

NASA Armstrong Flight Research Center

Dynamics and Controls (530)

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Overview

- **Research**

- Control of Flexible Aerostructures
- Autonomy
 - Trustworthy autonomy
 - Multi-Monitor Run Time Assurance
 - Cooperative Trajectories
 - Where to land
- Dynamics and Control of Hybrid Electric Vehicles

- **Current Projects**

- X-59 – Low Boom Flight Demonstrator
- X-57 Maxwell
- X-56A Multi-Utility Technology Testbed (Control of Flexible Structures)
- Resilient Autonomy
- DEP Controls

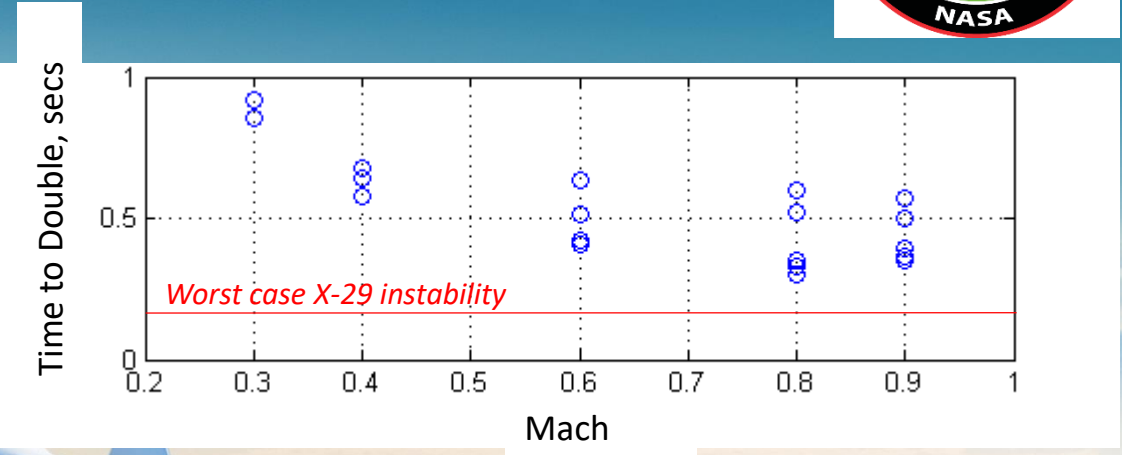
- **Capabilities**

- Flight control, estimation, and guidance
- Flight dynamics
- Flying qualities/handling qualities
- System integration, test, V&V
- Flight research, flight test techniques, data analysis
- Intelligent/adaptive/robust flight control
- Multi-vehicle control
- Autonomous/adaptive mission
- Precision trajectories

X-59 – Low Boom Flight Demonstration



- Mission objective: Provide data to regulatory organizations to support development of an overland supersonic noise standard.
- Challenges
 - External vision system
 - Pitch unstable
 - Weak C_{nb} , large C_{lb}
 - Sensitivity of boom perturbation to aft end of vehicle
- AFRC Controls and Dynamics branch role
 - Support development of piloted simulation trainer
 - Provide independent flight dynamics assessments
 - Studies to date: speed brake trade study, landing control system mode, tail-strike analysis, alpha-limiter analysis, external vision criticality for landing.
 - Boom autopilot development
 - Support V&V, envelope clearance, acoustic validation



X-57 Maxwell – Electric Aircraft

- Modified a Tecnam P2006T aircraft to be fully electric.
 - Mod II – Replace existing gas engines with electric cruise motors, inboard position on wing
 - Mod III – New higher aspect ratio wing, cruise motors moved to wing tips, and 12 smaller motors installed along wing but powered off.
 - Mod IV – 12 smaller motors powered on for high lift generation during takeoff and landing
- Currently aircraft is getting ready for Mod II flights.
- AFRC Control and Dynamics Role:
 - Dynamics analysis and handling qualities analysis of the various configurations
 - Simulation development for the various configurations
 - Failure modes and effects testing in simulation to determine effect of electric/motor failures.
 - Pilot training and emergency procedure development
 - Aircraft control surfaces are not fly by wire, however, potentially could do some interesting control methods with multi-motor configuration, not currently part of Mod IV though



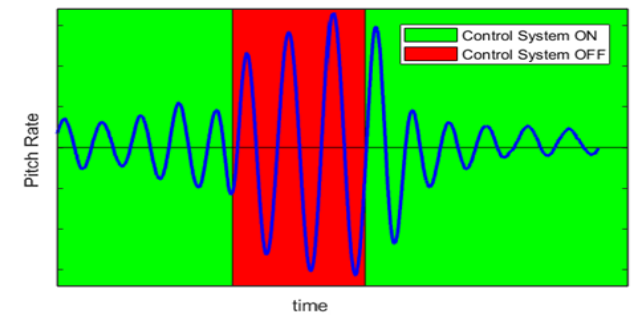
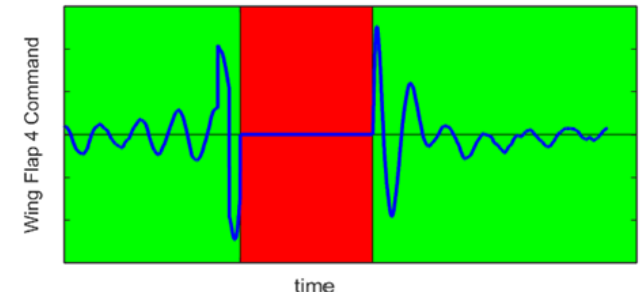
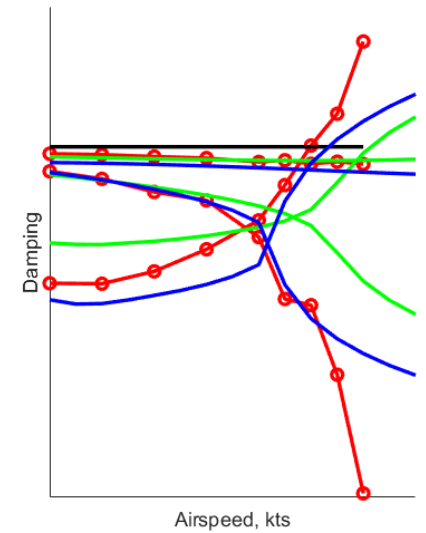
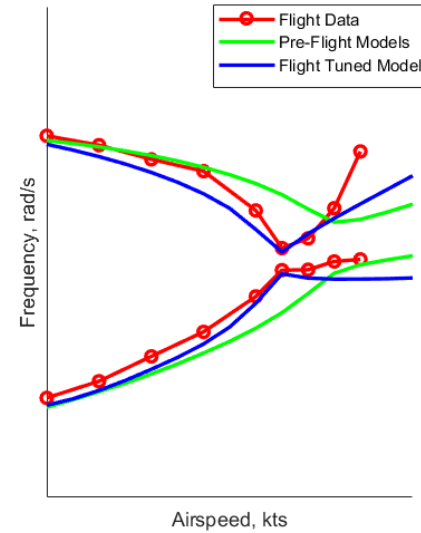
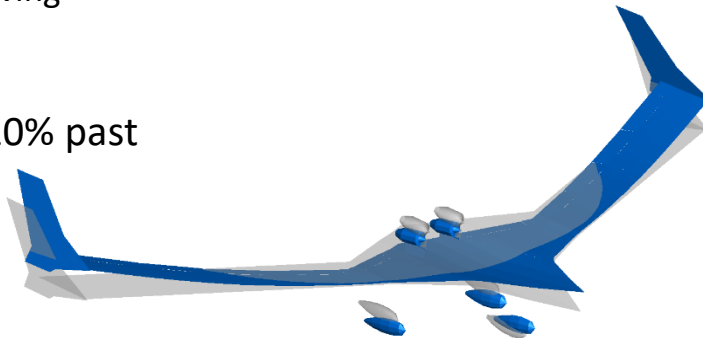
NASA/Ken Ulbrich

Sim Cockpit Instrument Panel



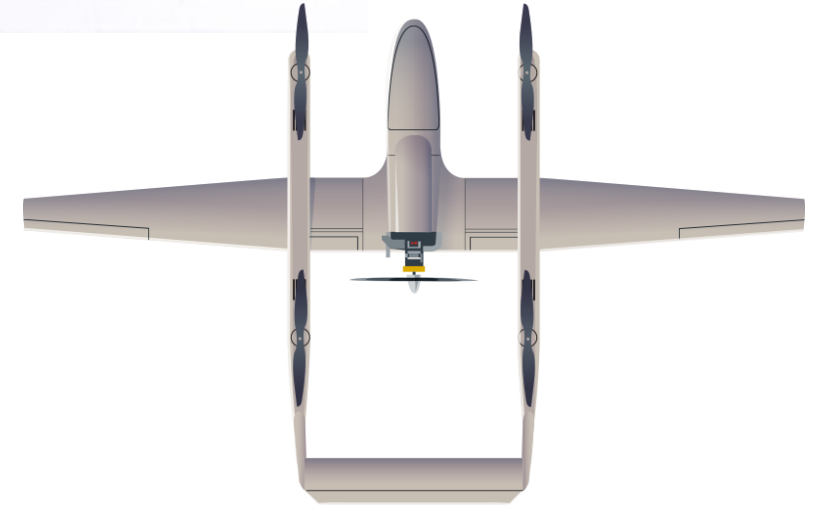
X-56A : Control of Flexible Structures

- The X-56A is a medium sized UAV (~500 lbs) designed with flexible wings, such that it has multiple flutter modes within its flight envelope.
 - Purpose is to demonstrate the use of active flight controls for suppression of flutter and to advance modeling methods for use in designing flutter suppression control laws
- AFRC Dynamics and Controls role
 - Model development
 - Control law development
 - Flight test
- Current status:
 - Successfully stabilized the first flutter mode.
 - Body-Freedom Flutter: short period and first wing bending coupled flutter mode.
 - Initial envelope expansion is complete and demonstrated controlled flight to air speeds 10% past flutter.



Resilient Autonomy

- **A certification approach to allow pilotless flight in public airspace**
 - An approach to a certifiable system that does not require a link to a human
 - Insures flight safety by bounding the behavior of the aircraft
- **AFRC Dynamics and Controls role**
 - Characterization of sensors such as radar, vision, ADS-B, etc. for detect and avoid (DAA) algorithms
 - Developing uncertainty models for sensors
 - Outer loop trajectory generation and command
 - Development of recommendations for autonomous system certification
- **Current status**
 - Started flight testing of low SWaP radar
 - Finished integration and V&V of trajectory generation code



DEP Flight Controls

- Highly Distributed Electric Propulsion (DEP) Systems will potentially benefit future aircraft designs of both eVTOL and Electric Regional Transports.
 - Greater Propulsive Efficiency
 - Propulsion-Airframe Interaction (PAI) Benefits
 - Smaller Tail and Control Surfaces
 - Improved Safety through Control Redundancy
- Establish new tools, methods, guidelines, and best practices for the design, implementation, analysis, and certification of integrated flight control / propulsion / power systems for DEP aircraft.
- Focus Areas:
 - Advanced Control Allocation for Command Tracking, Improved Efficiency, Thermal Management, and Failure Reconfiguration
 - Stability and Robustness of Integrated Flight Control and Power Systems
 - Impacts of DEP Flight Control on Aircraft Conceptual Design and Component Research and Development

