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X-31A EFM

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X-31A EFM

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

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