



# NASA Aeronautics Research Strategic Analysis, Vision, and Program Planning

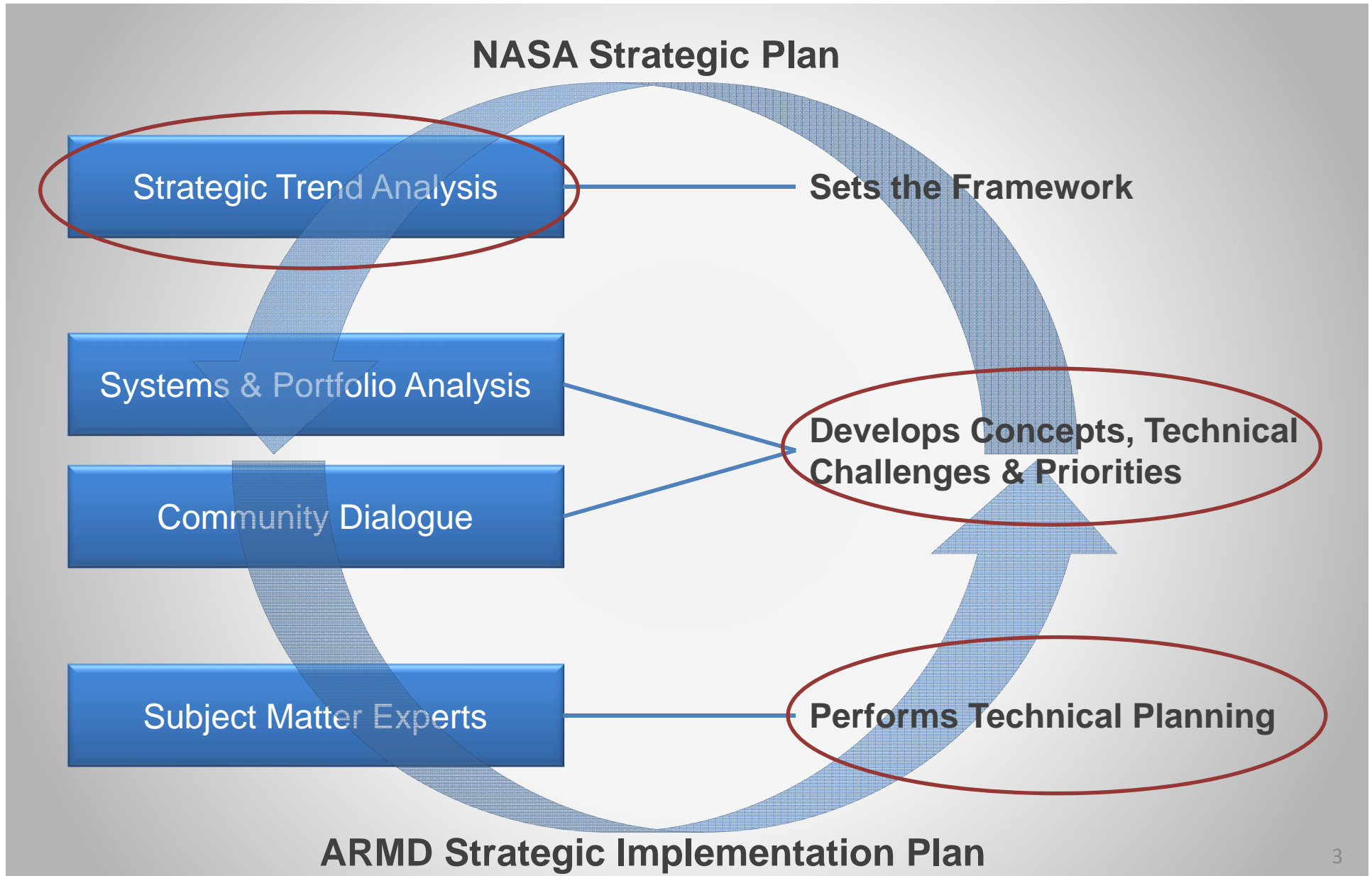
Presentation to REDAC Subcommittee for Aircraft Safety  
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Director, Airspace Operations and Safety Program

# Topics

- NASA Aeronautics Research Mission Directorate Strategy & Vision
- Six Strategic Thrusts
- FY15 Program Organization
  
- Acknowledgement:
  - Thanks to Robert Pearce, Director. Strategy, Architecture & Analysis, Aeronautics Research Mission Directorate

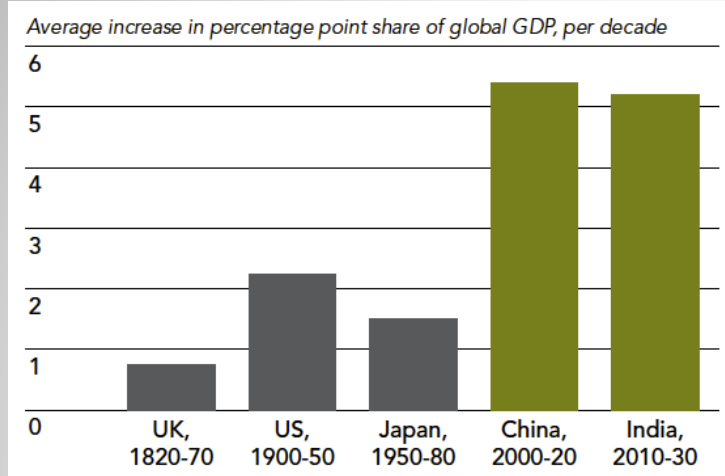
# Approach to Planning



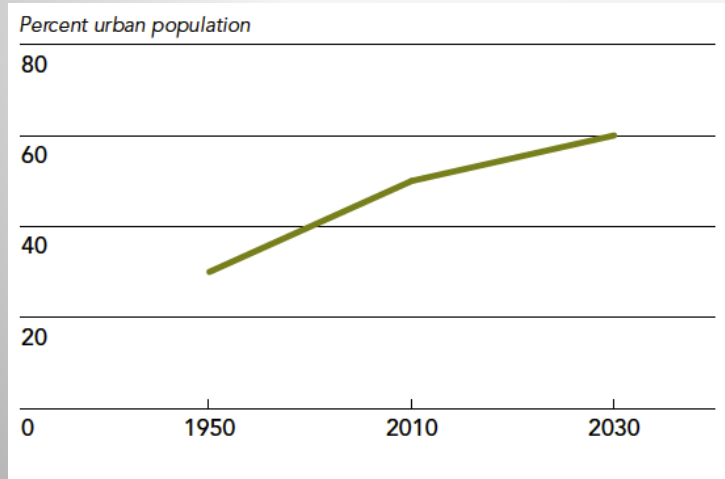
# Exploring Strategic Trends

## Challenges Traditional Approaches

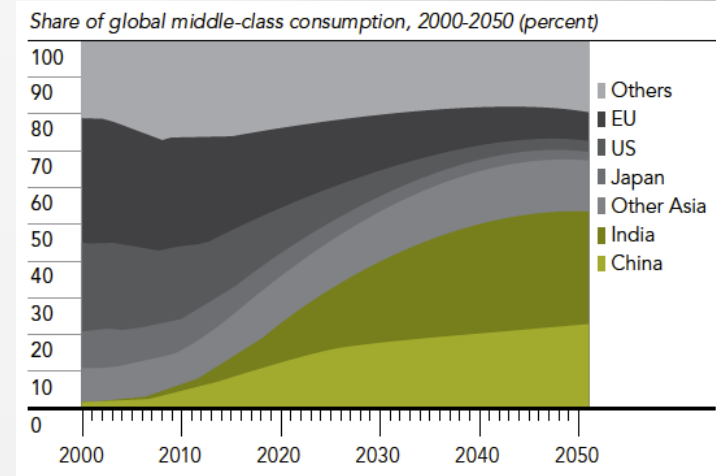
### China & India Growing Economically at Historically Unprecedented Rates



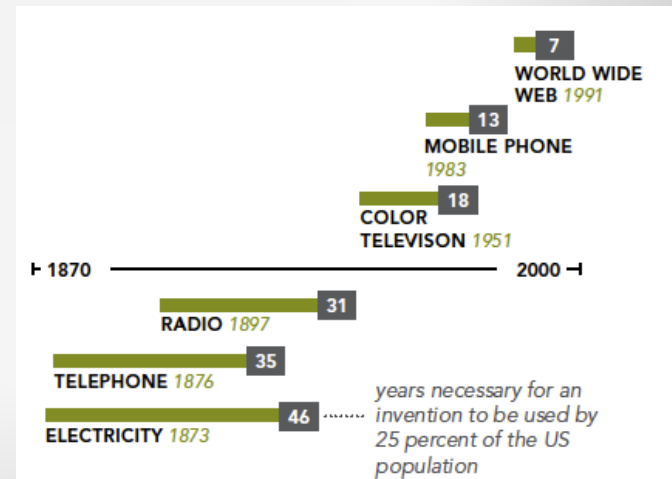
### The World will be Predominantly Urban



### They will have the Largest Middle-Class

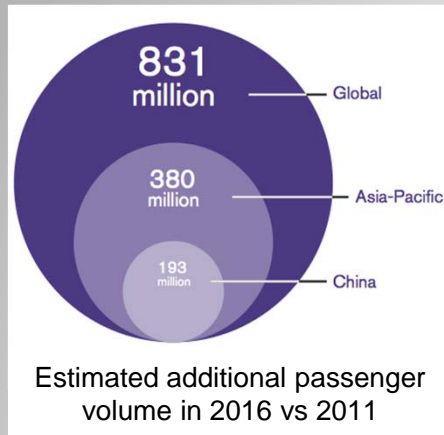


### Technology Development & Adoption is Accelerating

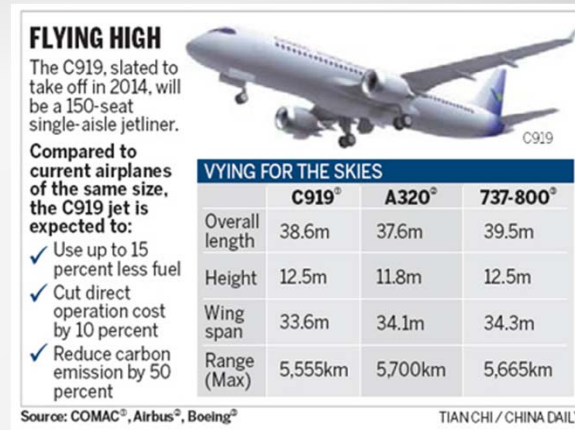


# Why are these trends important?

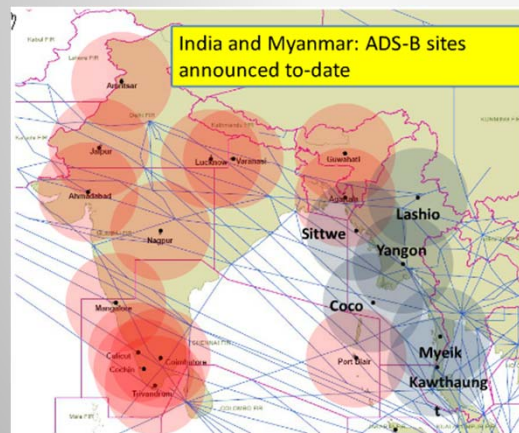
Challenges are multiplying and accelerating – technology is a key lever!



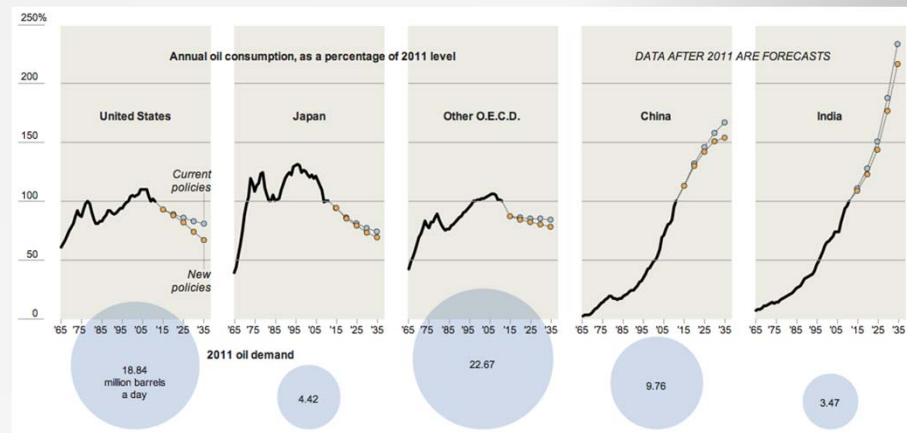
They drive global demand growth for air travel...



They drive expanding competition for high tech manufacturing...



They enable “leapfrog” adoption of new technology/infrastructure...



They drive resource use, costs, constraints and impacts...

# Three Mega Drivers Emerge



Traditional measures of global demand for mobility - economic development, urbanization - are growing rapidly



Severe energy and climate issues create enormous affordability and sustainability challenges



Revolutions in automation, information and communication technologies enable opportunity for safety critical autonomous systems

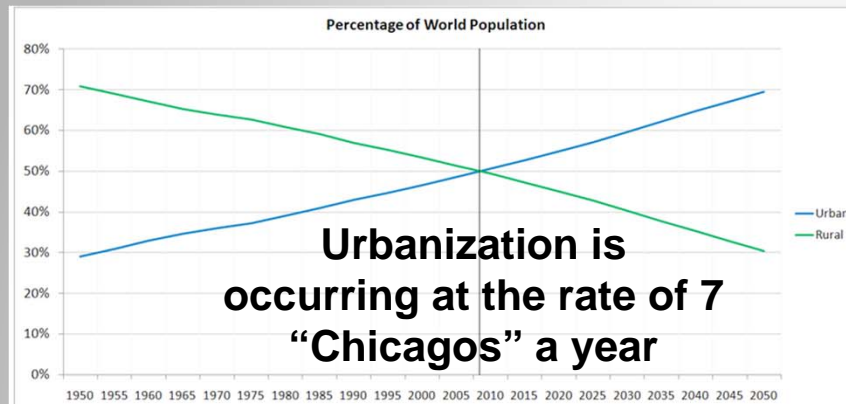






# Air Transportation - A Critical Global Capability

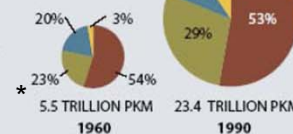
## Century long trend toward urbanization...



Source: United Nations

WORLD TRAFFIC VOLUME, measured in passenger-kilometers (pkm), will continue to balloon, with higher-speed transport gaining market share. By 2050, automobiles will supply less than two fifths of global volume.

RAILWAYS  
BUSES  
AUTOMOBILES  
HIGH-SPEED TRANSPORT



SOURCE: Andreas Schafer and David Victor

\* Includes high speed rail and air transportation

## Century long trend toward higher speed transport...

### International Air Transport Association (IATA) – Vision 2050

The world in 2050: "Traffic has grown from 2.4 billion to 16 billion passengers in the last 40 years...Technologically advanced aircraft operating on advanced renewable energy sources and capable of carrying anywhere from 2 to 2000 passengers connect intercontinental traffic through a dozen global gateways feeding them to 50-75 regional hubs which redistribute onwards to local airports."



# Global Competition from New Comers

## Research & Development

Brazil's aeronautical research capacity is still limited in comparison to the US and Europe, but it is expanding and aeronautics is a strategic sector for research investment.



Russia has a very mature and extensive multi-disciplinary aeronautical research capacity.



India's high quality aeronautical research capacity is limited to a few government and university labs. However, aeronautics research is a sector for strategic investment.



China has been developing its aeronautical research capacity since the 1960s. They have a national aeronautical laboratory system that is composed of over 10,000 technical staff and 2000 senior researchers.



## Product Development

Brazil develops and produces world-class regional aircraft, both turboprops and jets. Its largest regional jets can compete in the Boeing 737 class (single aisle transport) market.

Russia develops and produces regional and single aisle transports. Sales are limited, but they are working toward greater global penetration

India produces aeronautical components, but is also in development of prototype indigenous aircraft as well as the production of aircraft through international partnerships

China is developing the C919 single aisle commercial transport. China plans to be a major global competitor in aeronautical and aviation products by 2020.

US Industry has invested significantly in establishing research and development capacity and/or partnerships in these developing economies due to market growth realities and to take advantage of global research and innovation

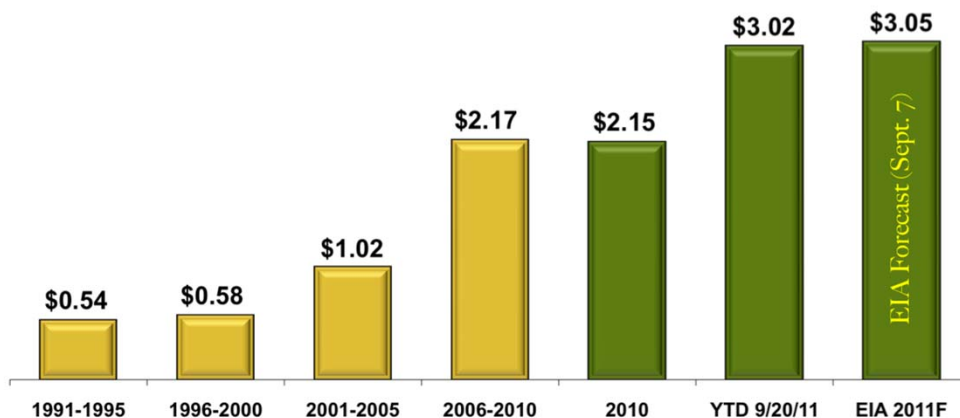
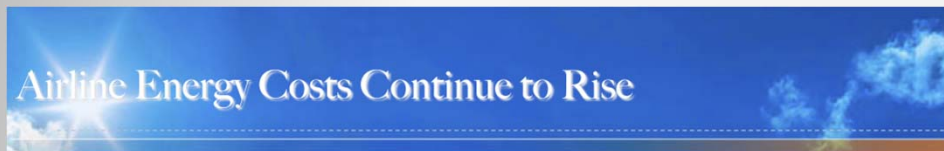


# Escalating Fuel Prices have a Large Aviation Impact



**“Fuel is the only major cost item that has become significantly larger over time”**

**IATA**



Source: EIA Weekly Petroleum Status Report for U.S. Gulf Coast jet fuel prices per gallon

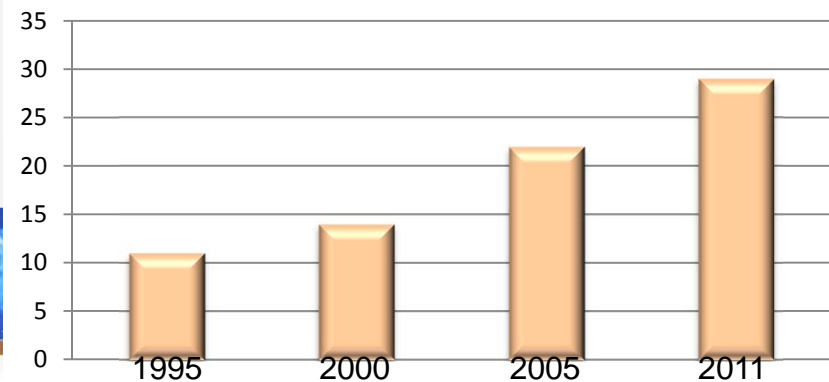
www.airlines.org



Source: A4A

Source: MIT Airline Data Project

## Fuel as Percentage of Total Airline Costs

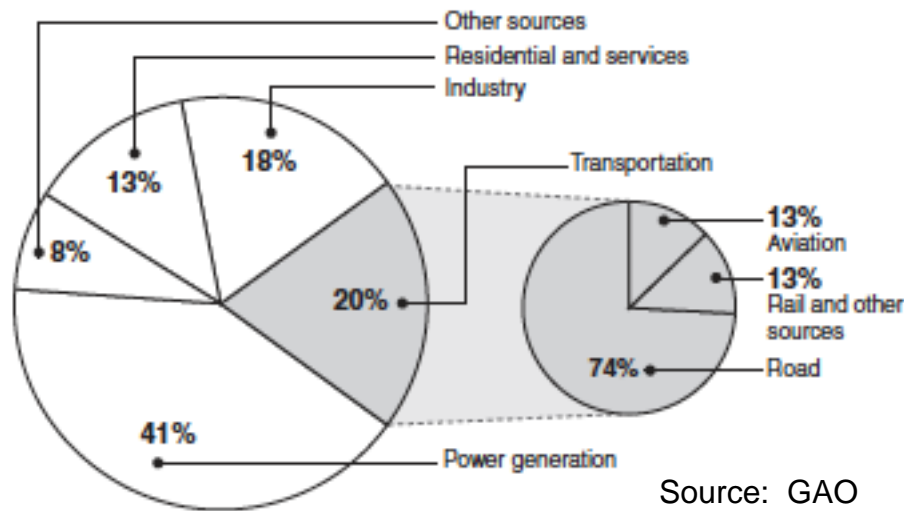


# Global Warming Imperative

How do we sustainably satisfy global demand for air transportation?



Global Transportation Contribution to CO<sub>2</sub> Emissions



## Strategies for Reducing Transportation-Related Greenhouse Gas Emissions

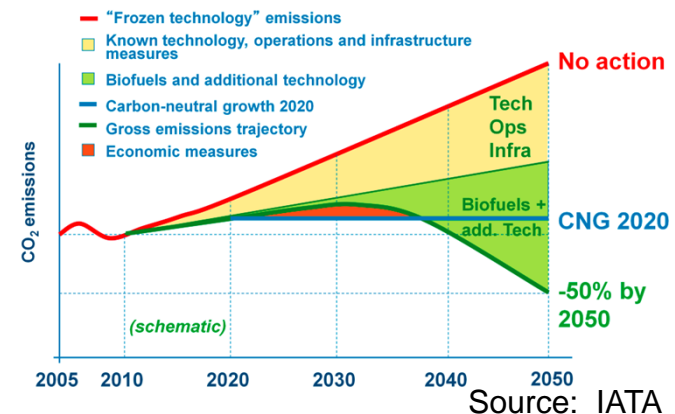
- Reduce the total volume of transportation activity;
  - Shift transportation activity to modes that emit fewer GHGs per passenger-mile or ton-mile;
  - Reduce the amount of energy required to produce a unit of transport activity (that is, increase the energy efficiency of each mode); or
  - Reduce the GHG emissions associated with the use of each unit of energy
- Source: NAS

## Global Aviation Industry Plan

- (1) From 2009 until 2020: average 1.5% efficiency improvement per year
- (2) From 2020: Capping emissions growth from aviation
- (3) By 2050: halving net emissions based on 2005 levels

Industry Goals

### Emissions reduction roadmap



# Technology Convergence

Enabling Assured Autonomy for Safety Critical Systems



**Reduce Operations Costs**

**Improve Performance**

**Increase Safety**

**Transform Mobility –  
On Demand Aviation**

Tomorrow

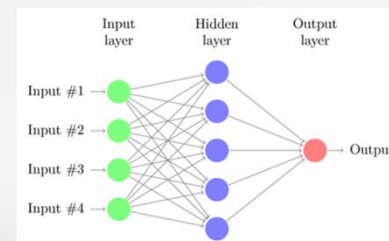
Today  
Centralized,  
Expert Operator

Embedded System  
Intelligence

More Distributed Management  
**Autonomous Systems**  
More System Intelligence

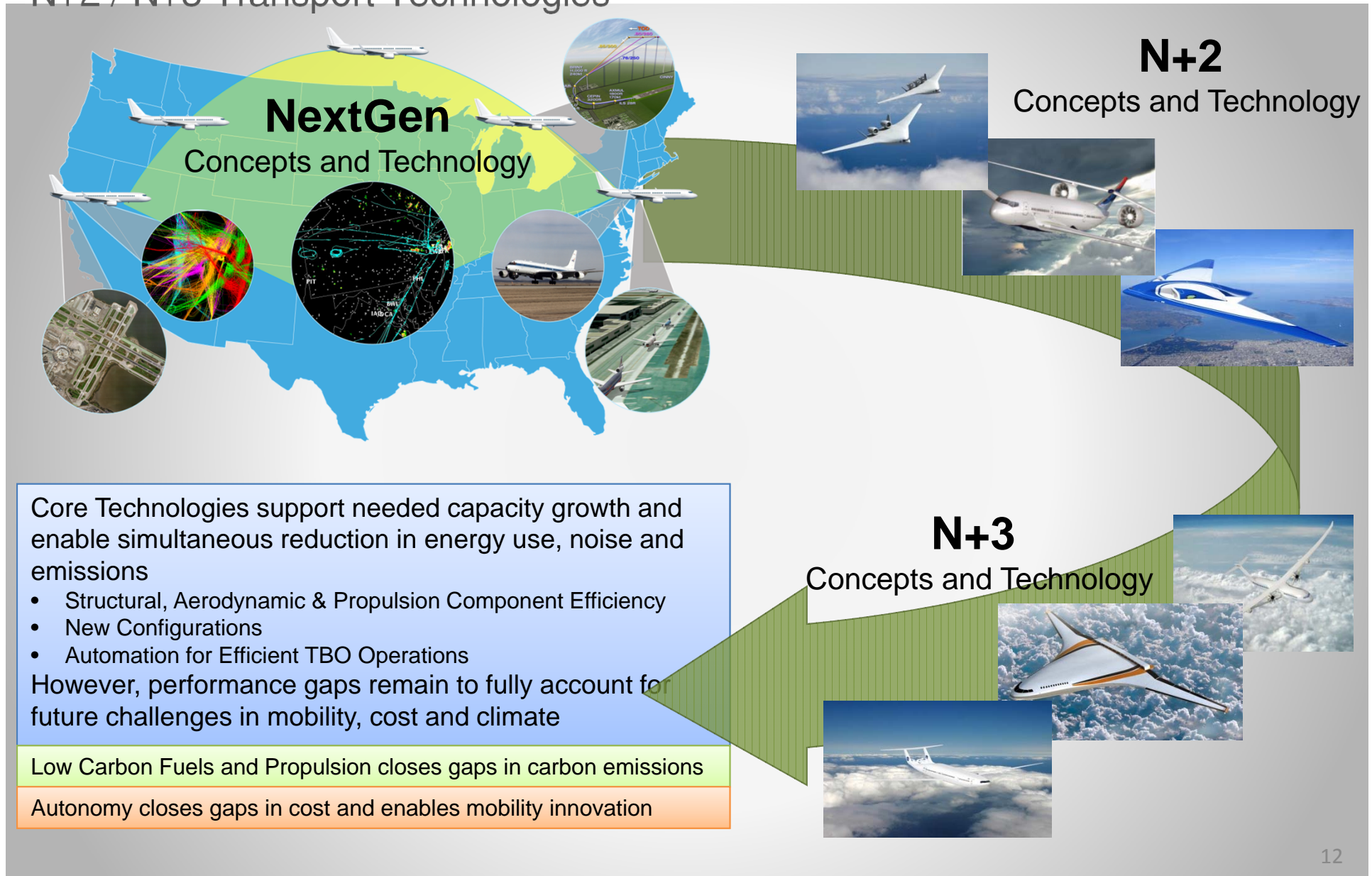


Net-Centric  
Information – Big Data



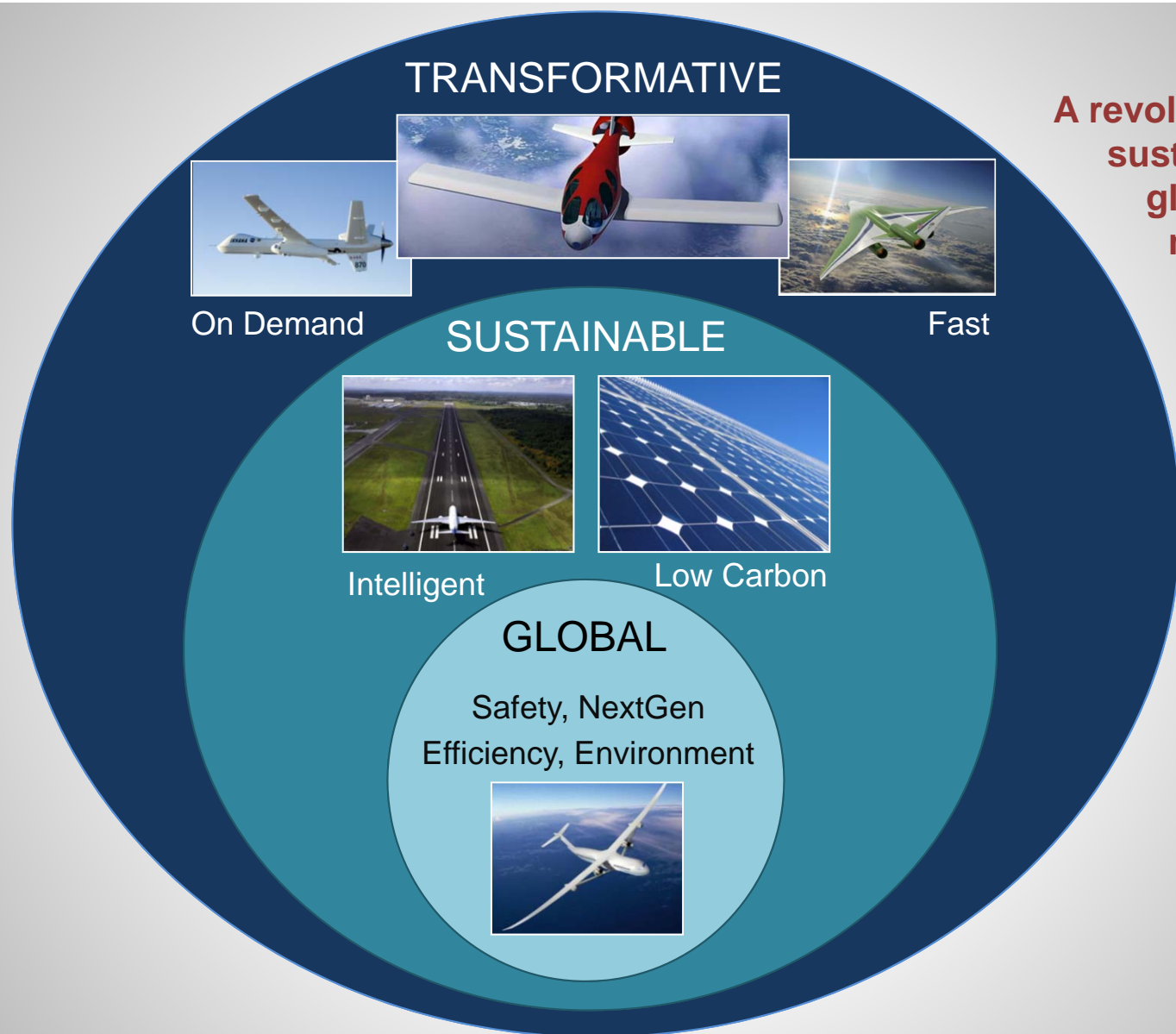
# Systems & Portfolio Analysis

Example of integrated assessment of core investments in NextGen and N+2 / N+3 Transport Technologies





# NASA Aeronautics Vision for the 21<sup>st</sup> Century



**A revolution in  
sustainable  
global air  
mobility**



# NASA Aeronautics Research Six Strategic Thrusts



## **Safe, Efficient Growth in Global Operations**

- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks



## **Innovation in Commercial Supersonic Aircraft**

- Achieve a low-boom standard



## **Ultra-Efficient Commercial Vehicles**

- Pioneer technologies for big leaps in efficiency and environmental performance



## **Transition to Low-Carbon Propulsion**

- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology



## **Real-Time System-Wide Safety Assurance**

- Develop an integrated prototype of a real-time safety monitoring and assurance system



## **Assured Autonomy for Aviation Transformation**

- Develop high impact aviation autonomy applications

# Proposed Program Reorganization

The Promotion of Innovation and Convergent Research.

## Goal 1: Pursue Innovative Solutions Aligned to the Strategic Thrusts

Enable programs to clearly define most compelling technical challenges and retire them in a timeframe that is supportable by stakeholders and is required by our customers.

Addressed through the formation of three Mission Programs and the integration of safety research throughout all programs.

- Airspace Operations and Safety Program
- Advanced Air Vehicles Program
- Integrated Aviation Systems Program

## Goal 2: Incentivize Multi-Disciplinary “Convergent” Research

Establish a flexible and organic environment to allow for the development of high-risk, leap-frog ideas to address “big problems.” This will allow rapid demonstration of feasibility with high turnover rates, conducted in a convergent, multi-disciplinary, integrated manner.

Addressed through the formation of the Transformative Aeronautics Concepts Program

## Goal 3: Enable Greater Workforce and Institutional Agility and Flexibility

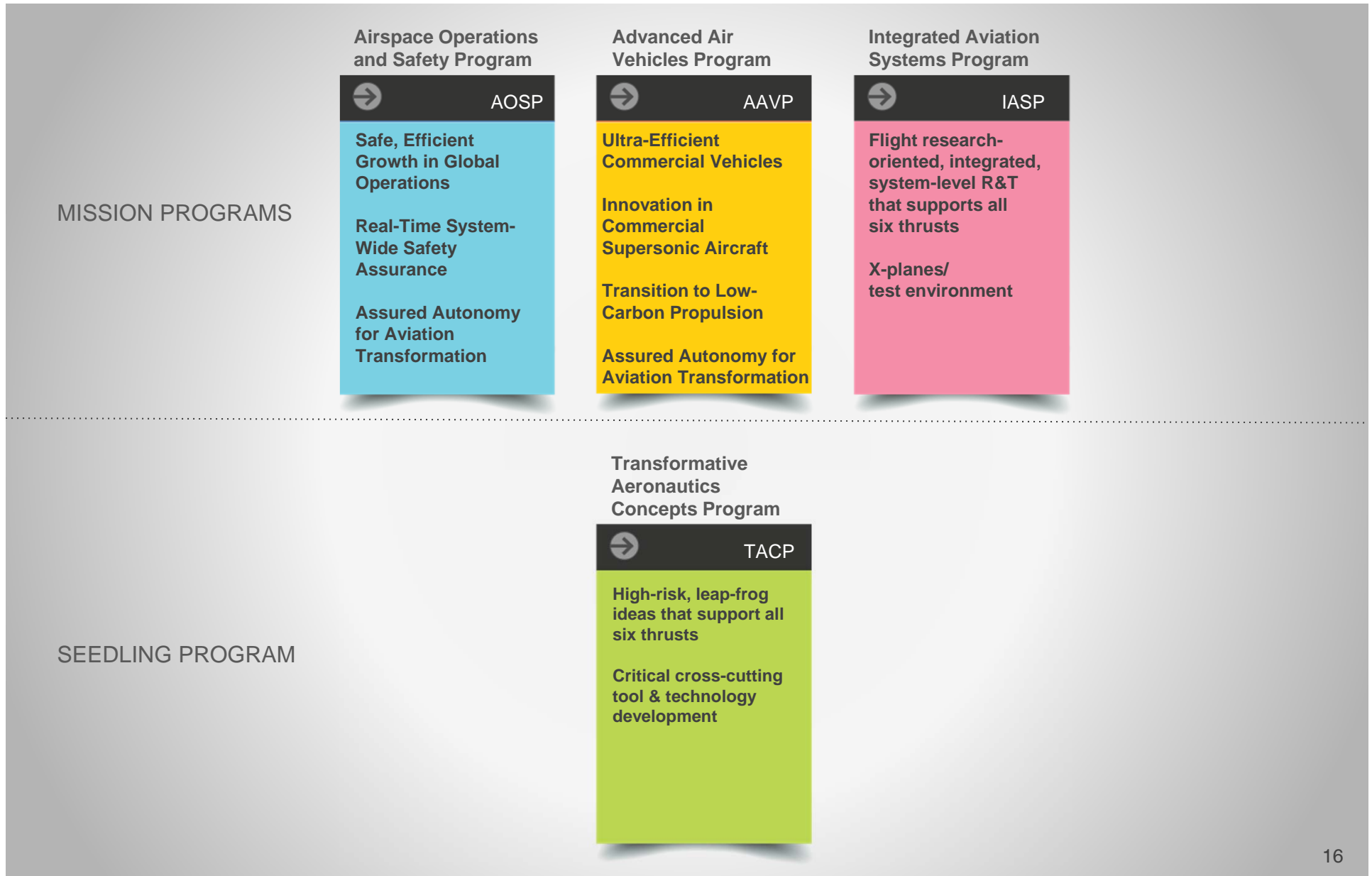
- Enable more flexibility to embed flight research throughout research phases and bring back X-plane culture.
- Enable more agile research practices that combine high-fidelity simulation, ground testing, and flight research.

Addressed by embedding the Aeronautics Test facilities and aircraft into the Advanced Air Vehicles and Integrated Aviation Systems Programs.



# How are the vision's research thrusts used?


All of the proposed programs address more than one, or all, of the research thrusts.



# Why a new aeronautics research strategy?

Now is the time to lay the groundwork for the next 100 years of excellence.

- NASA Aeronautics has solid partnerships, high relevancy, and is delivering high impact
- But need to recognize:
  - Rising competition in international R&D
  - Challenges in mobility, energy and climate
  - Opportunities to infuse rapidly advancing non-aerospace sector technologies
- ARMD's new strategy builds on current leadership and focuses on enabling revolutionary advances



“Civil aviation [is] blessed with growing demand, record orders and increasing deliveries, but facing global competitors, affordability and sustainability challenges, and an industry-shaking technological revolution.”

Graham Warwick,  
AvWeek, September 2013

## **The Time Bomb of Complacency – AvWeek Editorial, September 2, 2013**

“An alarm needs to be sounded. A vital and vigorous aeronautics research program is essential... NASA’s unveiling of a new strategy for aeronautics research is a bold and welcome move.”

NASA Aeronautics Research Mission Directorate

# **NEW PROGRAM ORGANIZATION**



# Program Directors

- **John Cavolowsky**  
Director, Airspace Operations and Safety Program (AOSP)
- **Jay Dryer**  
Director, Advanced Air Vehicles Program (AAVP)
- **Ed Waggoner**  
Director, Integrated Aviation Systems Program (IASP)
- **Doug Rohn**  
Director, Transformative Aeronautics Concepts Program (TACP)

# What is the Airspace Operations and Safety Program?

This program integrates the Airspace Systems Program and Aviation System-Safety work.



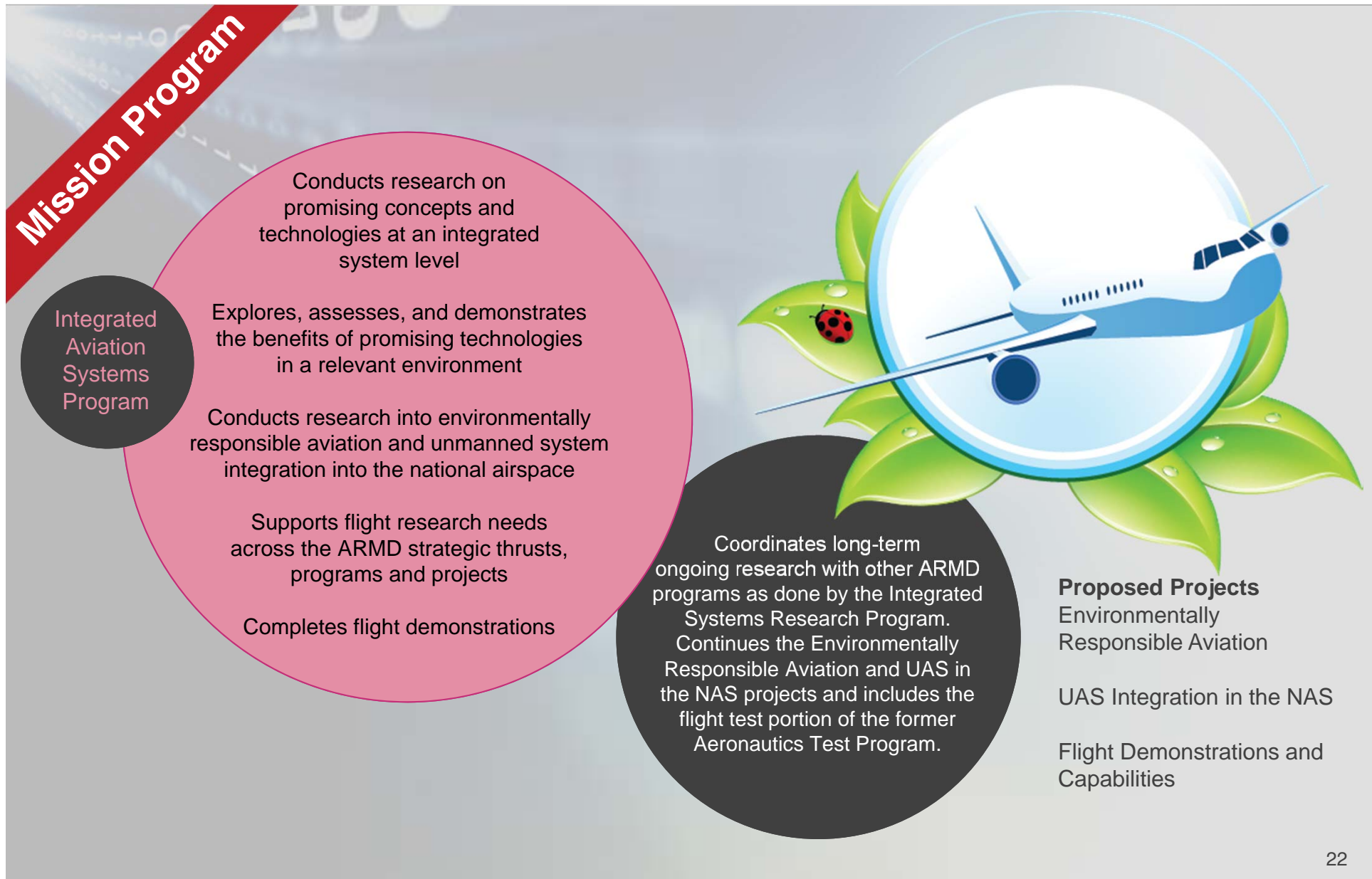
# What is the Advanced Air Vehicles Program?

The Fundamental Aeronautics Program, ground test capabilities, atmospheric environments related safety.



# What is the Integrated Aviation Systems Program?

Bridges the gap between technology readiness levels.





# What is the Transformative Aeronautics Concept Program?

While mission programs focus on solving challenges, this program focuses on cultivating opportunities.

**Seedling Program**

**Transformative  
Aeronautics  
Concept  
Program**

Cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation and harnesses convergence in aeronautics and non-aeronautics technologies to create new opportunities in aviation

Knocks down technical barriers and infuses internally and externally originated concepts into all six strategic thrusts identified by ARMD, creating innovation for tomorrow in the aviation system.

Provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation.

Solicits and encourages revolutionary concepts

Creates the environment for researchers to become immersed in trying out new ideas

Performs ground and small-scale flight tests

Drives rapid turnover into new concepts

## **Proposed Projects**

Leading Edge Aeronautics Research for NASA

Transformational Tools And Technologies

Convergent Aeronautics Solutions