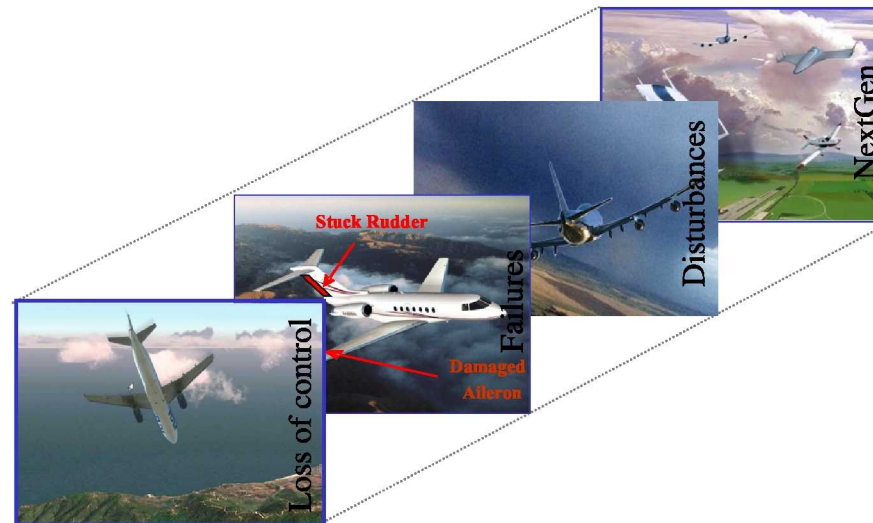# Integrated Resilient Aircraft Control Project
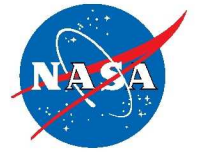
Full Scale Flight Validation

NESC GN&C Face-to-Face in Chicago

John Bosworth, VVMT Co-API

August 2009

Full-Scale Flight Test Overview

- Objective

  - Provide validation of adaptive control law concepts through full scale flight evaluation.

- Technical Approach

  - Engage failure mode – destabilizing or frozen surface.

  - Perform formation flight and air-to-air tracking tasks

  - Evaluate adaptive algorithm

      - Stability metrics

      - Model following metrics

NASA NF-15B #837

- Last flight flown on Jan 30, 2009
  - Indirect adaptive (Gen 1) – 1999
  - Direct adaptive (Gen 2) – 2006
  - Improved direct adaptive (Gen2a/b) – 2008

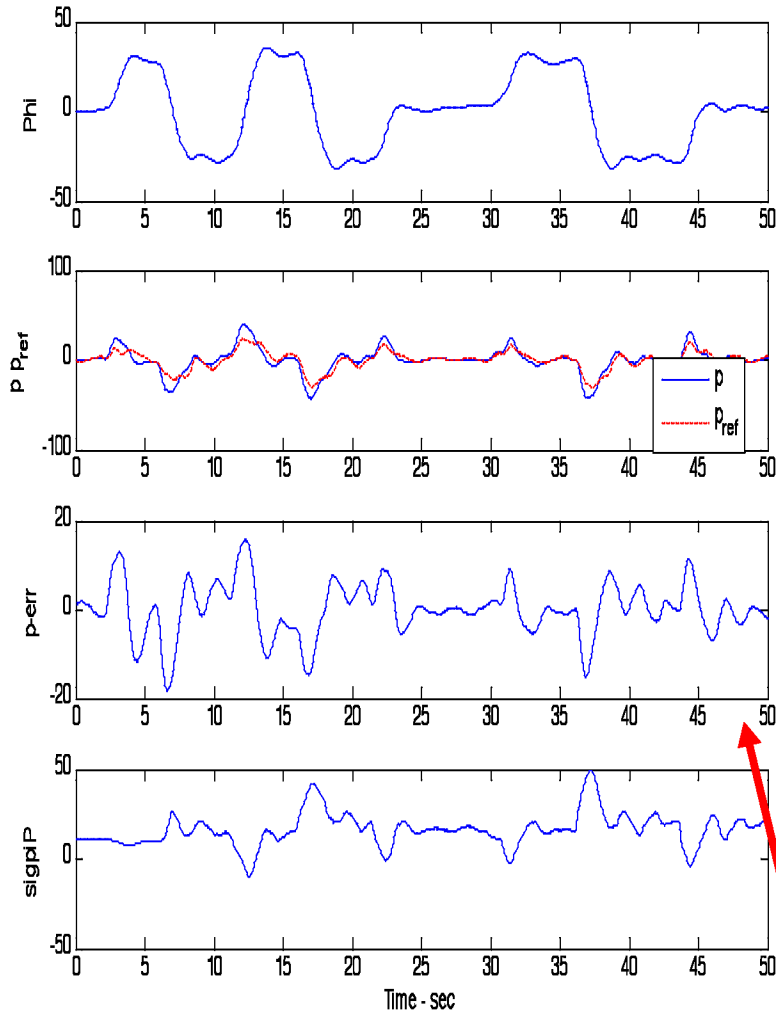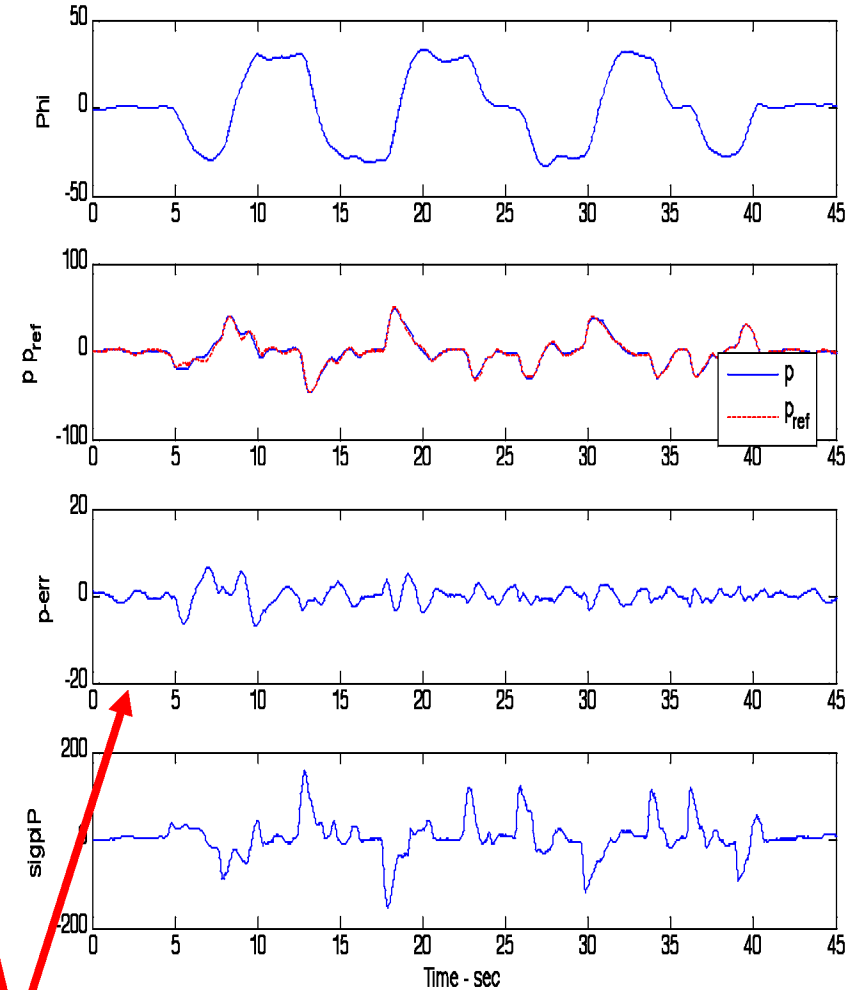- Future flights will be on F/A-18 #853

Video from F15 Flight Test

https://mars.ndc.nasa.gov/cpx/dsweb/View/Collection-46/Document-450057

Gen2 & Gen2a Sigma Pi Flight Results

Gen2 Results: Bank-to-Bank

Gen2a Results: Bank-to-Bank

Note: Reduced Tracking errors for similar Pilot Inputs

IRAC F-18 #853 Testbed

- Dedicated Ghz processor for experiment

- Shell & process for Simulink autocode (or c-code)

- Can control commands to:

  All aero surfaces (except speed brake)

  All pilot inputs

  Both engine throttles independently

- Limit checks done by Class A software in RFCS

- Potential for Class A experiment (dual ARTS IV or in quad RFCS) – take to landing?

- Tons of research instrumentation parameters

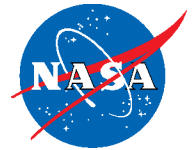- Simulated failure of multiple control surfaces
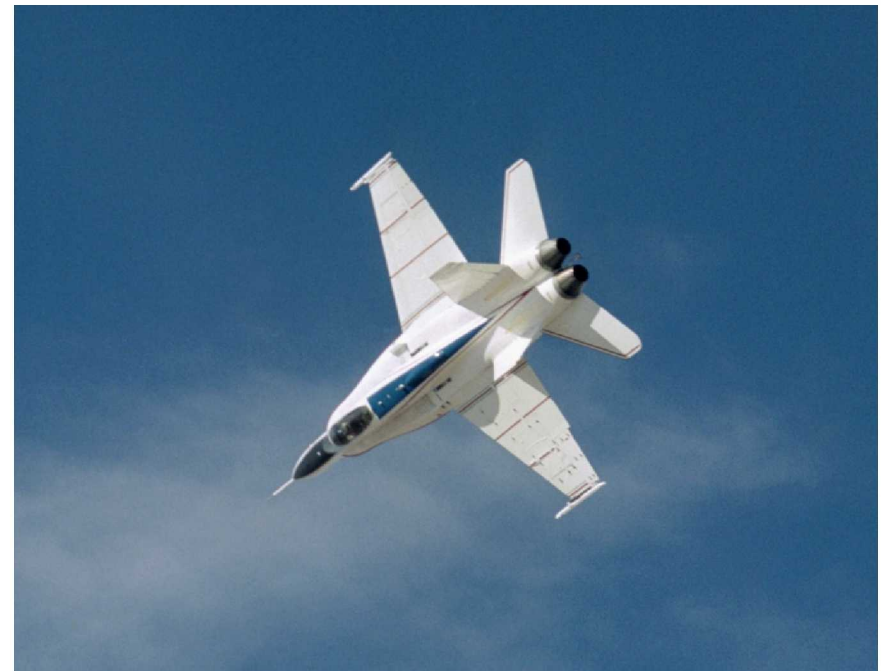
Experiment Peer Review Process

- Brainstorming within NASA

- Release an RFI for feedback and other ideas from Industry / Academia

- Workshop with Industry / Academia – possibly St. Louis at ACC time

- Final selection by NASA

- Flights in 2011

- Continue process for next experiments

RFI Objectives

- ## Objective 1: To validate adaptive control technology using manned flight experiments

  - Experiments addressing:
    - Challenges that can only be addressed by manned flight
    - Address barriers to implementation
    - Sufficiently large (or meaningful) failures

- ## Objective 2: To examine the benefits of manned Vs autonomous recovery

  - Experiments addressing:
    - Types of pilot input to system
    - Separate, backup, or primary flight control implementation
    - Interactive adaptive

RFI Objectives

- ## Objective 3: To test and validate system-level reasoning for flight control reconfiguration
  - Experiments addressing:
    - Detection, diagnosis, prognosis, and isolation technologies for control reconfiguration and envelope limiting controls

Conclusions

- Full scale flight testing provides an ability to validate different adaptive flight control approaches

- Full scale flight testing adds credence to NASA's research efforts

- A sustained research effort is required remove the road blocks and provide adaptive control as a viable design solution for increase aircraft resilience.