The NACA and NASA Aeronautics have made amazing contributions to U.S. and global aviation.
Air Transportation System Critical to U.S. Economy

- **$1.5 TRILLION**
  - TOTAL U.S. ECONOMIC ACTIVITY
  - (civil aviation-related goods and services, 2012)

- **$78.3 BILLION**
  - POSITIVE TRADE BALANCE
  - (aerospace industry, 2014)

- **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)
Aviation Market Growing and Moving East

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

Traffic in Asia-Pacific is forecasted to triple by 2030.

Estimated additional passenger volume in 2016 vs 2011:
- Global: 831 million
- Asia-Pacific: 380 million
- China: 193 million

New airplanes deliveries by region:
- Asia Pacific: 11,450
- Europe: 7,550
- North America: 7,530
- Latin America: 2,570
- Middle East: 2,520
- CIS: 1,080
- Africa: 800
- Total: 33,500

Current Market Outlook 2011-2030:

Source: Boeing
Rapid Urbanization

Source: National Intelligence Council
Technology Development and Adoption is Accelerating

<table>
<thead>
<tr>
<th>Invention</th>
<th>Year</th>
<th>Years to 25% Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>1873</td>
<td>46</td>
</tr>
<tr>
<td>Telephone</td>
<td>1876</td>
<td>35</td>
</tr>
<tr>
<td>Radio</td>
<td>1897</td>
<td>31</td>
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<tr>
<td>Color Television</td>
<td>1951</td>
<td>18</td>
</tr>
<tr>
<td>Mobile Phone</td>
<td>1983</td>
<td>13</td>
</tr>
<tr>
<td>World Wide Web</td>
<td>1991</td>
<td>7</td>
</tr>
</tbody>
</table>

Years necessary for an invention to be used by 25 percent of the U.S. population

Source: National Intelligence Council
Impact of NASA’s ATM Technologies

Transferred Precision Departure Release Capability (PDRC)

• Conducted two operational evaluations over 29 weeks at Dallas-Ft. Worth International Airport and Dallas-Ft. Worth FAA Air Route Traffic Control Center

• Number of flights departing within release window improved by more than 50% when compared to the baseline

• Reduce departure delays with potential to reclaim up to 80% of lost overhead slot opportunities
Advancement in Flight Deck

What made this possible?
- Flight deck enhancements
  - Improved aero & propulsion for safety and efficiency
  - Fly-by-Wire
  - Avionics automation
- Operational system enhancements
  - Enhanced weather prediction
  - Informed maintenance systems
  - Data analytics and sharing

What new technologies are coming that will allow a different way, a safer way, a better way?
- Advanced data communications
- Network-enabled ops/decision making
- Advanced human-system integration
- Real-time, system-wide safety
- Increasingly autonomous systems

Collaborative development with aviation community

Accomplished with unprecedented increased levels of safety and performance
Impact on Environmentally Responsible Aviation

Mature technologies and study vehicle concepts that together can simultaneously meet the NASA Subsonic Transport System Level Metrics for noise, emissions, and fuel burn in the N+2 timeframe.

-75% LTO & -70% Cruise NOx Emissions
42dB below Stage 4 Community Noise
-50% Aircraft Fuel/ Energy Consumption

Technical Focus Areas
Accelerate technology maturation through integrated system research

Innovative Flow Control Concepts for Drag Reduction
Advanced Composites for Weight Reduction
Advanced UHB Engines for SFC & Noise Reduction
Advanced Combustors for Oxides of Nitrogen reductions
Airframe & Engine Integration for Community Noise Reduction

Integrated potential Impact from 2025 – 2050 with broad application of technologies:
More than 80 B fewer gallons of fuel burned
Nearly 1 B fewer tons of CO2 emitted
Research into N+3 Configurations

Truss-Braced Wing Weight Uncertainty
- Previous TBW conceptual designs showed significant potential in meeting NASA N+3 goals
- Highlighted a significant uncertainty in wing weight estimates
- NASA performed high-fidelity computational simulations and experiments of a TBW conceptual design to measure performance improvements that would lead to reduced fuel burn

Integrated BLI Test of MIT D8 Aircraft
- D8 configuration provides a substantial performance benefit, a large part of which is attributed to boundary layer ingestion (BLI)
- Completed wind tunnel testing that collected force and moment data, surveys of engine inlet and exit flows, surface pressures and flow visualization
- Preliminary results indicate a 7% reduction in electrical power required for the integrated configuration when compared with the podded configuration at a simulated cruise condition.
Low Carbon Propulsion

NASA studies and industry roadmaps have identified hybrid electric propulsion systems as promising technologies that can help meet national environmental and energy efficiency goals for aviation.

Potential Benefits

- Energy usage reduced by more than 60%
- Harmful emissions reduced by more than 90%
- Objectionable noise reduced by more than 65%
Enabling Integration of UAS into NAS

Goal: Provide research findings to reduce technical barriers associated with integrating unmanned aircraft systems into the national airspace system utilizing integrated system-level tests in a relevant environment.

Partnership with FAA and RTCA to support development of UAS performance standards.
**UAS Traffic Management (UTM)**

Goal: Safely enable UAS operations at lower altitudes

**State-of-the-Art:** Commercial low-altitude UAS operations are disallowed and demand is likely to grow considerably

**Solution:** Develop UAS Traffic Management system to support airspace design, geo-fencing, wind/weather integration, separation management, and contingency operations

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**Partnerships**

NASA will be UTM technology developer and conduct collaborative tests

FAA: Research engagement

NOAA: Weather information at low altitudes

Novel partnerships: Vehicle manufacturers, test sites, DOI, insurance companies, academia, communication, surveillance, system integrators, etc.

Google, Amazon, Verizon, 3DRobotics, Airware
NASA Aeronautics is celebrating 100 years of excellence—from NACA to NASA

NASA Aeronautics is ready to usher in the next 100 years of excellence

• Compelling, community-endorsed vision and strategy
• Demonstrated ability to perform high-impact research, complete our commitments, and deliver results (Environmentally Responsible Aviation Project, Research Transition Teams)
• Taking on the community’s most urgent needs (Unmanned aircraft systems integration into the national airspace system)
• Leading the community with transformative concepts and solutions (UAS Traffic Management, Future Aircraft Concepts, Computational Fluid Dynamics 2030 Vision)
• Successfully collaborating with universities and industry (NASA Research Announcements, cost-sharing cooperative agreements)
• Global thought leaders that are leveraging international capabilities (International Forum for Aviation Research)