



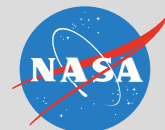
# Aeronautics Research Mission Directorate System-Level Research

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**Meeting of Experts  
Aeronautics and Space Engineering Board Meeting  
National Research Council**

**May 14, 2009**



# ARMD Mission and Principles

## **The Overarching Mission of NASA's Aeronautics Research Mission Directorate (ARMD):**

- To advance U.S. technological leadership in aeronautics in partnership with industry, academia, and other government agencies that conduct aeronautics-related research.
- ARMD supports the Agency's goal of developing a balanced overall program of science, exploration, and aeronautics, and ARMD's research plans also directly support the National Aeronautics R&D Policy and accompanying Executive Order 13419.

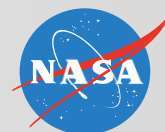
## **The Three Core Principles of ARMD:**

- 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 fundamental research needs of the Next Generation Air Transportation System (NextGen) in partnership with the member agencies of the Joint Planning and Development Office (JPDO).



# Major Aeronautics Challenges/Opportunities

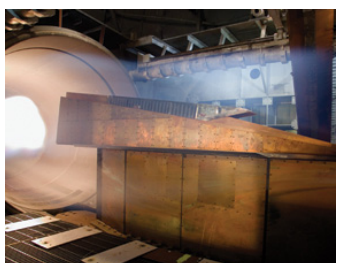
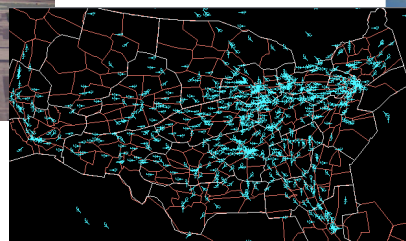
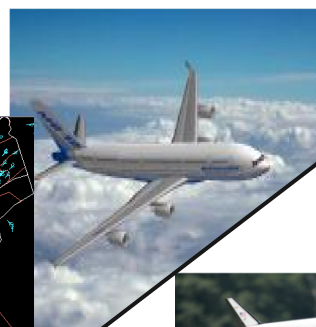
- **Environmental Compatibility**
  - Emissions - CO<sub>2</sub> and NO<sub>x</sub>
    - **Aviation creates 2% of worldwide emissions**
  - Noise
    - **Airport community noise reduction**
      - > Increased access to 5,221 US public use airports
      - > FAA attempt to reconfigure New York airspace resulted in 14 lawsuits
      - > Since 1980 the FAA has invested over \$5 billion in airport noise reduction programs
      - > Noise insulation of 6000 Chicago homes cost over \$180M and \$285M allocated for schools
    - **Sonic Boom over land**
      - > Enhance Supersonic Transport economic viability
- **Economic Efficiencies**
  - Airspace System Capacity
    - **56 minute average flight delay in 2007**
    - **\$5.9B economic impact of airline delays in 2005**
  - Fuel Consumption
    - **Exceeded 25% of airline operating cost in 2007**



# Current NASA Aeronautics Programs

## Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.



## Fundamental Aeronautics Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

## Aviation Safety Program

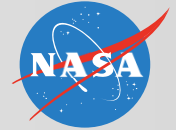
Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.

## Aeronautical Test Program

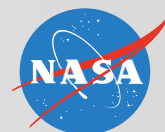
Preserve and promote the testing capabilities of one of the United States' largest, most versatile and comprehensive set of flight and ground-based research facilities.



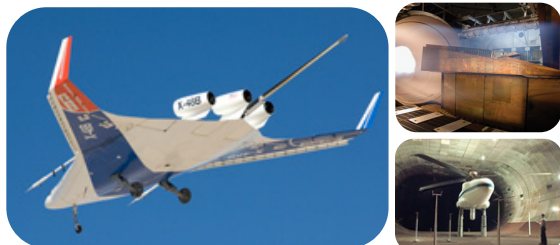
# Community input/alignment



- The NASA Advisory Committee (NAC)
  - Strongly supports ARMD’s fundamental research program.
  - However, the NAC members also have called for ARMD to plan and develop candidate systems-level research projects, consistent with the National Policy and Plan and leveraging NASA’s unique expertise and competencies, to advance the state-of-the-art capabilities in key disciplines and facilitate transition of results to the community.
- Congress
  - FY08 Congressional Augmentation - Invest in Next Generation Air Transportation System (NextGen) ; “Green” aircraft research that will yield advanced technologies to significantly reduce energy consumption, emissions, and noise; Research aligned with the top-ranked priorities in the National Academies’ Decadal Survey of Civil Aeronautics
  - American Recovery Act - System-level research, development and demonstration activities related to aviation safety, environmental impact mitigation and the NextGen
  - FY09 Congressional Augmentation – investments across all programs
- ARMD’s own assessment
  - Stable funding and consistent fundamental research direction has begun to produce promising concepts, capabilities, and technologies to be further developed, explored, and assessed at system level in a relevant environment



# NASA Aeronautics Programs in FY2010

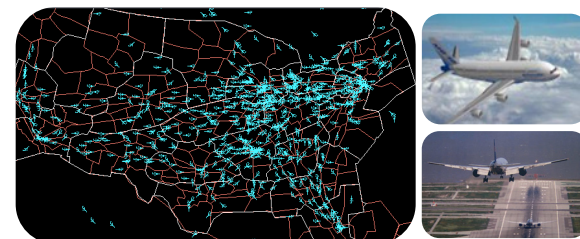


## Fundamental Aeronautics Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to enable revolutionary changes for vehicles that fly in all speed regimes.

## Integrated Systems Research Program

Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment



## Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.



## Aviation Safety Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.



## Aeronautics Test Program

Preserve and promote the testing capabilities of one of the United States' largest, most versatile and comprehensive set of flight and ground-based research facilities.

# Compelling Reasons for Research in Environmental Impact Mitigation in Aviation



## Operations

- Based on existing NASA data, investment in high-density, terminal procedures will yield the significant benefit to fuel reduction

Continuous climbs and descents (data from top-27 airports):

- 188M gal/year reduction in fuel burn with direct climbs
- 218M gal/year reduction in fuel burn with continuous descents

Direct routing/improved re-routing/collaborative TFM

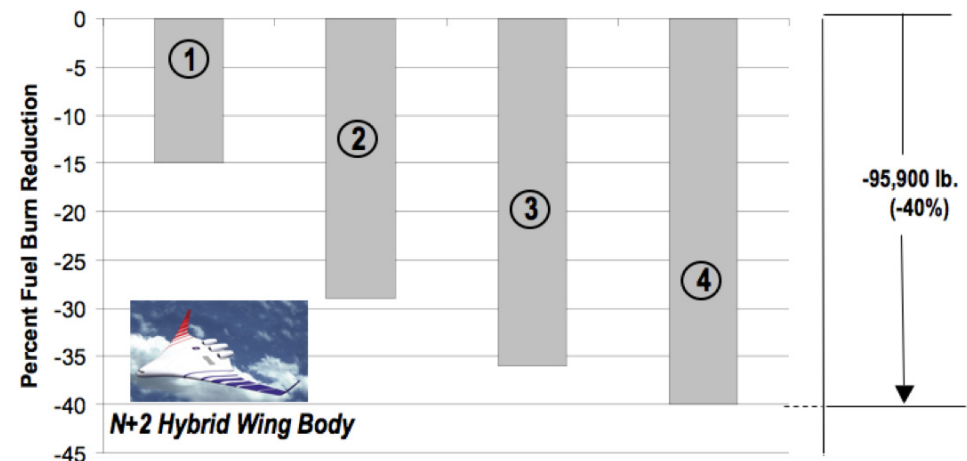
- 200M gal/year fuel savings

“No-stop” taxi operations (data on arrivals only at 35 OEP airports):

- 15M gal/year reduction in fuel burn
- 1M kg/year reduction in harmful emissions (CO, HC, NOx, SOx)

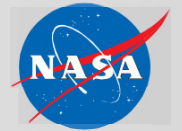
## Vehicle

*Achieving Significantly Reduced Fuel Burn Will Require Integration of Multiple Technologies*



- 1 = Hybrid wing configuration
- 2 = + advanced engine and airframe technologies
- 3 = + embedded engines with BLI inlets
- 4 = + laminar flow

# ARMD System-Level Research



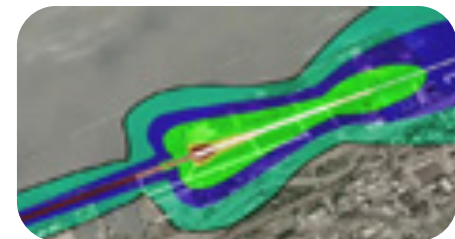
## **ISRP Environmentally Responsible Aviation Project:**

Explore and assess new vehicle concepts and enabling technologies through system-level experimentation to *simultaneously* reduce fuel burn, noise, and emissions



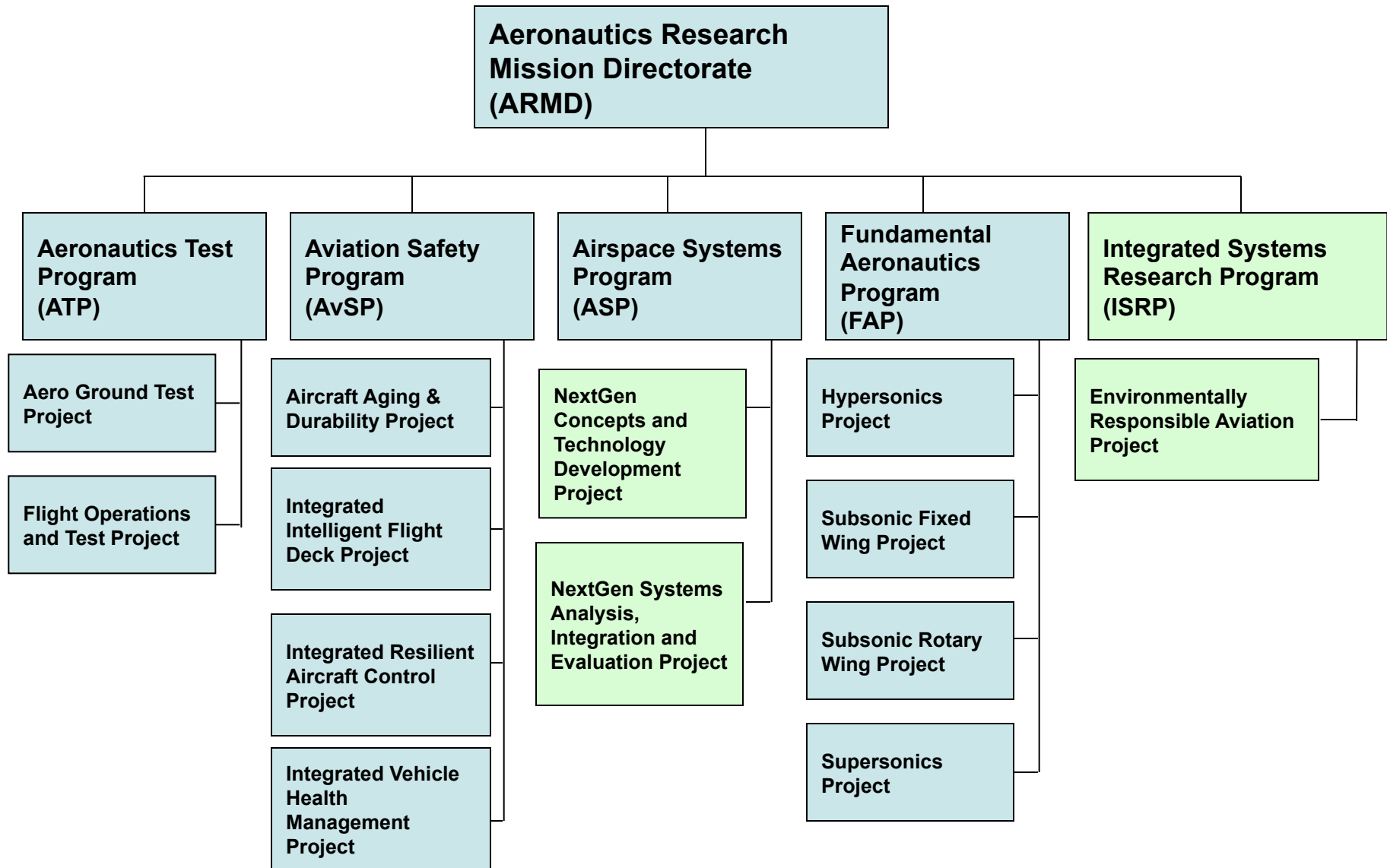
## **ASP NextGen Systems Analysis, Integration and**

**Evaluation Project:** Develop and mature key concepts integrating surface, arrivals, departures, terminal and en route capabilities and conduct integrated system testing to enable operational enhancements envisioned by NextGen





# ARMD Organization with New Program/Projects





# FY 2010 Budget Request

<b>Budget Authority (\$ millions)</b>	<b>FY 2008 Actual</b>	<b>FY 2009 Enacted</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>	<b>FY 2014</b>
<b>FY 2010 President's Budget Request</b>	<b>511.4</b>	<b>650.0</b>	<b>507.0</b>	<b>514.0</b>	<b>521.0</b>	<b>529.0</b>	<b>536.0</b>
Aeronautics	511.4	650.0	507.0	514.0	521.0	529.0	536.0
<b>FY 2009 President's Budget Request</b>	<b>511.7</b>	<b>446.5</b>	<b>447.5</b>	<b>452.4</b>	<b>456.7</b>	<b>467.7</b>	<b>-</b>
Aeronautics	511.7	446.5	447.5	452.4	456.7	467.7	-
<b>Total Change from FY 2009 President's Budget Request</b>	<b>-0.3</b>	<b>203.5</b>	<b>59.5</b>	<b>61.6</b>	<b>64.3</b>	<b>61.3</b>	<b>-</b>

Note: The FY2010 President's Budget Request depicts the September 2008 Operating Plan for the 2008 actuals and the 2009 Omnibus Appropriations Act (P.L. 111-8) and the American Recovery and Reinvestment Act (P.L. 111-5) for the 2009 enacted.



# FY 2010 President's Budget

	(\$ Millions)	<u>FY08 1/</u>	<u>FY09 2/</u>	<u>FY10</u>	<u>FY11</u>	<u>FY12</u>	<u>FY13</u>	<u>FY14</u>
<b>Aeronautics Total</b>		<b>\$511.4</b>	<b>\$650.0</b>	<b>\$507.0</b>	<b>\$514.0</b>	<b>\$521.0</b>	<b>\$529.0</b>	<b>\$536.0</b>
<b>Aviation Safety</b>		<b>\$66.5</b>	<b>\$89.3</b>	<b>\$60.1</b>	<b>\$59.6</b>	<b>\$59.2</b>	<b>\$61.7</b>	<b>\$62.5</b>
Aircraft Aging & Durability		9.1	13.4	11.4	11.2	11.7	12.1	12.1
Integrated Intelligent Flight Deck		14.1	16.3	12.5	13.2	11.6	12.5	13.3
Integrated Resilient Aircraft Control		21.8	37.3	16.4	17.0	17.6	18.2	18.2
Integrated Vehicle Health Management		21.5	22.3	19.8	18.2	18.3	18.9	18.9
<b>Airspace Systems</b>		<b>\$100.1</b>	<b>\$121.5</b>	<b>\$81.4</b>	<b>\$82.9</b>	<b>\$83.9</b>	<b>\$87.3</b>	<b>\$88.3</b>
NextGen - Concepts and Tech Development		0.0	0.0	53.3	54.5	55.4	57.8	58.7
NextGen - Systems Analysis & Integration		0.0	0.0	28.1	28.4	28.5	29.5	29.6
NextGen - Airspace		83.3	105.3	0.0	0.0	0.0	0.0	0.0
NextGen - Airportal		16.8	16.2	0.0	0.0	0.0	0.0	0.0
<b>Fundamental Aeronautics</b>		<b>\$269.7</b>	<b>\$307.6</b>	<b>\$228.4</b>	<b>\$230.0</b>	<b>\$233.6</b>	<b>\$239.0</b>	<b>\$245.9</b>
Subsonic-Fixed Wing		119.7	155.2	101.7	103.7	105.4	107.3	110.8
Subsonic-Rotary Wing		30.8	38.9	26.1	26.1	26.3	27.4	27.9
Supersonics		53.0	55.6	40.6	40.0	40.7	42.0	42.8
Hypersonics		66.2	57.9	60.0	60.2	61.2	62.3	64.4
<b>Aeronautics Test Program</b>		<b>\$75.1</b>	<b>\$131.6</b>	<b>\$74.7</b>	<b>\$77.1</b>	<b>\$77.2</b>	<b>\$76.6</b>	<b>\$78.8</b>
Aero Ground Test Facilities		50.0	100.0	48.6	50.1	50.2	49.8	51.2
Flight Ops & Test Infrastructure		25.1	31.6	26.1	27.0	27.0	26.8	27.6
<b>Integrated Systems Research</b>		<b>\$0.0</b>	<b>\$0.0</b>	<b>\$62.4</b>	<b>\$64.4</b>	<b>\$67.1</b>	<b>\$64.4</b>	<b>\$60.5</b>
Environmentally Responsible Aviation		0.0	0.0	62.4	64.4	67.1	64.4	60.5

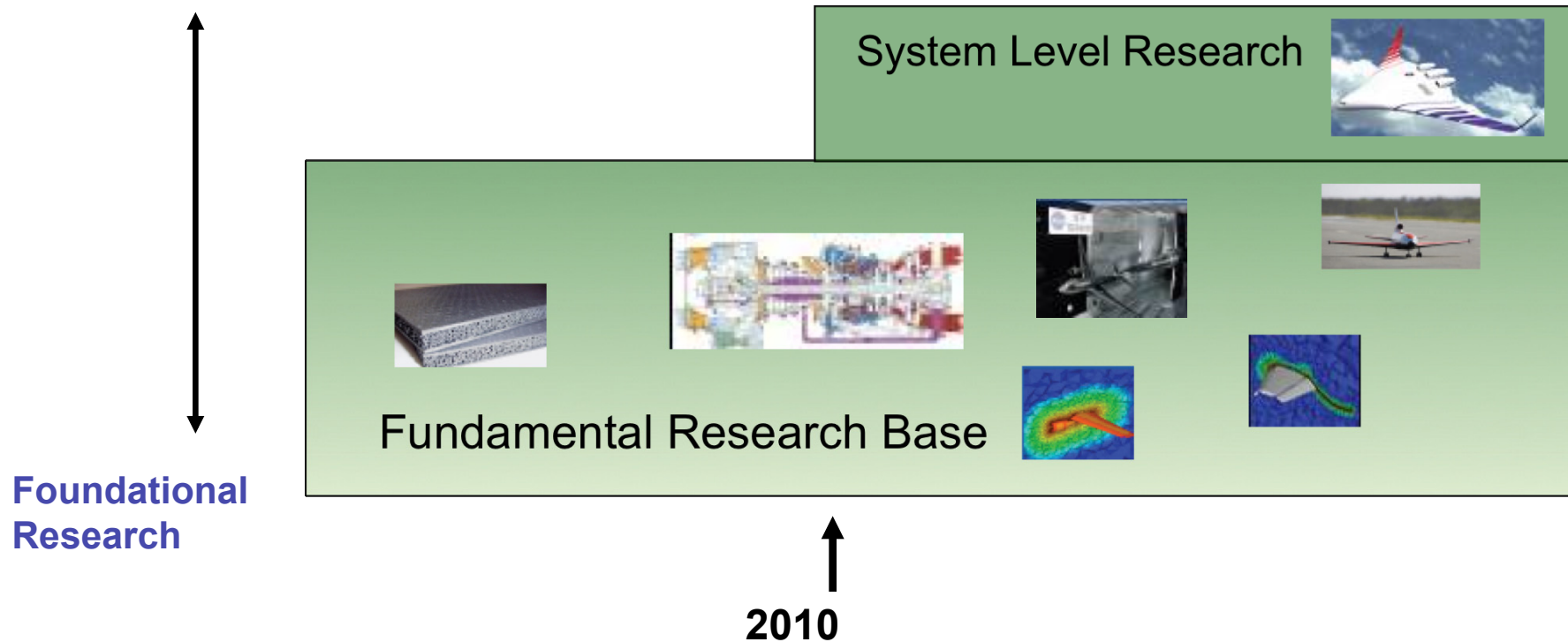
1/ FY08 reflects the September Operating Plan including Augmentation (\$60M)

2/ FY09 reflects the Enacted Appropriation Augmentation (\$53.5M) plus the Recovery Act (\$150M)



# Vision for NASA Aeronautics

System Level



Foundational Research

Enabling “Game Changing” concepts and technologies from advancing foundational research ultimately to understand the feasibility of advanced systems