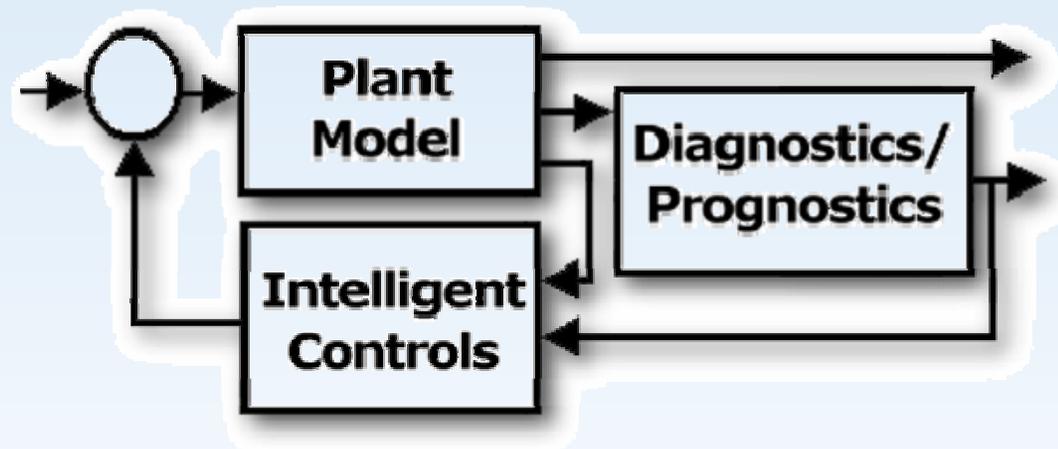


Propulsion Control and Diagnostics Research under NASA Aeronautics Research Mission Programs



Workshop at Ohio Aerospace Institute, Cleveland OH
Nov. 6-7, 2007

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Controls and Dynamics Branch

at Lewis Field



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

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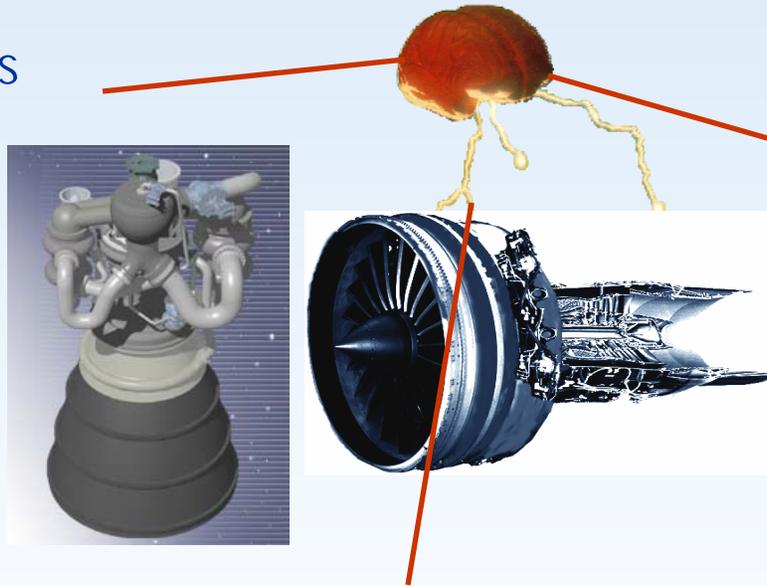


Intelligent Propulsion Systems Control System perspective

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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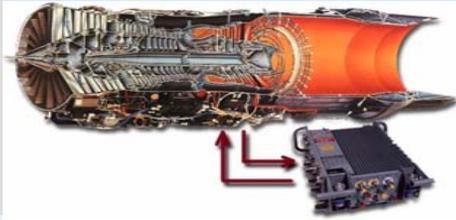
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Scope of Work

Propulsion Controls



Active Clearance Control

- Clearance Modeling
- Mechanical/Smart Materials Actuation Requirements

Active Flow Control

- High Bandwidth Actuation
- Stall Control
- Smart Vanes
- Turbine Film Cooling Control

Active Combustion Control

- Emission Minimization
- Control of Thermo-acoustic Instability

Advanced Control Logic

- Intelligent Adaptive Control
- Life Extending Control
- Resilient Propulsion Control

Health Management



Propulsion & Power Systems

- Sensor Selection
- Sensor Validation
- Fault Diagnostics
- Prognostics
- Post Test Diagnostic Systems
- Communication Requirements
- Real-Time Implementation Issues

Current NASA Programs

Aeronautics Research Mission

- Fundamental Aeronautics
- Aviation Safety

Exploration Systems Mission

- Crew Launch Vehicle

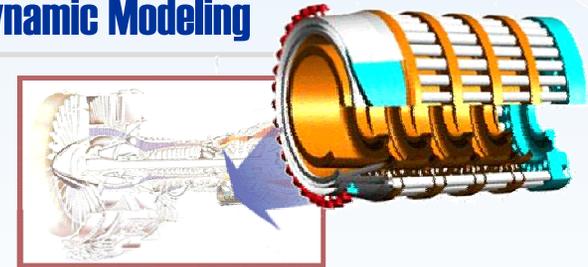
Autonomy



Maintainability & Reliability

- Autonomous Mobile Robotic Inspection & Repair

Dynamic Modeling



Advanced Propulsion Concepts

- Pulse Detonation Engine
- Fuel Cell Powered Aircraft
- Wave Rotors
- High-speed Systems

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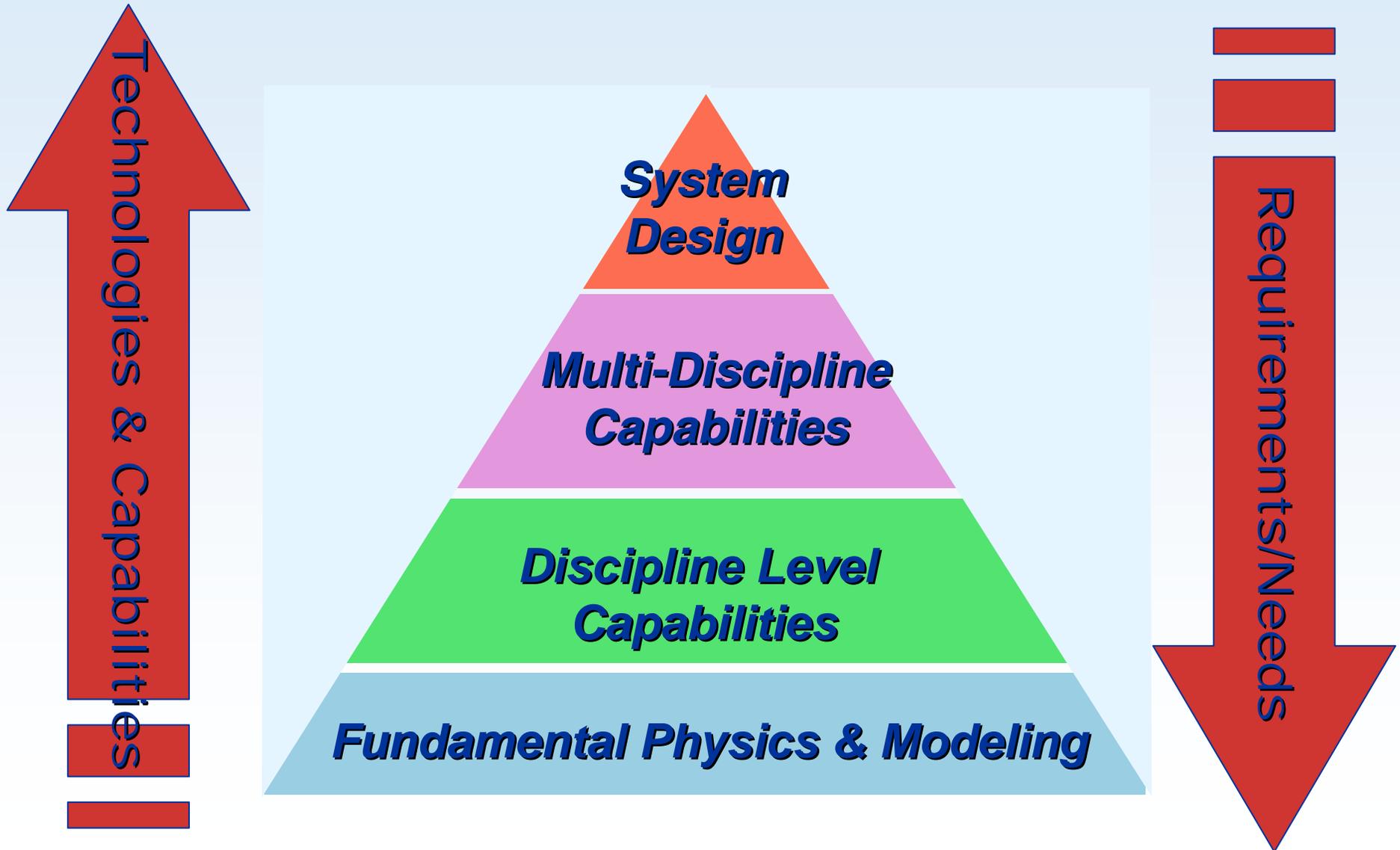
ARMD Guidance

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



ARMD Guidance

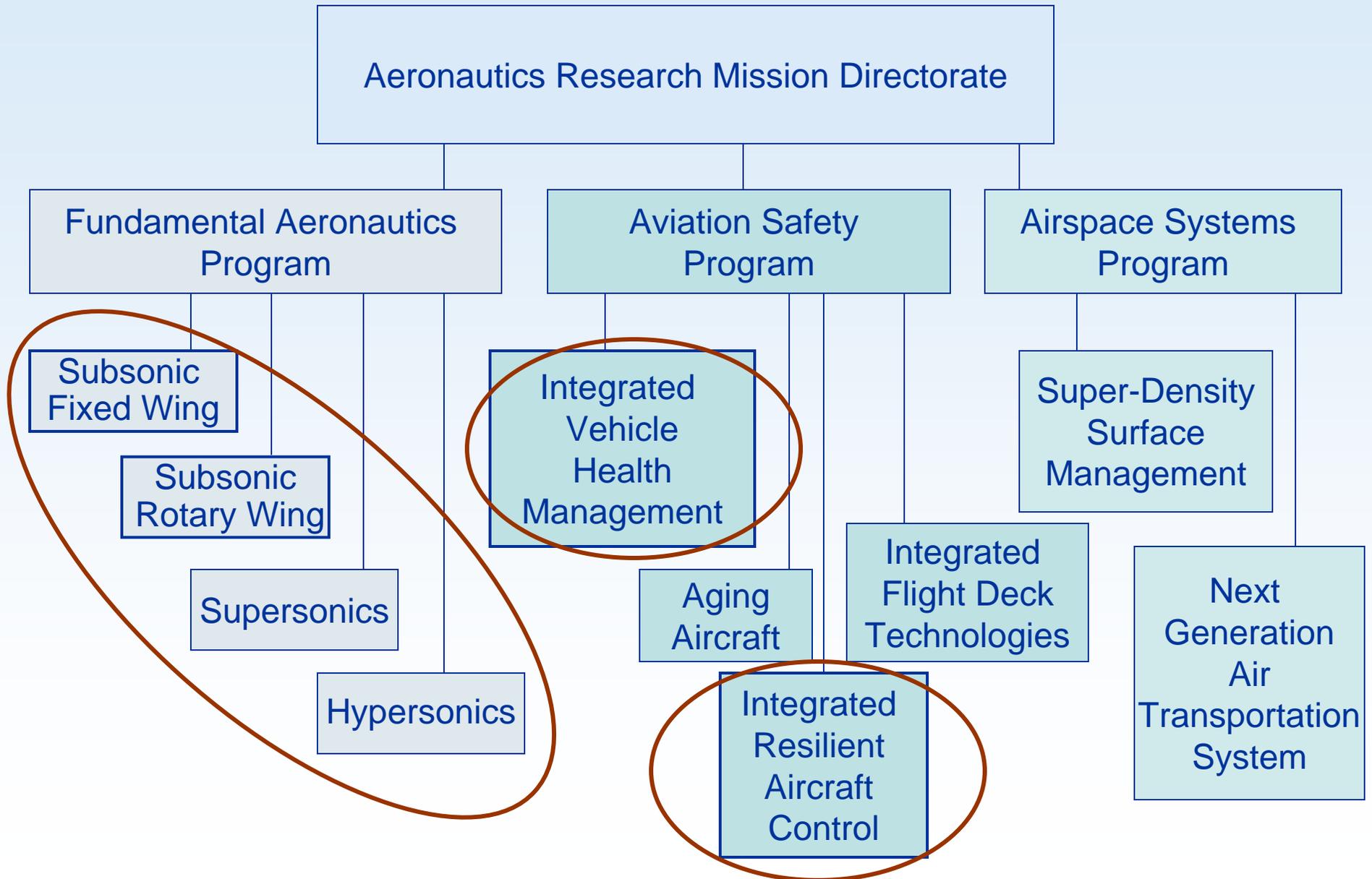


Impact on Partnerships

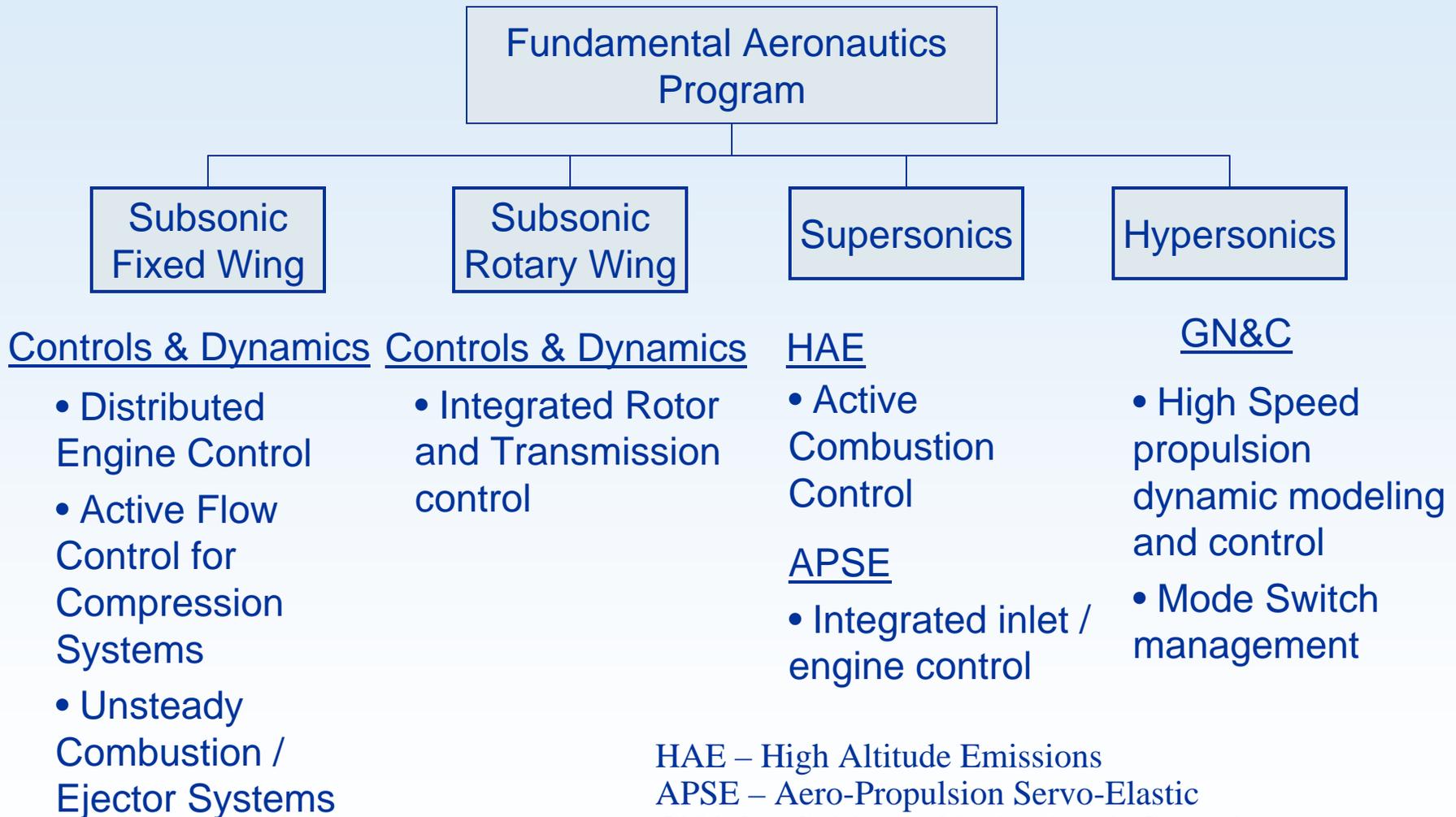
- NASA will take responsibility for the intellectual stewardship of the core competencies of Aeronautics for the Nation.
 - Ensures the availability of a world class resource (personnel, facilities, knowledge and expertise) ready to be drawn upon by our Government partners (e.g., DoD, FAA, JPDO) and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



Propulsion Control for Fundamental Aeronautics



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Propulsion Control and Diagnostics for Aviation Safety



- Gas Path health management
- Systematic Sensor Selection

- Control concepts and architecture for propulsion system to be an effective actuator for flight control in the presence of aircraft damage
 - Adaptive propulsion controls and risk management

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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)
- **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

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