Key Elements of Successful Environmental Strategy

1 Focusing on a Clear Vision
   • Technology unlocks the future
   • CO₂ (fuel) and Noise are the priority
   • System efficiency is essential
   • A global approach involves and benefits everyone

2 Achieving Specific Metrics and Milestones
   • Pioneer new technologies
   • Relentlessly pursue manufacturing and life cycle improvements
   • Create progressive new products and services
   • Improve performance of worldwide fleet operations

3 Delivering Global Aviation Industry Leadership
   • Continually work together with the industry to promote effective global public policies and best practices – for a better future
Airlines will need more than 29,400 new airplanes valued at $3.2 trillion

29,400 New Airplane Deliveries
2008 to 2027

- Regional jets: 2,510 (9%)
- Single-aisle: 19,160 (65%)
- Twin-aisle: 6,750 (23%)
- 747 and larger: 980 (3%)

$3.2 Trillion Market Value
2008 to 2027

- Regional jets: $80B (2%)
- Single-aisle: $1,360B (43%)
- Twin-aisle: $1,470B (46%)
- 747 and larger: $290B (9%)
Market for new airplanes set to become considerably more geographically balanced

### Deliveries by Region
2008 to 2027

- **North America**: 29%
- **Asia-Pacific**: 31%
- **Latin America**: 6%
- **Middle East**: 5%
- **Africa**: 2%
- **Europe and CIS**: 27%

### Market Value by Region
2008 to 2027

- **North America**: 23%
- **Asia-Pacific**: 38%
- **Latin America**: 4%
- **Europe and CIS**: 25%
- **Africa**: 2%
- **Middle East**: 8%
Technical solutions are being developed

Efficient Aircraft

Environmentally Preferred Operational Procedures

Exploration of alternative fuels and technologies such as fuel cell
Fuel Burn/Emissions by Phase of Flight
For nominal 500 nm flight by a single aisle airplane

- Climb: 34%
- Cruise: 43%
- Departure: 7%
- Approach: 8%
- Descent: 3%
- Take off: 1%
- Taxi out: 3%
- Taxi in: 1%
Efficient operating practices improve fuel and CO₂ efficiency

Target Opportunities

Reduce Aircraft Weight

Plan More Efficient Flights

Fly More Efficient Flights

Sample CO₂ Savings:

- Catering weight program: 2 – 3 Million lbs (0.9 – 1.4 Million kgs)
- Aircraft servicing
- Flight plans: 14 – 21 Million lbs (6.4 – 9.5 Million kgs)
- Speed schedule
- Aircraft loading
- Reserve fuels: 14 – 21 Million lbs (6.4 – 9.5 Million kgs)
- Idle reverse
- Efficient routings

Total CO₂ Annual Savings: 30 – 45 Million lbs (14 – 20 Million kgs)

It is not one thing, it is everything

Source: Boeing analysis for a 115 narrow body airplane operation (22B ASMs)
Technology Programs for Quiet Airplanes
Quiet Technology Demonstrator (QTD)

2001 QTD 1
Boeing
Rolls-Royce
American Airlines

2005 QTD 2
Boeing
General Electric
Goodrich
NASA
All Nippon Airlines

747-8
QTD 2 Technology Applied

787
QTD 2 Technology Applied

777
QTD 1 Technology Applied
QTD 2 Technology Application In Study

Analytical studies
Wind-tunnel tests
Static engine tests
QTD 2
Multiple Organization Working Together

Sustainable Solutions Require Working Together
Reducing Noise for Communities and Passengers

- Core Chevrons
- Fan Chevrons*
- Jointless Liner* + Lip Liner
- Quieter Landing Gear

*787 Features
Acoustic Camera Pin-points Noise Sources
Acoustic Camera Enables Flyover Noise Mapping

Identify opportunities for source noise reduction

Distinguishes between engine and airframe sources

Wing Anti-Icing Exhaust Vents
The 787 Dreamliner is cleaner, quieter and more efficient

The 787 Dreamliner delivers:
- **20%*** Reduction in fuel and CO₂
- **28%** Below 2008 industry limits for NOx
- **60%*** Smaller noise footprint

*Relative to the 767
The 747-8 is cleaner, quieter and more efficient

The 747-8 delivers:

- **16%** Reduction in fuel and CO₂
- **28%** Below 2008 industry limits for NOₓ
- **30%** Smaller noise footprint

*Relative to the 747-400
Hydrogen fuel cell powered airplane takes flight

- Fuel cell creates electricity
- No emissions
Priority technology research for sustainable next-generation biofuels

Demonstrating alternative, low-carbon life cycle fuels
Conducted the first biofuel demonstration on a commercial airplane

Researching potential of future environmentally progressive fuels
Plants, including algae, could supply fuel for the world’s airplane fleet while absorbing CO₂ from the atmosphere

Accelerating deployment of viable sustainable low carbon life cycle fuels
Initiated industry working group to facilitate alternative fuel research
Plant-based feedstocks naturally remove CO₂ from the atmosphere

**Plant-based fuel**

Plant-based feedstocks absorb CO₂ emissions as the feedstocks grow.

**Petroleum-based fuel**

CO₂ emissions from petroleum-based fuel are sourced from fossil material.
## Second-generation biofuels are efficient and sustainable

### First-generation biofuels
- Inefficient and unsustainable sources of energy
- Require large landmasses and mostly grown for human consumption

### Second-generation biofuels
- Derived from *non-food crops* utilizing *new biomass-to-fuel-conversion technologies*
- Exponentially more efficient and sustainable sources of energy
- Require small landmasses and proportionately less fertilizer and water

### Examples:
- **First-generation biofuels:** Ethanol produced from corn and soybean feedstocks
- **Second-generation biofuels:** New fuels from algae, babassu, switchgrass and jatropha

**Soybean**

**Babassu**

**Algae**
What is the global potential for Jatropha?

- More than 800 million hectares of sustainable, non-forested, non-food land are suitable for jatropha.
Successful flight test program demonstrated sustainable biofuel viability

- Identified sustainable biofuel sources
- Demonstrated technical feasibility on various engine / airframe combinations
- Promoted development of viable commercial markets

Increasing level of test objectives
Environmental solutions – we need to actively pursue all viable solutions

Efficient flight operations
- Ground movement and handling (departure and arrival)
- Takeoff and climb
- Cruise
- Descent, approach, landing

Newer solutions and alternatives
- Sustainable biofuels

More efficient airplanes
- Airplane programs
- Airline programs
Environmental solutions are being developed by Working Together Globally

Efficient Operations

Advanced Technology Airplanes

Alternative Fuels

Recycling