Flight Test of the F/A-18 Active Aeroelastic Wing Airplane

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Presenting

the

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F/A-18 AAW Airplane

NASA Photo: EC04-0361-08

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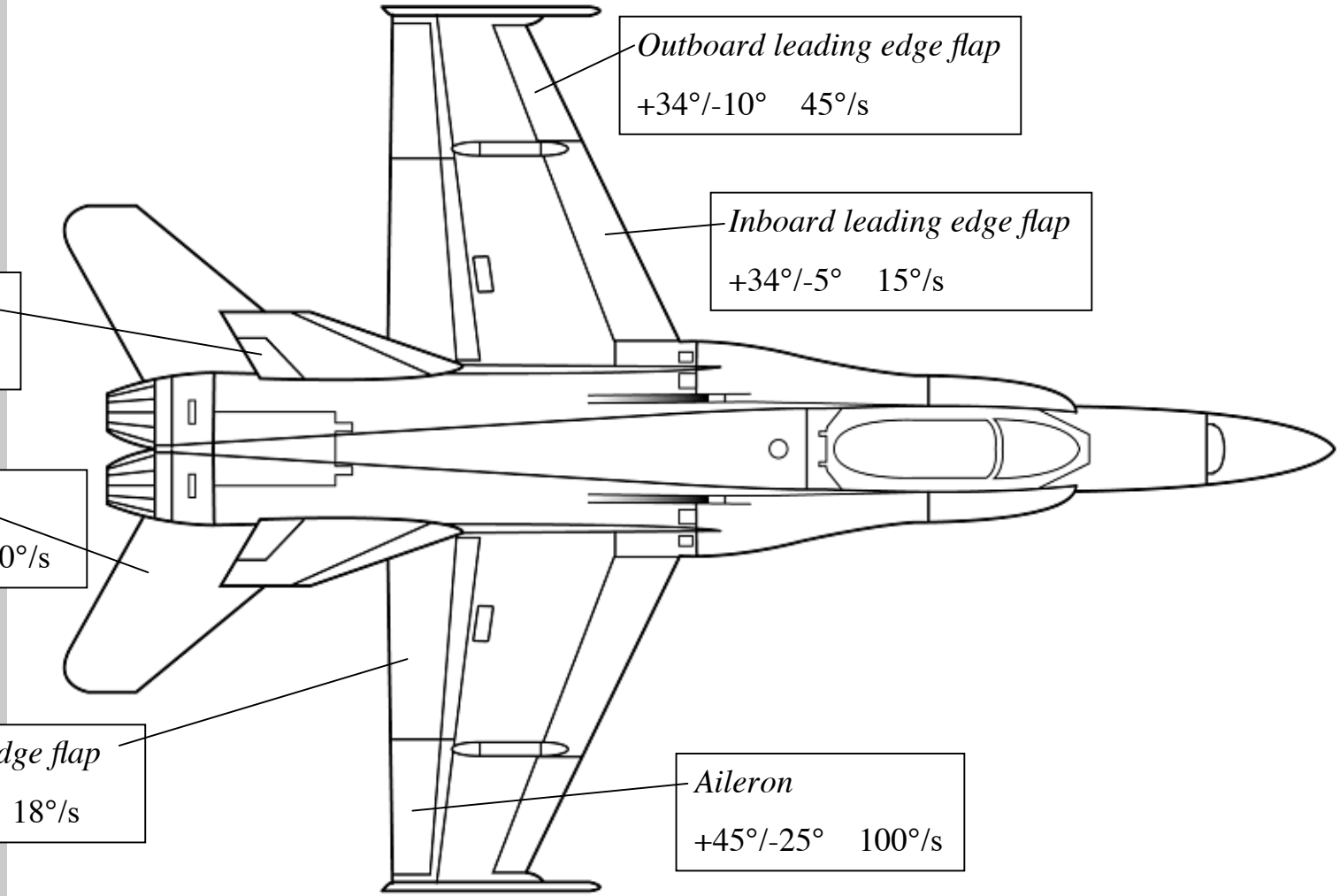
F/A-18 AAW Control Surfaces



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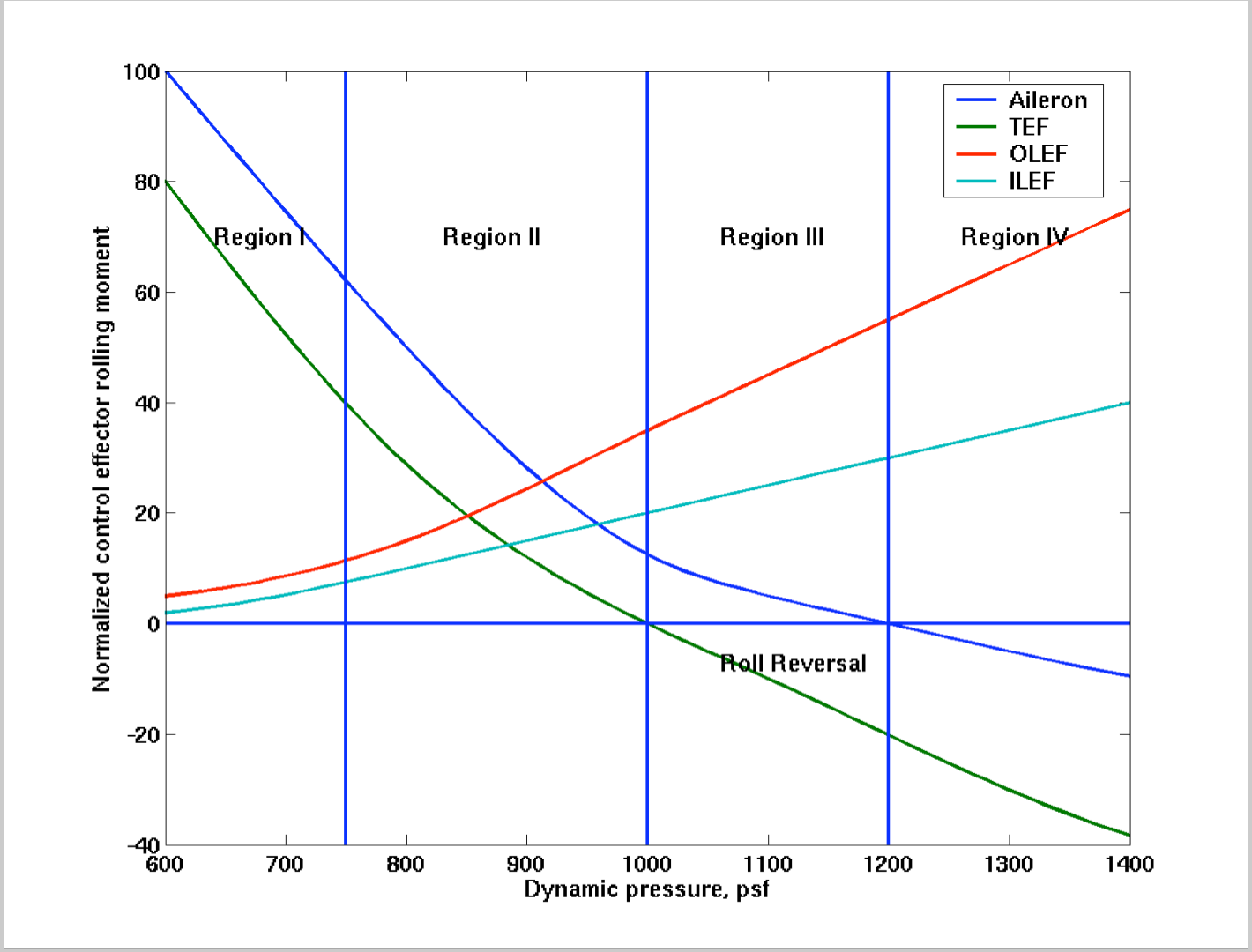
Flight Test Background

- Phase I - from Nov 02 to Jun 03
  - Flutter clearance, air data calibration, aerodynamic and loads model development
- Phase II - from Dec 04 to Mar 05
  - Boeing & DFRC CLAW designs
- Phase IA - Mar 05
  - Aeroservoelastic research
- Phase IIA - Mar 05
  - CLAW's at several test points were redesigned

Roll Control Effectiveness Regions



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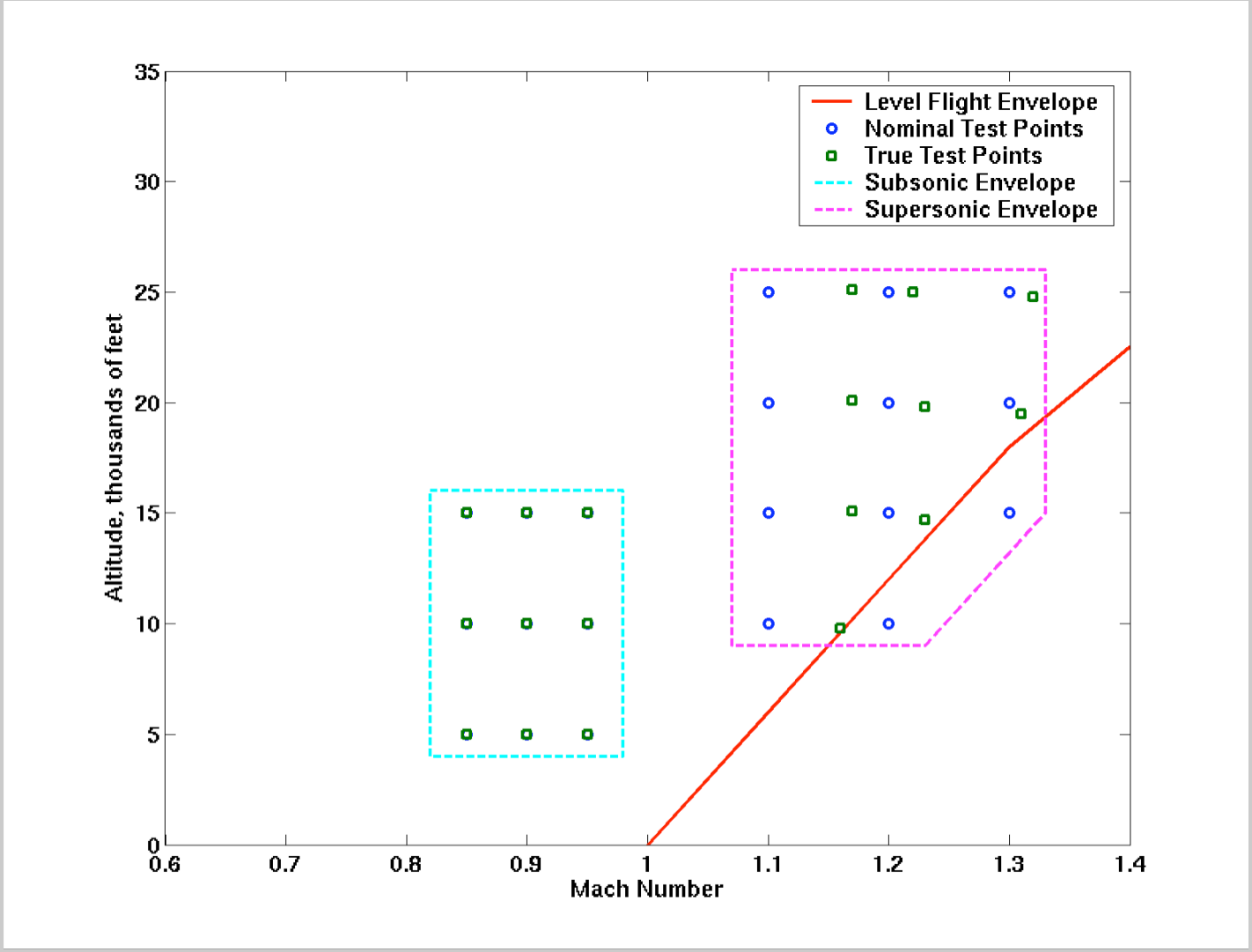
AAW Design Test Points



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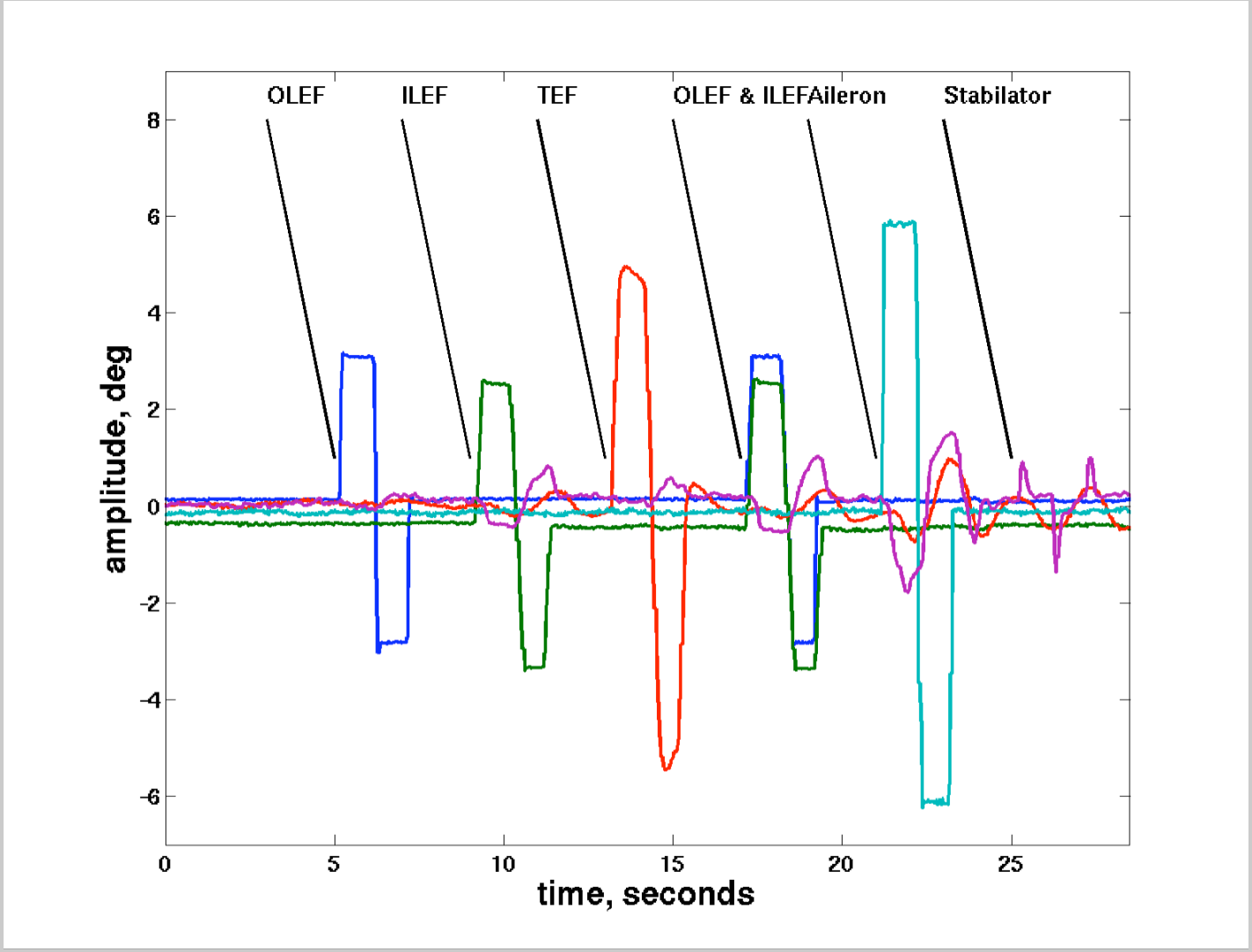
AAW Phase I Test Maneuvers

- OBES ASE/flutter clearance
- Air data calibration
  - Tower flyby
  - Level accel's
  - POPU's
  - Slow β sweeps
- Simulated OLEF failure (left OLEF)
- OBES pitch and roll doublets
- Demonstration maneuvers
  - 5-g WUT
  - 1-g bank-to-bank/360° rolls (incremental build-up to full stick or load limit)
  - 4-g RPO

OBES Pitch Doublets



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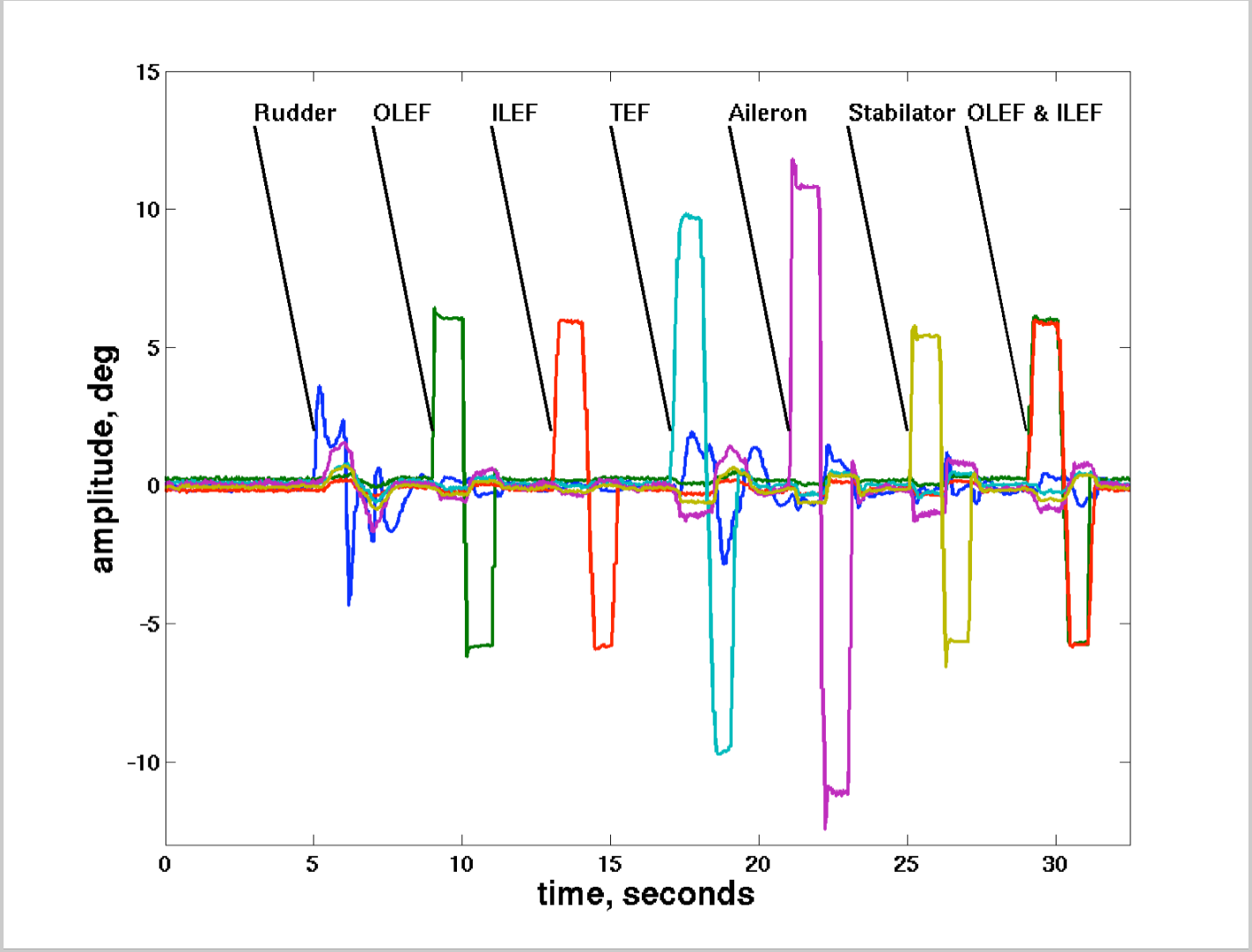
OBES Roll Doublets



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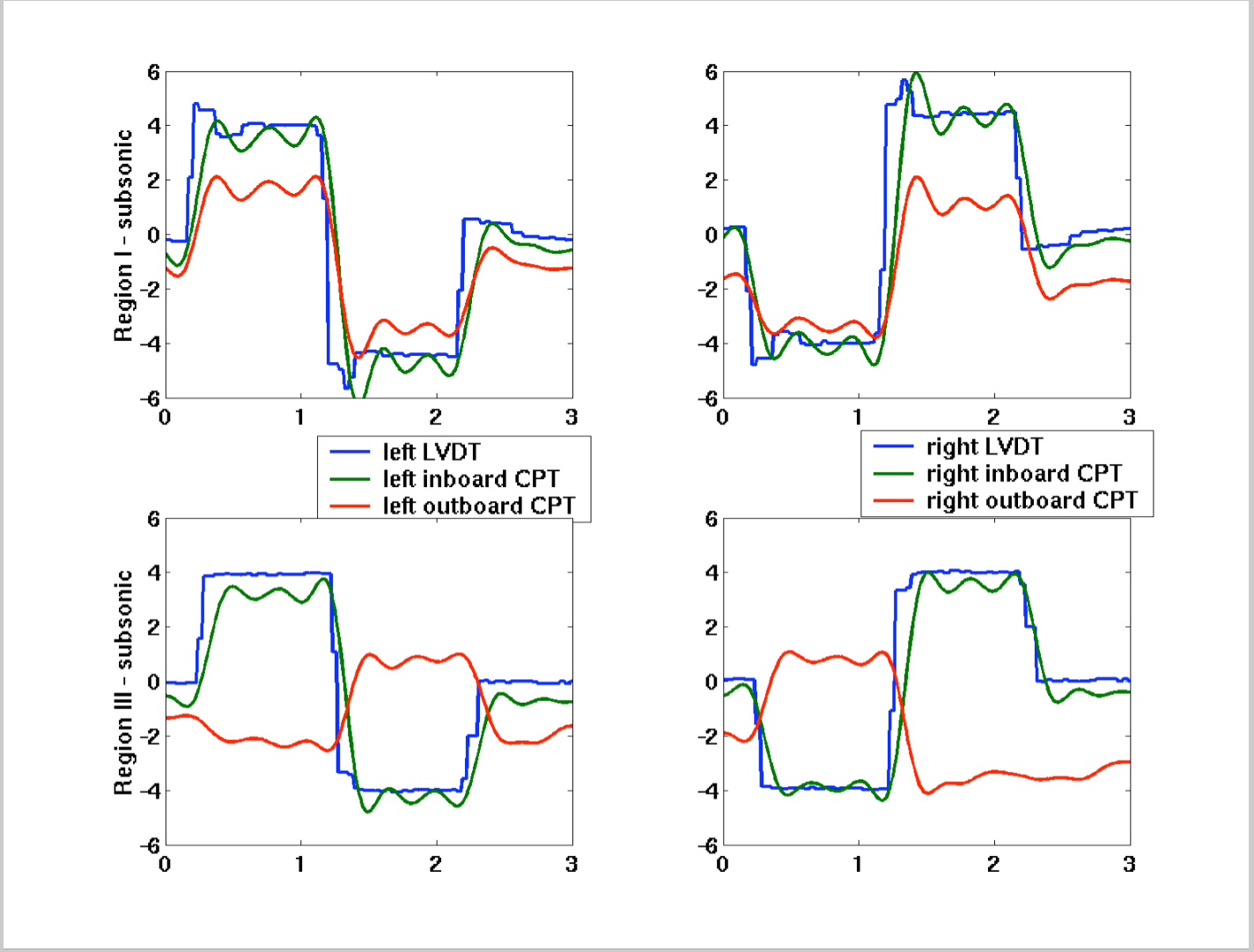
AAW Aileron Flexibility



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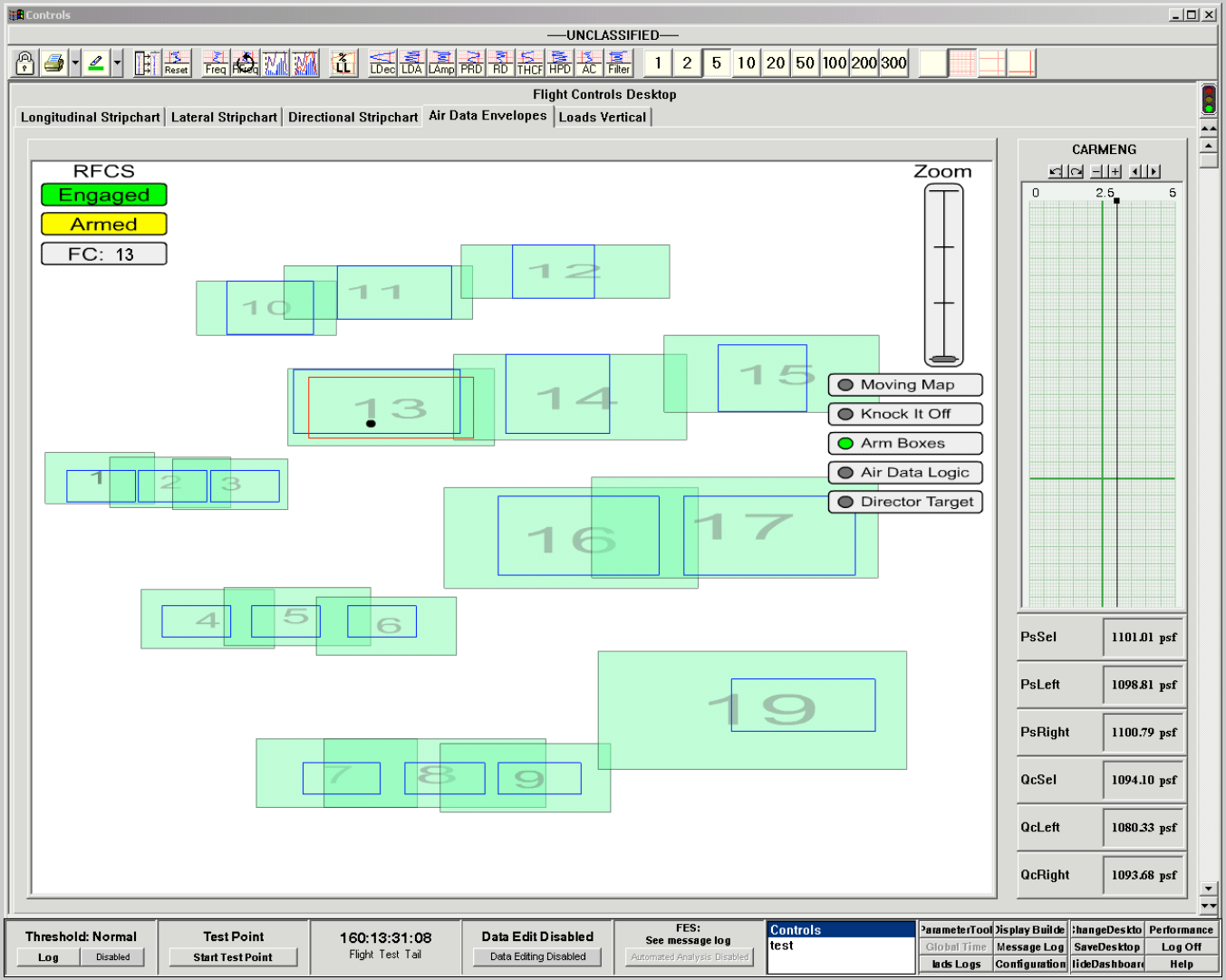
Phase I - Lessons Learned

- Phase I flight tests using OBES provided good data for aerodynamic and loads model development, but hindsight showed some of the doublet maneuvers were too small
- Phase I results showed no tendency for aileron reversal (flexibility of the aileron may have contributed to this)
- The AAW airplane was unable to accomplish any testing at two of the highest dynamic pressure test points
- Aileron hinge moment loads were a design driver for the Phase II CLAW's

Control Law Development and Verification & Validation Testing

- Both Boeing and NASA DFRC teams developed control laws for each design test point
  - Boeing used ISMD design process
  - NASA used CONDUIT® design process
- Verification testing and limited validation testing conducted by Boeing (FAST and piloted HIL)
- Extensive HIL V&V testing conducted at DFRC
  - Aerodynamic modeling issues were examined for safety-of-flight
  - IADS displays were used as part of test (built confidence in them before they were used for flight test)
  - Several errors in the flight code caught and fixed
    - Rudder trim gain had incorrect value
    - Transient free switches caused control surfaces to drift

AAW Phase II RFCS Envelopes



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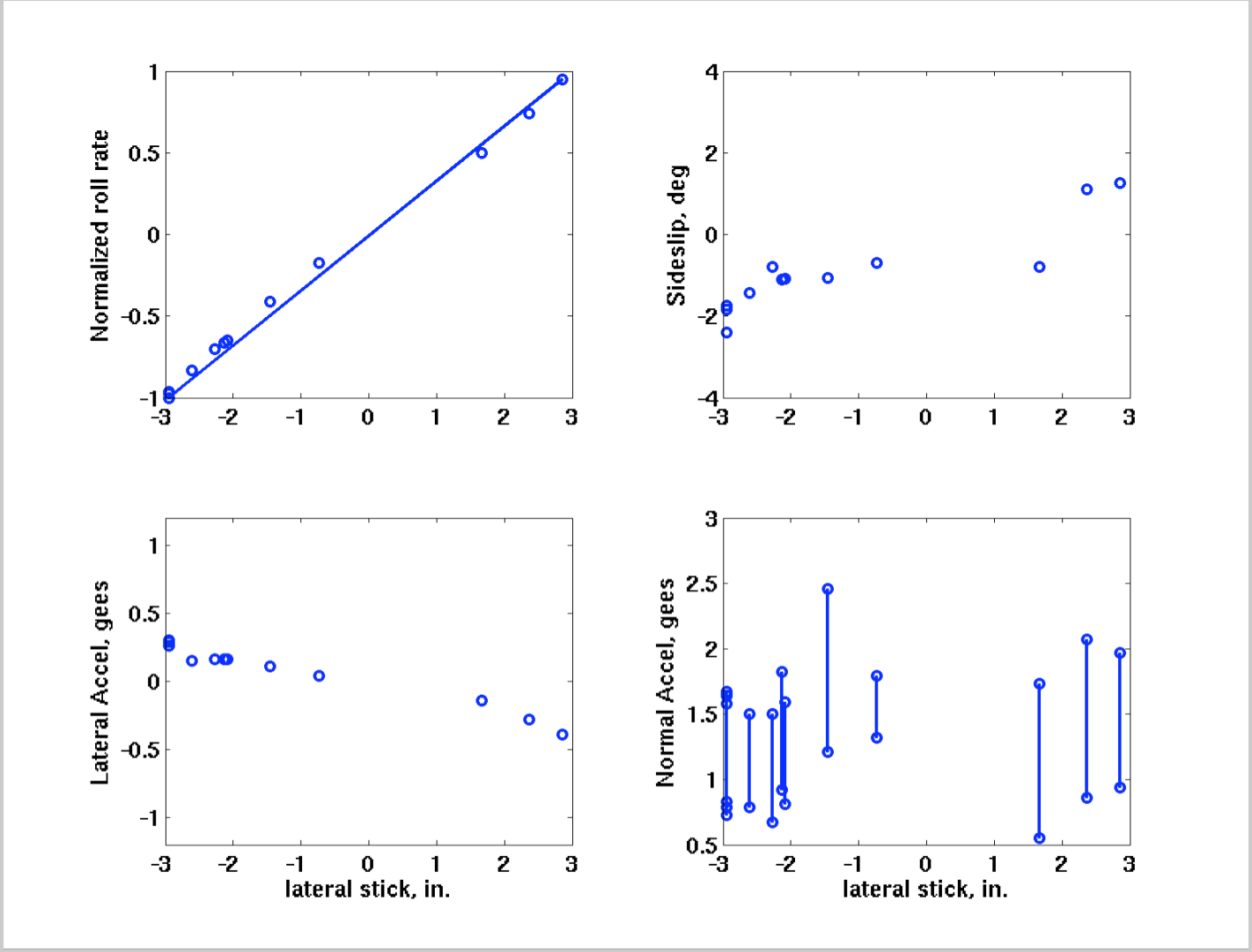
AAW 1-g Phase II Flight Test

- 1-g bank to bank and 360° rolls
  - Tested the primary AAW technology (ability to roll the airplane using only wing control surfaces)
  - Tested the ability of the control laws to achieve acceptable roll performance and flying qualities while maintaining loads within limits
- Learned how well the aerodynamic and loads models predicted the vehicle's response (issues were linearity and superposition)

Region I - Subsonic 1-g Rolls



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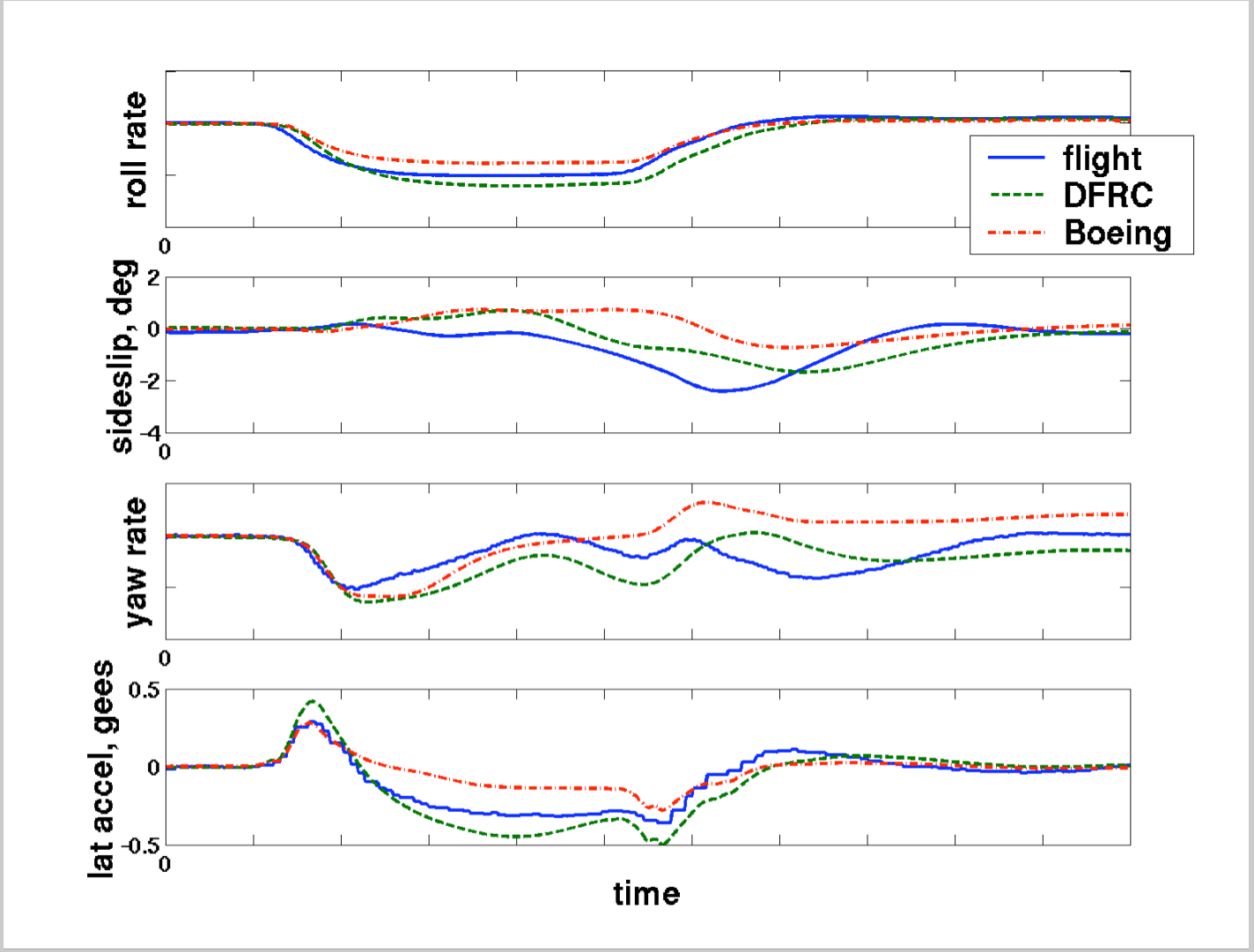
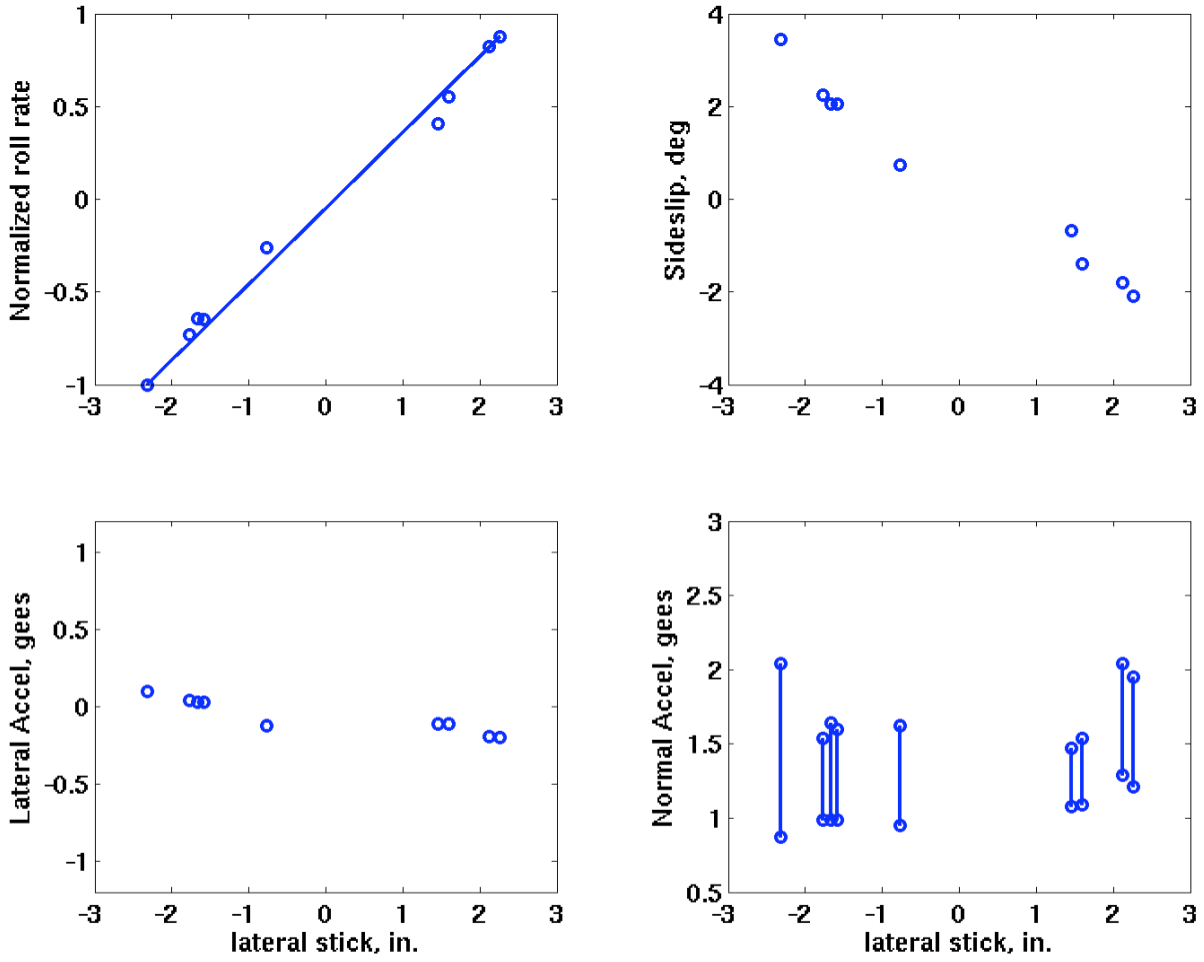
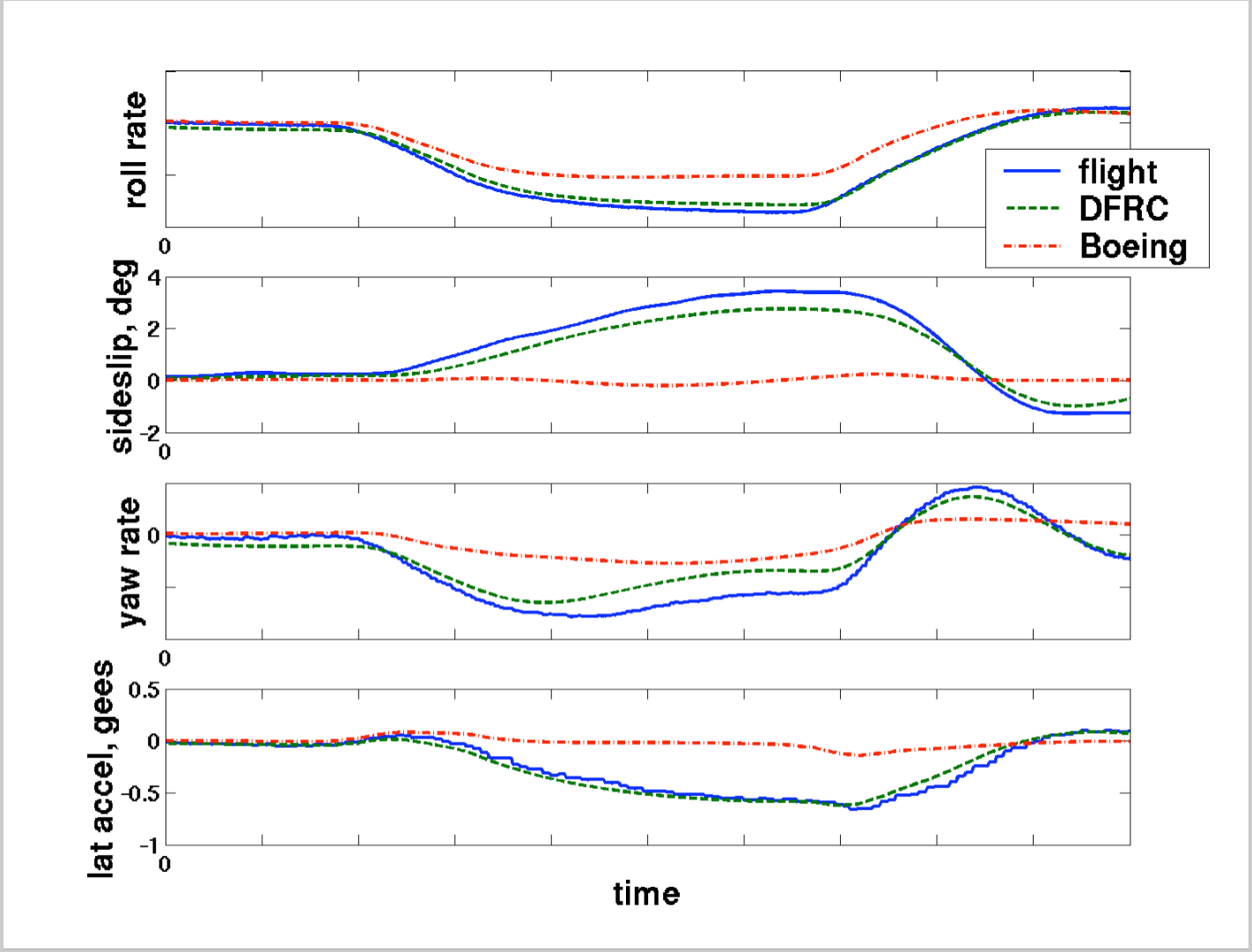
Region I - Subsonic 1-g 360°Roll



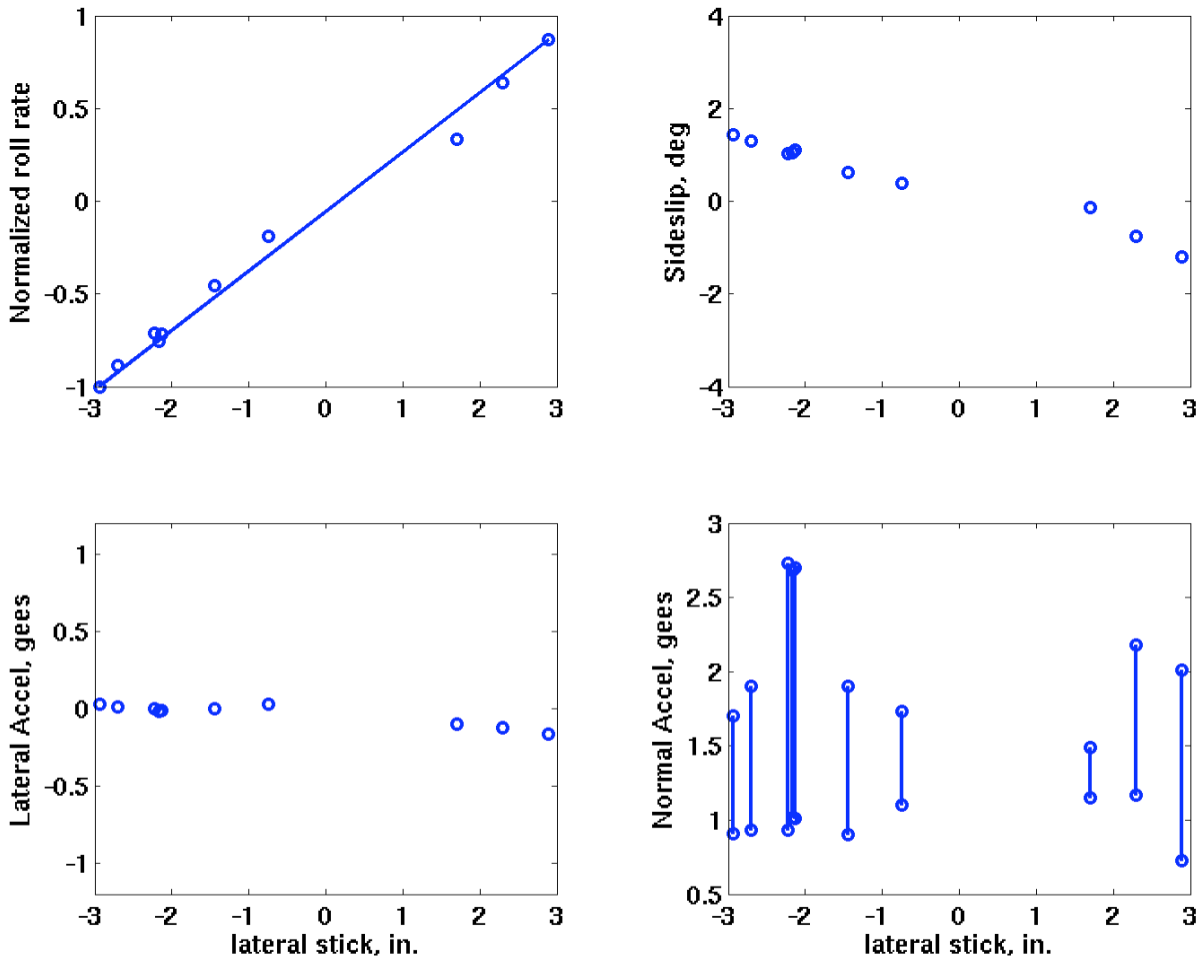
Region II - Supersonic 1-g Rolls



Region II - Supersonic 1-g 360° Roll



Region III - Subsonic 1-g Rolls



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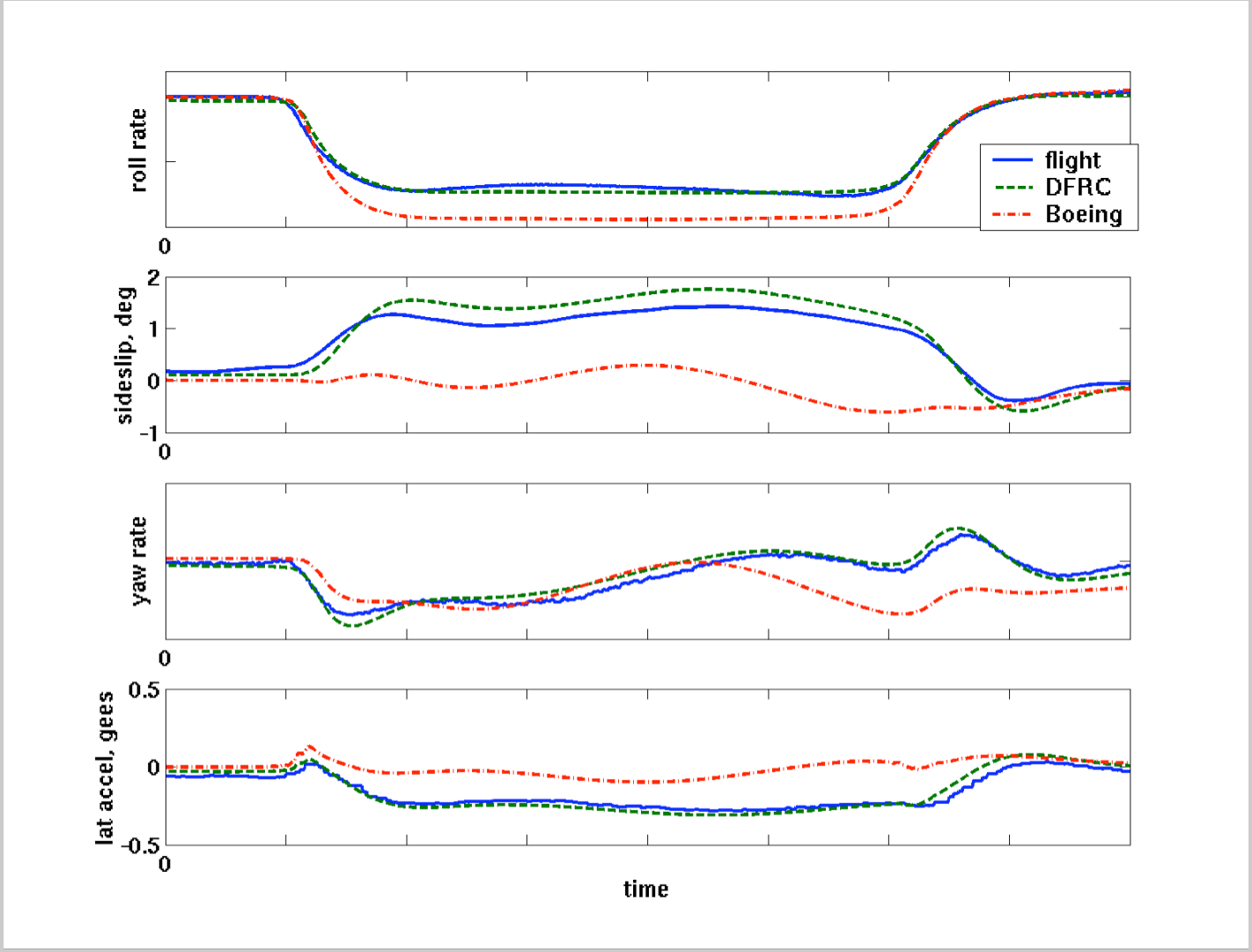
Region III - Subsonic 1-g 360°Roll



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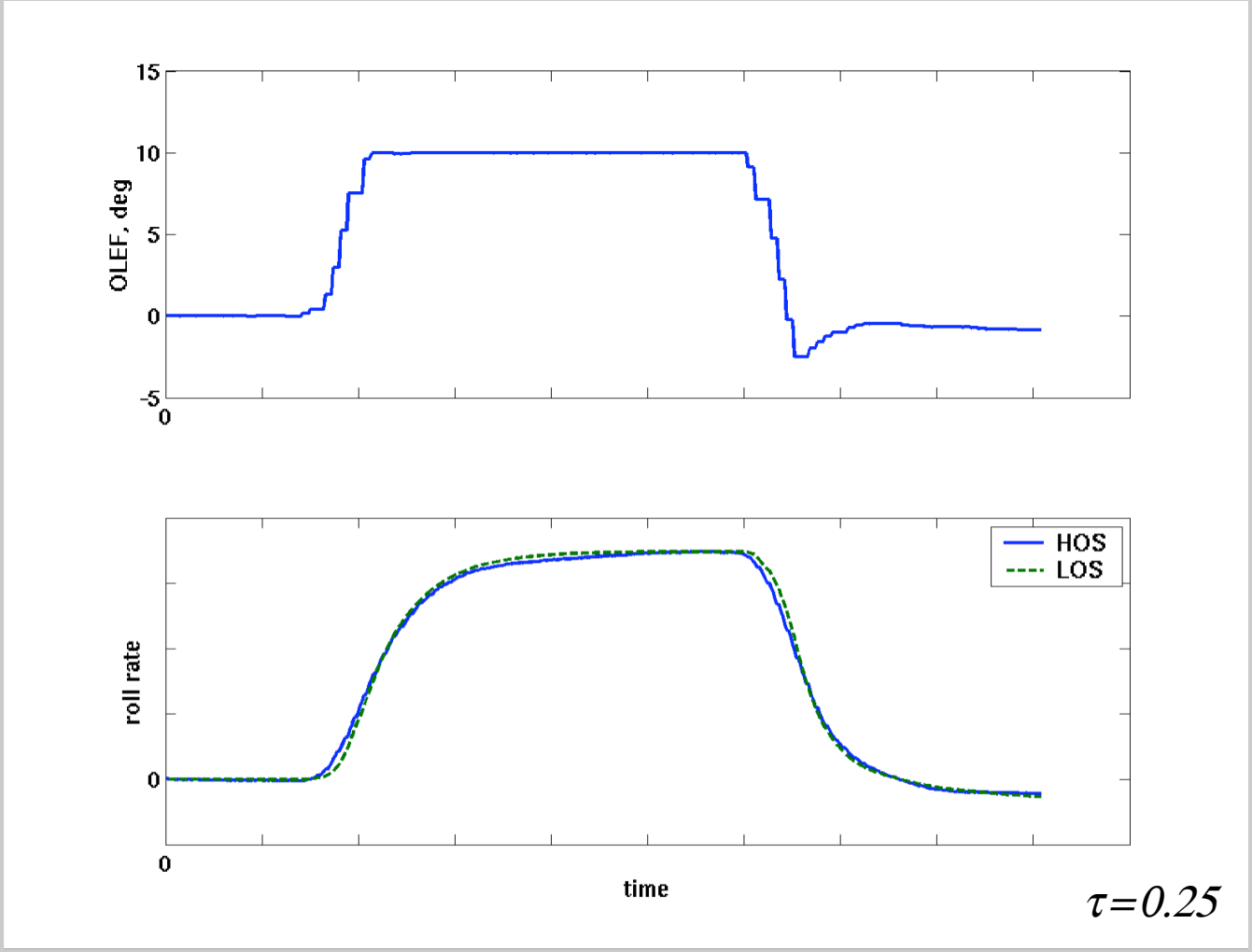
Roll Axis HOS/LOS Comparison
Region II - Supersonic (open-loop)



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Roll Axis HOS/LOS Comparison
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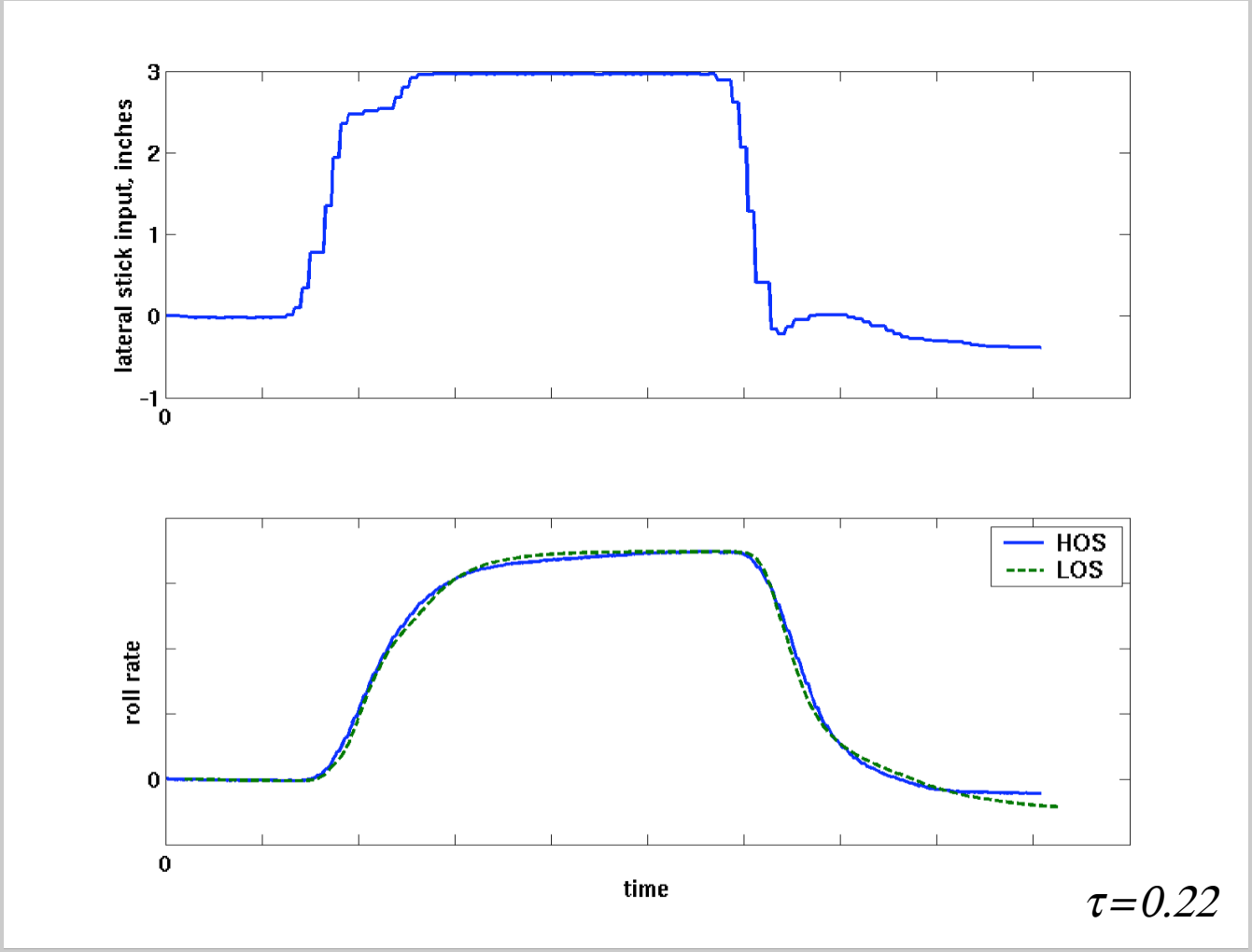

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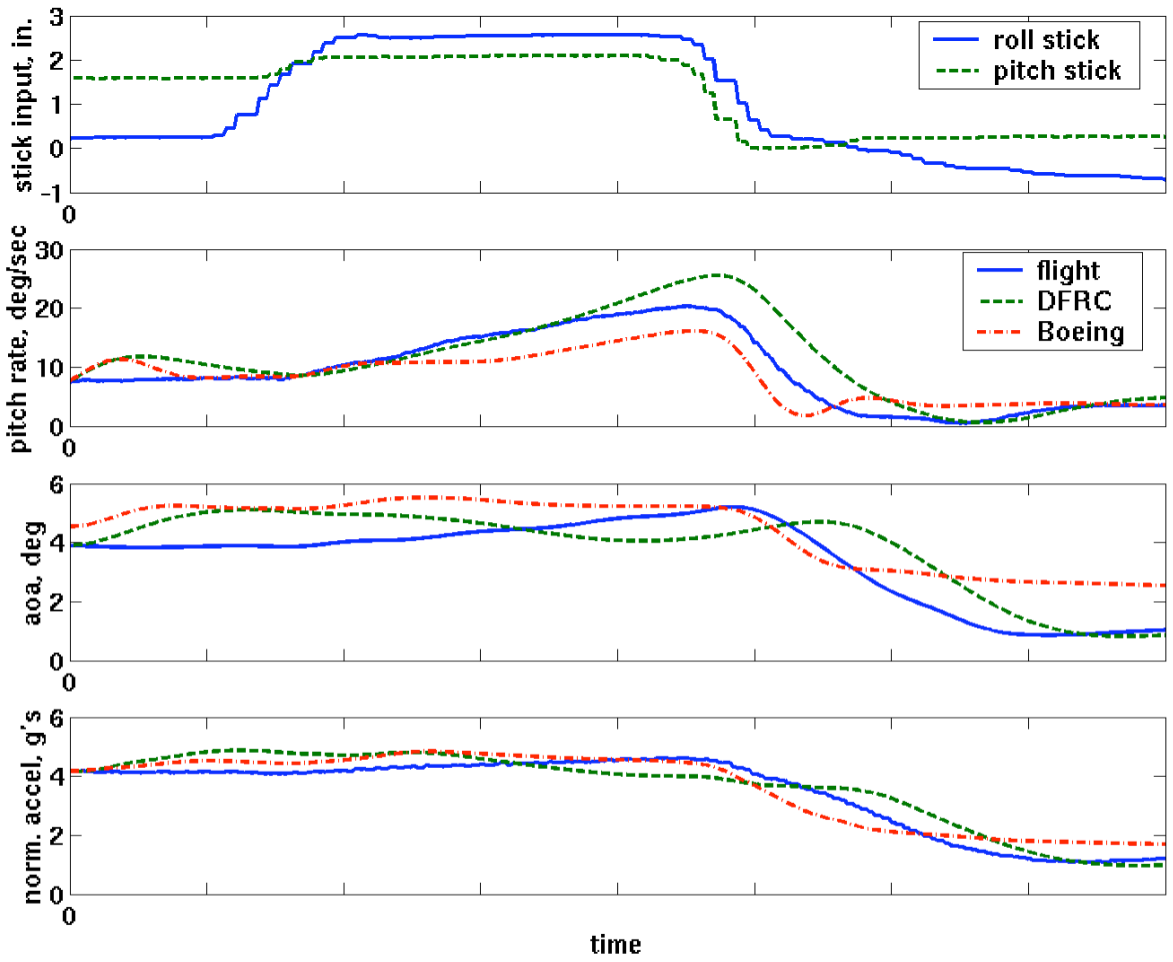
AAW Phase II Elevated-g Flight Test

- Windup Turn
  - Tested the ability of the control law designs to reduce wing loads (maneuver load control) or replicate basic F/A-18 trim schedules
- Rolling Pull Out
  - Tested the primary AAW technology (ability to roll the airplane using only wing control surfaces)
  - Tested the ability of the control laws to achieve acceptable roll performance and flying qualities while maintaining loads within limits
- Learned how well the aerodynamic and loads models predicted the vehicle's response (issues were linearity and superposition)

Region I - Subsonic 4-g RPO



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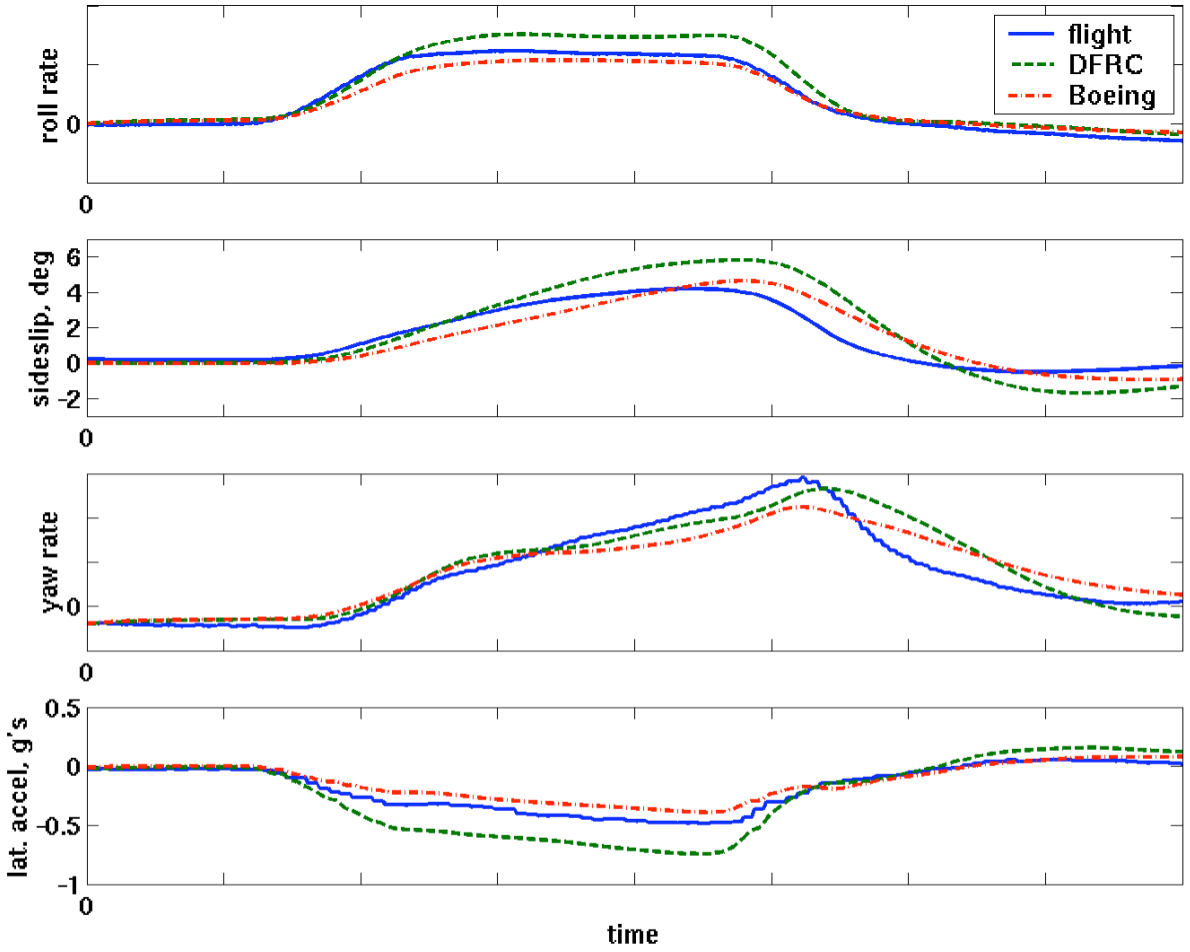

Phase II - Lessons Learned

- The RFCS worked well in both Phases I and Phase II
- The AAW program was the first program at DFRC to utilize a RFCS in a safety of flight critical envelope
- The IADS® displays worked well for safety monitoring
- Comparison of the flight data and predicted airplane response ranged from fair to excellent