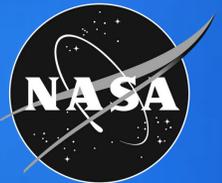




Integrated Flight and Propulsion Control (IFPC) Research

NASA Glenn Research Center
NASA Langley Research Center
Pratt & Whitney

National Aeronautics and
Space Administration



IFPC Description

- Currently, flight and propulsion controls are designed separately. Pilots integrate the two systems through the throttle.
- An integrated approach to flight and propulsion control system design will provide enhanced performance capability which can potentially increase airplane safety dramatically by allowing the use of propulsion system as a flight control effector.

Engines as Flight Effectors Benefits

- Control flight path and altitude
- Dampen oscillations
- Redundant means for effecting flight control
- Extra authority for loss of control prevention/recovery



United Flight 232 in Sioux City, IA
July 1989 - Total hydraulic failure



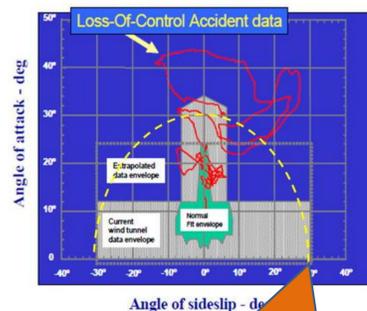
American Flight 587 in Queens,
NY, November 2001 - Excess
rudder motion

- Provides redundancy against aero surface failures
- Engines are mounted at structurally strong points
- Faster response engine control feasible

Approach

- Develop new integrated flight and propulsion controller architecture
- Develop control algorithms that can fully utilize the propulsion system as flight actuators with variable response time
- Develop a flight simulation platform that is suitable for IFPC research
- Demonstrate the impact of IFPC on
 - ✓ Envelope protection
 - ✓ Accommodation of actuator failures

Engine effective region



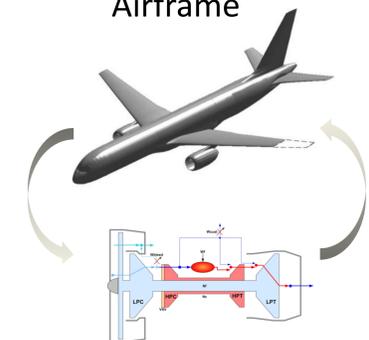
GRC Flight Simulator



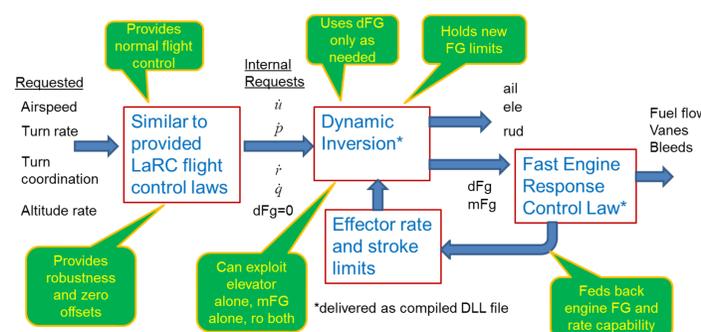
Recent Results

- Completed sensitivity study for engines as effectors using Transport Class Model (TCM).
- High level IFPC control architecture using constrained dynamic inversion (CDI) proposed.
- Completed the integration of C-MAPSS40k and TCM
- Implement the TCM/C-MAPS40k simulation in the new GRC flight simulator.

Integration of C-MAPSS40k and Airframe



High Level IFPC Control Law Architecture



Future Work

- Maturing IFPC control architecture
- Develop control algorithms for flight envelope protection using engines as effectors
- Demonstration of flight envelope protection using GRC flight sim
- Full scale integration of flight control and propulsion system using new IFPC architecture



Propulsion Control and Diagnostics
NASA Glenn Research Center
Controls and Dynamics Branch

Contact:

OA Guo

Ten-huei.guo-1@nasa.gov

Phone: 216-433-3734