



**Transportation Laboratory/Energy Sustainability Forum (IR3S)**

# **International Workshop on Sustainable Transportation and Energy**

**University of Tokyo**



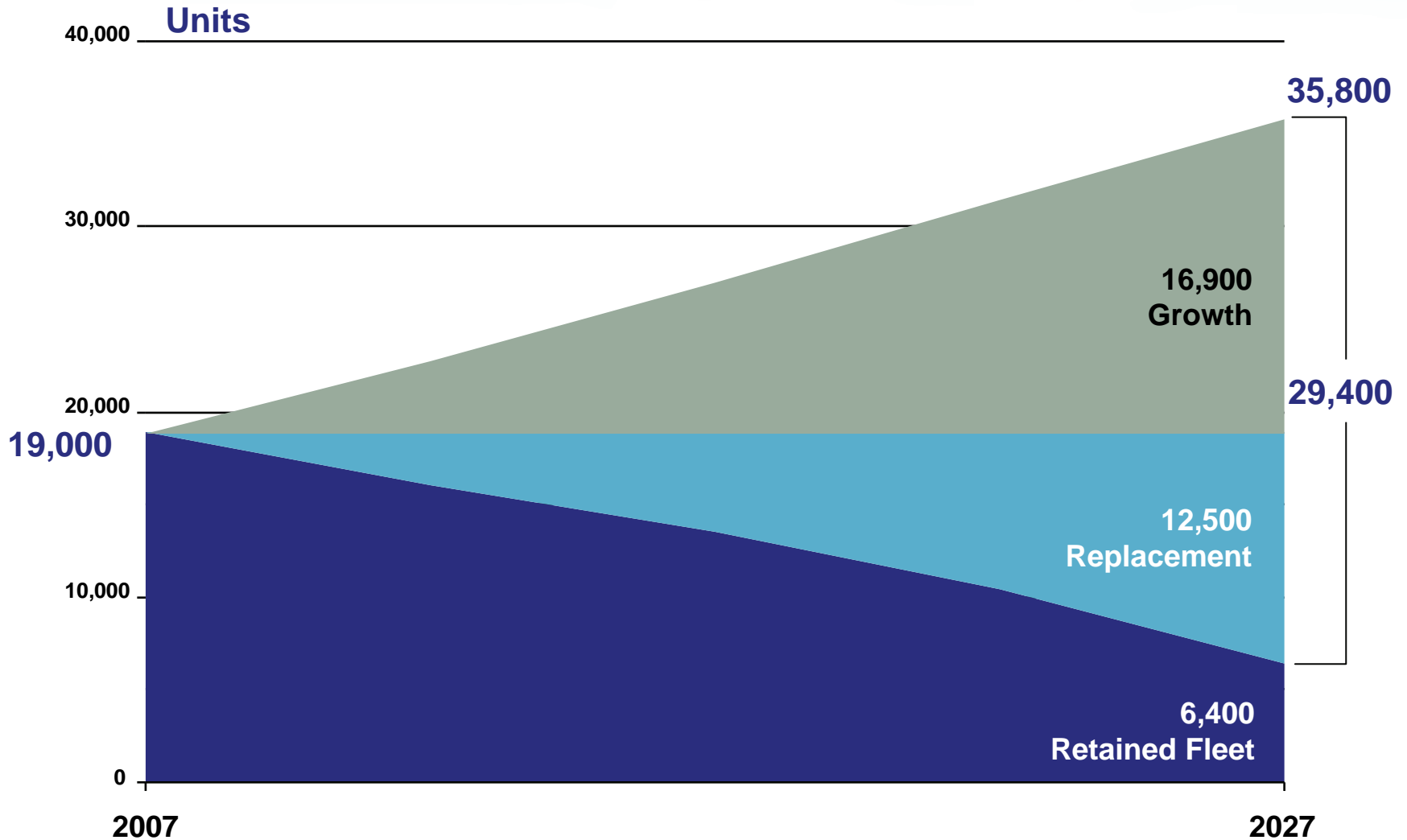
## **The future of Aviation and the Environment: Advanced Technologies and Innovation**

Duane Oda  
Product Development Chief  
Boeing Commercial Airplanes  
6 August 2009

# Key Messages

- **Challenges**
- **Plan and Commitment**
- **Pioneering new technologies**
- **Alignment of technologies to Products**

# Long-term demand for new airplanes remains strong

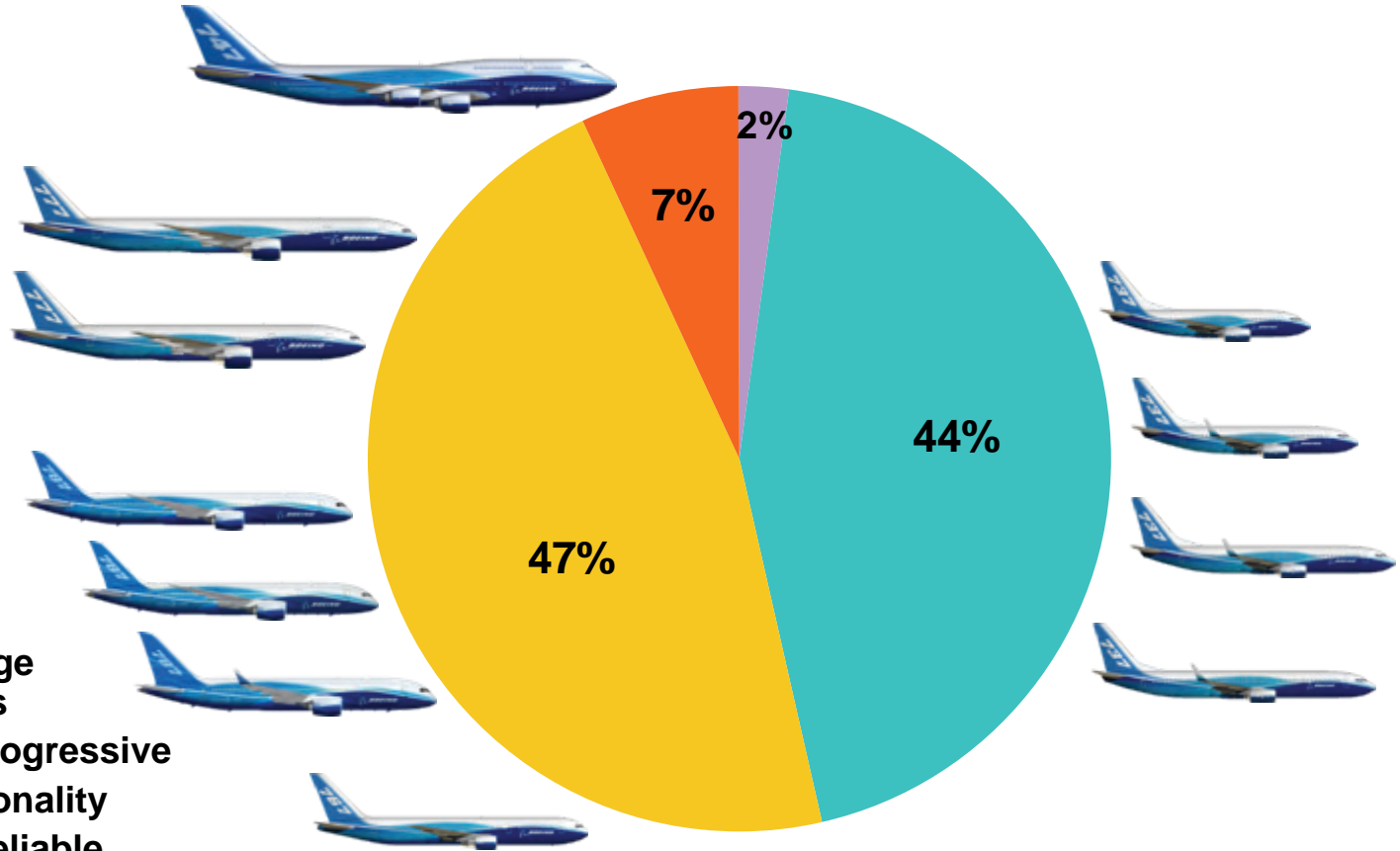


# Boeing Product Strategy

## Market-Driving Products and Services

**2009-2028**

- Regional jets
- Single-aisle
- Twin-aisle
- 747 and larger



- Full market coverage from 100-500 seats
- Environmentally progressive
- Operational commonality
- Long-range, fast, reliable
- Low operating cost
- Standardization
- Passenger experience
- Lifecycle solutions

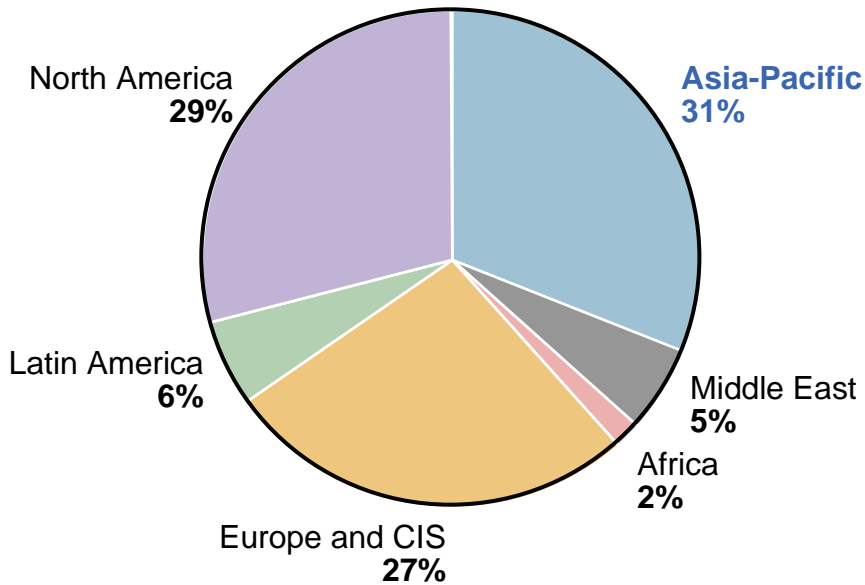
**3.2 trillion  
delivery dollars\***

\*In year 2008 dollars

# Airlines will need more than 29,400 new airplanes valued at \$3.2 trillion

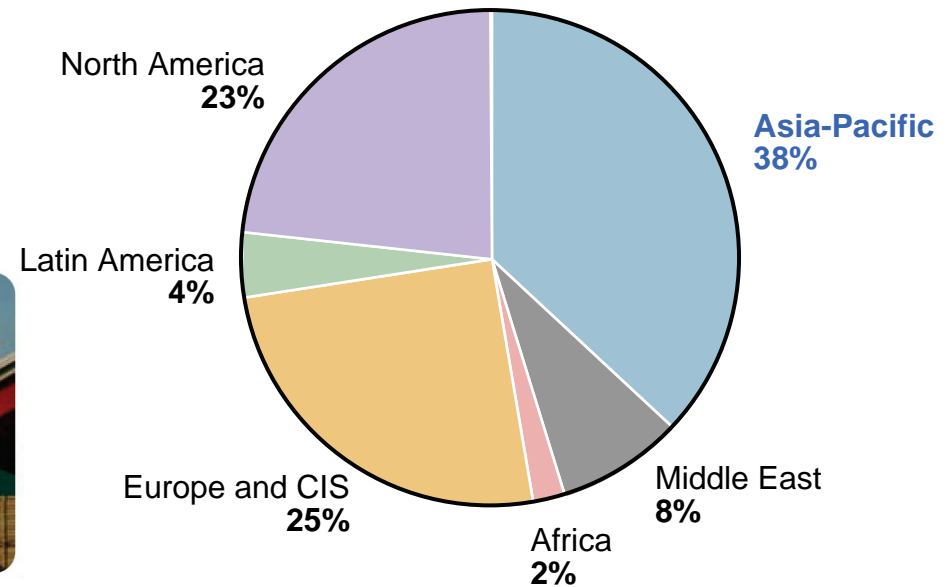
## Deliveries by Region

2008 to 2027



## Market Value by Region

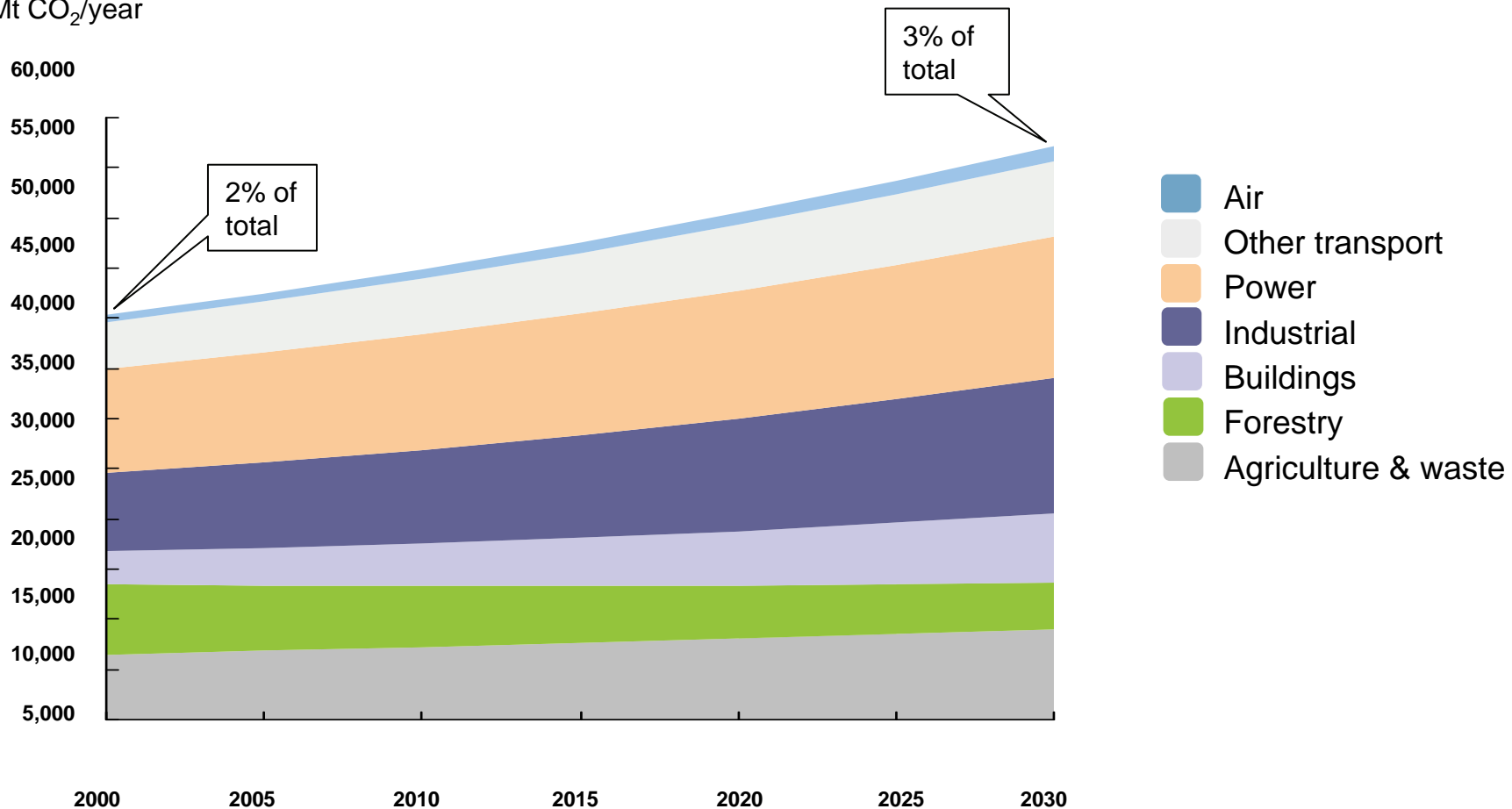
2008 to 2027



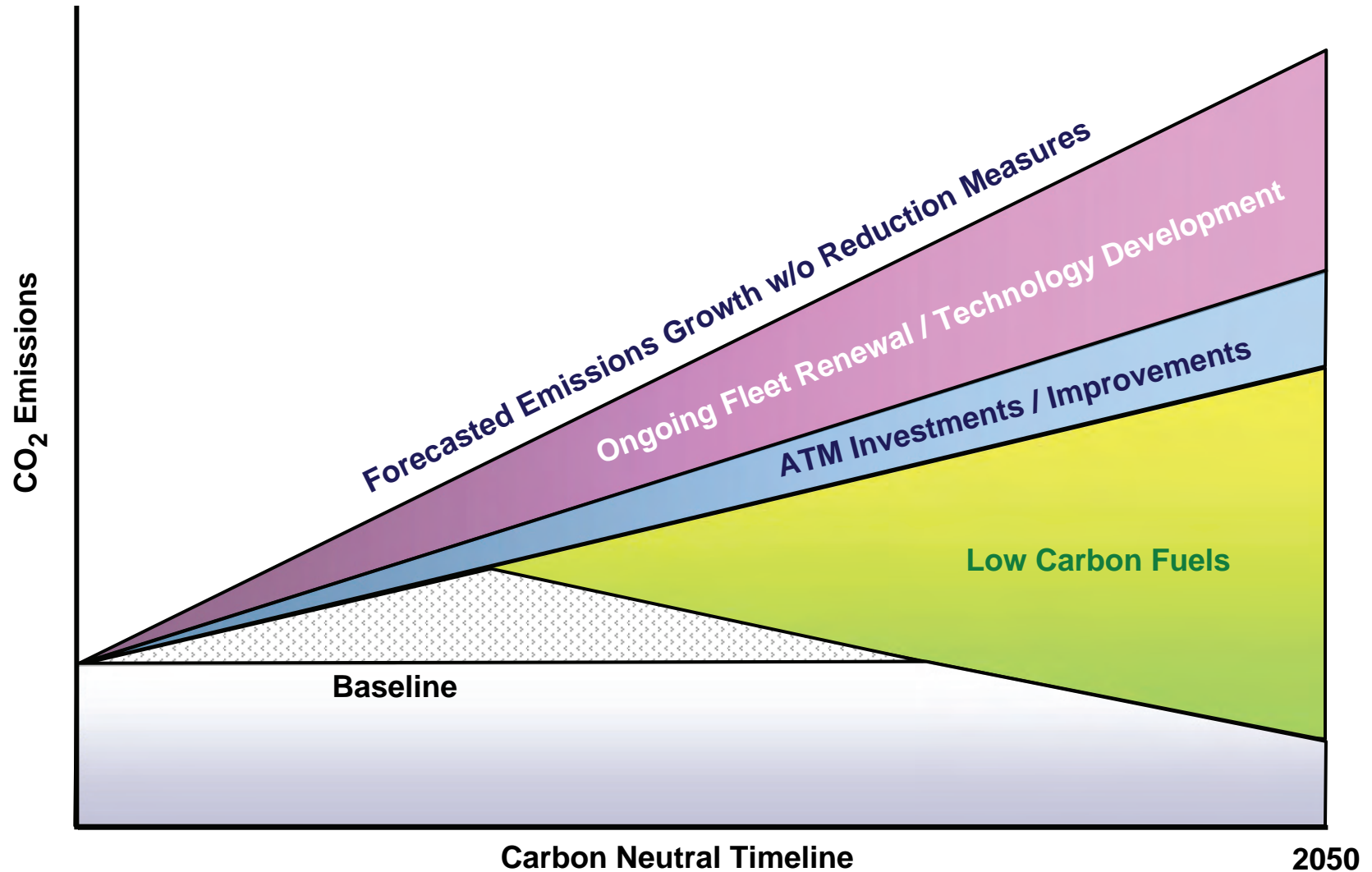
# Aviation: currently small, but without further action – CO<sub>2</sub> emissions will increase

Emissions by sector, 2000-2030

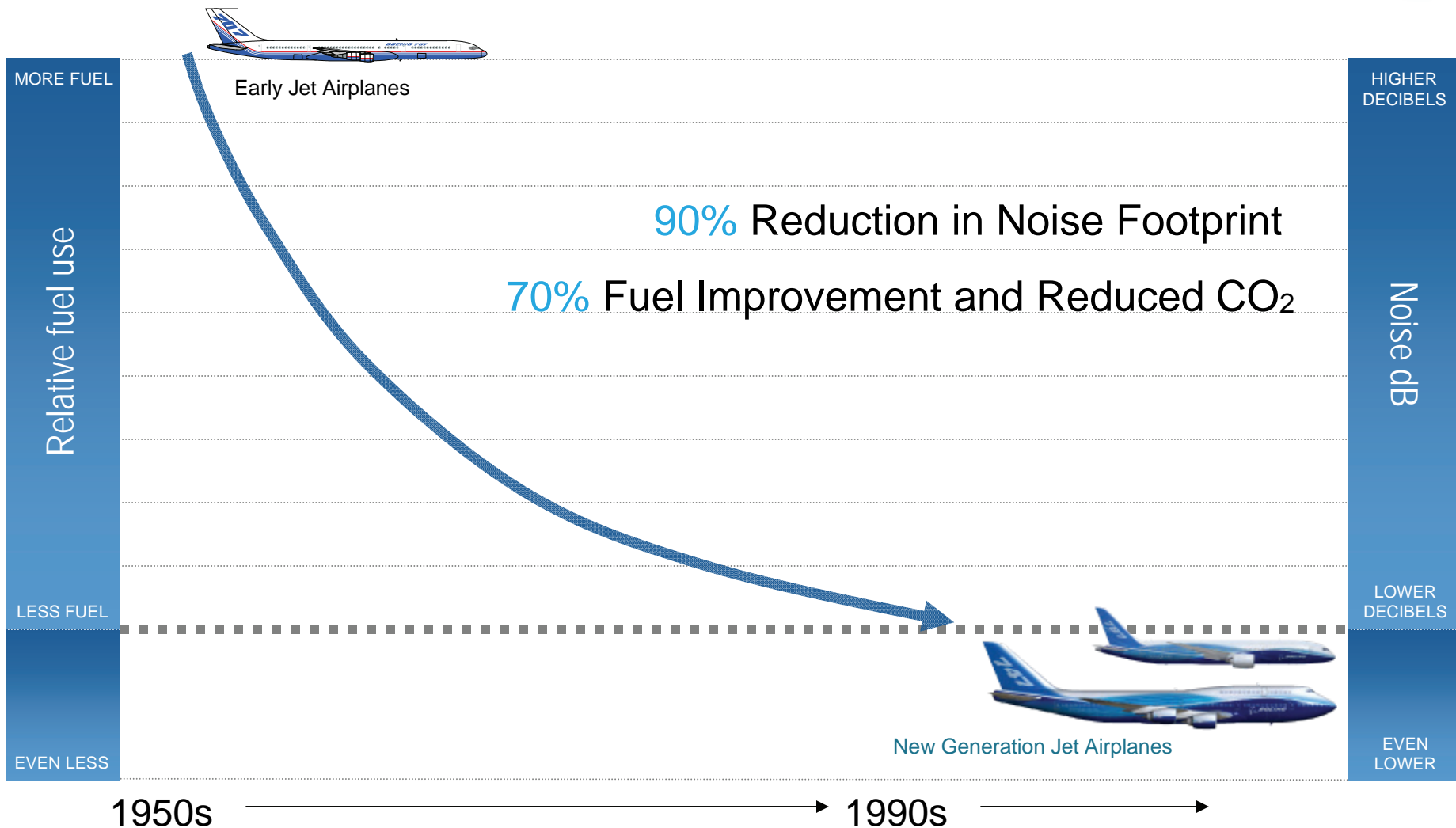
Mt CO<sub>2</sub>/year



# Key drivers of emissions reductions



# Building on a strong record of continuous innovation



Noise footprint based on 85 dBa.



# Our plan and commitments

**Relentlessly pursue manufacturing and life cycle improvements**



100%

Use ISO 14001 continuous improvement plan for 100% of BCA manufacturing sites

Maximize Lean and recycling

**Improve performance of worldwide fleet operations**



25%

Focus on 25% efficiency improvements in worldwide fleet fuel use and CO<sub>2</sub> emissions by 2020

**Deliver progressive new products and services**



15%

Improve CO<sub>2</sub> emissions and fuel efficiency by at least 15%

**Pioneer new technology**



75%

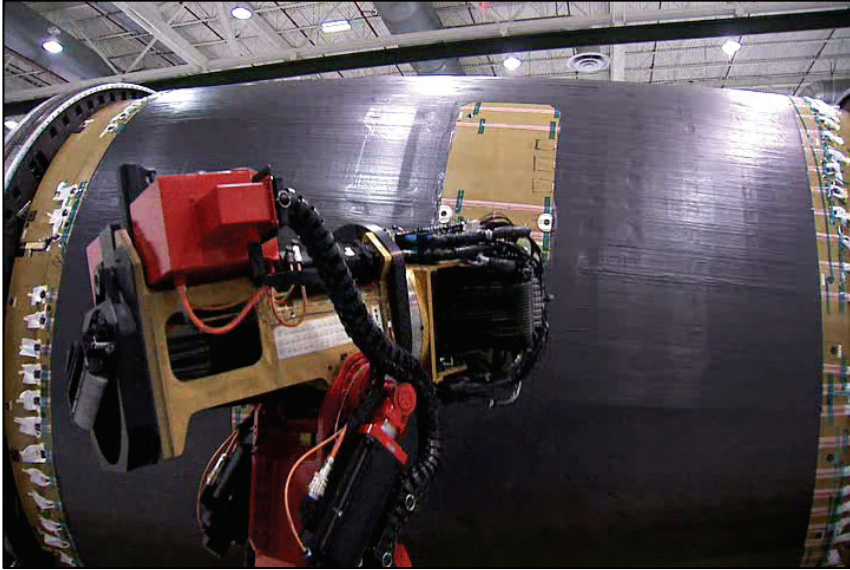
Devote more than 75% of R&D toward benefiting environmental performance

# Innovative technologies for improved performance

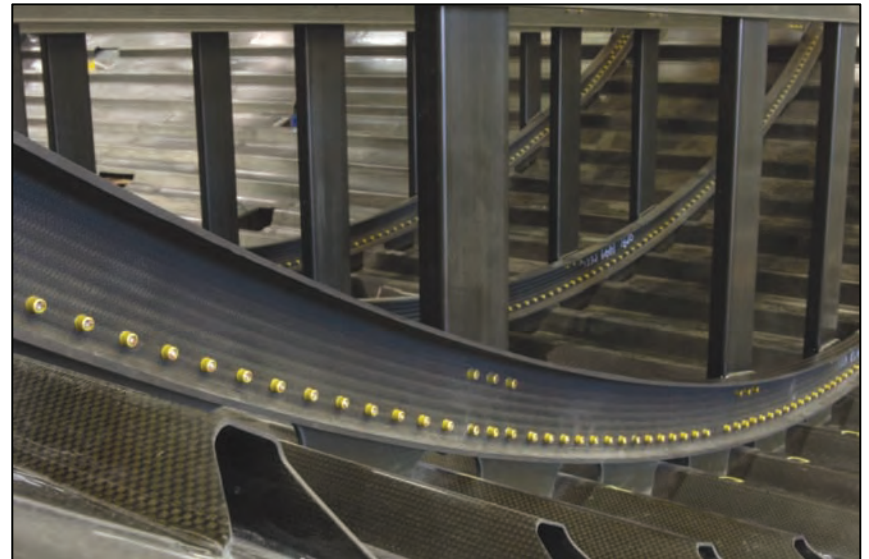
- **Materials research**
- **Advanced aerodynamics**
- **Noise reduction technologies**
- **Renewable energy sources**



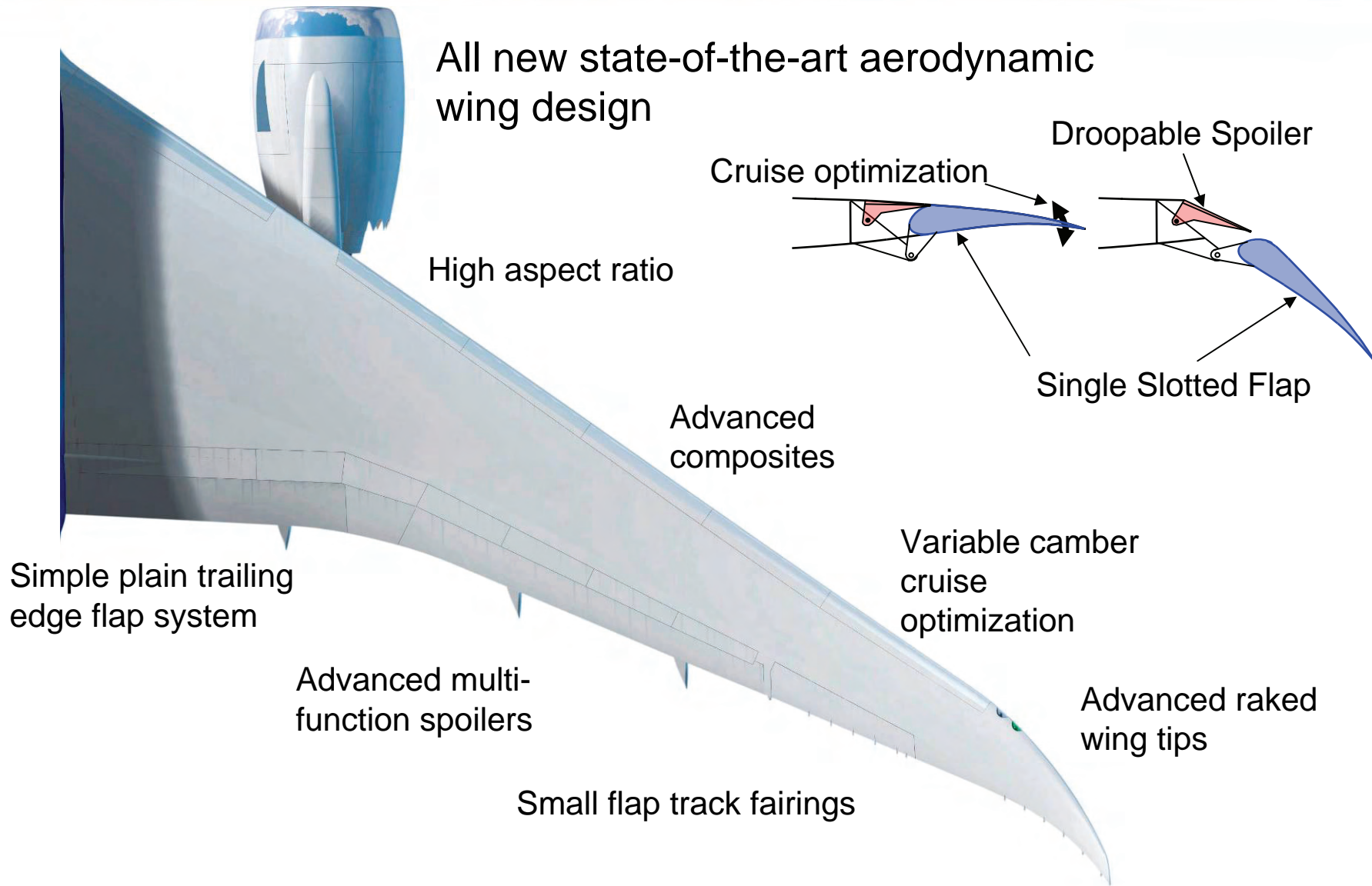
# Researching next-generation materials



Advancing both materials and manufacturing techniques to make structures lighter and more fuel efficient



# The 787 advanced smooth-wing design adds unmatched efficiency



# Actively pursuing noise reduction technologies



## Recent Research – Chevrons

2001: Quiet Technology  
Demonstrator 1 (QTD1)

2005: Quiet Technology  
Demonstrator 2 (QTD2)

## New innovations in noise reduction technology –

- Variable Area Fan Nozzle
- Smart Materials
- Chevron Core Nozzle with Microjets

# Actively pursuing renewable energy sources



## ENERGY HARVESTING TECHNOLOGIES

**Electrodynamic:** Powering light switches with your finger.

**Thermoelectric:** Using temperature gradients to power dimmable windows.

**Piezoelectric:** A vibration-powered wireless sensor

**The Spectrolab solar cell:** Concentrating solar power to make it cost-effective



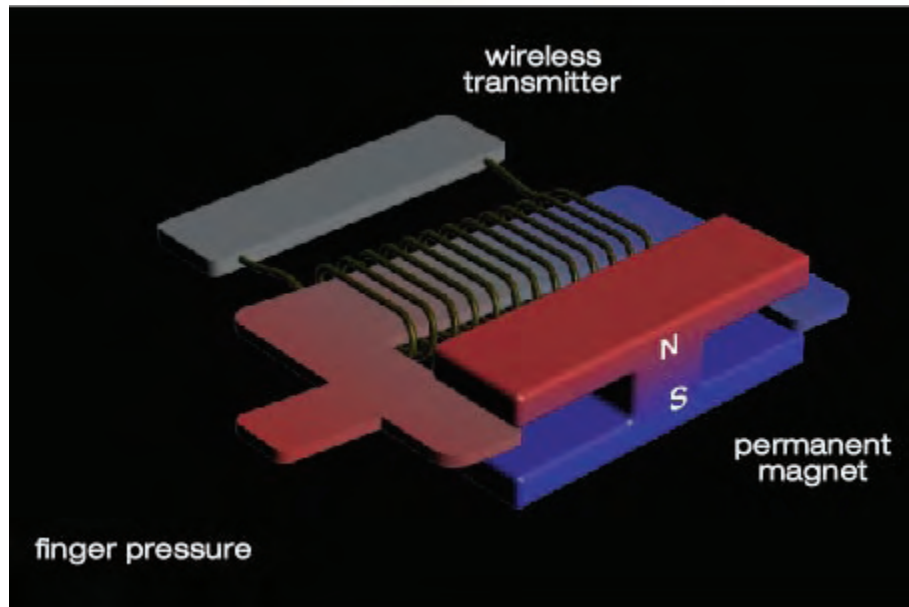
## FUEL CELLS

The Boeing Fuel Cell Demonstrator, achieved the first manned mission where straight-level flight was powered solely by a hydrogen fuel cell.

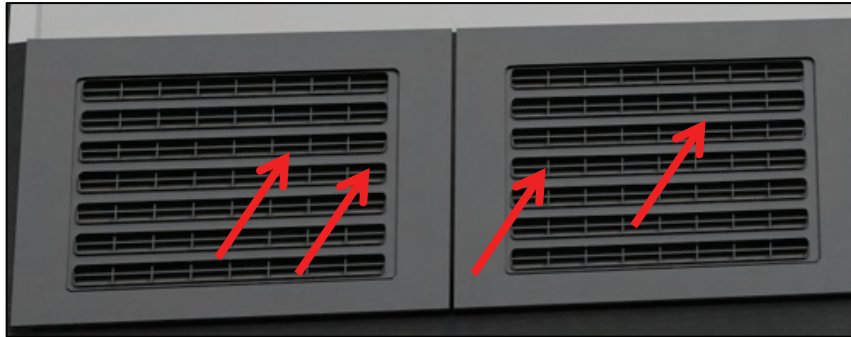
# Electrodynamics convert finger pressure into electrical power



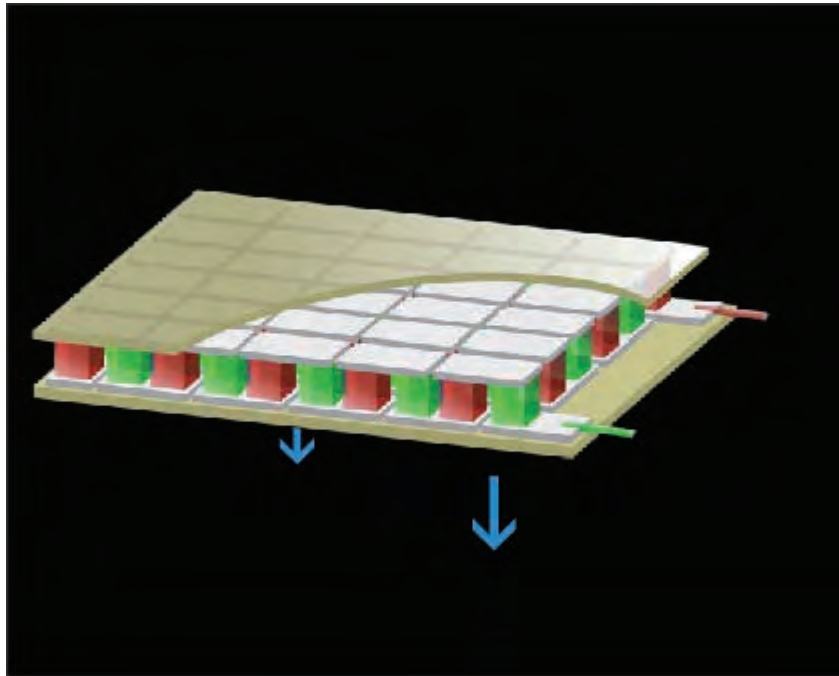
Eliminating wires between the seat and the PSU – saving weight which translates to fuel and emissions reductions



# Thermoelectric devices convert a temperature gradient into electrical power

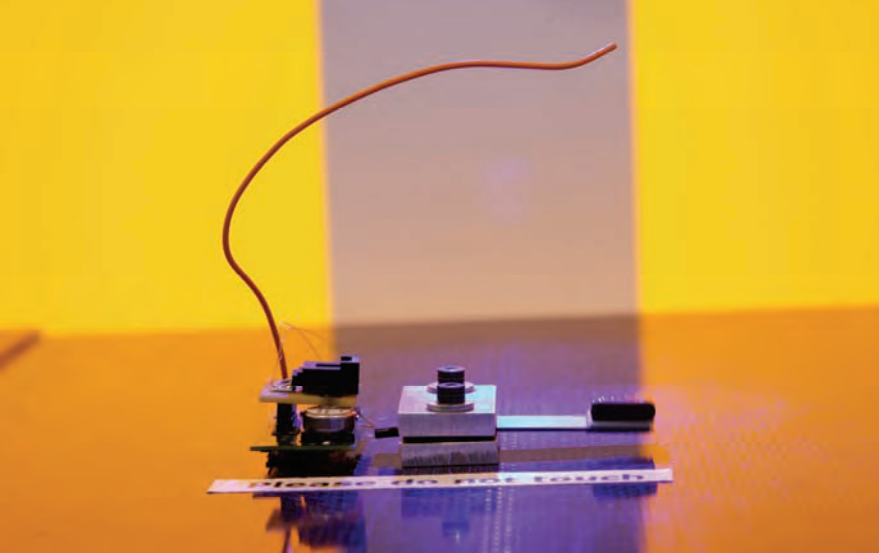


- Recaptures the energy used to warm the cabin air
- Provides power to dimmable window reducing electric demand

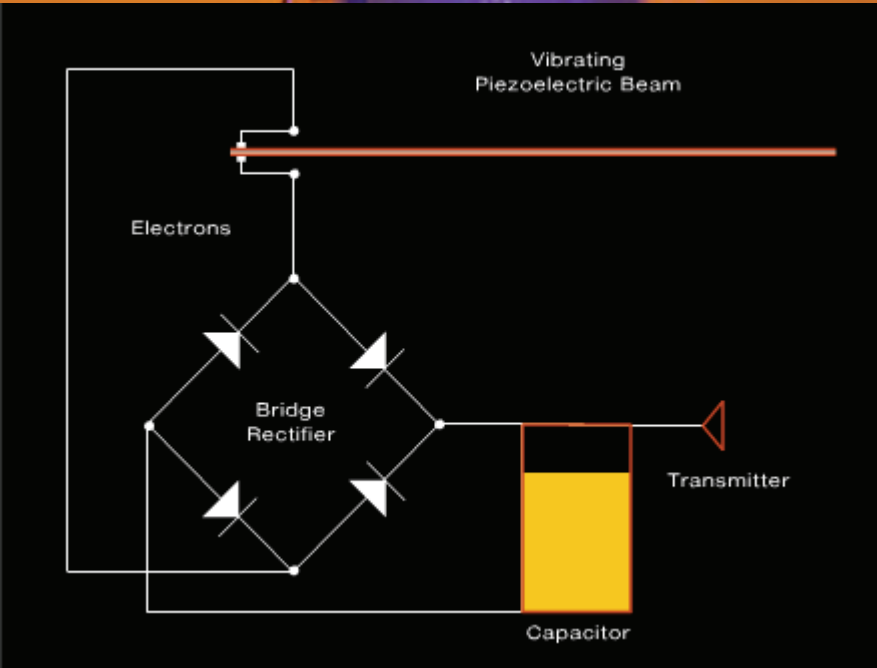




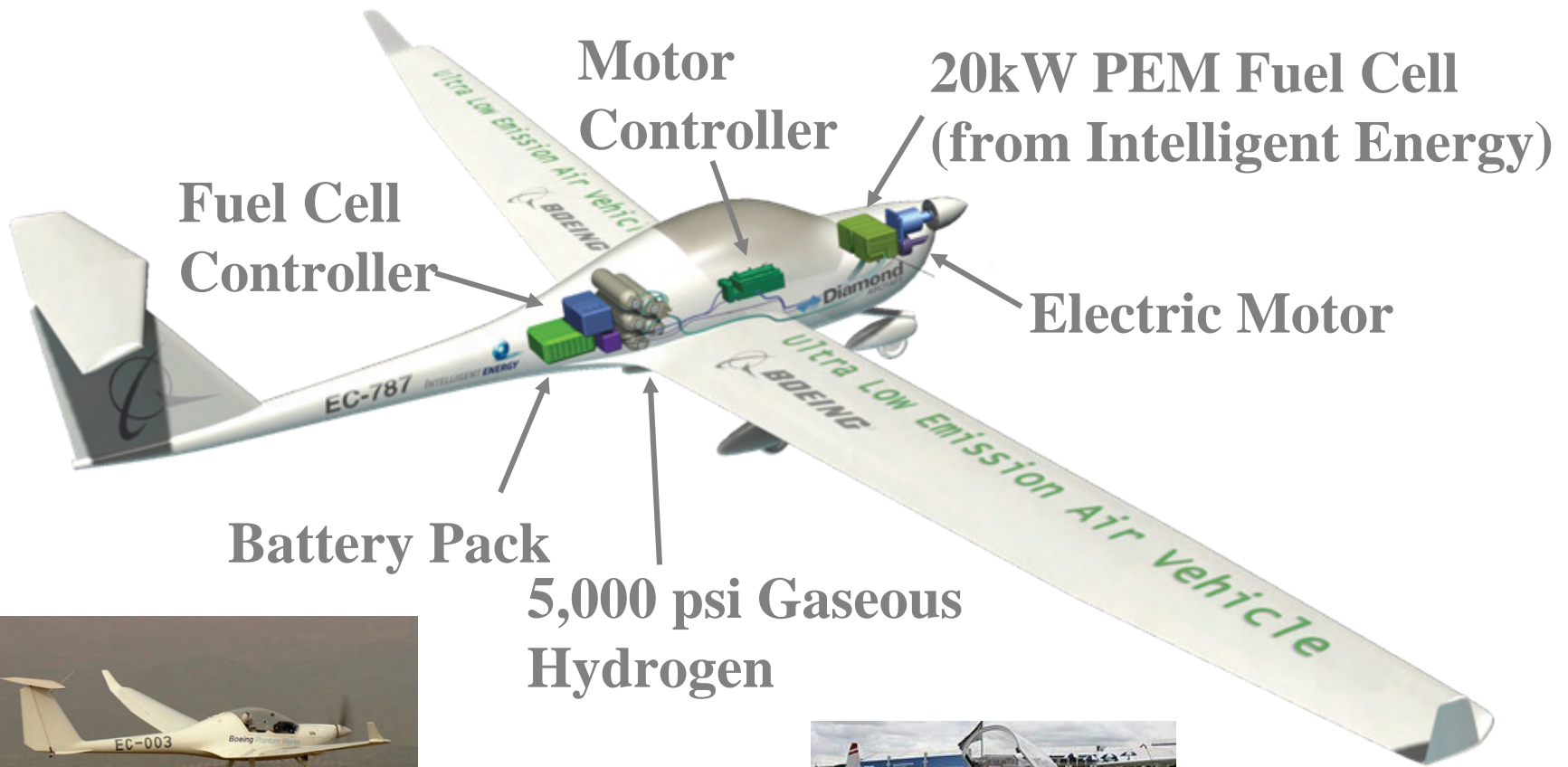
# Piezoelectric harvesters convert vibrations into electrical energy



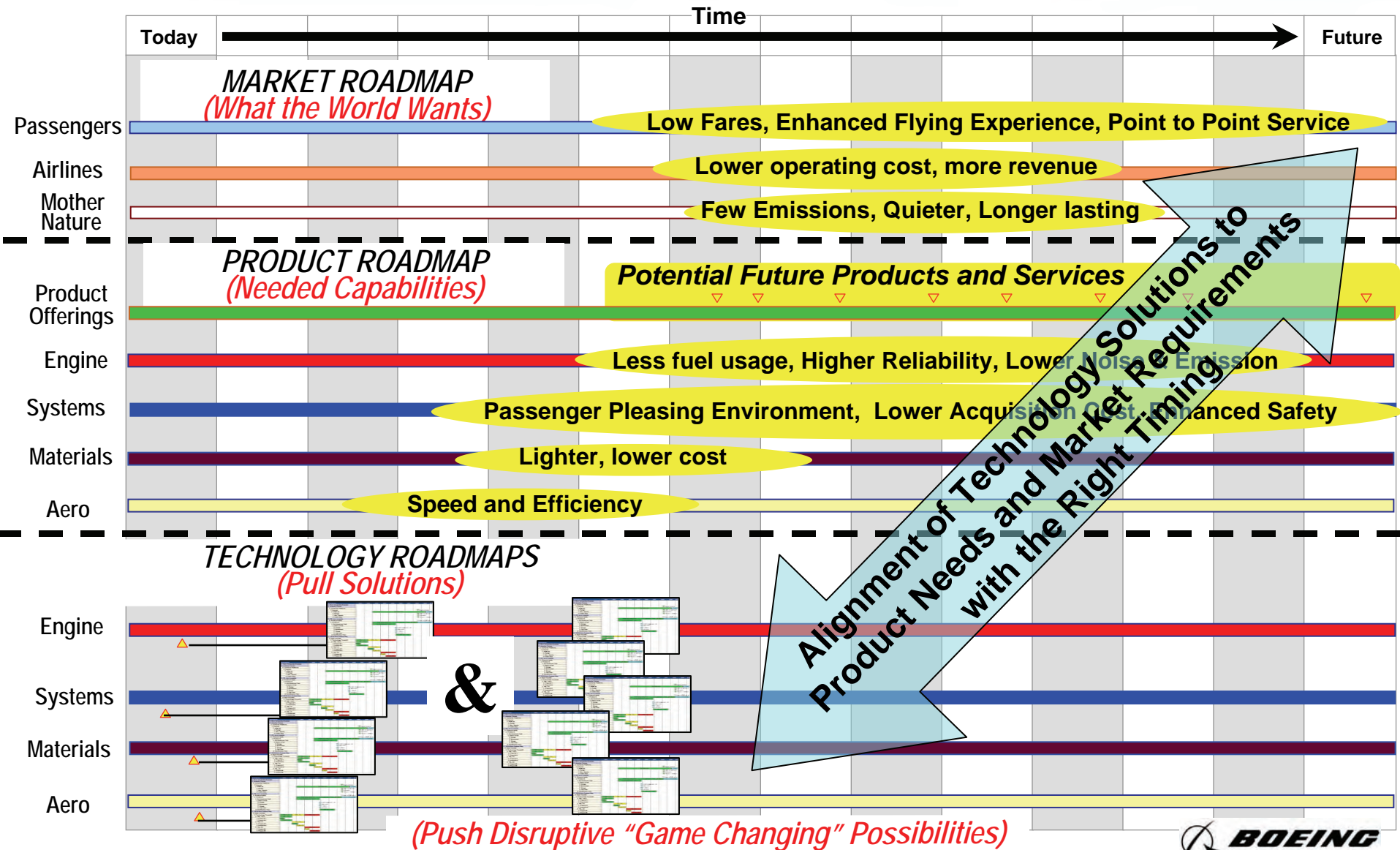
Uses airplane vibrations to power small electrical demand applications such as a wireless sensor to monitor structural health of the airplane



# Boeing Fuel Cell Airplane Demonstrator



# Roadmapping Focusing on the right Technologies



# The 787 Dreamliner uses advanced technologies to improve environmental efficiency



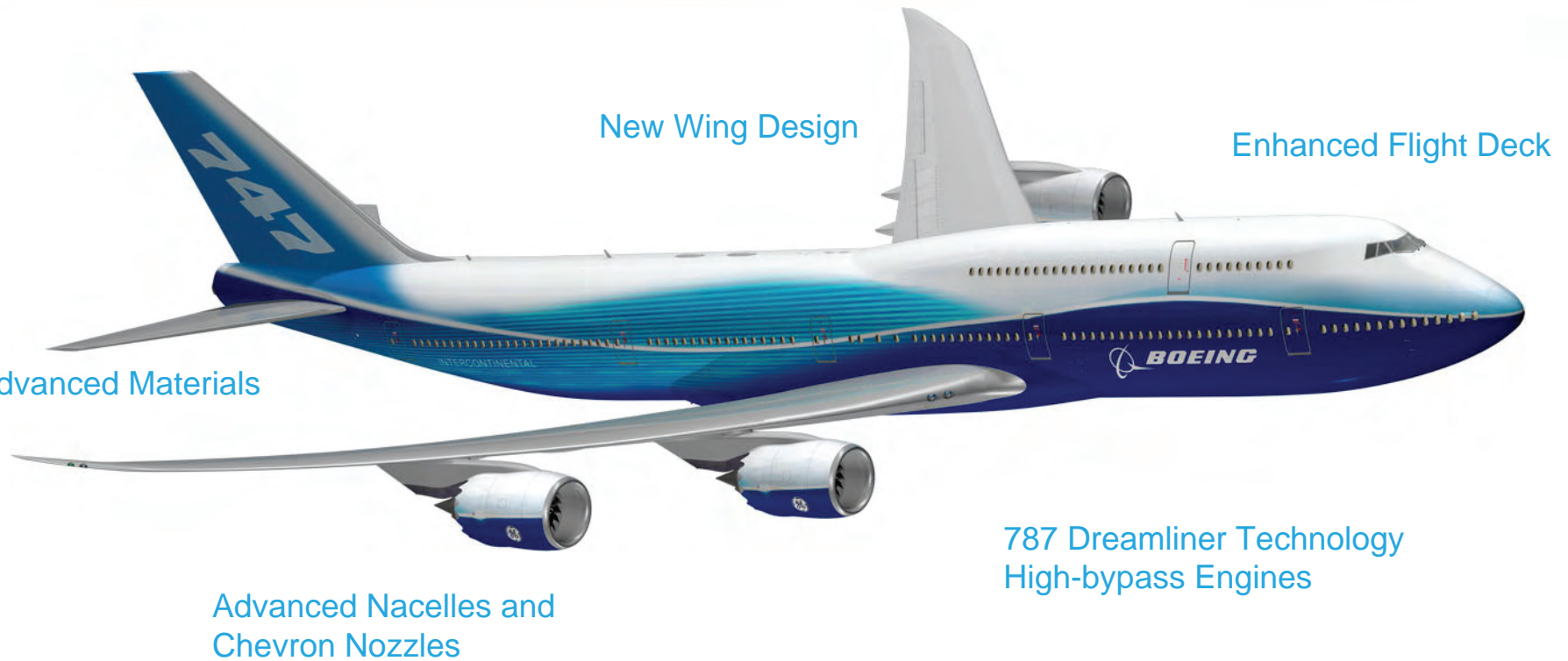
Cleaner, quieter and more efficient

20%\* Reduction in fuel and CO<sub>2</sub>

28% Below 2008 industry limits for NO<sub>x</sub>

60%\* Smaller noise footprint

# The 747-8 uses advanced technologies to improve environmental efficiency



Cleaner, quieter and more efficient

16%\* Reduction in fuel and CO<sub>2</sub>

28% Below 2008 industry limits for NO<sub>x</sub>

30%\* Smaller noise footprint

# Environmental Technology Demonstrator Program

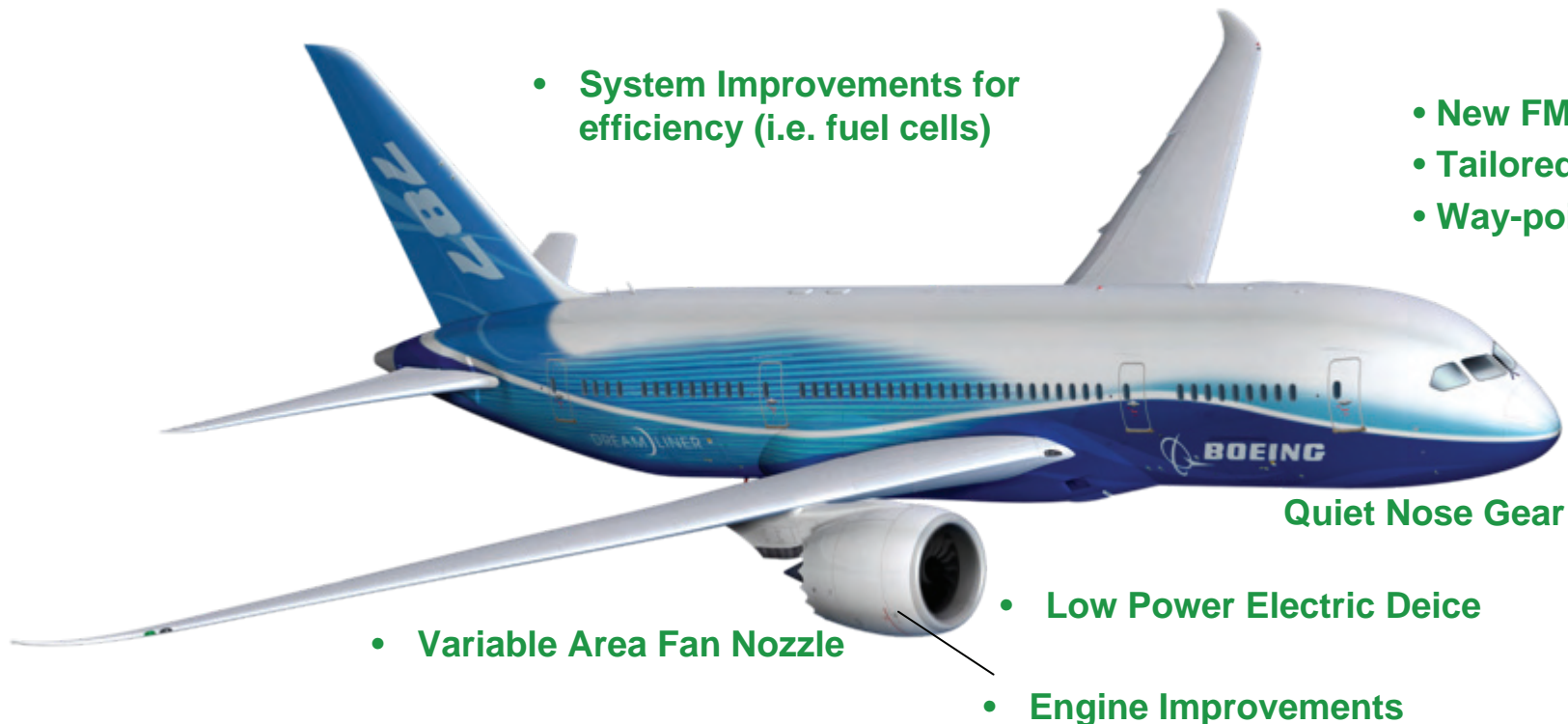
## Objective:

Reduce emissions and noise by enhancing efficiency of wing, propulsion system, and take-off and landing flight procedures

- Smart Wing Elements

- System Improvements for efficiency (i.e. fuel cells)

- New FMS Concepts
- Tailored Departures
- Way-point cut-back



- Variable Area Fan Nozzle

- Low Power Electric Deice

- Engine Improvements

Quiet Nose Gear

# 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



20%  
Coconut &  
Babassu

Feb 2008



50%  
Jatropha

Dec 2008



50%  
Algae &  
Jatropha

Jan 2009



50%  
Camelina,  
Jatropha & Algae

Jan 2009



Increasing level of test objectives

# Our plan and commitments

**Relentlessly pursue manufacturing and life cycle improvements**



100%

100% of Boeing major manufacturing sites will maintain ISO 14001 certification.

**Improve performance of worldwide fleet operations**



25%

Focus on 25% efficiency improvements in worldwide fleet fuel use and CO<sub>2</sub> emissions by 2020.

**Deliver progressive new products and services**



15%

Improve CO<sub>2</sub> emissions and fuel efficiency by at least 15%

**Pioneer new technology**



75%

Devote more than 75% of R&D toward benefiting environmental performance





# Looking to the Future

What is being done today and what is the future?