NASA Aeronautics: Overview & ODM

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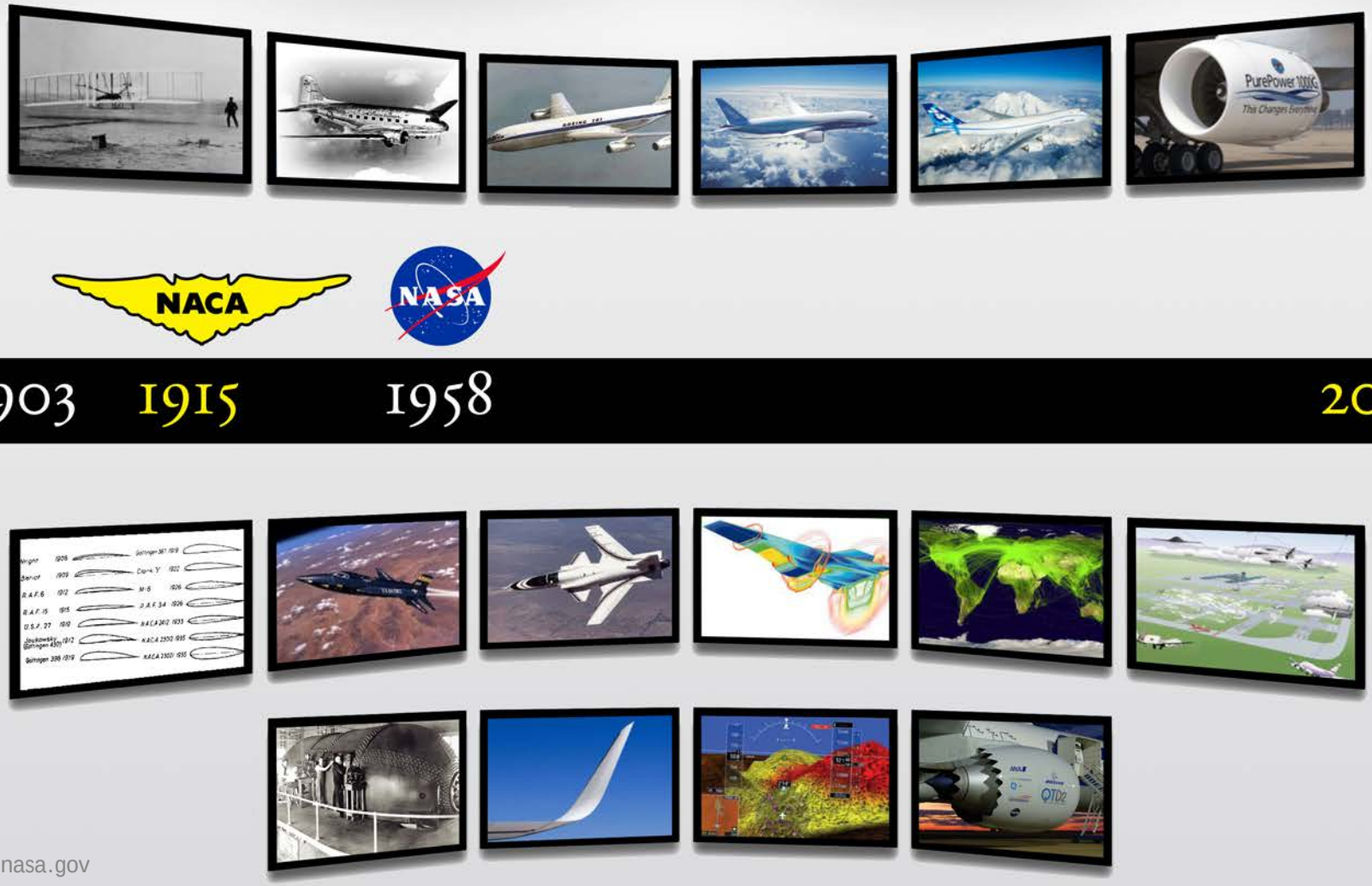
100 Years of Excellence

The NACA and NASA Aeronautics have made amazing contributions to U.S. and global aviation.



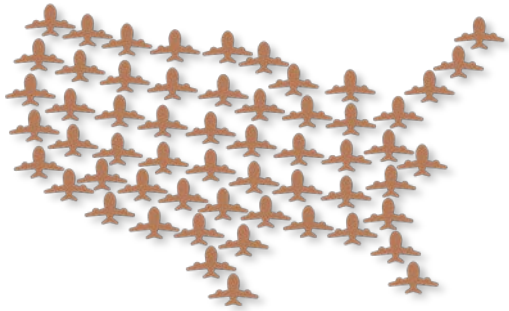
Why is aviation so important?

The air transportation system is critical to U.S. economic vitality.

$1.5 TRILLION

TOTAL U.S. ECONOMIC ACTIVITY

(civil aviation-related goods and services, 2012)



$75.1 BILLION

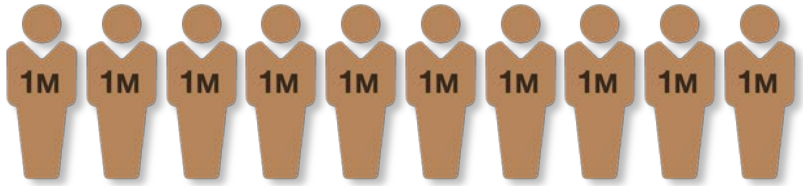
POSITIVE TRADE BALANCE

(aerospace industry, 2013)

11.8 MILLION

DIRECT AND INDIRECT JOBS

(civil and general aviation, 2012)

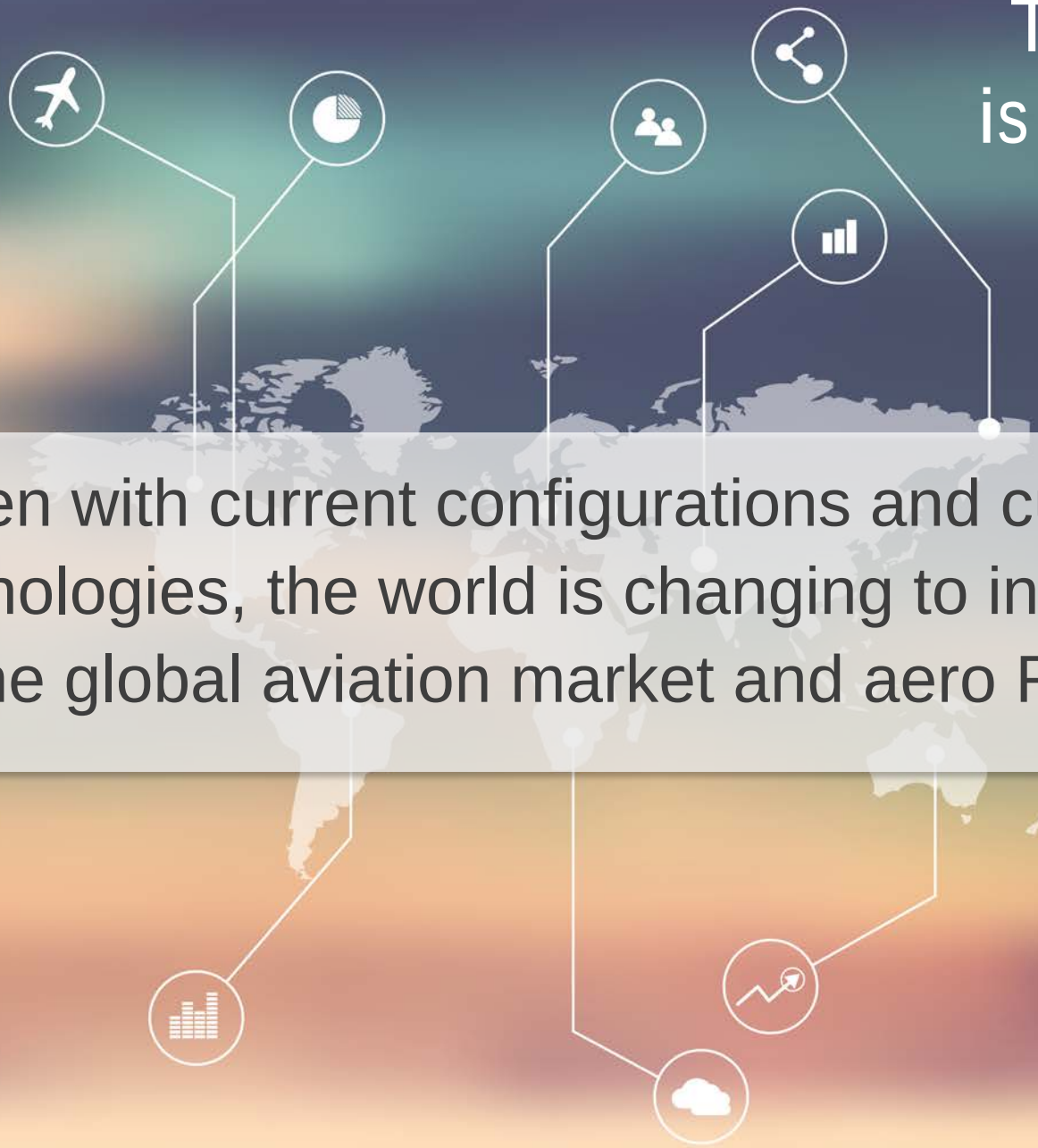


5.4% ($847.1 BILLION)

OF TOTAL U.S. GROSS DOMESTIC PRODUCT (GDP)

(civil and general aviation, 2012)

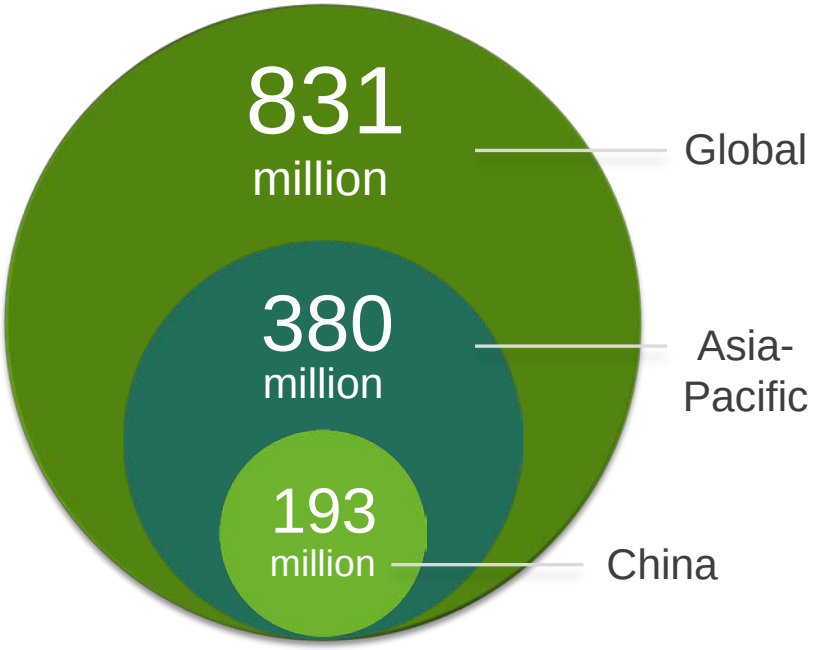
The world is changing



Even with current configurations and current technologies, the world is changing to influence the global aviation market and aero R&D

Aviation Market Growing and Moving East

Growth in passengers and traffic dominated by Asia Pacific region and aircraft orders and deliveries reflect this shift



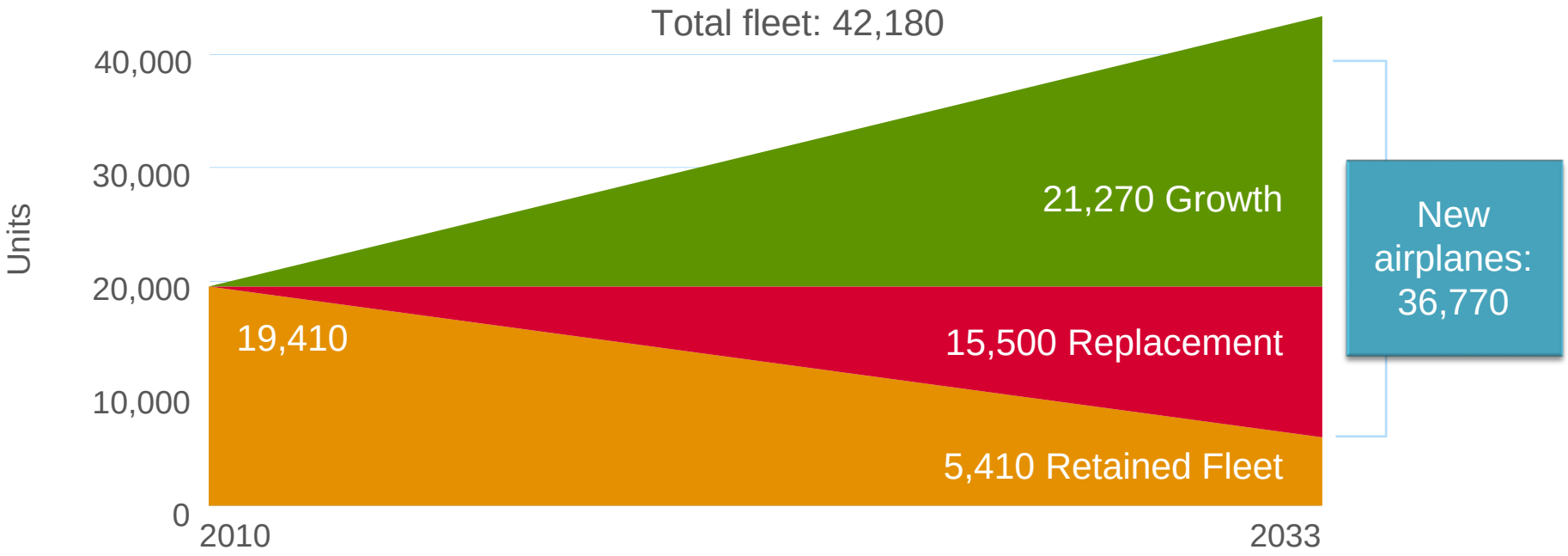
Estimated additional passenger volume in 2016 as compared with 2011

China to add 80 new airports by 2020

India's commercial service airports grow from 80 to 500 by 2021

Asia-Pacific traffic to triple by 2030

Growing Commercial Aircraft Market **and** Competition



Civil aircraft manufacturers in 2013
Boeing (LCA)
Airbus (LCA)
Embraer (LCA, RJ)
Bombardier (RJ)

Civil aircraft manufacturers in 2033
Boeing (LCA)
Airbus (LCA)
Embraer (LCA, RJ)
Bombardier (LCA, RJ)
Mitsubishi (RJ)
Sukhoi (RJ)
China/COMAC (LCA, RJ)
India (TBD)

Source: Boeing

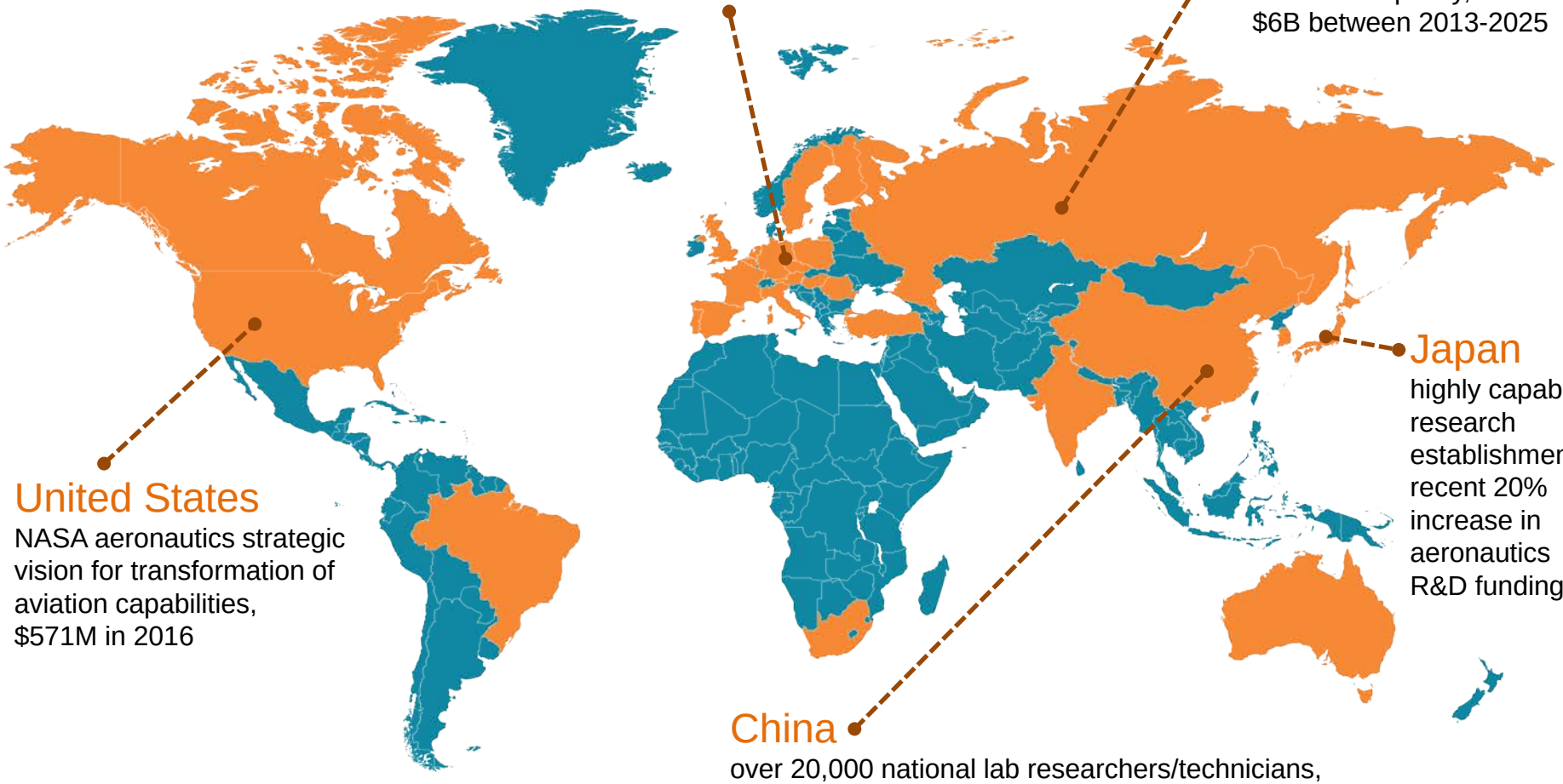
Global Government R&D Investment

Europe

l European countries with leading global aeronautics research establishments and infrastructure, funded through Horizon 2020 and EU member states.

Russia

disciplinary aeronautical research capacity, investing $6B between 2013-2025



United States

NASA aeronautics strategic vision for transformation of aviation capabilities, $571M in 2016

Japan

highly capable research establishment, recent 20% increase in aeronautics R&D funding

China

over 20,000 national lab researchers/technicians, aspires to be a global aeronautics competitor by 2020

Orange indicates membership in International Forum for Aviation Research

Dawn of a New Era?

Technology eventually gets to the end user

Three Aviation Mega Drivers

NASA Aeronautics research strategy proactively addressing critical long-term needs

Traditional measures of global demand for mobility—economic development, urbanization—are growing rapidly and creating transportation and competitive opportunities and challenges

Large and growing energy and environmental issues create enormous affordability and sustainability challenges

Revolutions in the integration of automation, information, communication, energy, materials and other technologies enable opportunity for transformative aviation systems

Vision for Aviation in the 21st Century

U.S. leadership for a new era of flight

Global

Sustainable

Transformative

6 Strategic Thrusts

- Safe, Efficient Growth in Global Operations
- Transition to Low-Carbon Propulsion
- Innovation in Commercial Supersonic Aircraft
- Real-Time System-Wide Safety Assurance
- Ultra-Efficiency Commercial Vehicles
- Assured Autonomy for Aviation Transformation

How NASA Aeronautics Collaborates

Revitalized collaboration with industry

• Work with Manufacturers

Boeing 787

NASA's work on these technologies

- Advanced composite structures
- Chevrons
- Laminar flow aerodynamics
- Advanced CFD and numeric simulation tools
- Advanced ice protection system

Was transferred for use here

1,054 confirmed orders through September 2014

Boeing 787

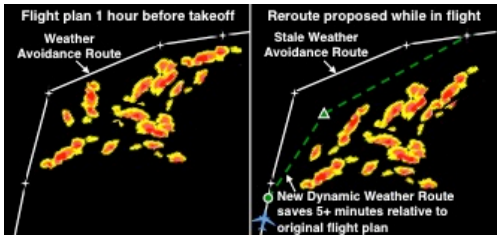
Benefits

- 20% more fuel efficient/ reduced CO_2 emissions
- 28% lower NO_x emissions
- 69% smaller noise footprint

Source: Boeing

• Work with Airlines

(e.g. Dynamic Weather Routes *DWR*) search engine that continuously and automatically analyzes in-flight aircraft in en route airspace to find time- and fuel-saving corrections to weather avoidance routes.



• Work with US Gov't (e.g. FAA)

• Work with Airports

(e.g. Spot and Runway Departure Advisor *SARDA*) Decision support tools for tower and ground controllers to reduce delays at airports.

Developing new, more direct working relationships with industry and a much tighter partnership with government partners.

Future Airplanes?

We don't stop at current configurations

ON-DEMAND MOBILITY

On-Demand Mobility – Definitions

- **Mobility**: Movement of people and goods.
- **High-speed Mobility**: Mobility at speeds significantly above typical surface transportation speeds (>>70 mph). Enabled by aircraft (air-mobility) for distributed travel needs and high-speed rail for centralized, dense urban corridors.
- **Scheduled Mobility**: Public transportation services aggregating the needs of many users with the specifics of a trip (origin, destination, and departure time) determined by service providers (e.g. bus, rail, airline operators).
- **On-Demand Mobility**: Personal transportation capabilities in which the specifics of a trip (origin, destination, and departure time) are chosen by the user.
- **High-Speed On-Demand Mobility**: ODM at >>70mph
  - Enabled by personal, charter, and high-frequency commuter aircraft (Thin-Haul)
  - Includes manned and unmanned (passengers & cargo; “piloted” & autonomous)
  - Currently a niche market due to cost, safety, and trip reliability considerations.

On-Demand Mobility – Potential Markets

Opportunities and challenges as defined by the Community

- **Thin Haul Commuters**
  - Connect smaller cities directly with point to point aviation services
  - Decrease total operating costs by 30%, with lower community noise and emissions.
- **Advanced General Aviation**
  - Re-energize the GA market
  - Early and rapid adopter of advanced aviation technologies; new certification standards
- **Small UAS Market**
  - Multiple new markets: package delivery, surveillance, photography, agriculture
  - VTOL concepts, robust/reliable control, ultra-low community noise, high cruise efficiency, and ultra-high safety.

On-Demand Mobility Research

Community and NASA Interest

- Community Vision
  - Potential to leverage rapidly developing convergent technologies to
    - Transform shorter-range transportation
    - Develop vibrant aviation markets
    - Dramatically increase regional productivity
- Technical Barriers
  - Solve challenges in safety, cost, efficiency, noise, accessibility
  - Pioneer the certification standards
- NASA Opportunities
  - Enable solutions to technical barriers
    - *E.g.: distributed electric propulsion*

  - Leverage ODM as early adopter of transformational technologies
  - Establish applicability to larger-scale commercial transportation

ODM Contributions to Strategic Outcomes

Enabling Transformation

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

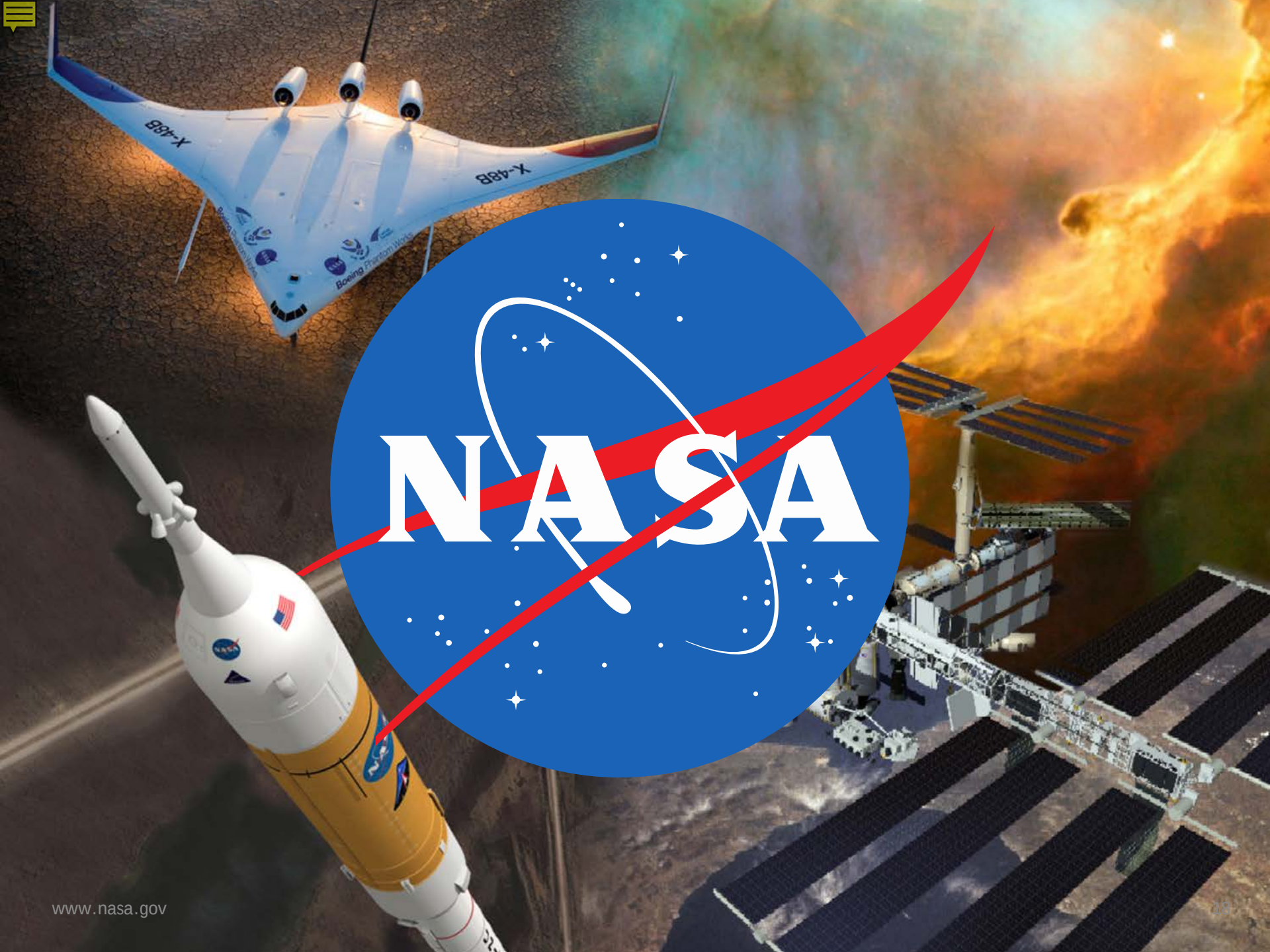
- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation

- **Develop high impact aviation autonomy applications**

Primary

Secondary


X-48B
Boeing Phantom Works
NASA