



Commercial Airplanes

Strategic Partnerships - Industry Technological Challenges and Potential Solutions

Jeanne Yu, Director
Environmental Performance
Product Development
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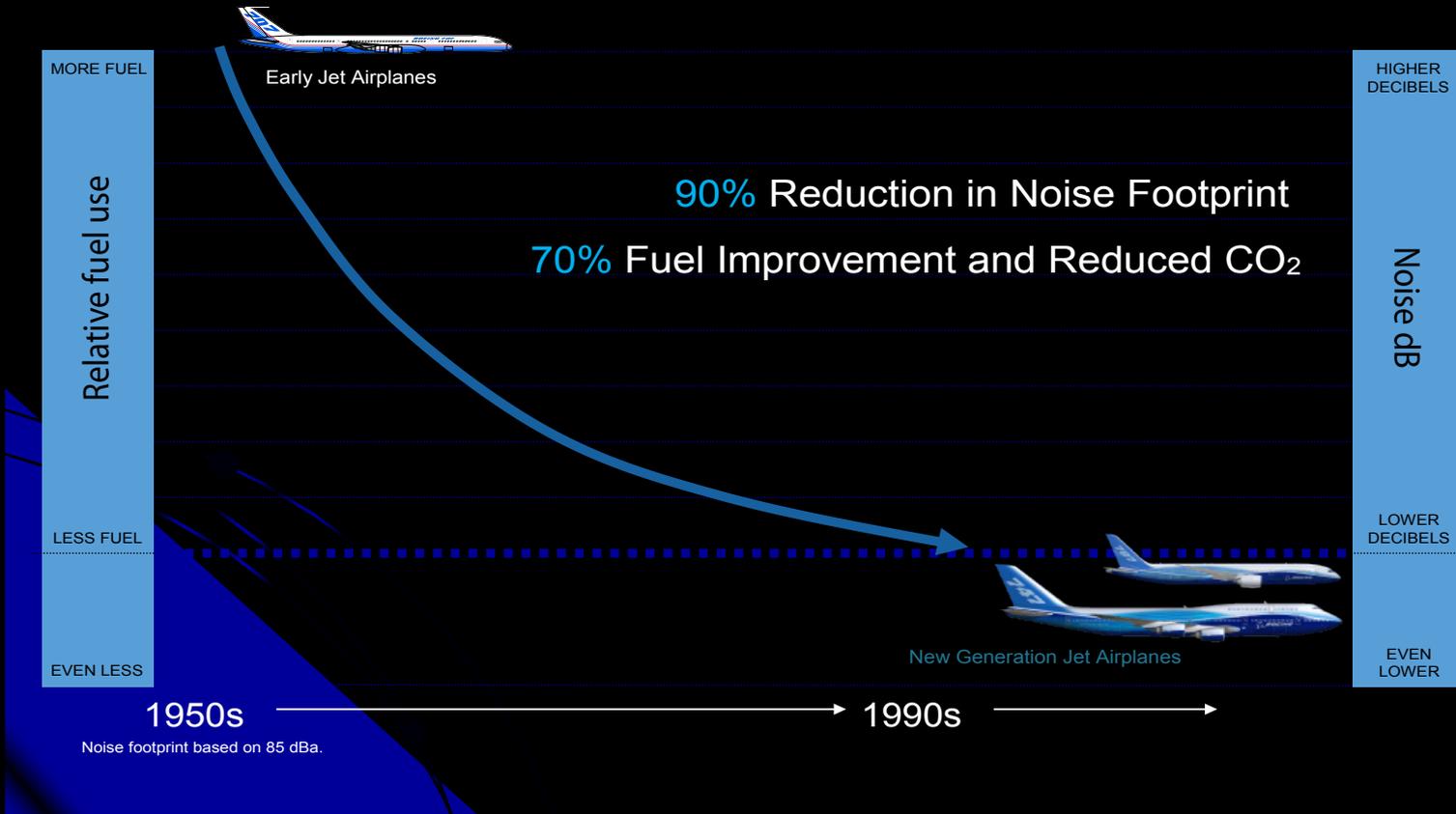
Environmental Stewardship Strengthens Business

- **Pollution and climate change are serious challenges that require aggressive action.**
- **Customers, communities and investors expect environmental stewardship.**
- **Environmental improvement supports business performance.**

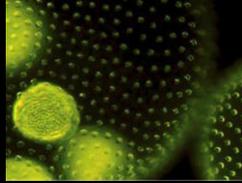


Innovating Breakthrough Technologies

Building on a strong track record



Addressing CO₂ as a priority



- **Renewable fuel and energy solutions**



- **Operational efficiency**



- **Environmentally progressive products and services**

Through innovative research and development

Improving New Airplanes In Service

Fuel Efficiency



787

- **20% more fuel efficient than airplanes it will replace**



747-8

- **16% more fuel efficient than airplanes it will replace**



Boeing KC-X NewGen Tanker

- **5.5% more fuel efficient with addition of winglets**



777-200, -200ER and -300

- **1% more fuel efficient**



Next-Generation 737

- **2% more fuel efficient**

Fuel efficiency = less CO₂

The 787 Dreamliner integrates advanced technologies to improve environmental efficiency



Cleaner, quieter and more efficient

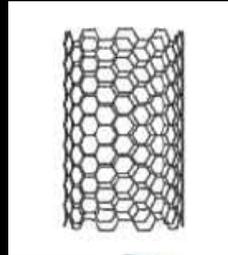
20%* Reduction in fuel and CO₂

28% Below 2008 industry limits for NO_x

60%* Smaller noise footprint

*Relative to the 767

Actively pursuing technology research for fuel, CO₂ and noise efficiency



Researching next generation materials

Example: Next generation composites

Result: Reduces weight, which reduces fuel use and emissions



Designing aerodynamic improvements

Example: Advanced wing design, raked wing tip

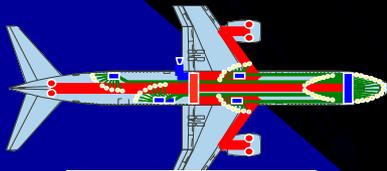
Result: Reduces drag which reduces fuel use and emissions



Researching improved propulsion systems

Example: Integrating new, more efficient engines

Result: Reduces fuel consumption and emissions and lowers noise



Researching less energy-intensive electric systems

Example: Reducing pneumatic systems

Result: Improving electrical and fuel efficiency

NASA DNA



Advanced wing designs

- CFD
- Wind tunnel validation



Composites for efficient structure



Structural analysis methods



Efficient low emissions engines

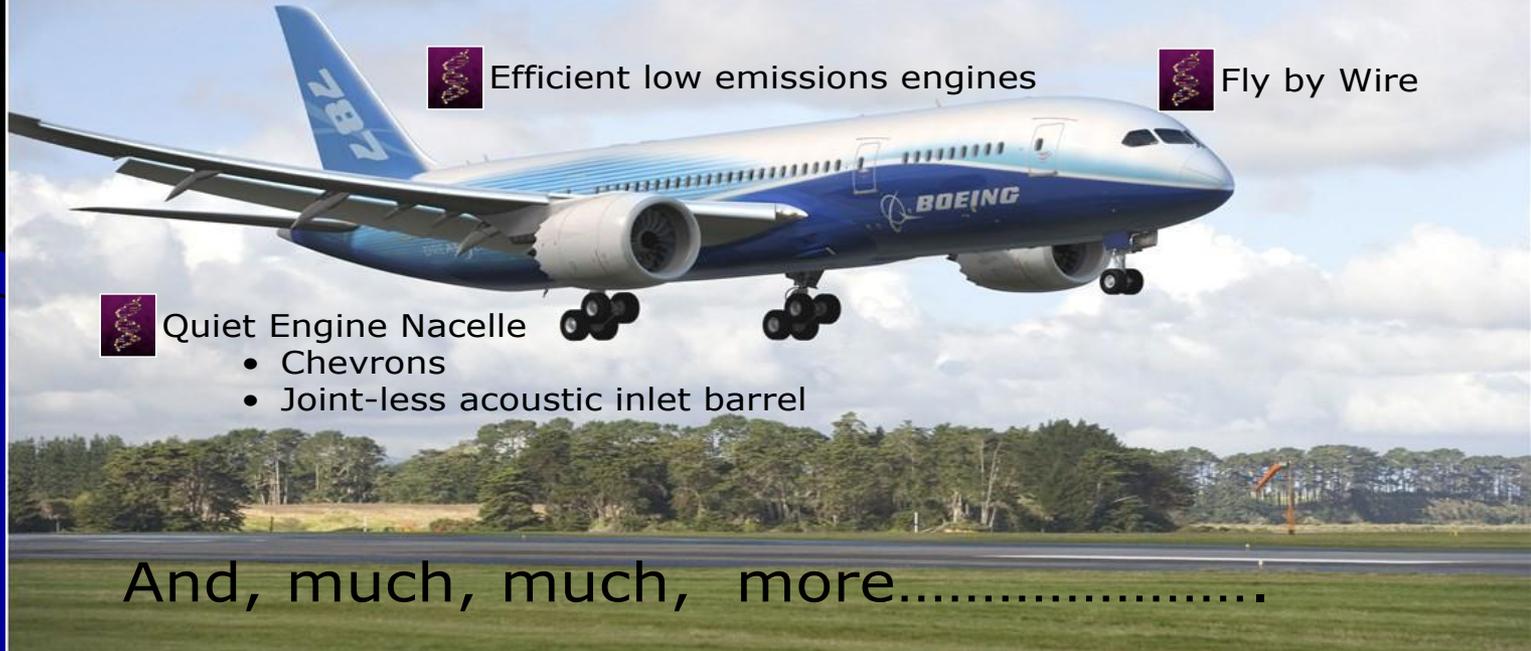


Fly by Wire



Quiet Engine Nacelle

- Chevrons
- Joint-less acoustic inlet barrel

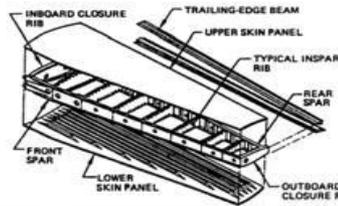


And, much, much, more.....

Composite technology to full application timeline

Composite evolution—1970s

- High strength/stiffness concepts development
 - Working with NASA, Boeing designed, fabricated and certified carbon/epoxy production demonstrators
 - 727 elevators
 - 737 horizontal stabilizers

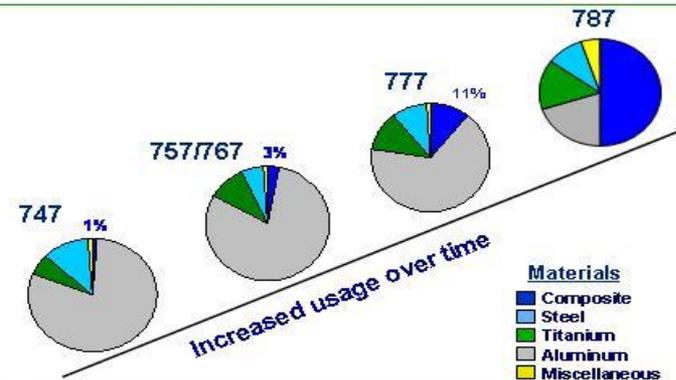


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Use of composites has increased, yielding higher airplane performance



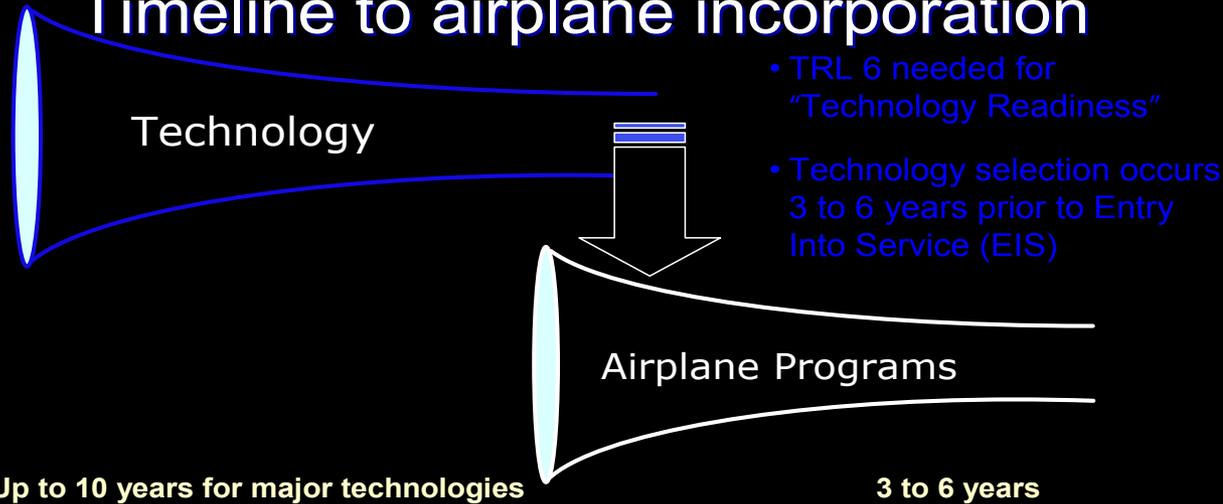
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Composite

Technology Maturity Levels

Timeline to airplane incorporation



Technology Ready

Entry Into Service

BASIC RESEA		TECHNOLOGY DEVELOPMEN			SYSTEM/SUBSYSTEM DEVELOPMENT				READINES S FOR
TR L 1	TR L 2	TR L 3	TRL 4	TRL 5	TRL 6	TR L 7	TR L 8	TR L 9	TRL 10

Demonstrators accelerate implementation

Noise reducing chevrons were developed during the Quiet Technology Demonstrator Program



ecoDemonstrator - Accelerating Advances to Improve Environmental Performance

Vision:

- Accelerate technology maturation
- Build & integrate more rapidly

Result:

- To market faster
- Higher success rates
- Technology leadership



Model:

- A continuum of technology demonstrations
- Working together: industry, suppliers and government

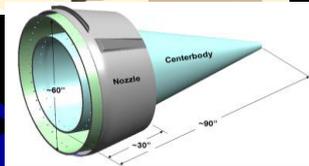
ecoDemonstrator Program – Working together



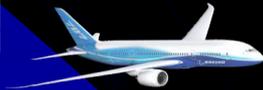
N+1 FAA CLEEN
Continuous Lower
Energy Emissions Noise



N+2 NASA ERA
ISRP, SMAART, RTAPS
N+3



Supplier
Integrated
Research



Successful breakthrough innovation will require integrated aviation industry efforts

Focus

- Aviation industry technology innovation portfolio construct
 - Near term, long term vectors
- Tools and targeted pathfinder projects to create focus, opportunity e.g. **eco**Demonstrator, FAA CLEEN, NASA ERA

Commitment

- Sustained long term research investment for Environment
- Appropriate incentives for Environment
 - Implement technologies that are ready
 - Research towards goals

Presented to DOT Future of Aviation Advisory Committee, August 25, Chicago, IL

Breakthrough innovation requires integration of leading edge technologies

NASA Integrated System Research Program (ISRP)

- System-level approach, to explore, assess and demonstrate NextGen technologies in a relevant environment

NASA Environmentally Responsible Aviation (ERA)

- Vehicle technologies - simultaneously reduce fuel burn, noise and emissions - Airframe Technology, Propulsion Technology and Vehicle Systems Integration

Material and manufacturing technology capability are important elements

Demonstrators can create targeted integration focus:

- Advanced wing
- Optimized Integration
- Hybrid propulsion/power

Integration progress results more rapidly from focused industry targets

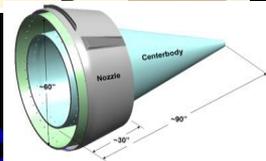
ecoDemonstrator Program – Working together



N+1 FAA CLEEN
Continuous Lower
Energy Emissions Noise



N+2 NASA ERA
Env Responsible Aviation
SMART, RTAPS, ISRP
N+3



Supplier
Integrated
Research



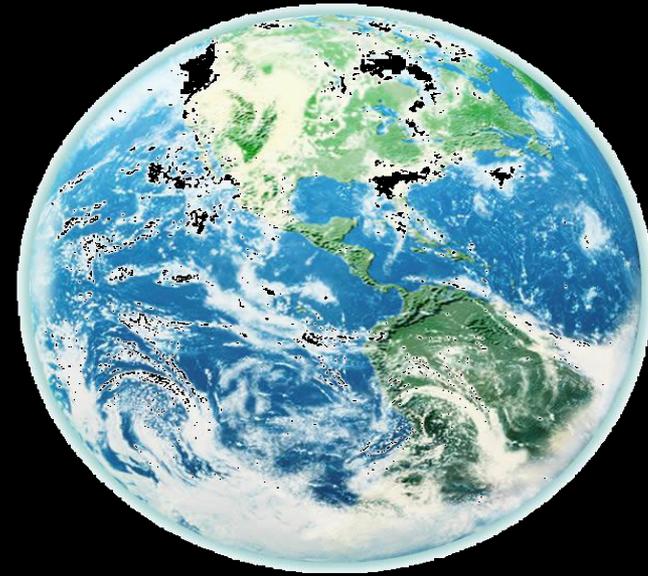
2012	2013	2014	2015	2016	2017	-----	20XX
737 Platform	Twin Aisle		TBD-XX Advanced Wing		TBD-XX Optimized Integration		TBD-XX Hybrid

Continuum of demonstrators to accelerate technology

The Challenge

"Just as {we} mastered 'impossible' challenges like supersonic flight, stealth, space exploration and super-efficient composite airplanes, now we must focus our spirit of innovation and our resources on reducing greenhouse-gas emissions in our products and operations."

W. J. McNerney
Chairman, President and CEO
The Boeing Company



Working together for a better
future

THANK YOU