Aviation and the Environment

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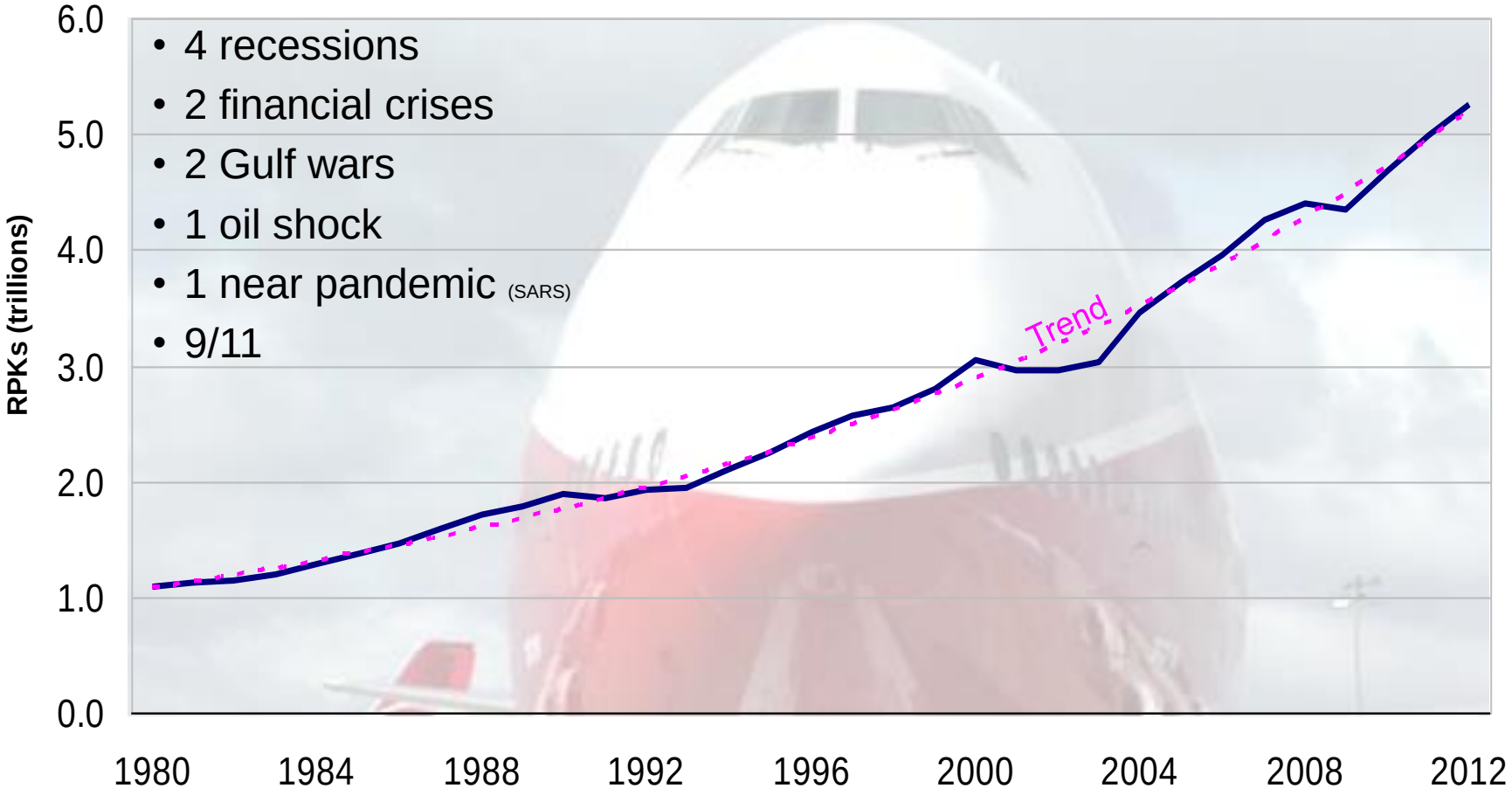
Sean Newsum
Director, Environmental Strategy
Boeing Commercial Airplanes

Environmental Stewardship Strengthens Business

- Climate change and noise are serious challenges that require credible action.
- Employees, customers, communities and investors expect environmental stewardship.
- Environmental improvement supports business performance.

It's good for customers, good for employees, good for the planet. It's the right thing to do.

World air travel has grown 5% per year since 1980

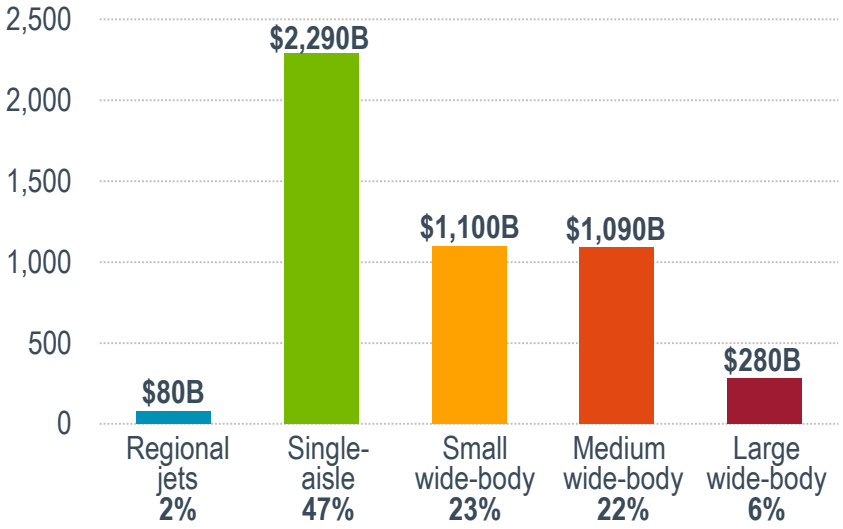


RPKs = Revenue Passenger Kilometers
Source: ICAO scheduled traffic

20-year forecast: Airlines will need more than 35,000 new airplanes valued at $4.8 trillion

Market value: $4.8T

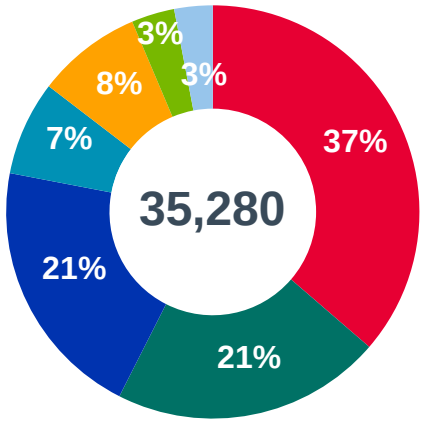
2013 - 2032



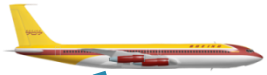
New airplane deliveries by region

2013–2032

Region	Airplanes
Asia Pacific	12,820
Europe	7,460
North America	7,250
Middle East	2,610
Latin America	2,900
C.I.S.	1,170
Africa	1,060
World Total	35,280



Track Record of Significant Progress



MORE FUEL

Relative fuel use

LESS FUEL

EVEN LESS

Early Jet Airplanes

90% reduction in noise footprint

70% fuel improvement and reduced CO_2

HIGHER DECIBELS

Noise dB

LOWER DECIBELS

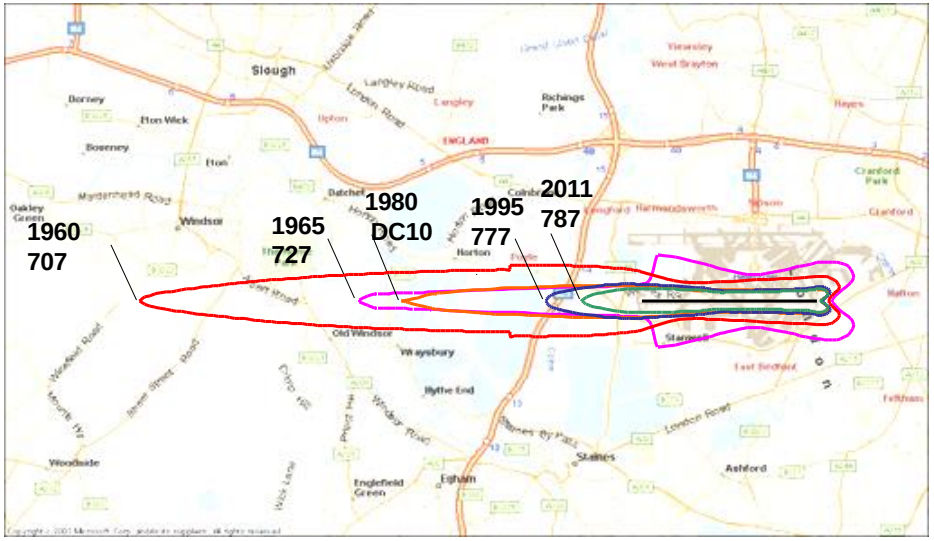
EVEN LOWER

New-Generation Jet Airplanes

1960s → 2000s

Noise footprint based on 85 dBa

We've come a long way…



85 dBA takeoff noise contours, London Heathrow

Enabling Technologies

- ✓ Advanced airframe design
- ✓ Higher bypass ratio
- ✓ Enhanced fan design
- ✓ Chevrons
- ✓ Laminar Flow Nacelle
- ✓ Close-coupled engine placement
- ✓ Electrical bleed system

Continuous innovation has enabled significant noise reduction

Technologies For Quieter Airplanes

Design for efficiency and lower noise

Quiet flight operational procedures

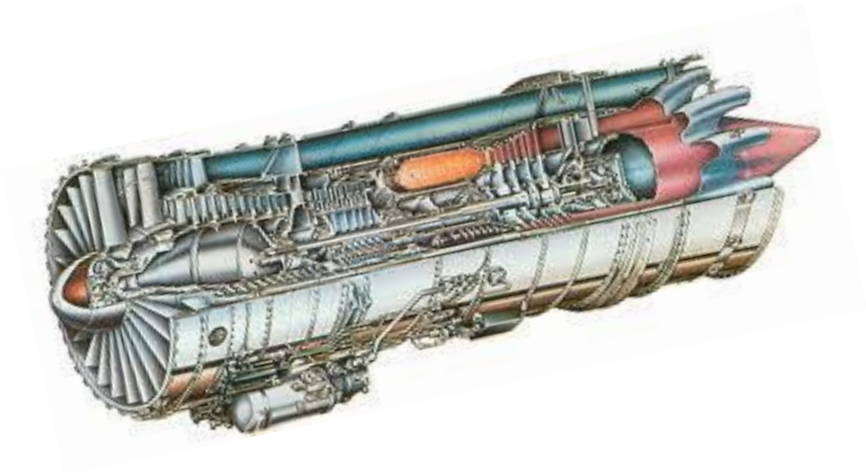
Source noise reduction

Advancing wing technologies

- **Droopable spoilers increase wing efficiency during takeoff and landing**
- **Variable camber for wing optimization during cruise**
- **Multi-function ailerons optimize the wing for takeoff and cruise**
- **Composite structure enables high-aspect ratio design**
- **Smaller fairings reduce drag**
- **Raked wing tips enhance wing efficiency**

Engines Have Become More Powerful, Efficient and Quiet

1950-1960s: Bypass ratio 0 to 1.5



787 example: Bypass ratio 7 to 11+

Source noise reduction via improved designs and new technologies

Improved high lift system design and aerodynamic efficiency

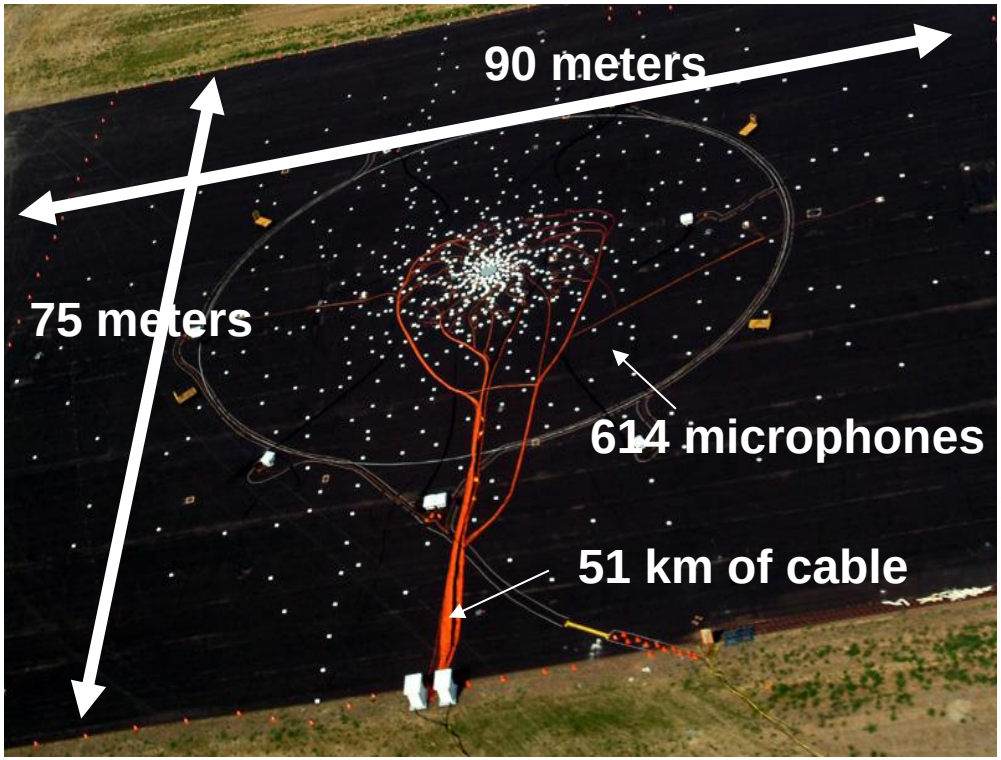
Inlet acoustic treatment for community and cabin noise reduction

Chevron nozzle for community and cabin noise reduction

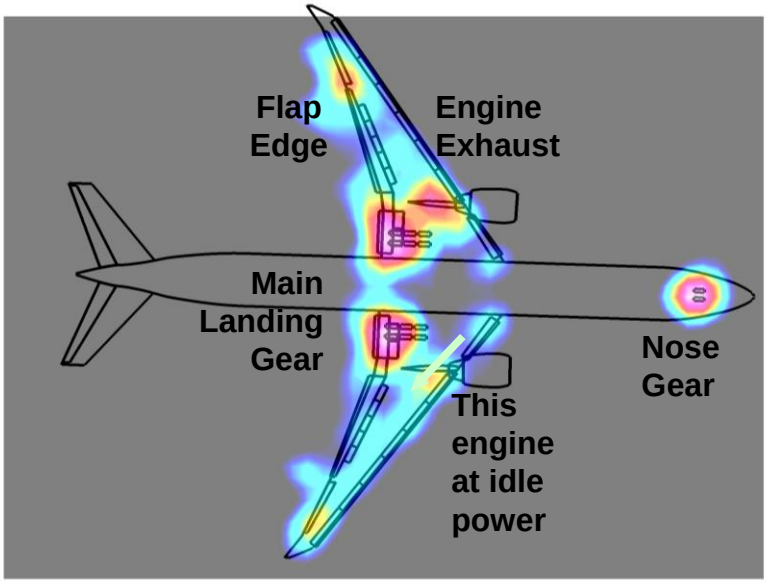
Noise Source identification

Advanced Test Techniques

Phased Array Technology



Identify noise sources



More Efficient, Quieter Family of New Airplanes
787 Dreamliner, 737 MAX, 747-8

The 787 designed to deliver:

20%* Reduction in fuel and CO_2

28% Below 2008 industry limits for NOx

60%* Smaller noise footprint

*Relative to the 767

The 737 MAX designed to deliver:

14%* Reduction in fuel and CO_2

40%* Smaller noise footprint

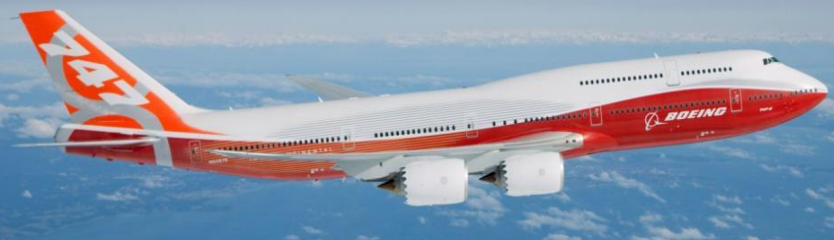
*Relative to the 737 NG

The 747-8 designed to deliver:

Double digit reduction in fuel and CO_2

28% Below 2008 industry limits for NOx

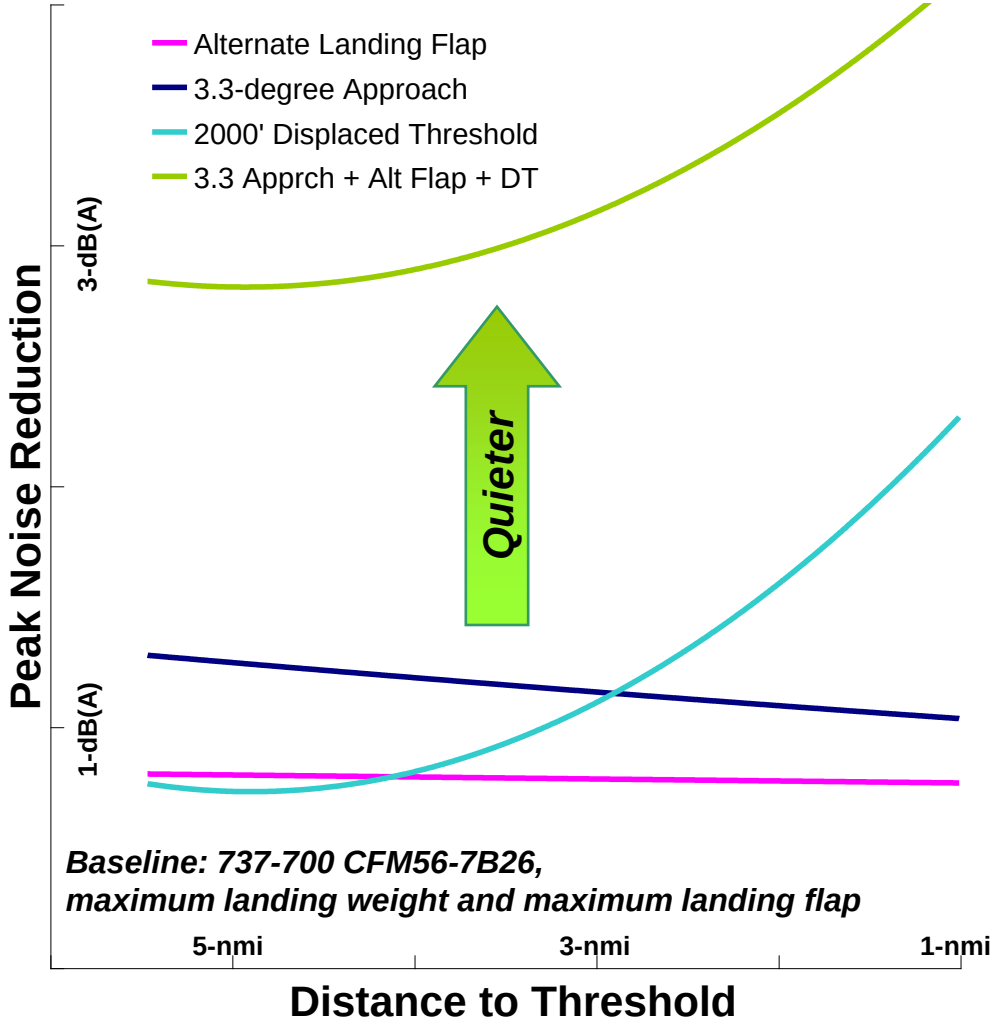
30%* Smaller noise footprint



*Relative to the 747-400

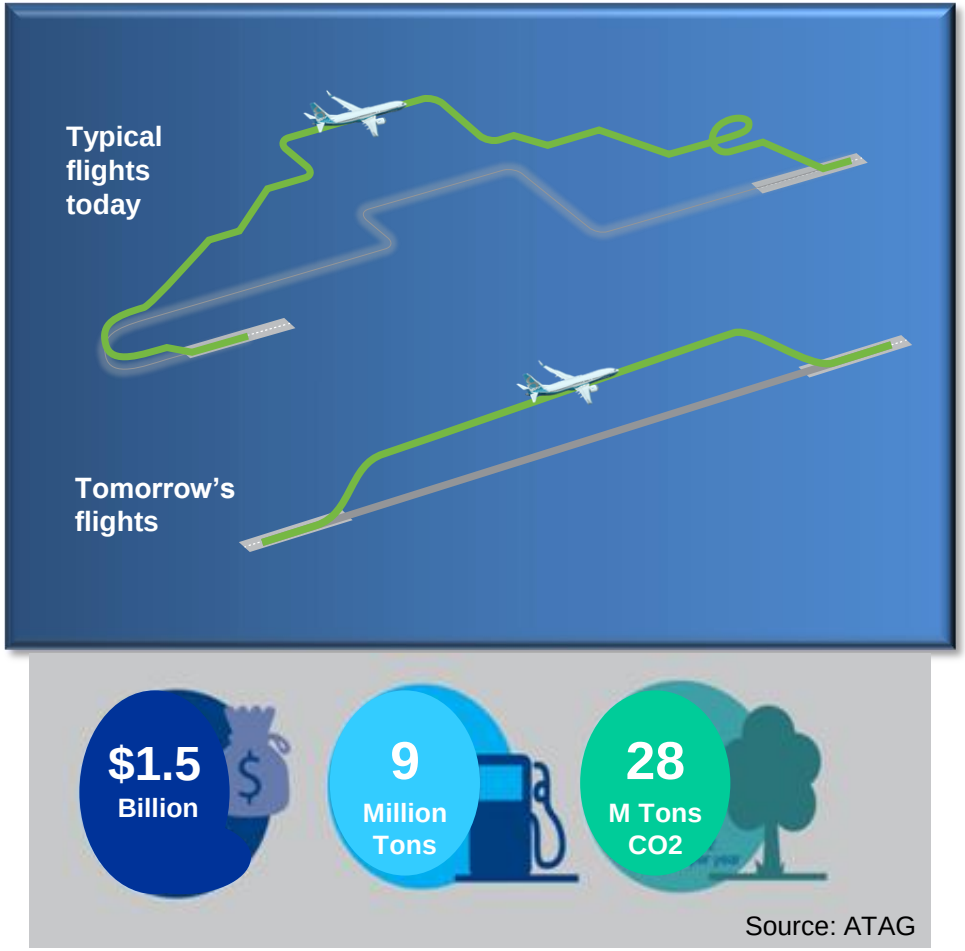
Technologies are in place for quieter operations

- **Alternate Landing Flap**
  - Less thrust / fuel to fly path
  - Increased landing speed
- **Displaced Threshold**
  - More height
  - Reduced runway length
- **Increased approach angle**
  - Less thrust / fuel to fly path
  - More height
  - Increased vertical energy



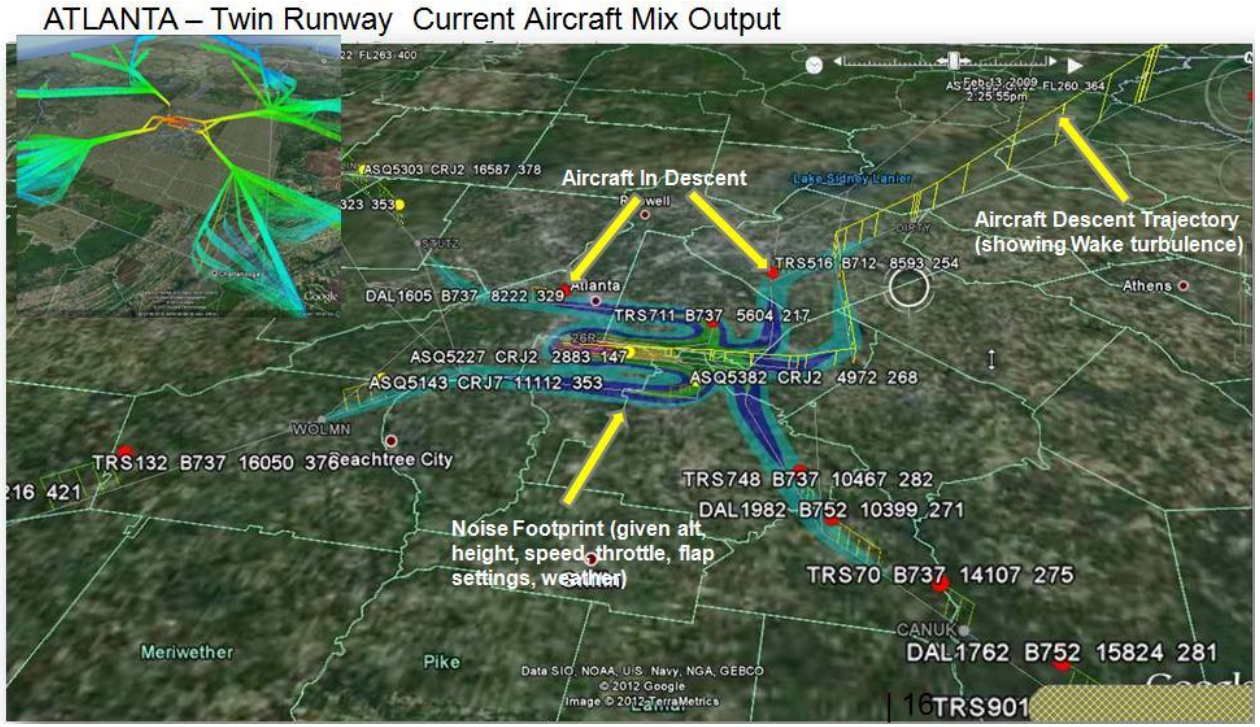
Operational Efficiency
Fly Cleaner, Smarter

- Allow airlines to realize the full potential of current airplane capabilities
- Optimize flight paths and reduce airport congestion
- Reduce time spent idling on runways or circling airports waiting to land



Advanced systems modeling can enable enhanced scenario analysis and stakeholder collaboration

- Event-driven fast-time air traffic simulation based on high-fidelity models: aircraft performance, Flight Management System/guidance algorithms, wind/temperature uncertainty, ground-based ATC automation functions (e.g. Arrival Management)



Airplane and operations technologies have potential…

Stakeholder collaboration is key to success

Thank you!

787-9 first flight,
September 7, 2013