Propulsion Control and Diagnostics Research under NASA Aeronautics Research Mission Programs

2nd NASA GRC PCD Research Workshop
Dec. 8-10, 2009, Cleveland, OH

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Glenn Research Center
Controls and Dynamics Branch at Lewis Field
Code RH Division Organizational Structure

RH Communications, Instrumentation and Controls Division
Division Chief: Gary Seng
Deputy for Communications: Calvin T. Ramos
Deputy for Instrumentations and Controls: M. V. Zeller

RHA Antennas and Optical Systems
Chief: F.A. Miranda

RHC Controls and Dynamics
Chief: S. Garg

RHD Radio and Signal Processing
Chief: G. Fujikawa

RHE Electronic Devices
Chief: R.N. Simons

RHI Optical Instrumentation and NDE
Chief: G.Y. Baaklini

RHN Networks and Architectures
Chief: D.S. Ponchak

RHS Sensors and Electronics
Chief: L.G. Matus

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Controls & Dynamics Branch Overview

• Mission
  – Research, develop and verify aerospace propulsion dynamic modeling, health management, control design and implementation technologies that provide advancements in performance, safety, environmental compatibility, reliability and durability
  – Facilitate technology insertion into the mainstream aeropropulsion community

• Capabilities
  – 20+ engineers and scientists - most with advanced degrees and extensive experience in aeropropulsion controls related fields
  – Extensive computer-aided control design and evaluation facilities including real-time and man-in-the-loop simulation facility
  – Strong working relationship with controls technology groups in the aerospace propulsion industry, academia and other agencies
Intelligent Propulsion Systems
Control System perspective

Multifold increase in propulsion system Affordability, Capability
Environmental Compatibility, Performance, Reliability and Safety

Active Control Technologies
for enhanced performance and reliability, and reduced emissions
- active control of combustor, compressor, vibration etc.
- MEMS based control applications

Advanced Health Management technologies for self diagnostic and prognostic propulsion system
- Life usage monitoring and prediction
- Data fusion from multiple sensors and model based information

Distributed, Fault-Tolerant Engine Control for enhanced reliability, reduced weight and optimal performance with system deterioration
- Smart sensors and actuators
- Robust, adaptive control

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ARMD Guidance

The Three Principles

• NASA is dedicated to the mastery and intellectual stewardship of the core competencies of Aeronautics for the Nation in all flight regimes

• Research will focus in areas that are appropriate to NASA’s unique capabilities

• NASA will directly address the needs of the Next Generation Air Transportation System (NGATS) in partnership with the member agencies of the Joint Planning and Development Office (JPDO)
ARMD Guidance
Research Philosophy

Technologies & Capabilities

System Design

Multi-Discipline Capabilities

Discipline Level Capabilities

Fundamental Physics & Modeling

Requirements/Needs
ARMD Guidance

Impact on Partnerships

- NASA will take responsibility for the intellectual stewardship of the core competencies of Aeronautics for the Nation.
  - Ensures the availability of a world class resource (personnel, facilities, knowledge and expertise) ready to be drawn upon by our Government partners (e.g., DoD, FAA, JPDO) and by the private sector.

- University partnerships
  - We will integrate students and faculty as true partners in our research projects.
    - Enables replenishment of workforce at both NASA and in industry.
  - Full and open competition for funds.

- Industry partnerships
  - We will shift from near-term, evolutionary procurements to long-term, intellectual partnerships.
    - Ensures ability to provide long-term, stable investment in capabilities that will benefit all of industry.
NASA ARMD Management Structure

Program Director - HQ

Project PI, PM, PS - Centers

Discipline API, APM

Elements Leads

Tasks Leads

- Each Center: ARC, DFRC, GRC, LaRC; has a center Point of Contact (PoC) who coordinates with Program Directors and Project PIs
- Line Management coordinates with APIs and Element/Task Leads

Fig. 4.3.2-1 from NPD 1000

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Propulsion Control for Fundamental Aeronautics

Fundamental Aeronautics Program

Subsonic Fixed Wing
- Distributed Engine Control
- Active Flow Control for Compression Systems
- Unsteady Combustion / Ejector Systems

Supersonics
- Active Combustion Control
- Integrated inlet / engine control

Hypersonics
- High Speed propulsion dynamic modeling and control
- Mode Switch management

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Propulsion Control and Diagnostics for Aviation Safety

Aviation Safety Program

Integrated Vehicle Health Management
- Gas Path health management
  - Model-Based on-line diagnostics
  - Optimal sensor selection
  - Benchmark diagnostics problem

Integrated Resilient Aircraft Control
- Integrated Propulsion Control and Dynamics
  - Rapid and high thrust response to use propulsion system as an effective actuator for flight control in the presence of aircraft damage
  - On-board life assessment for life/performance trade-off
  - Intelligent propulsion control for mitigating deterioration effects

IIFD
AAD

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Propulsion Control and Diagnostics Support for Exploration Systems

Exploration System Mission Directorate

- Sensor Data Qualification System
  - Part of Advanced Sensor Task
  - Provide a validated analytical redundancy-based methodology for on-board data qualification of sensors with application to various Upper Stage subsystems.

- Thrust Vector Control Modeling and Performance Evaluation
  - Part of SE&I (Systems Engineering & Integration) Task
  - Develop integrated TVC subsystem models for performance assessment relative to requirements. Perform fault propagation & timing studies to identify health management needs.

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Collaboration Opportunities

• NRA (NASA Research Announcements)
  – Open to industry and universities
  – Very focused on specific topics
  – Announced by Projects on a periodic basis
    http://www.aeronautics.nasa.gov/nra.htm

• SBIR (Small Business Innovative Research)
  – Open to small businesses
  – Very broad areas of call
    • Fundamental Aeronautics – Flight and Propulsion Control and Dynamics (A2.07)
    • Aviation Safety – IVHM: Advanced Health Management for Aircraft Subsystems (A1.07)
    • Aviation Safety – IRAC: Engine Lifing and Prognosis for In-Flight Emergencies (A1.08)

• Space Act Agreement – no direct NASA funding
  – Open to industry/universities/govt. agencies
  – Ideal for collaboration on mutual areas of interest without exchange of funds or with inflow of funds to NASA efforts
  – Opportunity for industry to leverage NASA investment in projects

• Student and Faculty Programs
  – http://www.nasa.gov/centers/glenn/education/index.html

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