NASA Aeronautics Research
Strategy & Partnerships

Thomas B. Irvine

NASA TECHNOLOGY DAYS 2012
Cleveland, Ohio
• Why Is Aviation So Important?
• What Role Does NASA Play in Aviation?
• What Does NASA Do?
• How Do We Engage the External Research Community?
Why is aviation so important?

- **$1.3 TRILLION**
  TOTAL U.S. ECONOMIC ACTIVITY
  (civil and general aviation, 2009)

- **$47.1 BILLION**
  POSITIVE TRADE BALANCE
  (civil aviation, 2011)

- **10.2 MILLION**
  DIRECT AND INDIRECT JOBS
  (civil and general aviation, 2009)

- **5.2%**
  OF TOTAL U.S. GROSS DOMESTIC PRODUCT (GDP)
  (civil and general aviation, 2009)
Why should I care?

$1.6 \text{ TRILLION}
VALUE OF FREIGHT TRANSPORTED BY AIR
(exports, domestic, indirect spending, 2008)

$636.1 \text{ BILLION}
SPENT BY AIR TRAVELERS IN U.S. ECONOMY
(foreign and domestic travelers, 2008)

728 \text{ MILLION}
PASSENGERS ON U.S. CARRIERS
(domestic and international, 2011)
What are the challenges?

- **28%**: Rise in jet fuel costs from 2010-2011
- **16.4 billion gallons**: Of jet fuel burned in 2011
- **$7.7 billion**: Cost of delays to U.S. airlines in 2011
- **$9.3 billion**: Spent by airports on noise abatement since 1982
- **3%**: Of global CO₂ and **5%**: Warming effects projected from aviation by 2050
- **360 million**: Passengers being added in Asia Pacific from 2009 to 2014

(Market is growing and moving East)
Aeronautics is on the Move: The Market is Growing and Moving East

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

Adding 360 million passengers in Asia Pacific

Additional passengers 2014 vs 2009

And it is Driving Growth in Global Competition!

- Was U.S.
- Is U.S. and EC
- Will be U.S., EC, China, Brazil, Canada, Russia...??

Source: Boeing

New airplanes
Deliveries by region

<table>
<thead>
<tr>
<th>Region</th>
<th>New airplanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia Pacific</td>
<td>11,450</td>
</tr>
<tr>
<td>Europe</td>
<td>7,550</td>
</tr>
<tr>
<td>North America</td>
<td>7,530</td>
</tr>
<tr>
<td>Latin America</td>
<td>2,570</td>
</tr>
<tr>
<td>Middle East</td>
<td>2,520</td>
</tr>
<tr>
<td>CIS</td>
<td>1,080</td>
</tr>
<tr>
<td>Africa</td>
<td>800</td>
</tr>
<tr>
<td>Total</td>
<td>33,500</td>
</tr>
</tbody>
</table>

New airplanes
Boeing order backlog: 2011 to 2030

<table>
<thead>
<tr>
<th>Region</th>
<th>Delivery units</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 to 2030 New airplanes</td>
<td>33,500</td>
</tr>
</tbody>
</table>

Current Market Outlook 2011–2030

Copyright © 2011 Boeing. All rights reserved.
Fuel Efficiency Needed!

Rising fuel costs have led to energy being the dominant cost factor for air transportation.

Airline Energy Costs Continue to Rise

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

Source: A4A

Fuel Cost to DOC Ratio

Source: ARMD Analysis
What role does NASA play in aviation?

- The U.S. competitive edge in aviation can only be sustained through appropriate industry and government research and development, which includes aeronautics research done by NASA.

- Research and development can make substantial contributions to economic growth, and provide the foundation for commercial aviation products.

- NASA aeronautics research promotes the private sector's ability to make use of new technologies as they become available, generally within a 10- to 20-year horizon.
What does NASA do?
Technology for the Next Generations of Transports

- BPR 20 (or prop) with small, high efficiency cores
- Tailored, lightweight fuselage, higher wing aspect ratio and quiet, simplified high lift
- Hybrid electric propulsion and alternative fuels
- Propulsion airframe integration

- Innovative flow control concepts
- Advanced composites, combustors and UHB engines
- Airframe and engine integration

Higher Efficiency
Lower Noise
Fewer Emissions

NASA Technology Leadership in a National Partnership with Industry, FAA, DoD
NextGen ATM for Efficient Operations

Lower Cost  Higher Efficiency  More Capacity  More Flexibility

- Tactical Automation for Complex Choke Points
- Strategic Automation for Flow Management
- Human/Automation & Air/Ground Functional Allocation
- Seamless Integration of Automation into TBO

NASA Technology Leadership in a National Partnership with FAA, Industry, DoD
Safety for Today’s System, NextGen and Beyond

- Assurance of Flight Critical Systems
- Discovery of Precursors to Safety Incidents
- Assuring Safe Human Systems Integration
- Improve Crew Decision-Making and Response in Complex Situations
- Maintain Vehicle Safety between Major Inspections
- Assure Safe and Effective Aircraft Control under Hazardous Conditions
- Engine and Airframe Icing
- Atmospheric Hazard Sensors and Mitigation

NASA Technology Leadership in a National Partnership with FAA, Industry, DoD
Impact
- Total Fuel Usage Rises Only 2%
  Despite a Projected Increase in Total Seat KM Flown of 44%
- 31% Reduction in Noise
- 27% Reduction in NOx

Source: JPDO/ARMD Analysis
What are benefits of NASA’s work?

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

Benefits:
- 20% more fuel efficient/
  reduced CO₂ emissions
- 28% lower NOₓ emissions
- 60% smaller noise footprint

824 confirmed orders through August 2012

Source: Boeing

Boeing 747-8

NASA’s work on these technologies:
- Advanced composite structures
- Chevrons
- Laminar flow aerodynamics
- Advanced CFD and numeric simulation tools

Was transferred for use here

Benefits:
- 16% more fuel efficient/
  reduced CO₂ emissions
- 30% lower NOₓ emissions
- 30% smaller noise footprint than 747-400

106 confirmed orders through August 2012

Source: Boeing

P&W PurePower 1000G Geared Turbofan

NASA’s work on these technologies:
- Low NOₓ Talon combustor
- Fan Aerodynamic and Acoustic Measurements
- Low noise, high efficiency fan design
- Ultra High Bypass technology
- Acoustics Modeling and Simulation tools

Was transferred for use here

Proposed for Airbus A320NEO,
Bombardier C-Series,
Mitsubishi Regional Jets

Benefits:
- 16% reduction in fuel burn/
  reduced CO₂ emissions
- 50% reduction in NOₓ
- 20dB noise reduction

Source: Boeing

CFM LEAP-1B

NASA’s work on these technologies:
- Compression system aerodynamic performance advances
- Low NOₓ TAPS II combustor
- Low pressure turbine blade materials
- High-pressure turbine shroud material
- Nickel-aluminide bond coat for the high pressure turbine thermal barrier coating

Was transferred for use here

Proposed for Airbus A320NEO, Boeing 737MAX

Benefits:
- 15% reduction in fuel burn/
  reduced CO₂ emissions
- 50% less NOₓ
- 15dB noise reduction

Source: CFM
How Do We Engage the External Research Community?

• There are a variety of ways to participate
• Industry, Academia, Small Businesses, and entrepreneurs all partner in the success of NASA’s Aeronautics Research

• We use the following mechanisms:
  1) NASA Research Announcement / Research Opportunity in Aeronautics
     • Solicitation for research in areas that enhance our core capabilities
     • Seek the best / new ideas in support of our goals and research objectives
     • Average total funding: ~ $60M / yr (goal: $75M / yr)
     • Target Participants: Industry, Academia, Non-Profit
  2) Small-Business Innovative Research
     • Funds to support innovation by small businesses in fundamental research disciplines
     • Dec. 2010 cycle funding: 95 of 495 awards for aeronautics research at $9.5M
     • Target Participants: Small Businesses
How Do We Engage the External Research Community? (cont.)

- We use the following mechanisms:
  3) LEARN (Leading Edge Aeronautics Research for NASA)
     - Invests in innovation ideas from outside of NASA
     - Open to all domestic researchers
     - Annual solicitation via NSPIRES (NASA Solicitation and Proposal Integrated Review and Evaluation System)
     - Funding: $5M / yr and Phase 1 awards at $200K and Phase 2 awards at $400K
     - Target Participants: Academics, entrepreneurs, citizen inventors
  4) Space Act Agreements
     - Agreements with large and small businesses, others to conduct research, test novel concepts and technologies
     - Leverages non-NASA party’s own investments in order to enhance transition of technology from the laboratory to the field
     - ~ 80 active aero-related agreements in force at any given time
     - Range from fully-reimbursable to non-reimbursable
We use the following mechanisms:

5) Challenges / Prizes
   • Promote creative solutions and harness innovation
   • Address gaps in current aeronautics solutions, e.g., Green Aviation Challenge
Successful Partnership Example
NextGen Operations

Problem
Current ground delay policy at SFO can lead to excessive unrecoverable delays due to fog

Approach
Conducted a simulation recommending Ground Delay Program (GDP) parameters for SFO airport. Merges National Weather Service real-time data with Air Traffic Control departure scheduling.

Results
Significant near-term reduction in ground delays at San Francisco Airport.

Next Steps
- Brief FAA Air Traffic Control System Command Center (Dec. 2010)
- Delivery of implementation plan (Jan. 2010)

Partners: FAA, Mosaic ATM, and MIT Lincoln Laboratory