Commitment to a Better Future

Jeanne Yu

Director
Environmental Performance

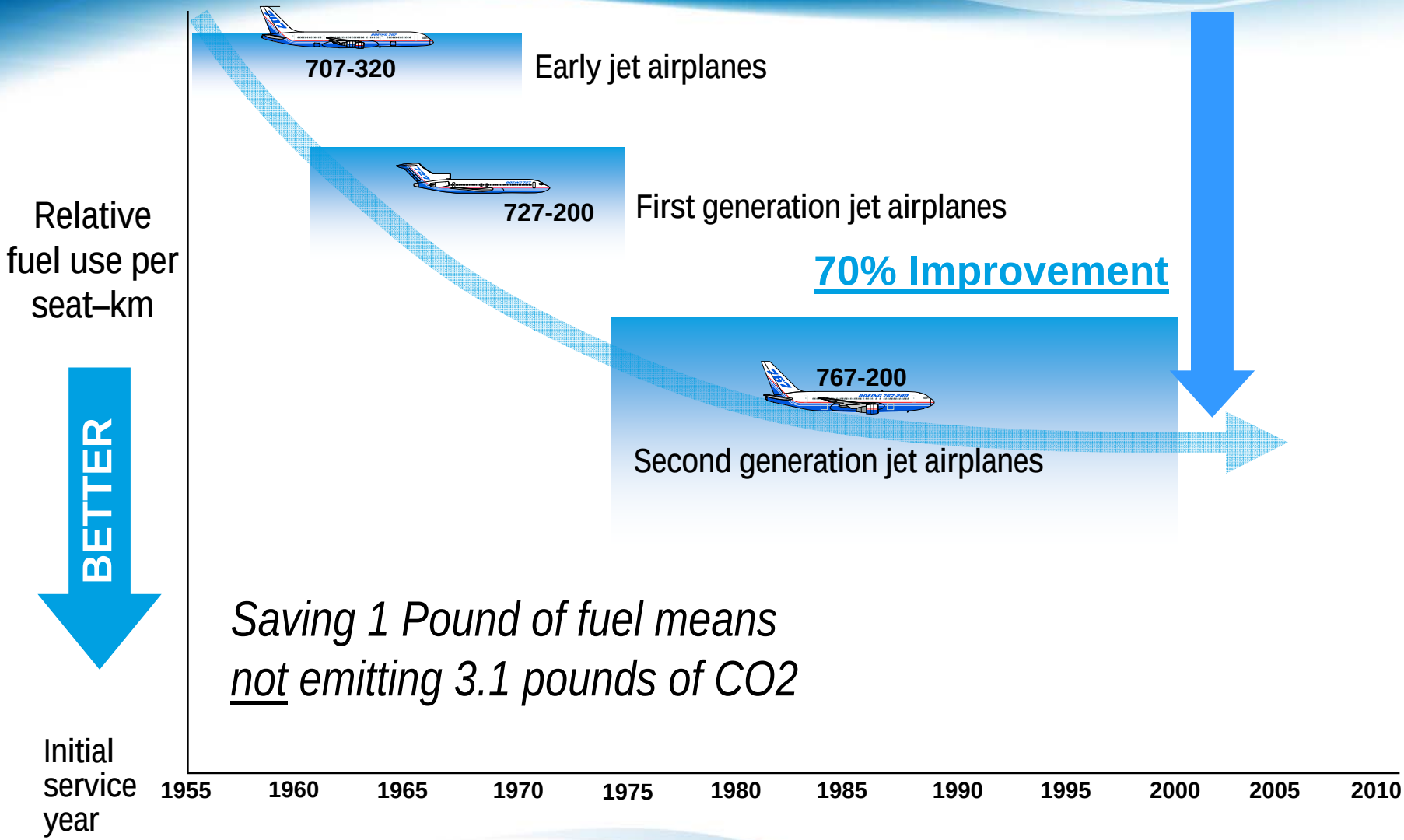
Boeing Commercial Airplanes

March 2007

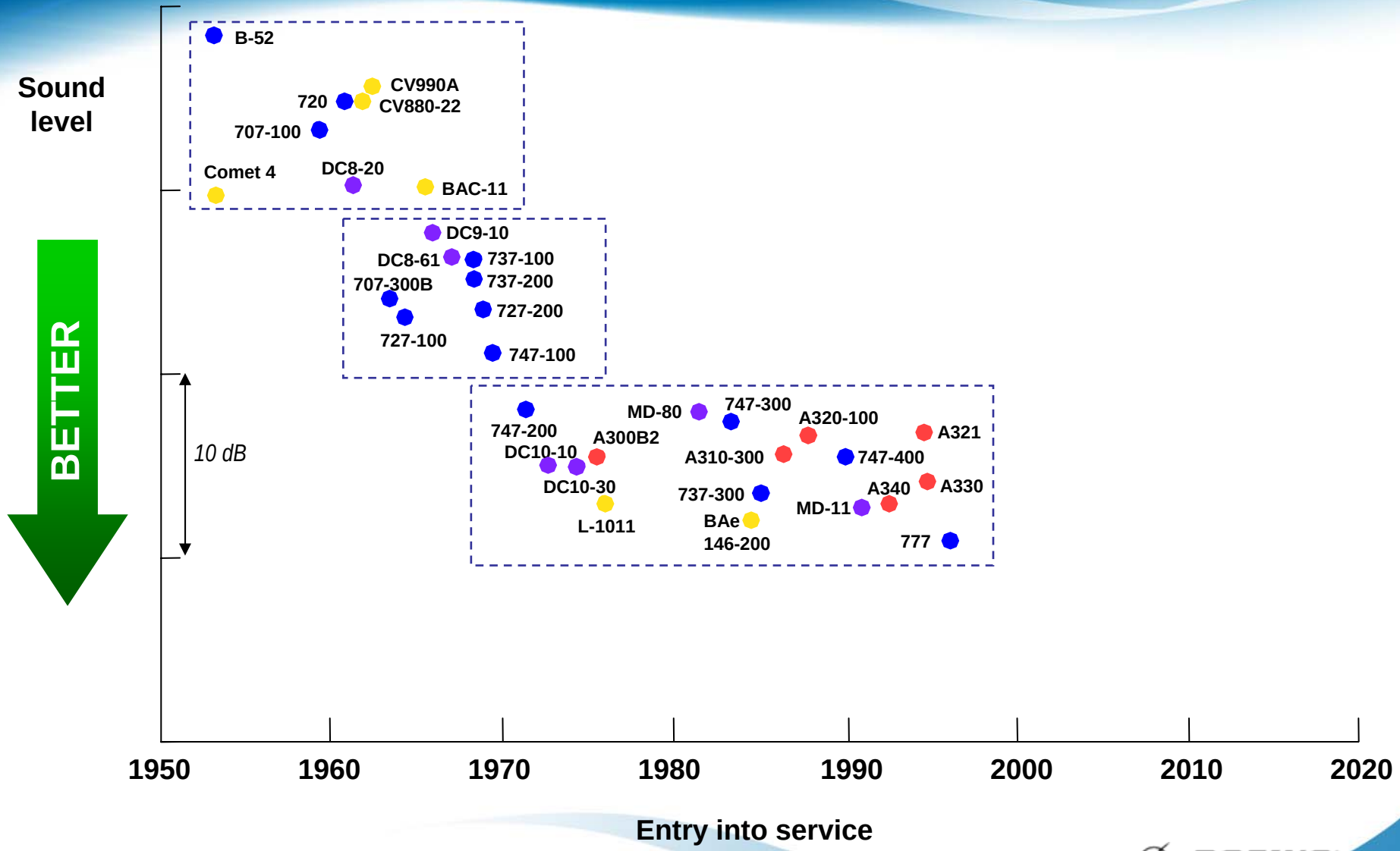
Outline for Today's Briefing

- **History of Progress**
- **Life Cycle Perspective – Key to Progress**
- **Summary**

Modern Airplanes Are More Fuel Efficient



Modern Aircraft Are Quieter



New Designs Continue to Address Environmental Performance

Issue	Expected Trend	Performance Comparisons	
		787 re: 767	747-8 re: 747-400
Carbon Dioxide (CO_2)	Continual reduction	20 percent reduction	15 percent reduction
Noise	Smaller footprint	60 percent smaller	30 percent smaller
Other Emissions	Continual reduction	Meets all anticipated new regulations	

Outline for Today's Briefing

- **History of Progress**
- **Life Cycle Perspective – Key to Progress**
- **Summary**

Life Cycle Environmental Considerations

RESEARCH & DEVELOPMENT

DESIGN	MANUFACTURE	AIRLINE OPERATIONS/MAINTENANCE		END OF LIFE
Materials Selection Processes Requirements	Energy Labor Chemicals Water Components Raw Materials	Energy Labor Chemicals Water Components Fuel		Energy Labor
	Air Emissions **Solid Waste** **Hazardous Waste** **Waste Water** **Factory Noise**	**Air Emissions** **Solid Waste** **Hazardous Waste** **Waste Water**	**Cabin Environment** **Community Noise** **Global Warming** **Airport Air Quality** **Ozone Depletion**	**Components** **Solid Waste** **Hazardous Waste** **Airplane Fluids**

BOEING

Many Factors Contribute to Progress Environmental Performance

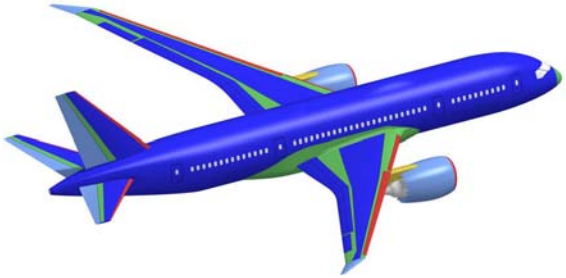
RESEARCH & DEVELOPMENT

DESIGN	MANUFACTURE	AIRLINE OPERATIONS/MAINTENANCE	END OF LIFE

Engine

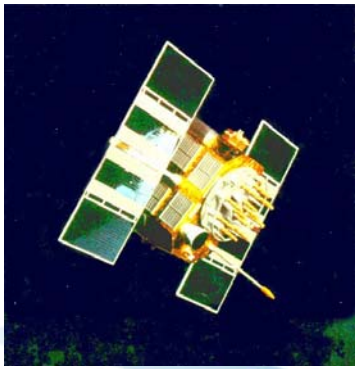
Aerodynamics

Structures and materials



Systems

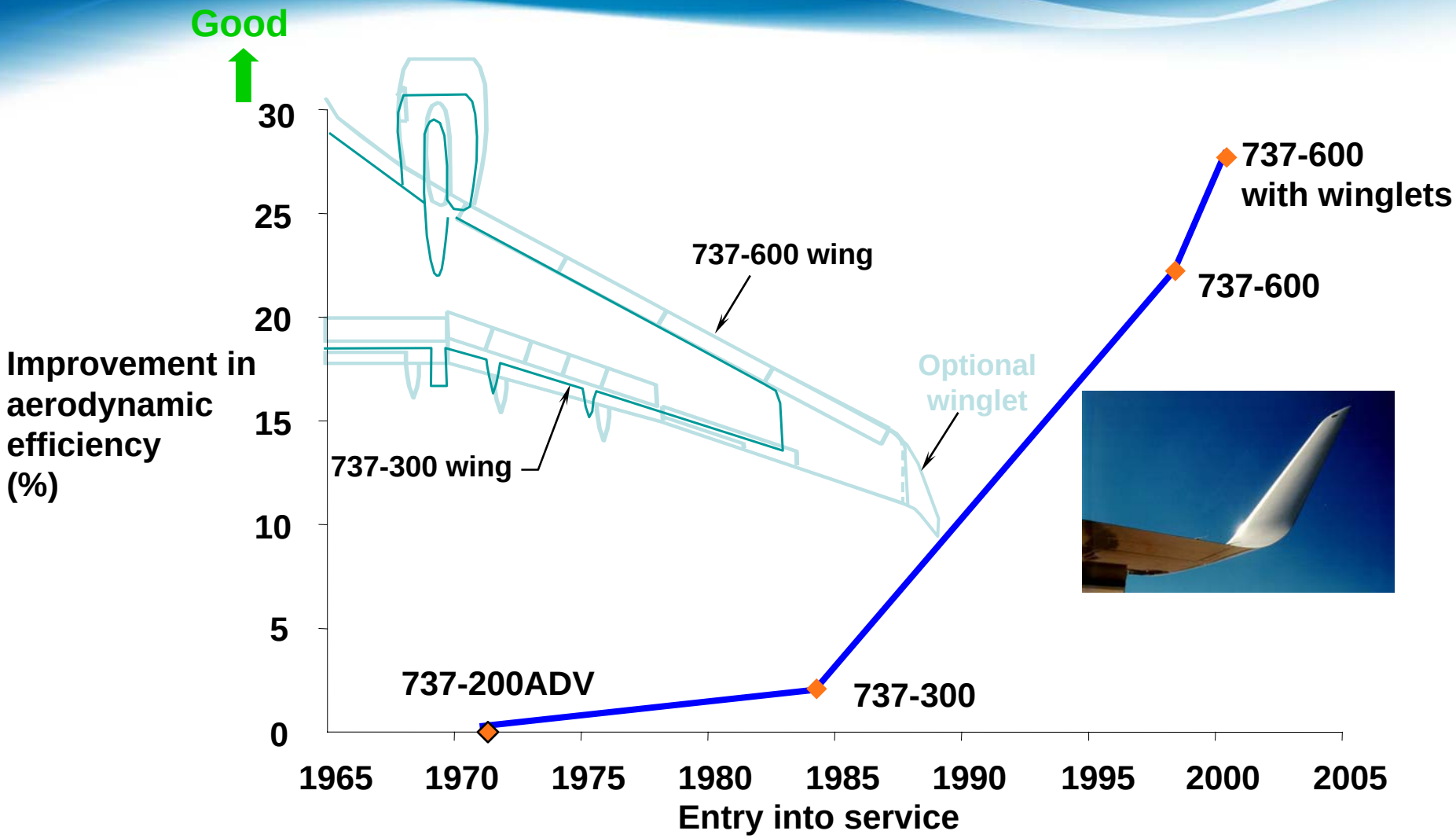
Air traffic management



Engine/airframe integration

BOEING

Wing Aerodynamics Technology Improves Airplane Efficiency



BOEING

Noise, Emissions and Efficiency Benefit with More-Electric Systems

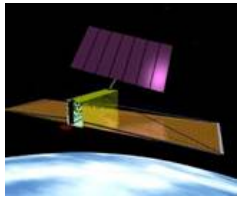
More-electric technologies

HIGH-POWER ELECTRONICS

EFFICIENT ENERGY STORAGE

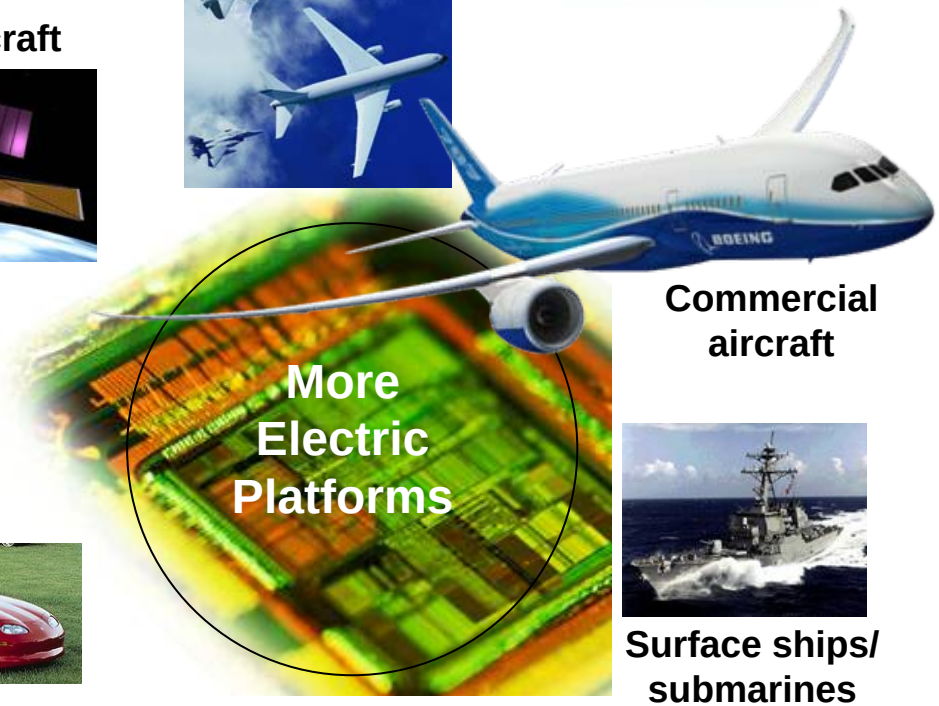
ELECTRIC POWER GENERATION & UTILIZATION

POWER DISTRIBUTION & SYSTEM INTEGRATION



Spacecraft

Military aircraft



Commercial aircraft

Surface ships/ submarines

Consumer automotives

Trains

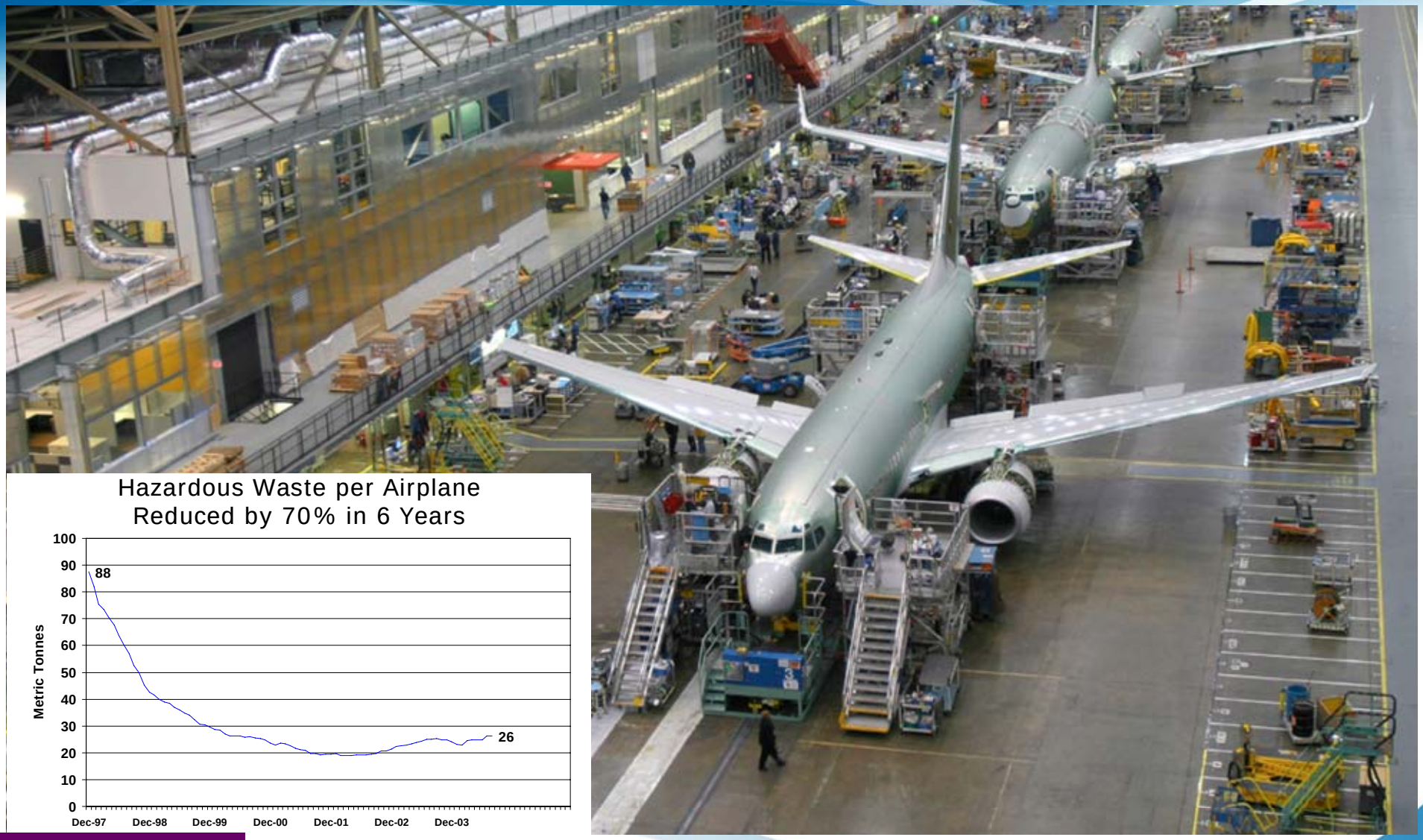
Trucks

More-electric is an industry-wide trend

BOEING

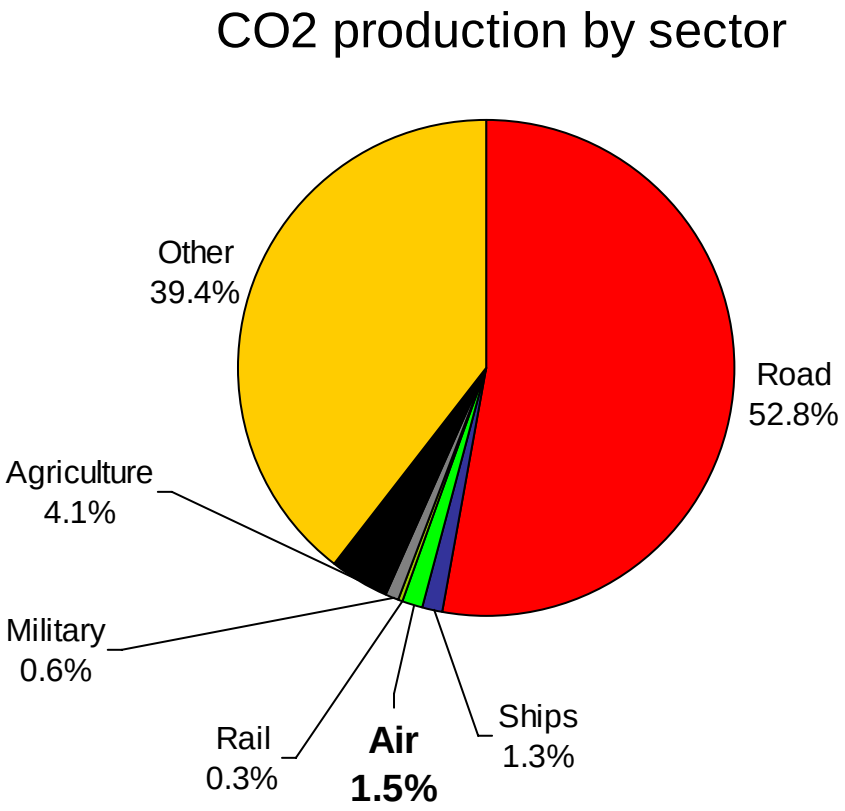
Bringing Lighter Weight Materials to Reality

Lean Manufacturing Reduces Waste



BOEING

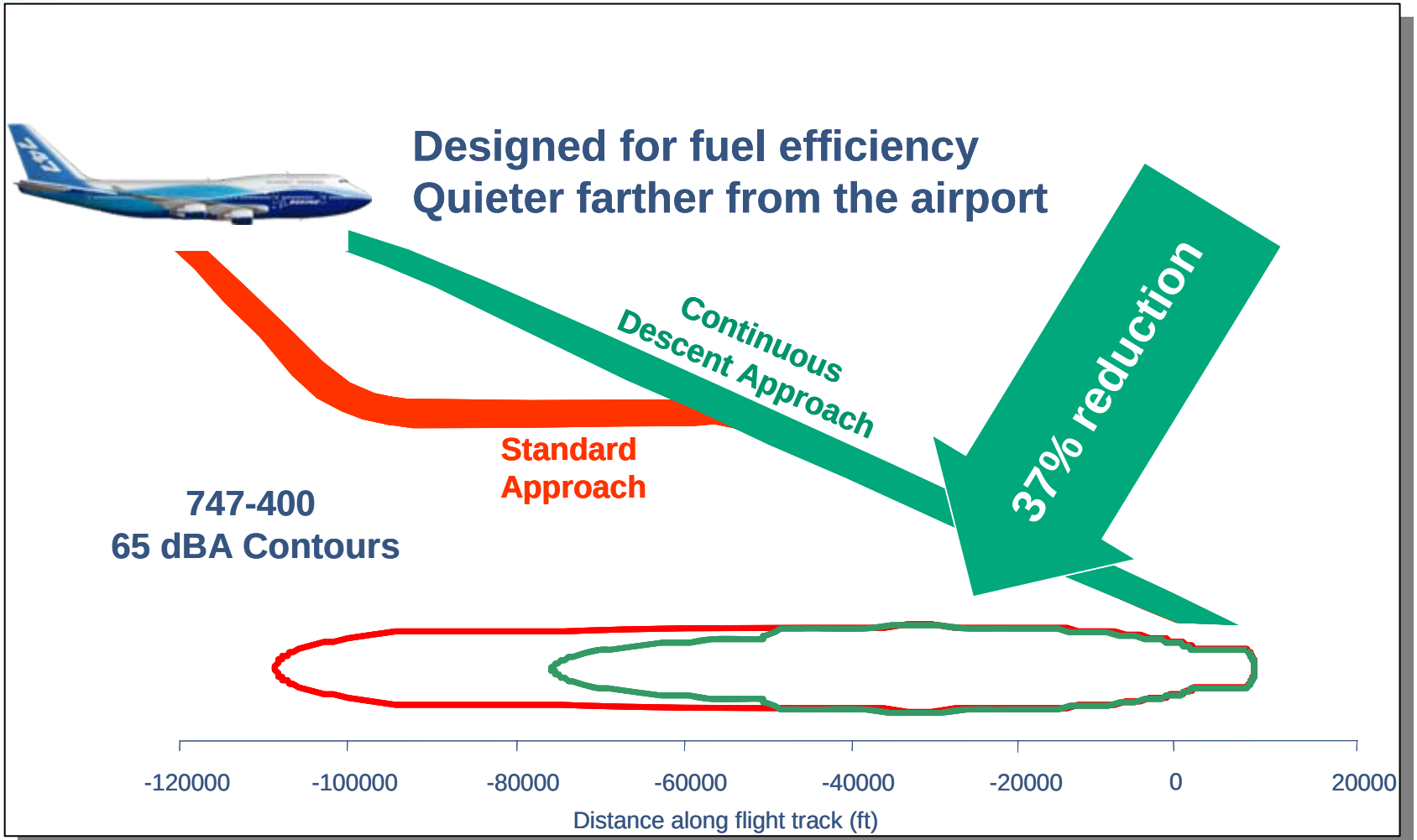
Aviation Produces a Small Percentage of CO2



Source: EU Commission Study 2006

www.eper.ec.europa.eu

Quiet and Clean Procedures in Development



Amsterdam Schiphol Joint Program to Enhance Efficiency, Capacity, Safety and Environment

Objectives:

Validate concepts an

Fewer Delays
Lower Emissions
Lower Noise

Completed:

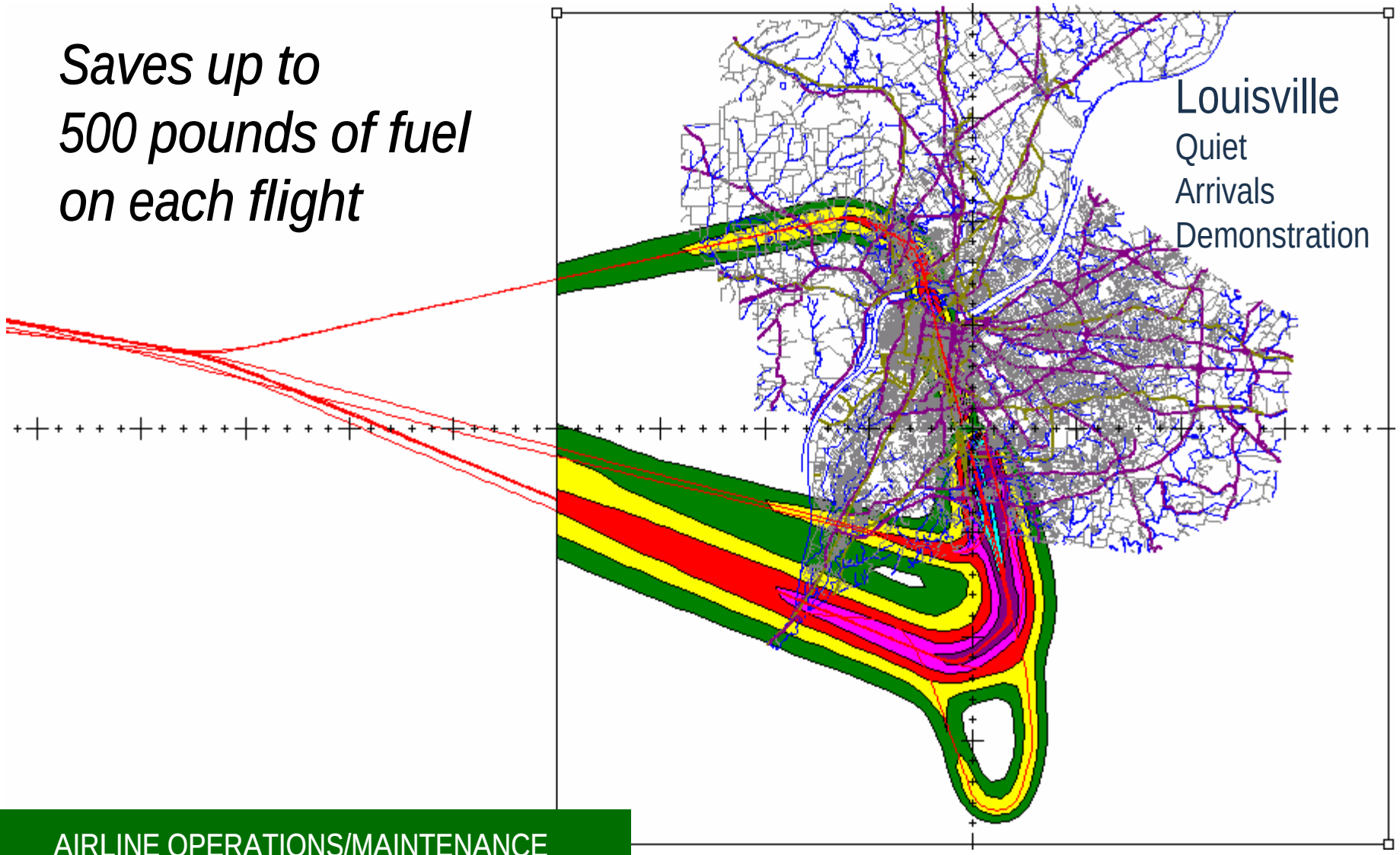
- **Inbound Priority S**
  2 trials completed
- **Continuous Descent Approach**
  3 months of trials completed in 2006

EUROCONTROL Luchtverkeersleiding Nederland Martinair transavia.com BOEING KLM

BOEING

Continuous Descent Approach Procedures -- Lower Noise and Emissions

Saves up to 500 pounds of fuel on each flight



Materials Can be Re-Used

DESIGN	MANUFACTURE	AIRLINE OPERATIONS/MAINTENANCE		END OF LIFE
Materials Selection Processes Requirements	Energy Labor Chemicals Water Components Raw Materials	Energy Labor Chemicals Water Components Fuel		Energy Labor
	Air Emissions Solid Waste Hazardous Waste Waste Water Factory Noise	Air Emissions Solid Waste Hazardous Waste Waste Water	Cabin Environment Community Noise Global Warming Airport Air Quality Ozone Depletion	Components Solid Waste Hazardous Waste Airplane Fluids

- **Recycle manufacturing scrap**
- **Recycle metallic & composite materials at end of life**

- **High value industrial uses**

MANUFACTURE	END OF LIFE

Boeing assisted formation of Aircraft Fleet Recycling Association

- **AFRA Members/Associates:**
  - Chateauroux Air Center (France)
  - Evergreen Air Center (USA)
  - Adherent Technologies (USA)
  - Air Salvage International (UK)
  - Bartin Recycling Group (France)
  - Huron Valley Fritz West, LLC (USA)
  - Milled Carbon Ltd (UK)
  - The Memphis Group (USA)
  - SAFRAN/SNECMA (France)
  - Volvo Aero (USA)
  - Rolls Royce (UK)
  - Wingnet (UK)
  - The Boeing Company (USA)

- **Unique Capabilities:**
  - Carbon fiber recovery
  - Aluminum sorting by alloy
  - Electronic recycling
  - Processing > 100 airplanes/yr
  - 1,500 airplanes re-marketed
  - Airplane processed to date:
    - >2500 commercial
    - > 1,000 military

An International Association to Improve Aircraft Industry Sustainability
www.afraassociation.org

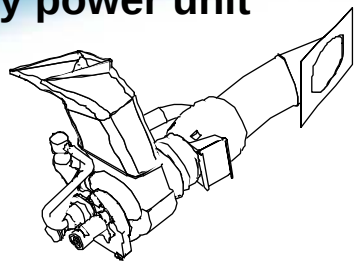
BOEING

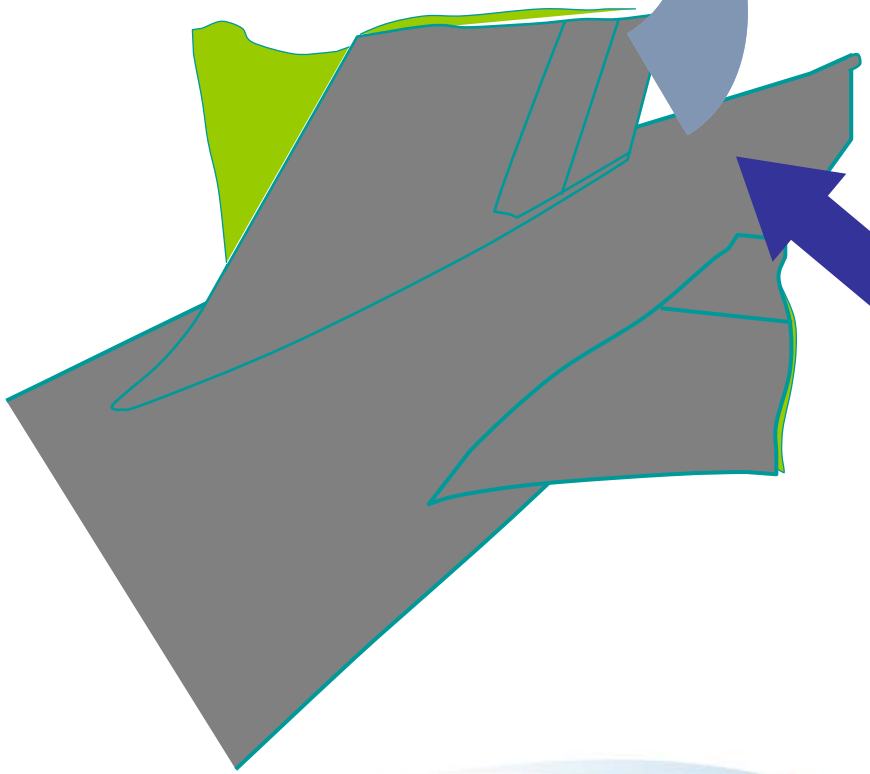
Fuel Cells Offer Ultra Clean Power

- *Chemical Reaction Provides Electric Power*
- *Primary Emission is Water*

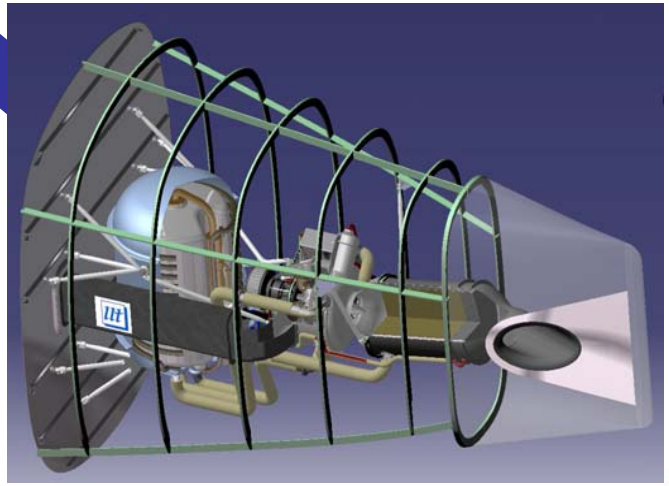
Boeing is Developing Ultra Clean Auxiliary Power

Auxiliary power unit





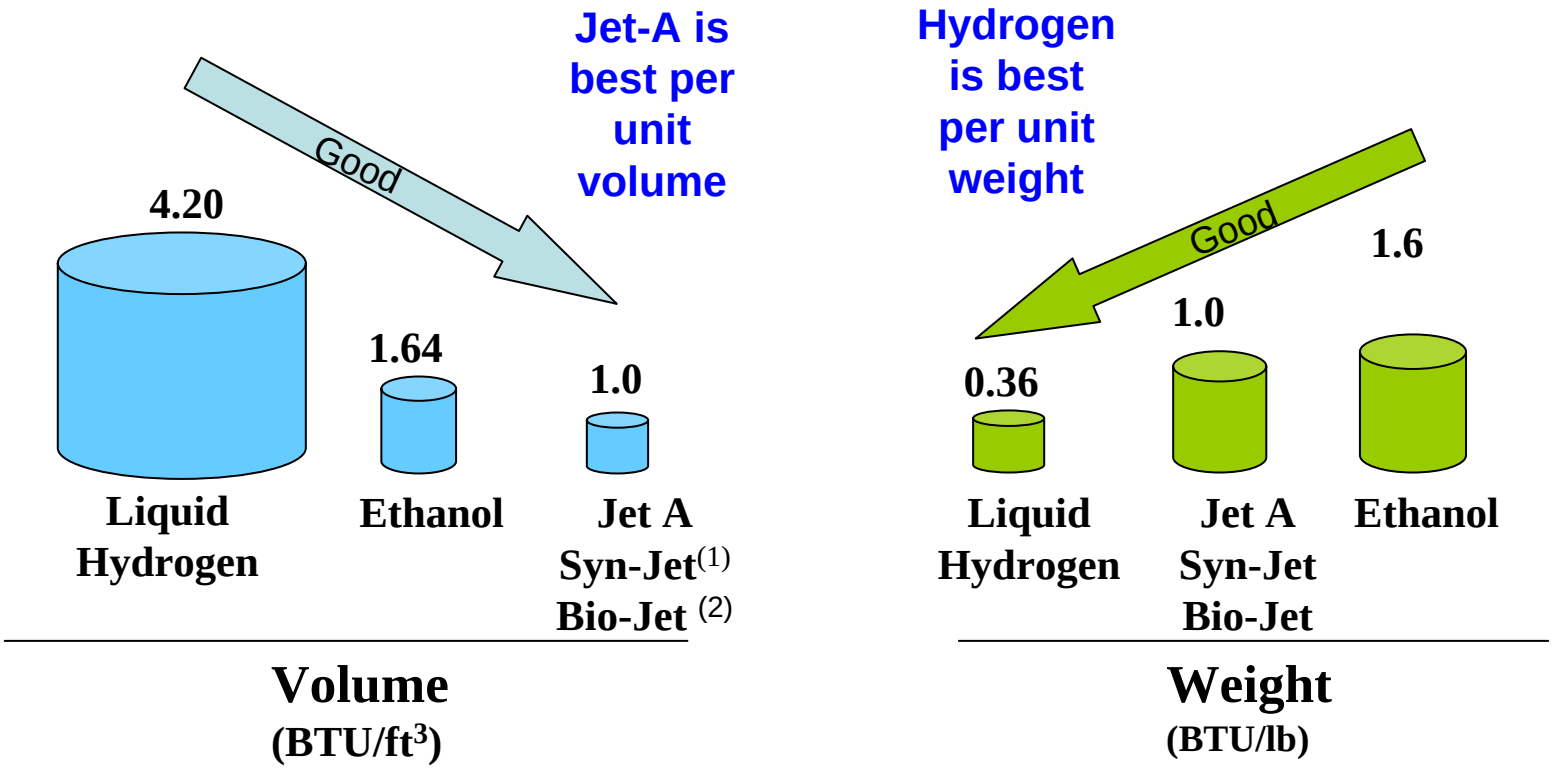
Solid oxide fuel cell power unit



RESEARCH & DEVELOPMENT

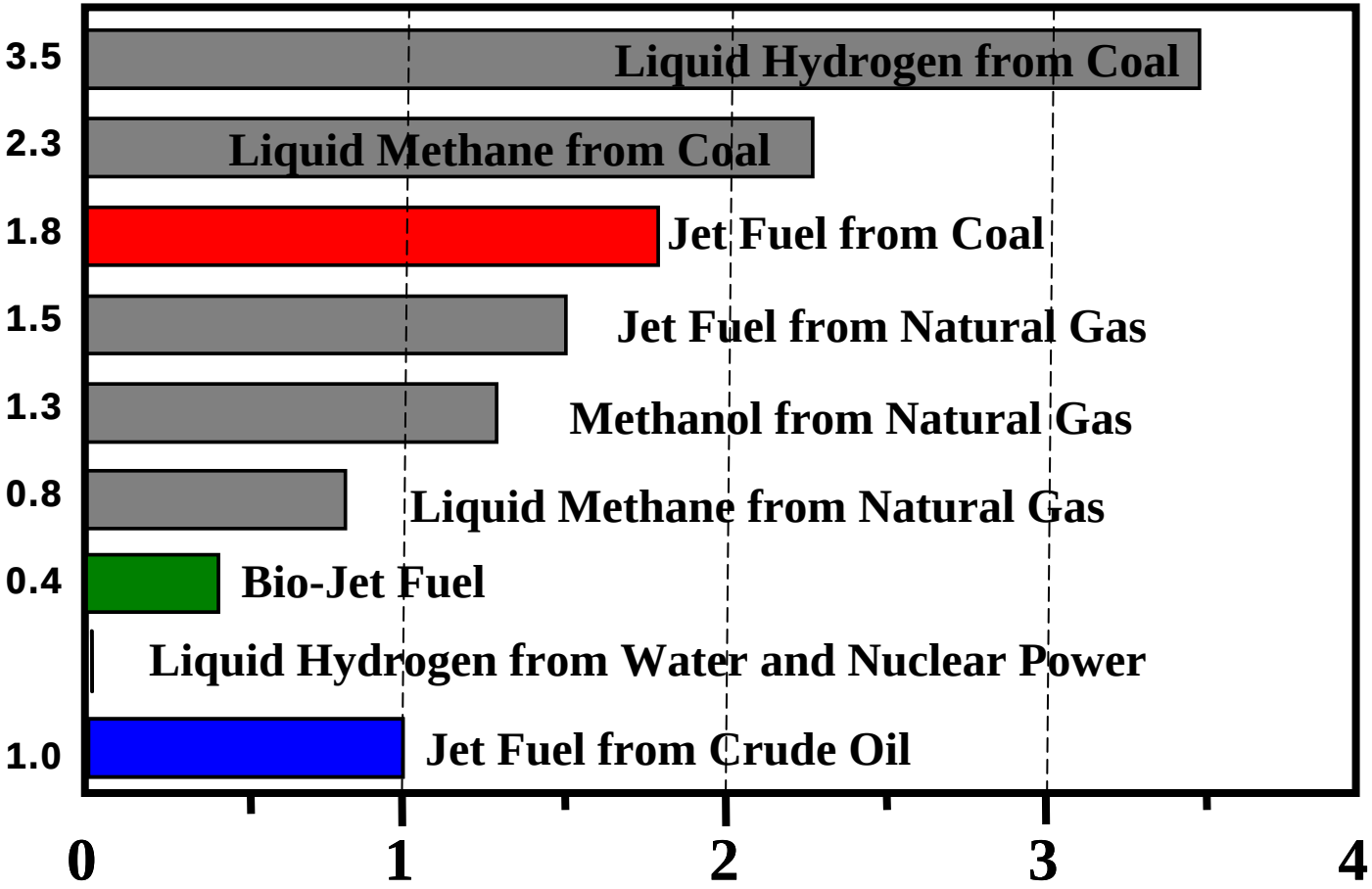
BOEING

Finding an Alternative Fuel is Difficult



Equivalent Energy Comparison

Carbon dioxide emissions should be an important consideration in selection of alternate fuels



Relative CO_2 emissions as compared to conventional Jet fuel

Synthetic and Bio-fuels May Supplement Conventional Jet Fuel

Synthetic Derived

coal

and/or

F-T fuel plant

0-100%

Conventional Jet Fuel

0-100%

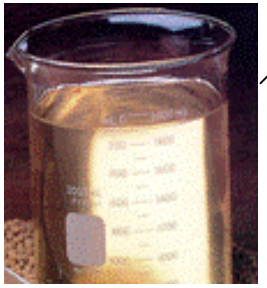
fuel blend?

Renewable Derived

Algae

and/or

Plants



Future bio-jet fuel process

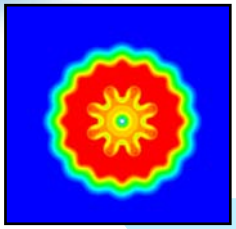
0-50%

Fuel Source

Processing

BOEING

Commitment to a Better Future



Analytical studies

Wind-tunnel tests

Static engine tests

2001 QTD 1

Quiet Technology Demonstrator

Boeing
Rolls-Royce
American Airlines

2005 QTD 2

Quiet Technology Demonstrator

Boeing
General Electric
Goodrich
NASA
All Nippon Airlines

747-8

The shape of the future

787

Dreamliner

Sustained Technology Programs Deliver Efficient Quiet Designs

Outline for Today's Briefing

- **History of Progress**
- **Life Cycle Perspective – Key to Progress**
- **Summary**

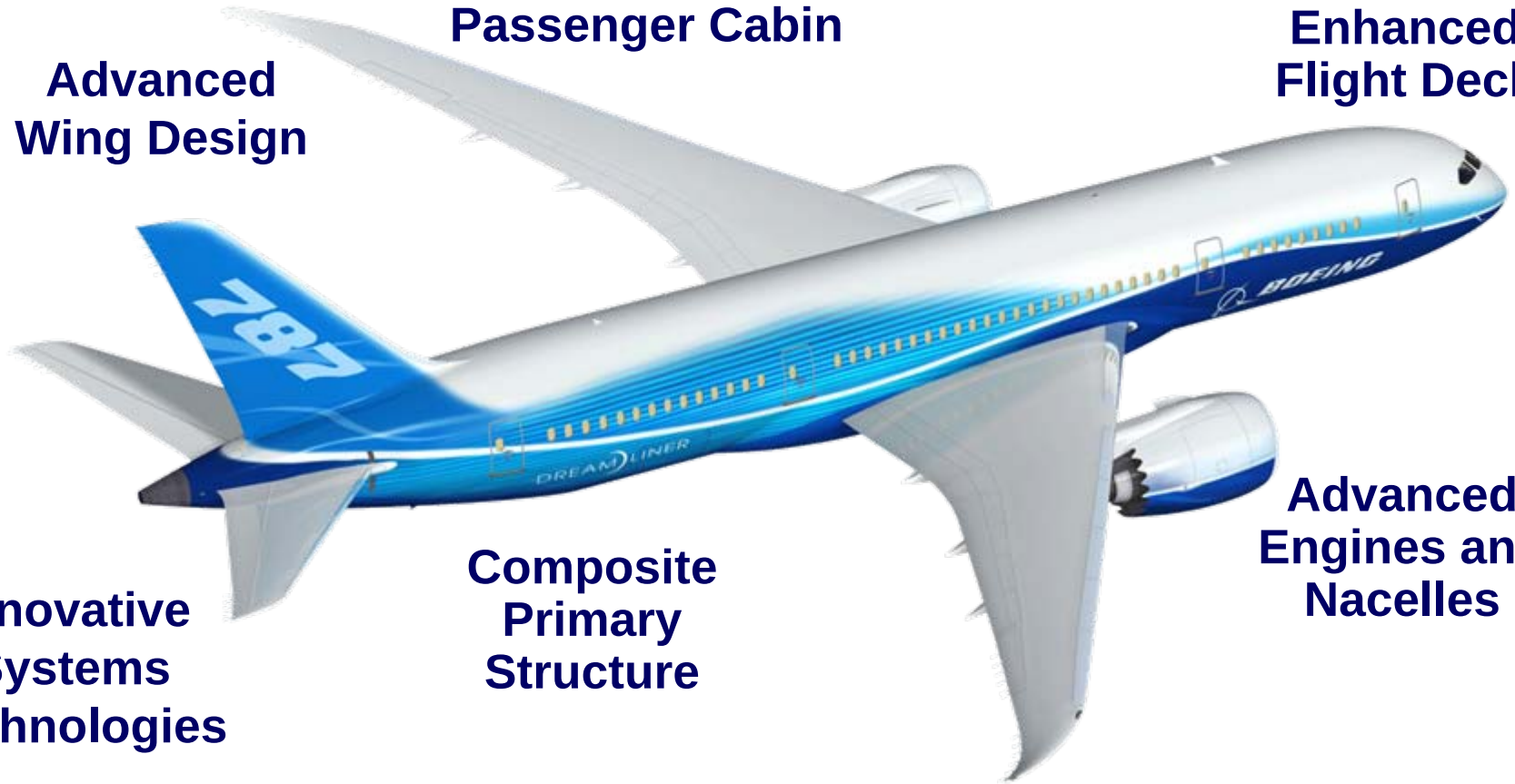
787 Design for Environment

Design Features

Breakthrough Passenger Cabin

Advanced Wing Design

Enhanced Flight Deck



Advanced Engines and Nacelles

Composite Primary Structure

Innovative Systems Technologies

Fly Quieter - Use Less Fuel - Lower Emissions

747-8 Design for Environment

Design Features

New design wing

Enhanced Flight Deck

787 Technology High Bypass Engines

Advanced Nacelles and Chevron Nozzles

Fly Quieter - Use Less Fuel - Lower Emissions

BOEING

New Designs Continue to Address Environmental Performance

Issue	Expected Trend	Performance Comparisons	
		787 re: 767	747-8 re: 747-400
Carbon Dioxide (CO_2)	Continual reduction	20 percent reduction	15 percent reduction
Noise	Smaller footprint	60 percent smaller	30 percent smaller
Other Emissions	Continual reduction	Meets all anticipated new regulations	

Our Commitment

- **Boeing has demonstrated progressive environmental improvements and continues to pioneer technologies and procedures to address all elements of the life cycle.**

- **Environmental considerations are integral to the design of our products (e.g. 787 and 747-8).**

- **We are demonstrating our commitment with our actions.**

RESEARCH & DEVELOPMENT			
DESIGN	MANUFACTURE	AIRLINE OPERATIONS/MAINTENANCE	END OF LIFE

BOEING

Thank you…