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Reshaping NASA's Aeronautics Program

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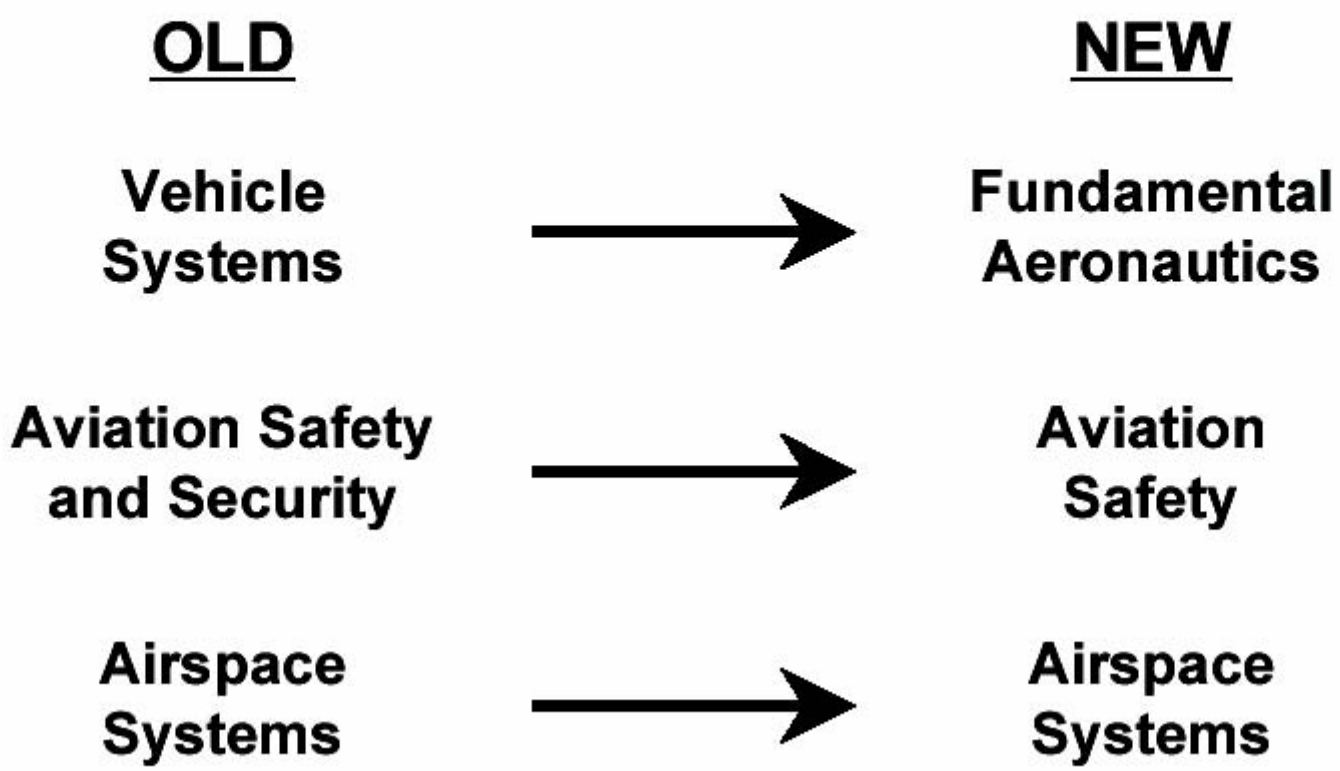
The Three Principles

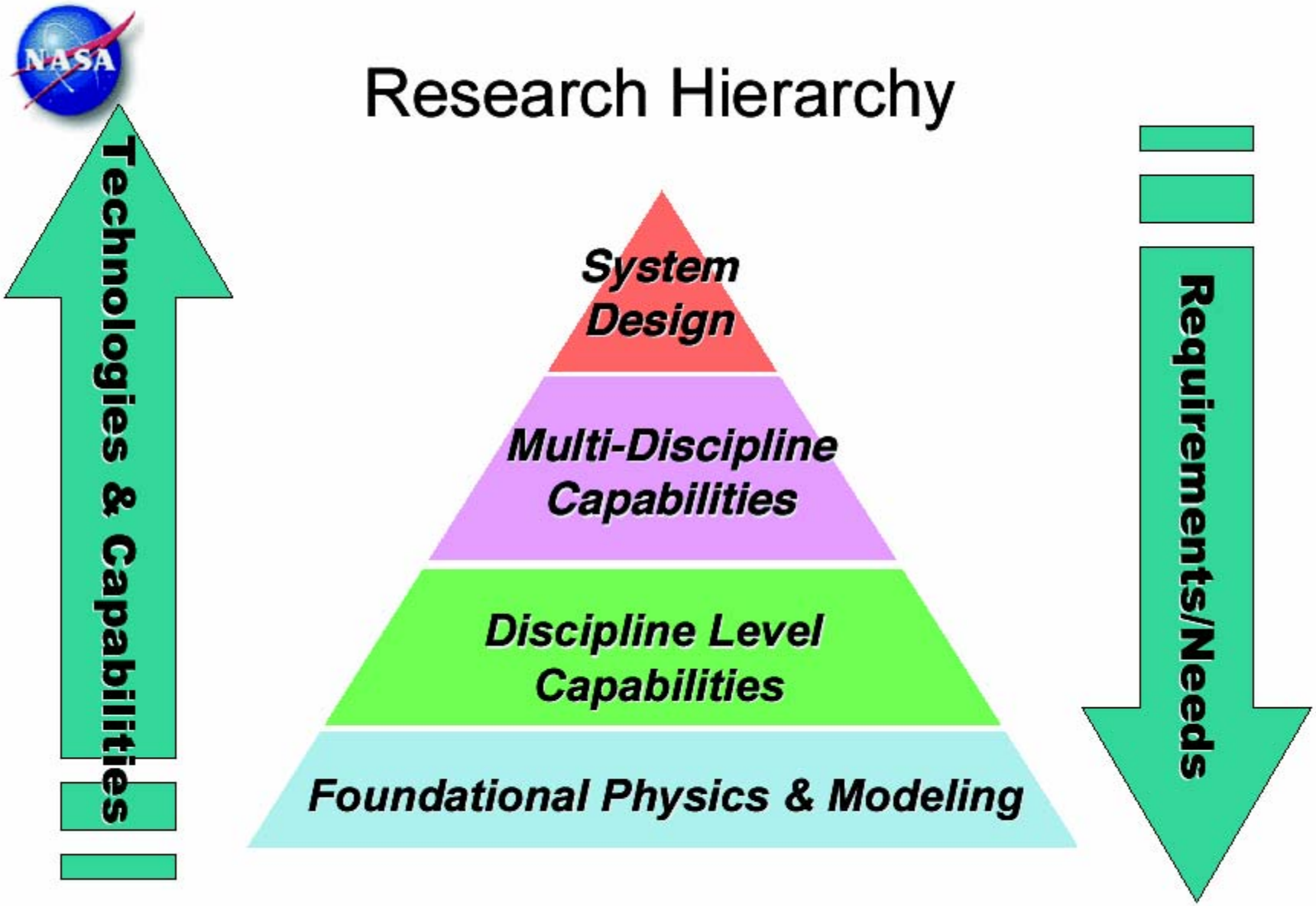
- We will dedicate ourselves to the mastery and intellectual stewardship of the core competencies of Aeronautics for the Nation in all flight regimes.
- We will focus our research in areas that are appropriate to NASA's unique capabilities.
- We will directly address the R&D needs of the Next Generation Air Transportation System (NGATS) in partnership with the member agencies of the Joint Planning and Development Office (JPDO).

Re-shaping Aeronautics



Re-shaping Aeronautics

- **Fundamental Aeronautics Program (FAP)**
  - We will conduct long-term, cutting-edge research in the core competencies of aeronautics in all flight regimes, producing knowledge/data/capabilities/ design tools that are applicable across a broad range of air vehicles.
  - Four thrust areas:
    - Hypersonics
    - Supersonics
    - Subsonics: fixed wing
    - Subsonics: rotary wing
- **Aviation Safety Program (AvSP)**
  - We will build upon our unique safety-related research capabilities to…
    - Improve the inherent safety attributes of new and legacy vehicles.
    - Overcome aircraft safety technological barriers that would otherwise constrain the full realization of the NGATS.
- **Airspace Systems Program (ASP)**
  - We will directly address the Air Traffic Management R&D needs of the NGATS as defined by the Joint Planning & Development Office (JPDO).
- **Aeronautics Test Program (ATP)**
  - We will protect and maintain our key research and test facilities.


Research Hierarchy
Technologies & Capabilities
Requirements/Needs
System Design
Multi-Discipline Capabilities
Discipline Level Capabilities
Foundational Physics & Modeling

Approach

Use Space Act Agreements to collaborate with industry; Establish partnerships with other Govt agencies (FAA, DOD, JPDO).

Develop system-level capabilities to enable our civilian and military partners to develop revolutionary systems to meet their needs.

Level 4

NASA development of multidisciplinary methods and technologies.

Integrate methods and technologies to develop multi-disciplinary solutions.

Level 3

NASA development of discipline-related solutions.

Leverage the foundational research to develop technologies and analytical tools focused on discipline-based solutions.

Level 2

Use NASA Research Announcements (NRAs) to solicit proposals for foundational research in areas where NASA needs to enhance its core capabilities.

Conduct foundational research to further our fundamental understanding of the underlying principles.

Level 1

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.

Four-Step Planning Process

Step 1: Assess the long-term research needs and goals in Fundamental Aeronautics and establish technical roadmaps to accomplish those goals.

Step 2: Solicit information on key areas of interest from the external community and determine opportunities for collaboration through an RFI

Step 3: Define research proposals at the field centers

Step 4: Issue a NASA Research Announcement to solicit proposals for foundational research

Planning Details and Status

Step 1: Technical Roadmaps

- Conducted workshops to develop 10-year schedule/milestone roadmaps for each Project in each Program.
- Cross-cutting workshops held to identify research areas of overlap and collaboration across Projects and Programs.
- Workshop results presented to Government partners (DoD, FAA and JPDO).
- Roadmaps presented at 2006 AIAA Reno Conference and subsequently posted on NASA website.

Step 2: Request for Information

- Released RFIs to solicit interest from industry to collaborate at the system level. The RFIs:
  - Expressed interest in collaborations in pre-competitive research to benefit industry broadly.
  - Stated that Industry work would be conducted on a non-reimbursable basis.
- All RFI responses (~ 240 total) were provided to targeted Projects for consideration as part of their research proposal submissions.

RFI Release…….. 3 Jan 2006
RFI Responses Due:……..31 Jan 2006

Step 3: Proposals

- Researchers develop proposals that include partnerships with industry & OGA.
- Proposals underwent HQ peer-review. Peer-review panels included Government SMEs from:
  - USAF - FAA - US Army
  - DARPA - JPDO - NOAA
- Proposals underwent a simultaneous, independent review conducted by the 4 research centers
- Proposals were evaluated based on the following criteria: Technical Plan, Resource Allocation, Management Plan & Partnership Plan

Step 4: NRA

- Proposals that are approved will release NASA Research Announcements (NRAs) for foundational research.

NRA Est Release……..…… 24 May 2006
NRA Response …….. 7 July 2006

- NRAs will provide full and open competition.
- NRAs reviewed and selections will be announced by end of 2006.
- Prepare for Phase 2 NRA Release

Fundamental Aeronautics

Research Thrusts

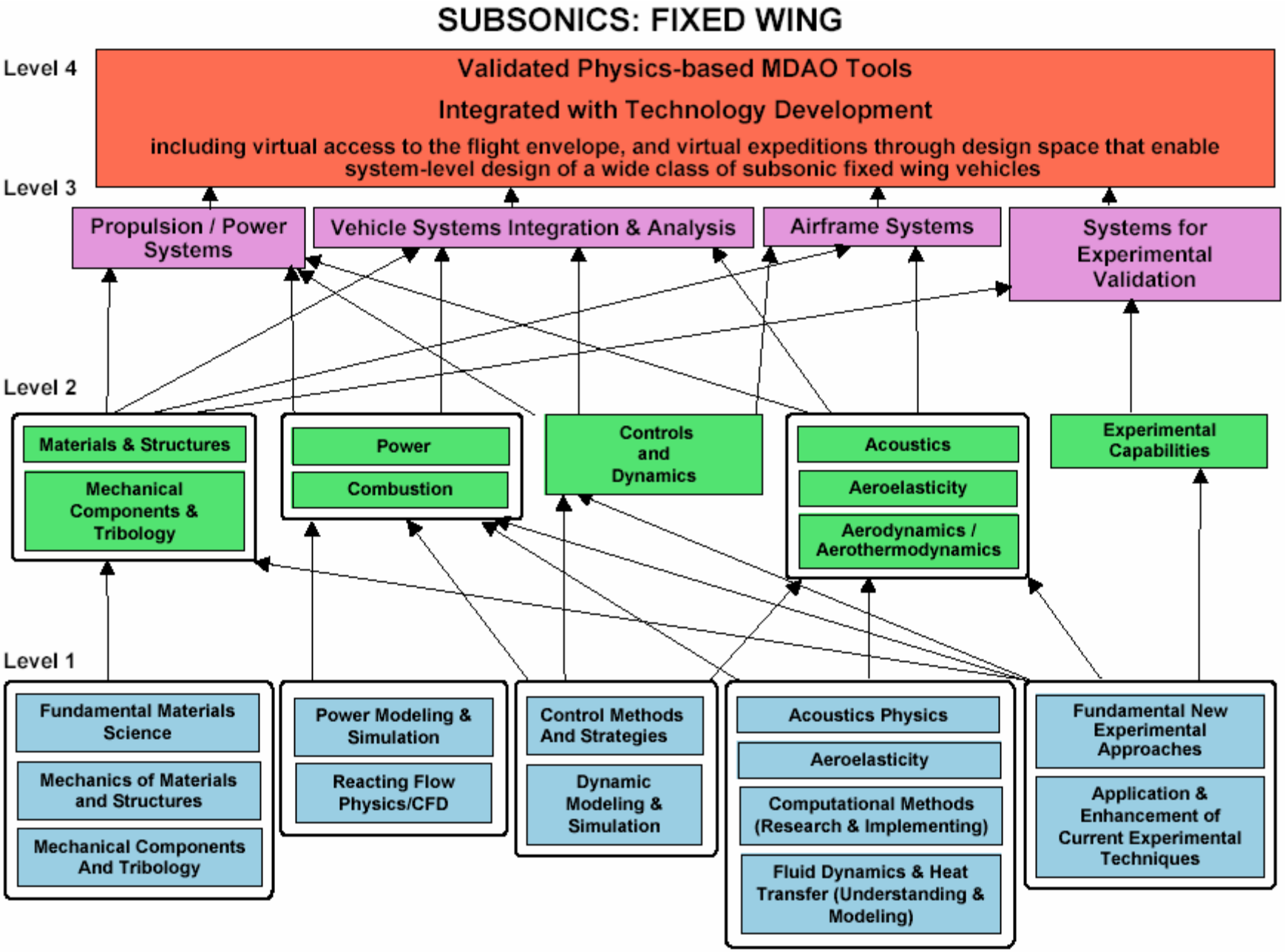
Hypersonics	Subsonics: Rotary Wing	Subsonics: Fixed Wing	Supersonics

Objective

- Development of system-level, multi-disciplinary capabilities for both civilian and military applications
- Provide long-term investment in research to support and sustain expert competency in critical core areas of aeronautics technology

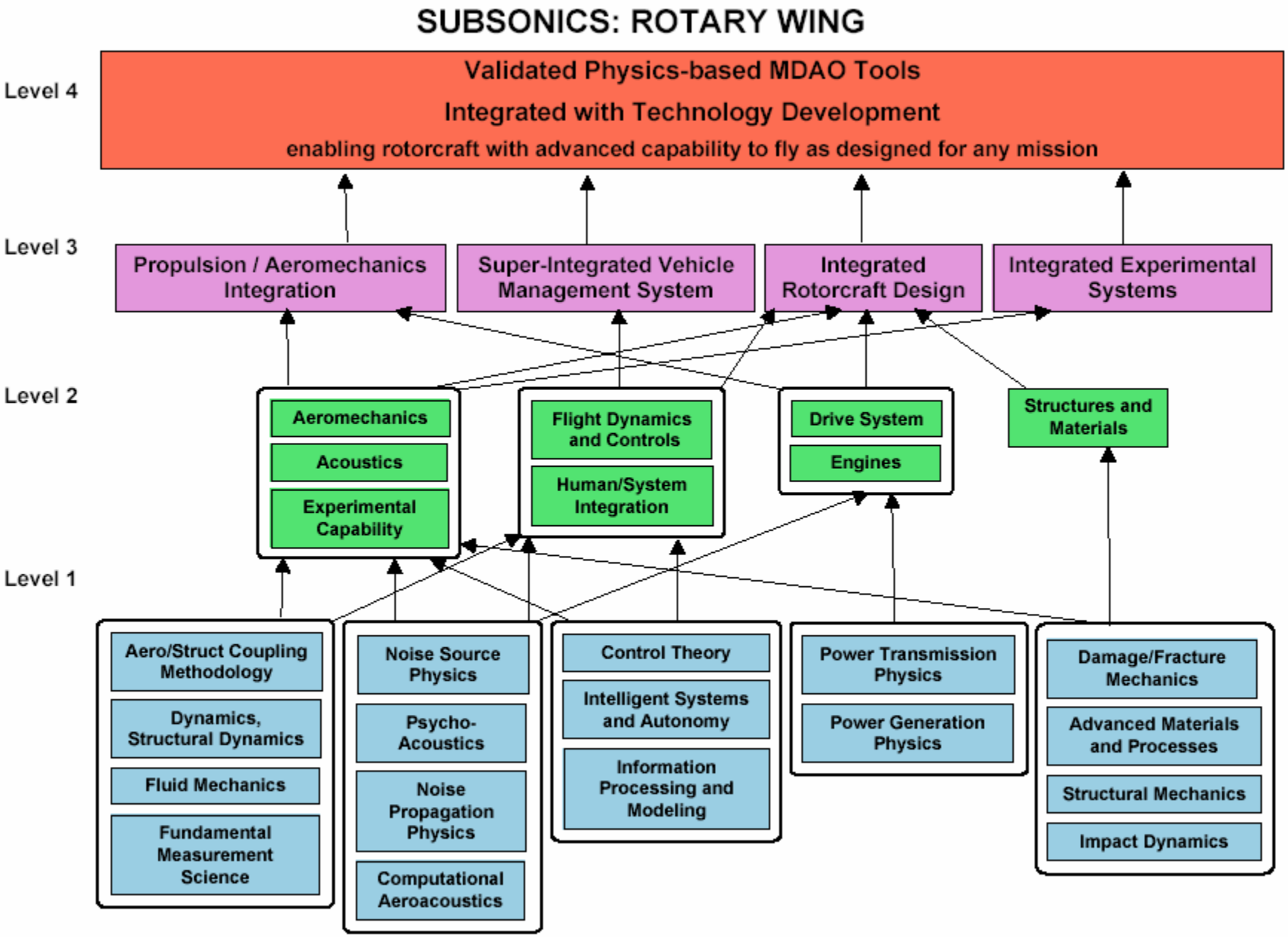
Results

- Technology innovation and integrated, multidisciplinary analysis tools to:
  - Provide rapid evaluation of new concepts and technology
  - Accelerate the application of new technology to a wide array of vehicles
  - Reduce the environmental impact and increase the public benefit of future aircraft: lower emissions, less noise, higher efficiency, safer operation


SUBSONICS: FIXED WING
Level 4
Validated Physics-based MDAO Tools
Integrated with Technology Development
including virtual access to the flight envelope, and virtual expeditions through design space that enable system-level design of a wide class of subsonic fixed wing vehicles
Level 3
Propulsion / Power Systems
Vehicle Systems Integration & Analysis
Airframe Systems
Systems for Experimental Validation
Level 2
Materials & Structures
Mechanical Components & Tribology
Power
Combustion
Controls and Dynamics
Acoustics
Aeroelasticity
Aerodynamics / Aerothermodynamics
Experimental Capabilities
Level 1
Fundamental Materials Science
Mechanics of Materials and Structures
Mechanical Components And Tribology
Power Modeling & Simulation
Reacting Flow Physics/CFD
Control Methods And Strategies
Dynamic Modeling & Simulation
Acoustics Physics
Aeroelasticity
Computational Methods (Research & Implementing)
Fluid Dynamics & Heat Transfer (Understanding & Modeling)
Fundamental New Experimental Approaches
Application & Enhancement of Current Experimental Techniques

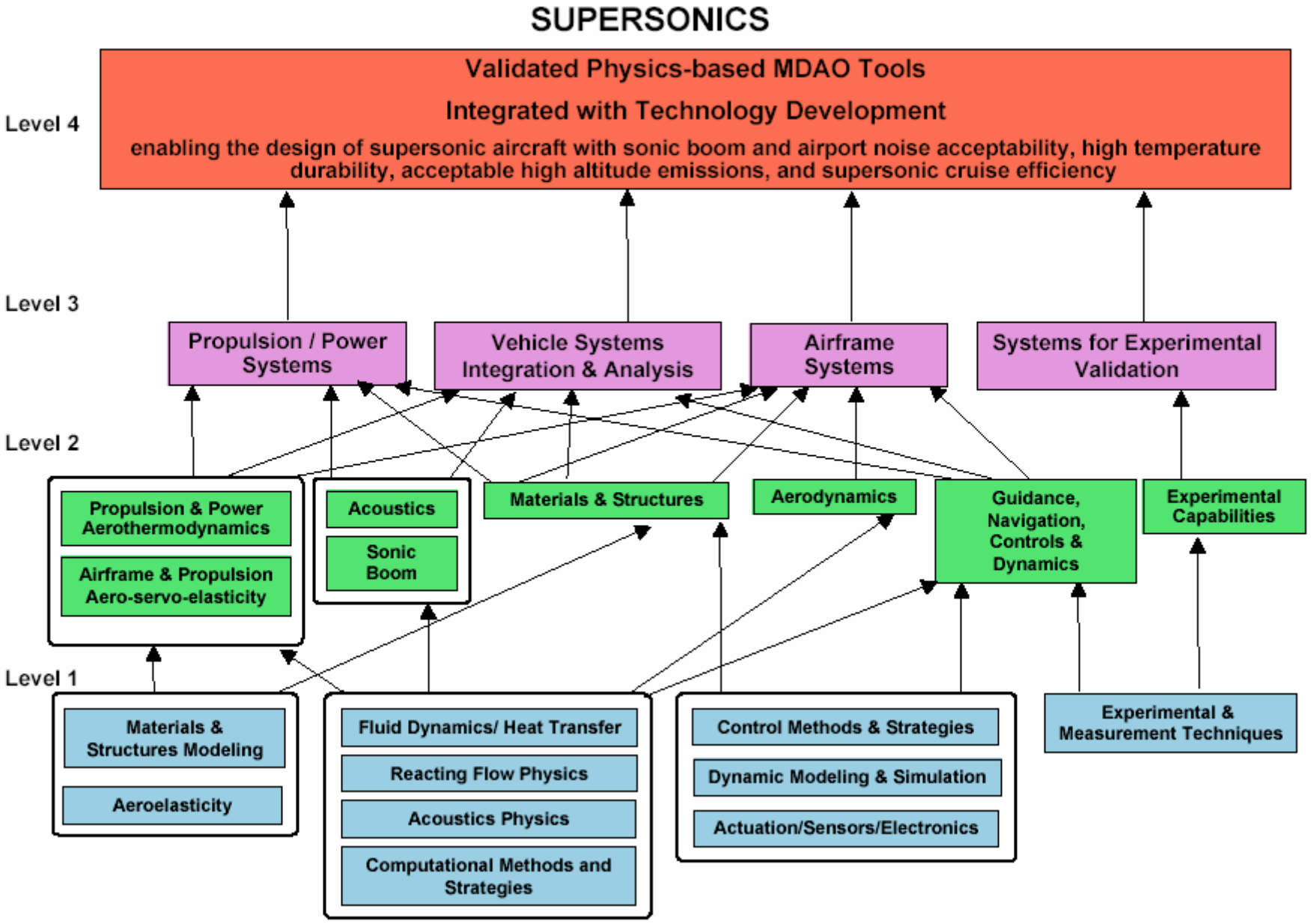
Subsonics Fixed Wing: Research Topics

Propulsion and Power Systems	Alternative propulsion and power concepts
	Materials and structures technologies for durable, active, multi-functional propulsion and power systems
	Advanced technologies for intelligent engines, and engine icing characteristics
Vehicle Integration and Analysis	Engine and airframe noise source decomposition
	Advanced control techniques and autonomous control architectures
	Aeroelastic analysis methods
Airframe Systems	Metallic, composite, and hybrid materials and structures, analysis methods for property characterization
	Multifunctional materials and structures concepts
	Advanced materials, processing and manufacturing technologies
	Expanded design space enabled by high-lift design, edge of envelope stability and control
	Enhanced physics-based noise prediction, integrated aerodynamic, acoustic, and structural advanced analysis tool
Systems for Experimental Validation	Autonomous testbeds
	High-fidelity piloted simulations, and instrumentation with new capabilities integrated into multidisciplinary system validated with flight tests as appropriate


SUBSONICS: ROTARY WING
Level 4
Validated Physics-based MDAO Tools
Integrated with Technology Development
enabling rotorcraft with advanced capability to fly as designed for any mission
Level 3
Propulsion / Aeromechanics Integration
Super-Integrated Vehicle Management System
Integrated Rotorcraft Design
Integrated Experimental Systems
Level 2
Aeromechanics
Acoustics
Experimental Capability
Flight Dynamics and Controls
Human/System Integration
Drive System
Engines
Structures and Materials
Level 1
Aero/Struct Coupling Methodology
Dynamics, Structural Dynamics
Fluid Mechanics
Fundamental Measurement Science
Noise Source Physics
Psycho-Acoustics
Noise Propagation Physics
Computational Aeroacoustics
Control Theory
Intelligent Systems and Autonomy
Information Processing and Modeling
Power Transmission Physics
Power Generation Physics
Damage/Fracture Mechanics
Advanced Materials and Processes
Structural Mechanics
Impact Dynamics

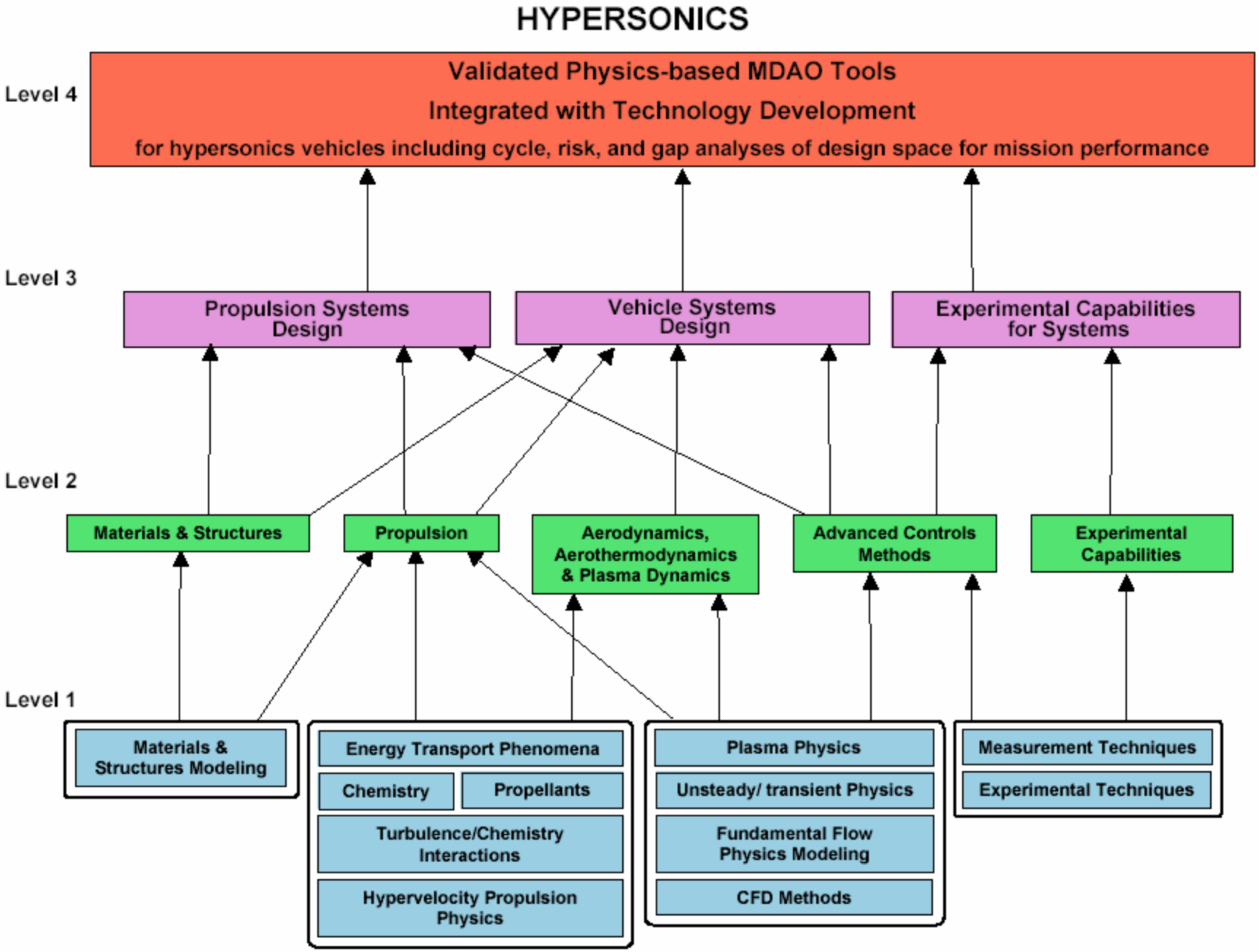
Subsonics Rotary Wing: Research Topics

Propulsion-Aeromechanics Integration	Variable speed drive systems
	Minimal or no-lubricant transmission concepts
	Life extension component technologies
	Alternative engine designs to address on-condition health management and interior noise
Super-Integrated Health Management System	Simulations and flight test to validate investigative results of active-control techniques
	Adaptive displays to address control system design capabilities
Integrated Rotorcraft Design	Aeromechanics and aeroacoustics predictive design capabilities for various size and flight regime operations
Integrated Experimental Systems	Methodology for real-time comparison of computational fluid- and structural-dynamics with experimental data
	Integrated diagnostic instrumentation systems into facilities for operational efficiency
	Simultaneous, multi-parameter diagnostic techniques that enable rapid testing and validation of rotorcraft behavior


SUPERSONICS
Level 4
Validated Physics-based MDAO Tools
Integrated with Technology Development
enabling the design of supersonic aircraft with sonic boom and airport noise acceptability, high temperature durability, acceptable high altitude emissions, and supersonic cruise efficiency
Level 3
Propulsion / Power Systems
Vehicle Systems Integration & Analysis
Airframe Systems
Systems for Experimental Validation
Level 2
Propulsion & Power Aerothermodynamics
Airframe & Propulsion Aero-servo-elasticity
Acoustics
Sonic Boom
Materials & Structures
Aerodynamics
Guidance, Navigation, Controls & Dynamics
Experimental Capabilities
Level 1
Materials & Structures Modeling
Aeroelasticity
Fluid Dynamics/ Heat Transfer
Reacting Flow Physics
Acoustics Physics
Computational Methods and Strategies
Control Methods & Strategies
Dynamic Modeling & Simulation
Actuation/Sensors/Electronics
Experimental & Measurement Techniques

Supersonics Research Topics

Propulsion and Power Systems	Tools to predict propulsion system noise, efficiency and high altitude emissions
	Reduced emissions combustor predictive capability
	Variable geometry nozzle aerodynamic predictive capability
	Multi-fidelity engine-aircraft structural simulation
	Ice accretion prediction
	High-pressure recovery predictive capability
	Low distortion and unstart mitigation inlets, integrated inlet-fan-nozzle predictive capability for steady-state and transient conditions
Vehicle Systems Integration and Analysis	Tools to predict integrated vehicle performance, noise and sonic boom,
	Installed propulsion system noise-performance trades for supersonic propulsion cycles, and integrated inlet-fan-nozzle
Airframe Systems	Tools to predict airframe noise, lift-drag, flight dynamics, stability and handling qualities
	High-fidelity computation method for achieving simultaneous gust and maneuver loads, ride quality due to elasticity, and flutter suppression control
Systems for Experimental Validation	Systems for experimental validation of capabilities for field noise measurements and techniques
	Requirements for national facilities to support propulsion and airframe systems tests


HYPERSONICS
Level 4
Validated Physics-based MDAO Tools
Integrated with Technology Development
for hypersonics vehicles including cycle, risk, and gap analyses of design space for mission performance
Level 3
Propulsion Systems Design
Vehicle Systems Design
Experimental Capabilities for Systems
Level 2
Materials & Structures
Propulsion
Aerodynamics, Aerothermodynamics & Plasma Dynamics
Advanced Controls Methods
Experimental Capabilities
Level 1
Materials & Structures Modeling
Energy Transport Phenomena
Chemistry
Propellants
Turbulence/Chemistry Interactions
Hypervelocity Propulsion Physics
Plasma Physics
Unsteady/ transient Physics
Fundamental Flow Physics Modeling
CFD Methods
Measurement Techniques
Experimental Techniques

Hypersonics Research Topics

Propulsion Systems Design	Technology development for Turbine Based Combine Cycle (TBCC) and Rocket Based Combined Cycle (RBCC) propulsion systems to aid mode transition between low-speed and high-speed flowpaths, and address engine system thermal management and inlet operability
	Materials for cryogenic tanking applications
Vehicle Systems Design	Technologies to address the physics of combustion, hypersonic flows, and entry, descent and landing
	Lightweight high temperature materials for rotating and static components
	Structural durability analysis methods including deterministic and probabilistic life prediction techniques and non-destructive evaluation
	Material and structure alternatives for vehicle hot structures
	Methods and materials for developing improved thermal protection systems for extreme flight regimes of hypersonic flight
Experimental Capabilities for Systems	Methods for a single extreme environment sensor to measure multiple flow and structural values
	Optical sensors for flow characterization
	Multi-discipline control techniques for health monitoring
	Air data system allowing air-ground communication with the vehicle traveling Mach 12+ along the horizon

Aviation Safety Program

Research Thrusts

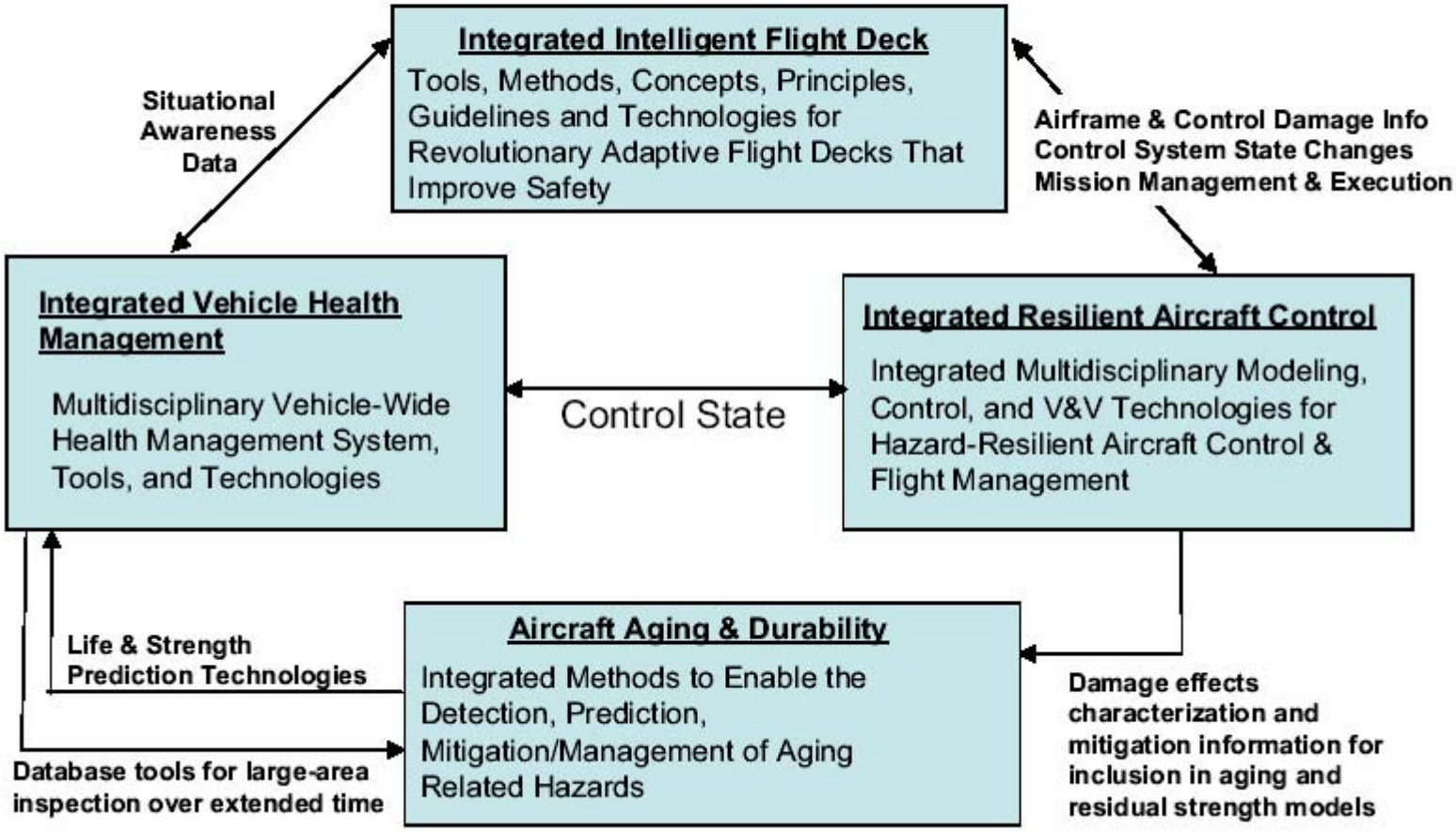
Integrated Vehicle Health Management	Integrated Intelligent Flight Deck	Integrated Resilient Aircraft Control	Aircraft Aging & Durability

Develop technologies, tools, and methods to:

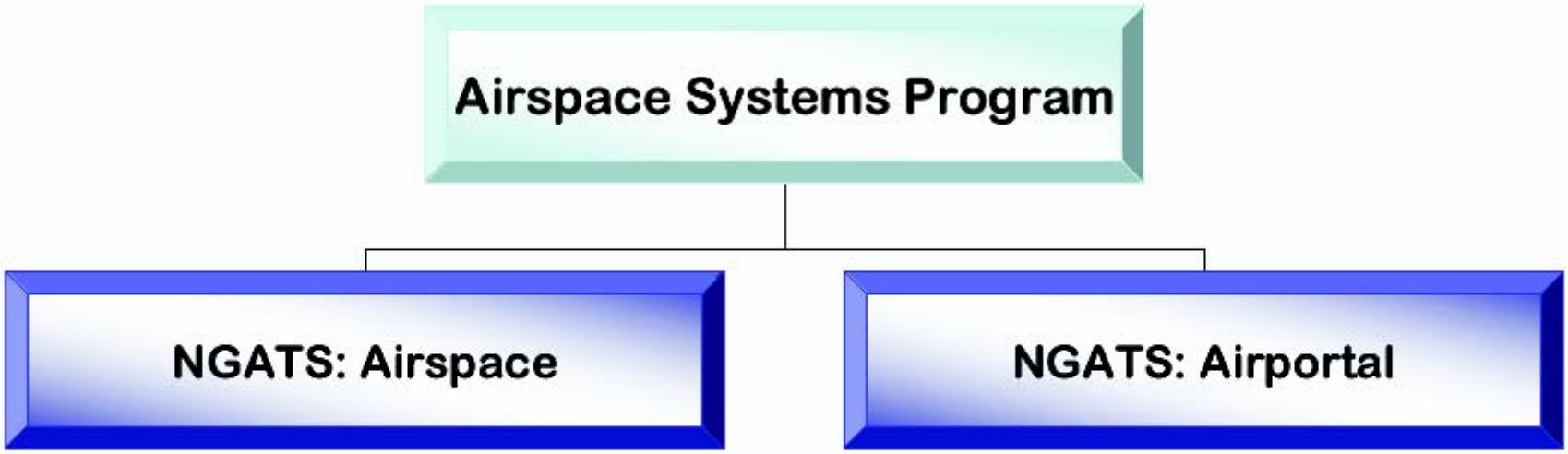
- Improve inherent safety attributes of new and legacy vehicles
- Overcome safety technology barriers that would otherwise constrain full realization of the Next Generation Air Transportation System

Aviation Safety Program

Project Area Interdependencies - Examples



ASP Structure



Program Elements developed through a rigorous technical workshop process. Workshop participants comprised NASA Aeronautics' best and most experienced ATM technical experts.

AS Program Deliverables

Integrated Solutions for a Safe, Efficient and High-Capacity Airspace System
Evaluator: Strategic, NAS level
4D Trajectory Operations: Strategic, NAS level
Automated Separation Assurance
Dynamic Airspace

Integrated Solutions for Safe, Efficient and High-Capacity Airportals
Evaluator: Terminal and airport surface level
4D Trajectory Operations: Terminal and airport surface level
Super-Density Optimization

- AS Program is aligned with JPDO plans as articulated through NGATS capabilities and roadmaps.
- Consistent with NGATS requirements, key AS Program elements will address:
  - Evaluator (Strategic and terminal area focused)
  - 4-D Trajectory Based Operations (Strategic and terminal area focused)
  - Automated Separation Assurance
  - Dynamic Airspace Configuration
  - Super-Density Surface and Terminal Area Traffic Optimization

AS Program Deliverables (cont.)

- Airspace and Airportal deliverables will be integrated for gate-to-gate solutions.
  - Projects have been defined by domains.
  - Technical discipline overlap exists between these two projects.
  - Development of Airportal products will substantially leverage fundamental technology advances made in Airspace.
- Program elements were developed with a focus on technical R&D needs.
- Prioritization of efforts is essential.
  - ASP leadership has asked the JPDO to review the re-shaped ASP with regards to its relevance to NGATS goals and provide guidance for our final determination of work elements.

Where to find more information?

www.aeronautics.nasa.gov