Beyond the 787: Developing the Future of Structures And Materials That Shape Aerospace

Dr. Greg Hyslop
Vice President / General Manager
Boeing Research & Technology
The Boeing Company

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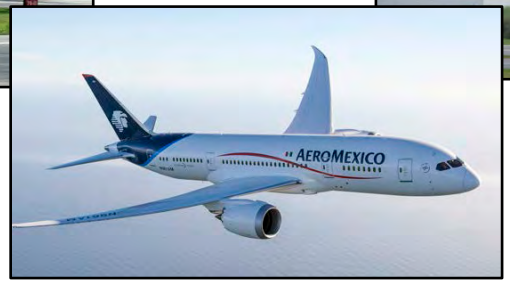
The Future, Delivered Today



More than 90 787's in service

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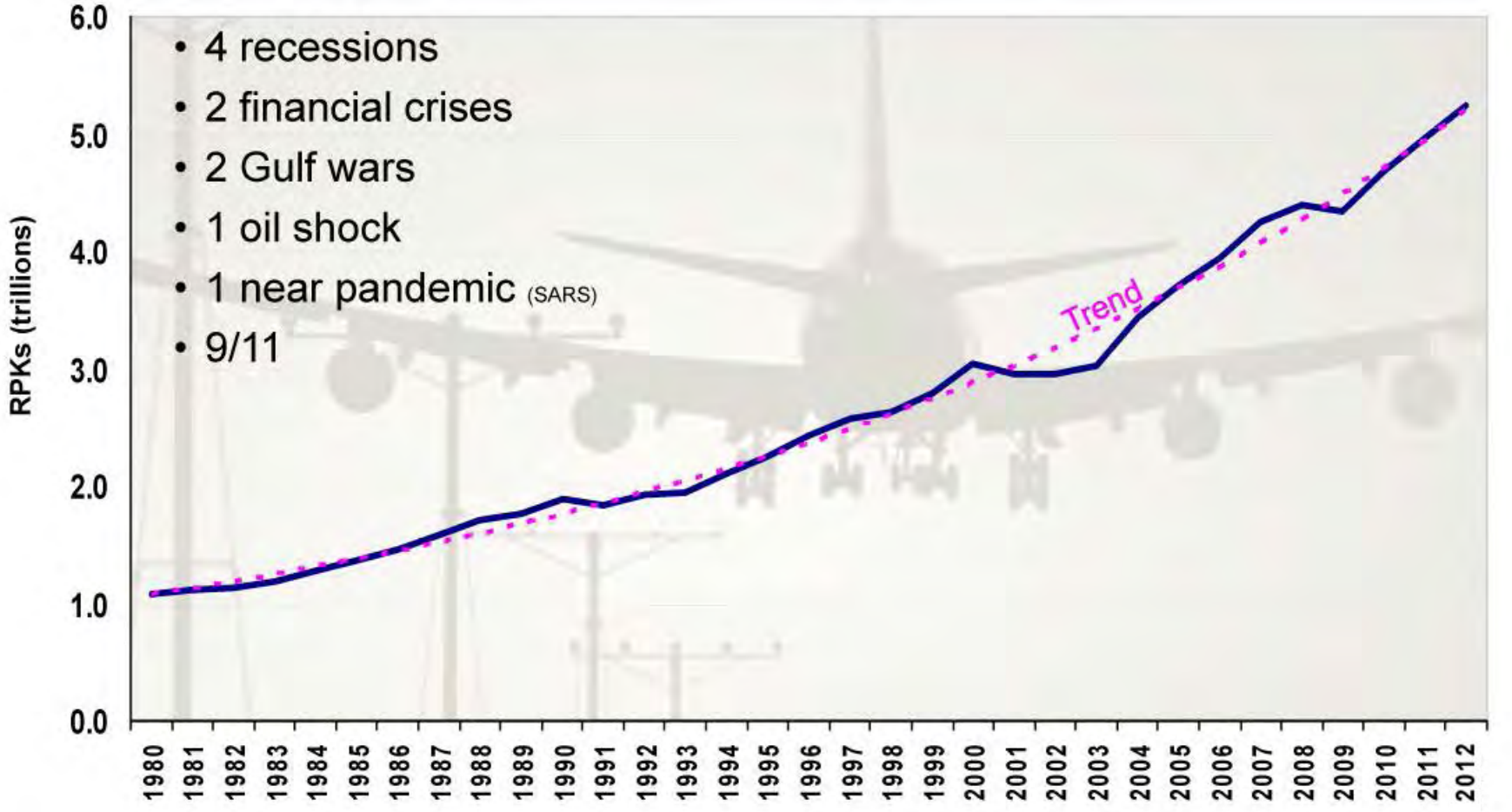
World Air Travel: Steady Growth



RPKs = Revenue Passenger Kilometers.

Source: ICAO Scheduled Traffic

Despite short-term issues, world air travel grown 5% annually since 1980

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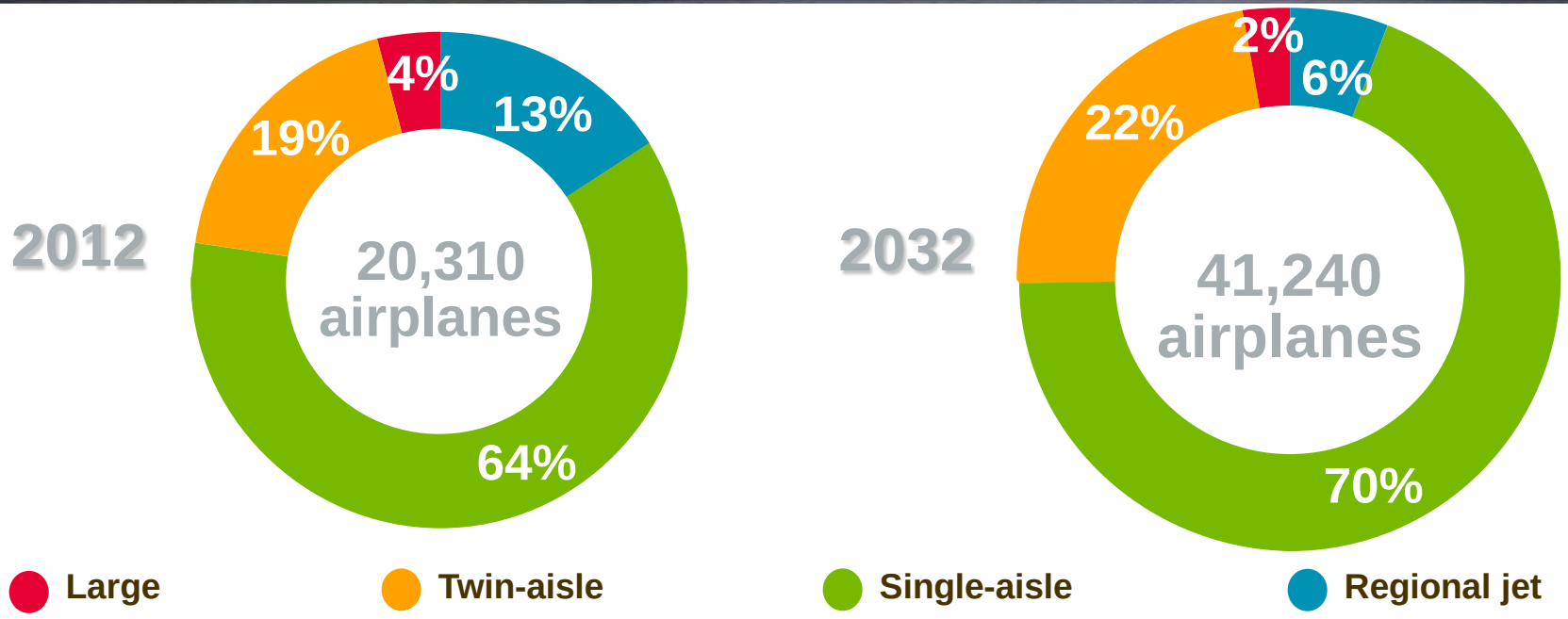
Air Travel Projected to Keep Growing



World's fleet will nearly double in next 20 years

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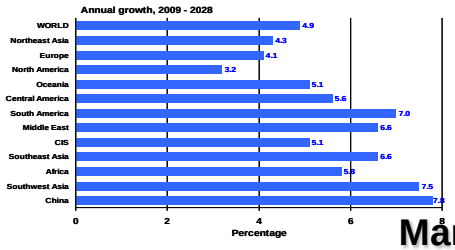
What Drives Innovation In Aerospace?

Traffic forecast



Network development

Economic growth

Market liberalization

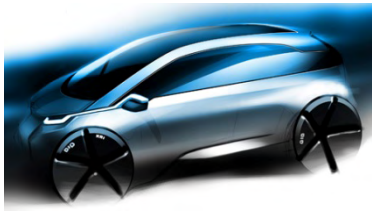
Airplane capabilities

Fuel price

Infrastructure

Environment

Ground Transportation



Airline strategies & business models

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Focusing Technology Investments on Future Needs

Extreme Affordability

… in development, production, operations, and support

Breakthrough Performance

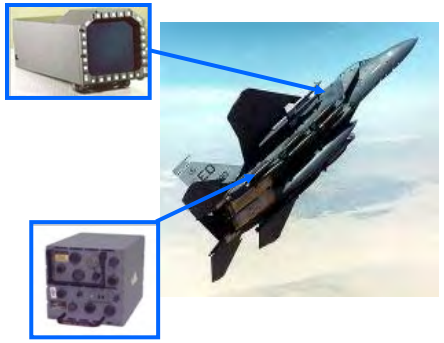
…to meet the customer needs (range, payload, speed, mission effectiveness, availability, reliability, etc.)

Enduring Sustainability

… easy to mod, open system architecture, easy to upgrade

Environmentally Responsible

… non-polluting in production (no VOC, lead free solder, no carcinogens, no chromium), quiet, non-polluting, fuel efficient in operation, disposable/ recyclable at end of life



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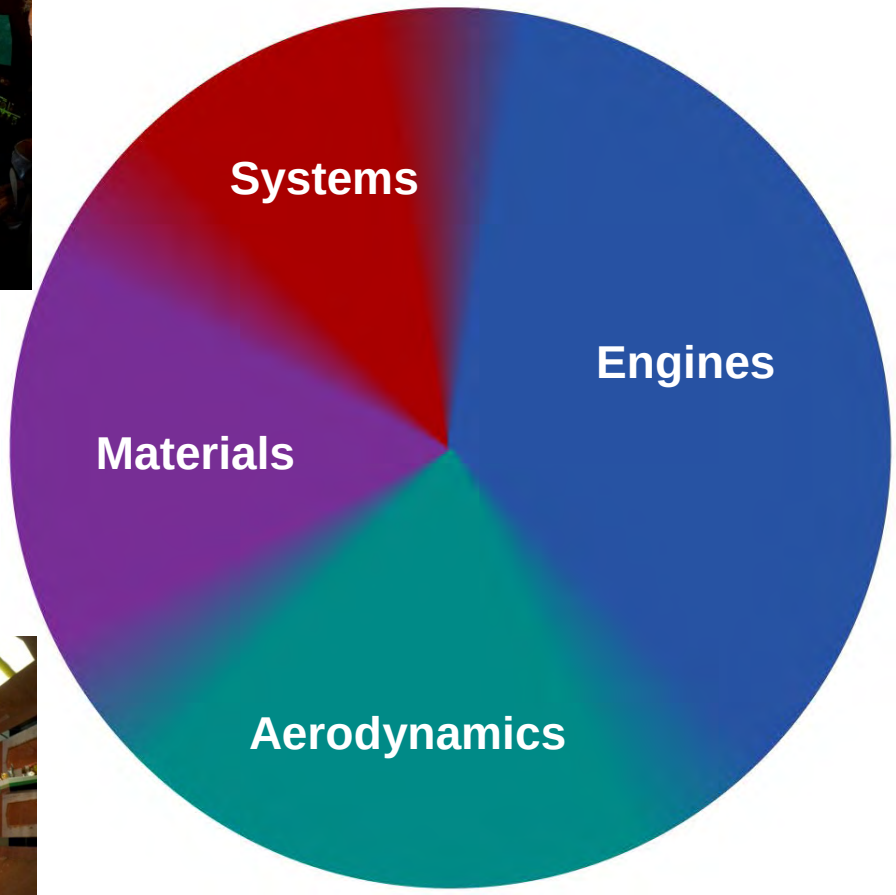
Sources Of Improved Capabilities



Multiple sources complement each other – but must be integrated

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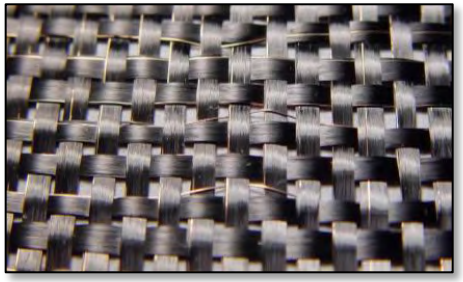
Composites: A Key Element In Airplane Performance Improvement



Key benefits:

- Tailorable properties
- Reduced drag and weight
- Less susceptible to fatigue
- Corrosion resistance

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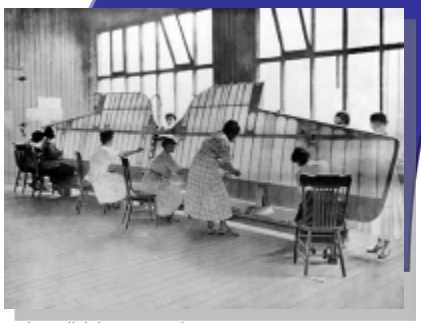
New Chemistries, Materials Enable Product Advances and Product Differentiation

- Extreme environmental requirements
- Decades of required reliability

- Wood and Fabric



- Low Strength Al

- High Strength/ Stiffness Al
- Fiberglass
- CRES
- Ti

- Carbon Thermoset Composites
- Ti

Tremendous strides in Material Science over the last century

Higher performance at lower cost

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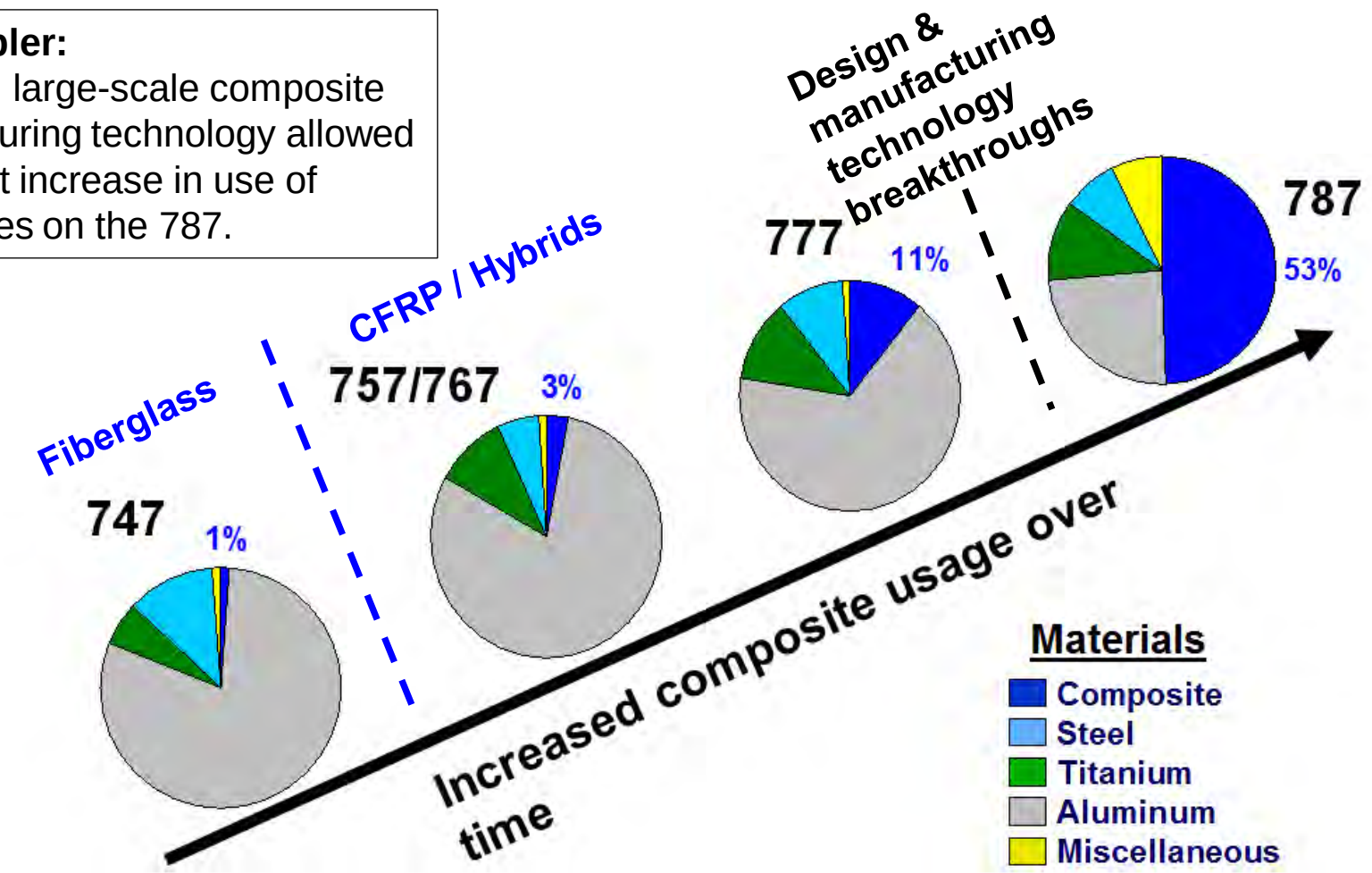
Boeing's Composites Usage Increases

Key enabler:
Low-cost, large-scale composite manufacturing technology allowed significant increase in use of composites on the 787.



Many advances in the past 40+ years

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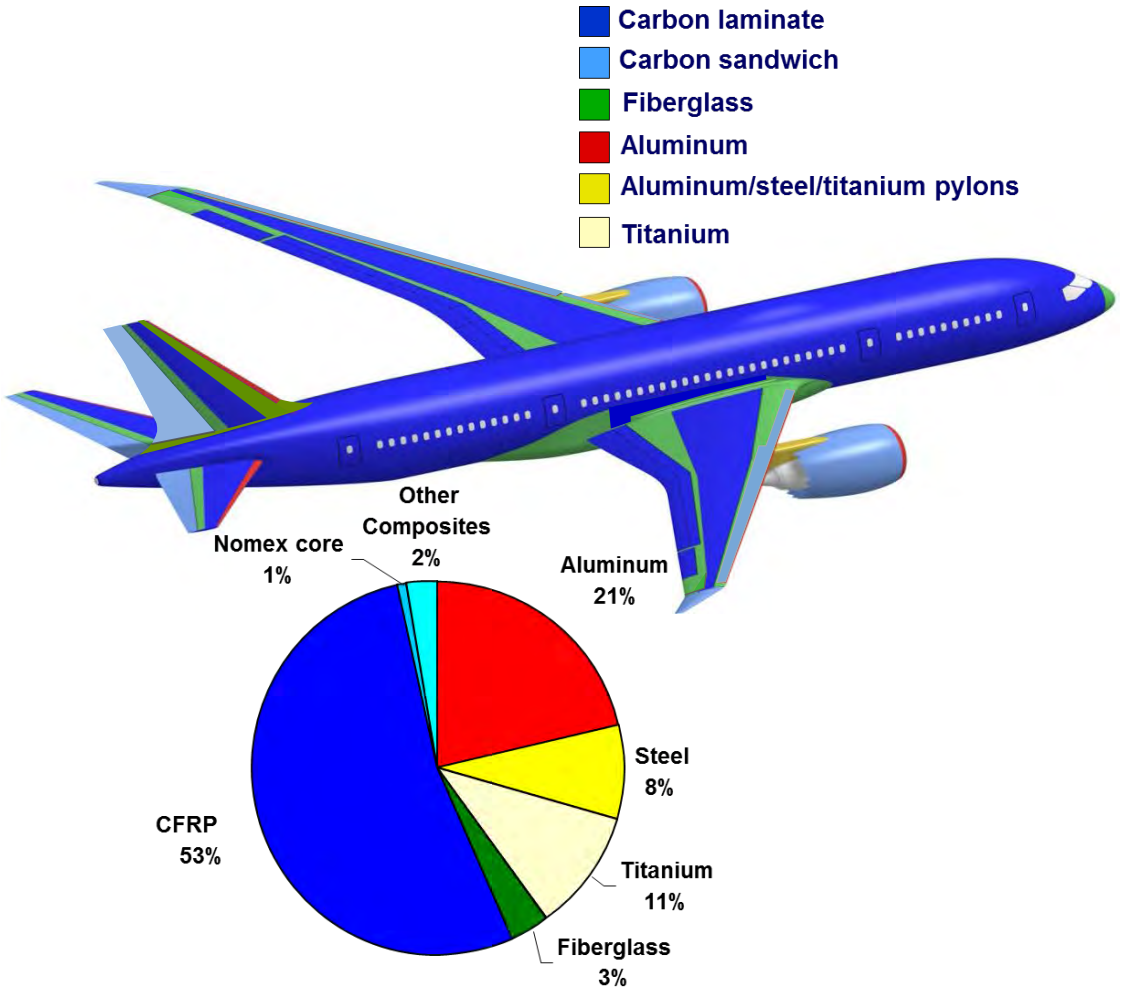
787: Composite Structure

- Lighter
- More durable
- Negligible corrosion and fatigue
- Reduced scheduled maintenance
- Opens new design possibilities



Composites are the right material choice for the 787

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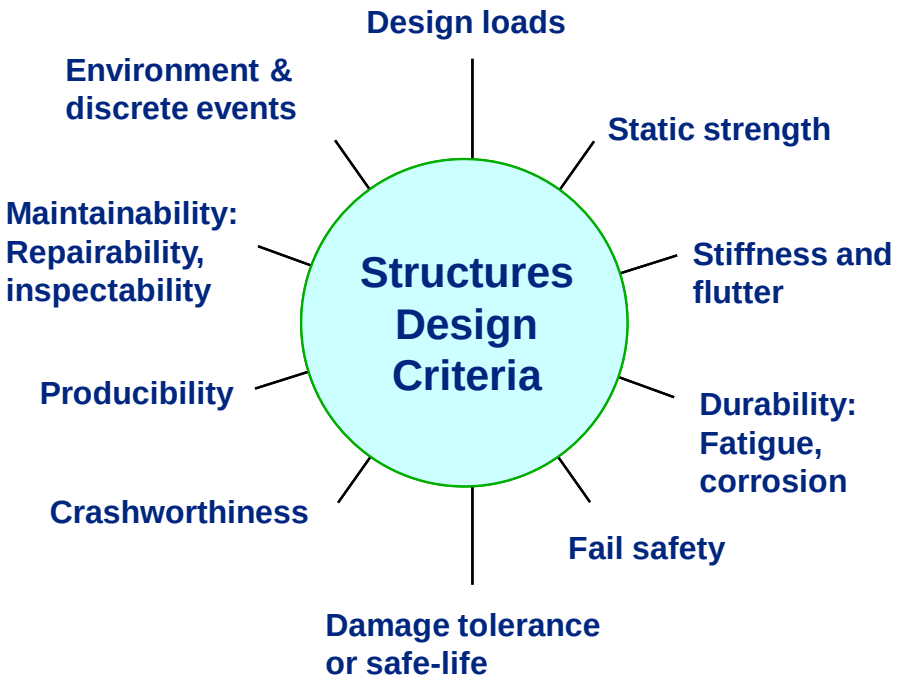
New Material System Must Earn Its Way Onto an Aircraft



- **Targeted application**
- **Breakthrough performance improvements**
  - Material substitution
  - Reduced minimum gauge
  - System level functionality
- **Value / affordability across the lifecycle**
  - Material cost
  - Fabrication
  - Service

Significant improvements must be realized to offset the development and certification costs

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Composites Grand Challenges, for the Next 20 Years

- **Anisotropy** for efficiency
- **Certification** by analysis
- **Simulation-based** manufacturing
- Robust **multi-scale** simulation
- **Multifunctional** nanocomposites arrive
- Pervasive composites **knowledge and learning**

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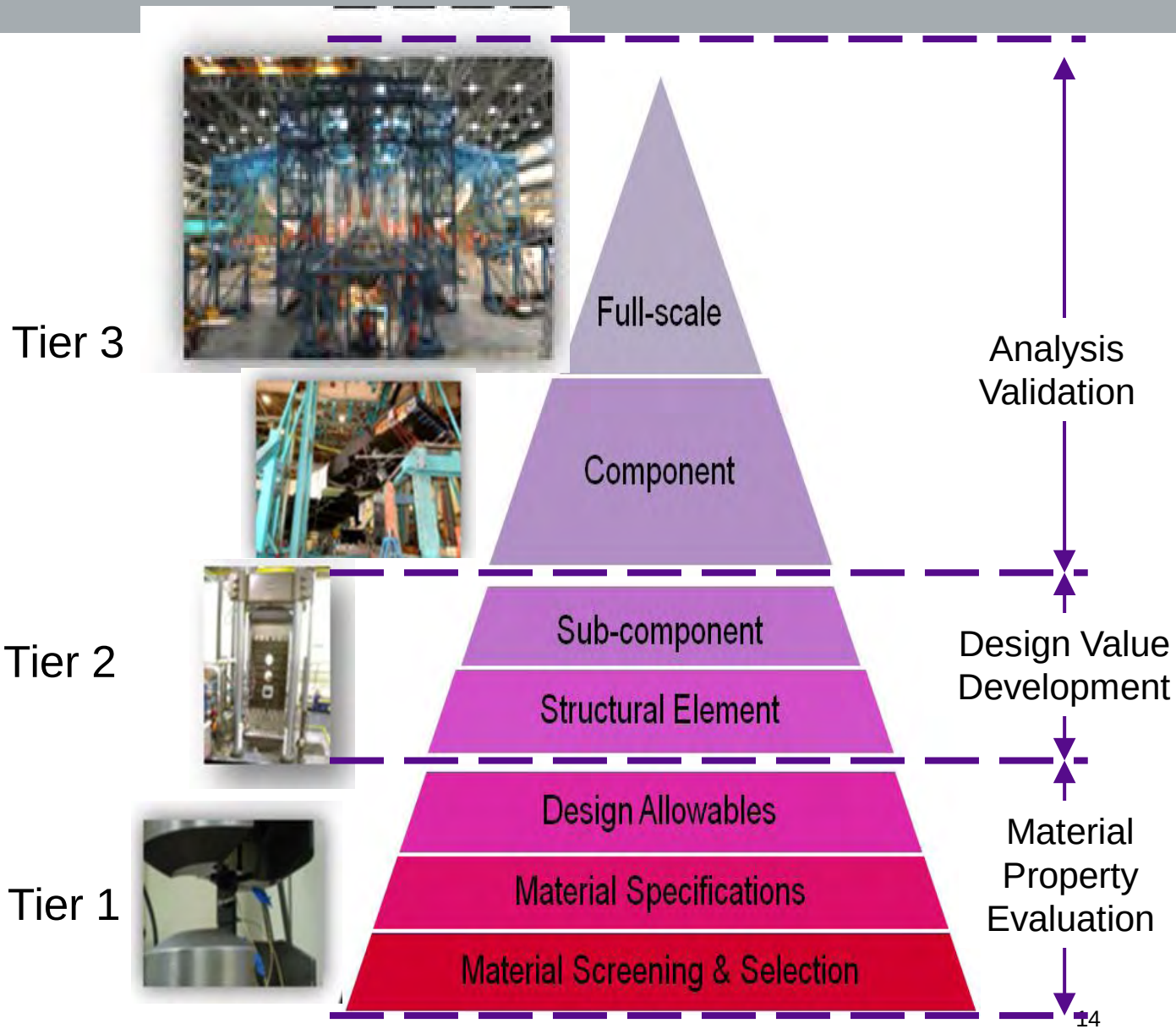
Courtesy Prof. Byron Pipes, Purdue University

Testing and Certification, Today

Extensive testing, done to support analysis



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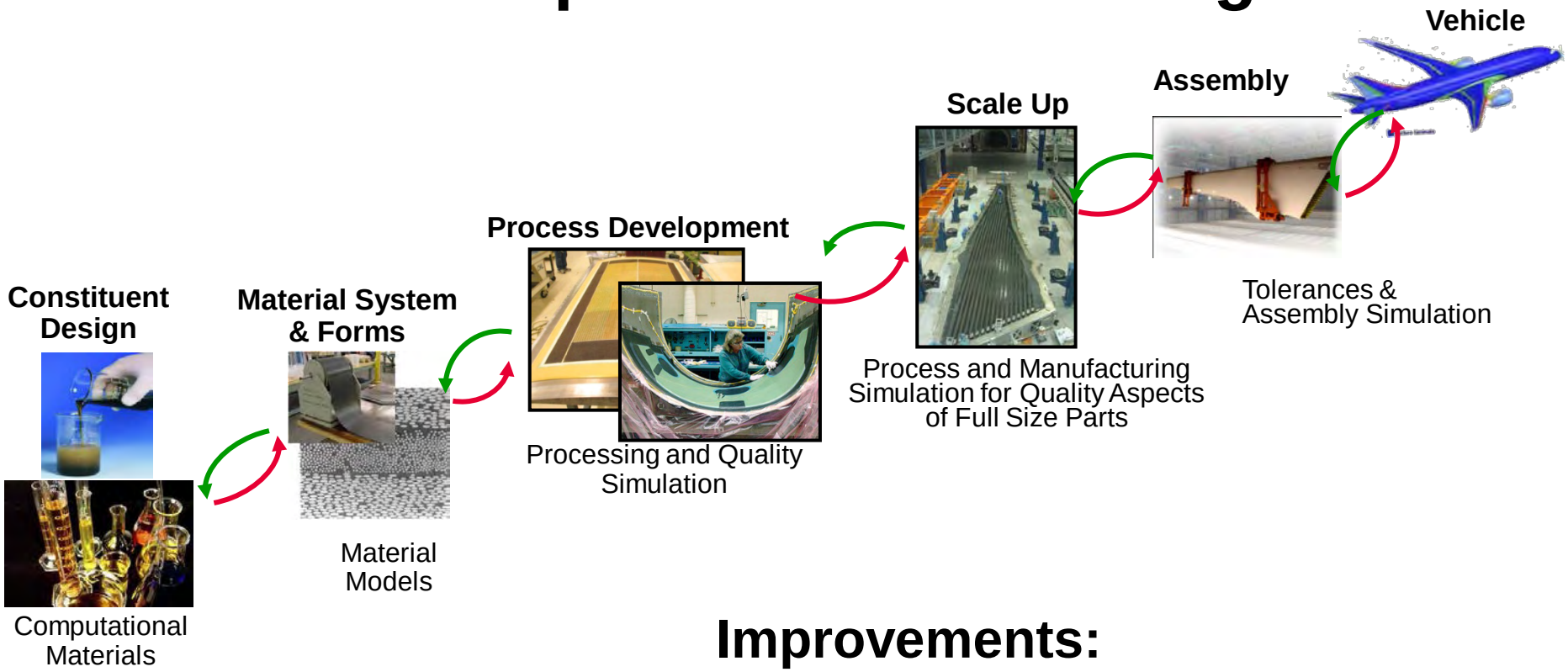
Testing and Certification, In the Future

Advanced computational technologies



Improvements:

- **Qualification, certification**
- **Reduced cost, time to market**

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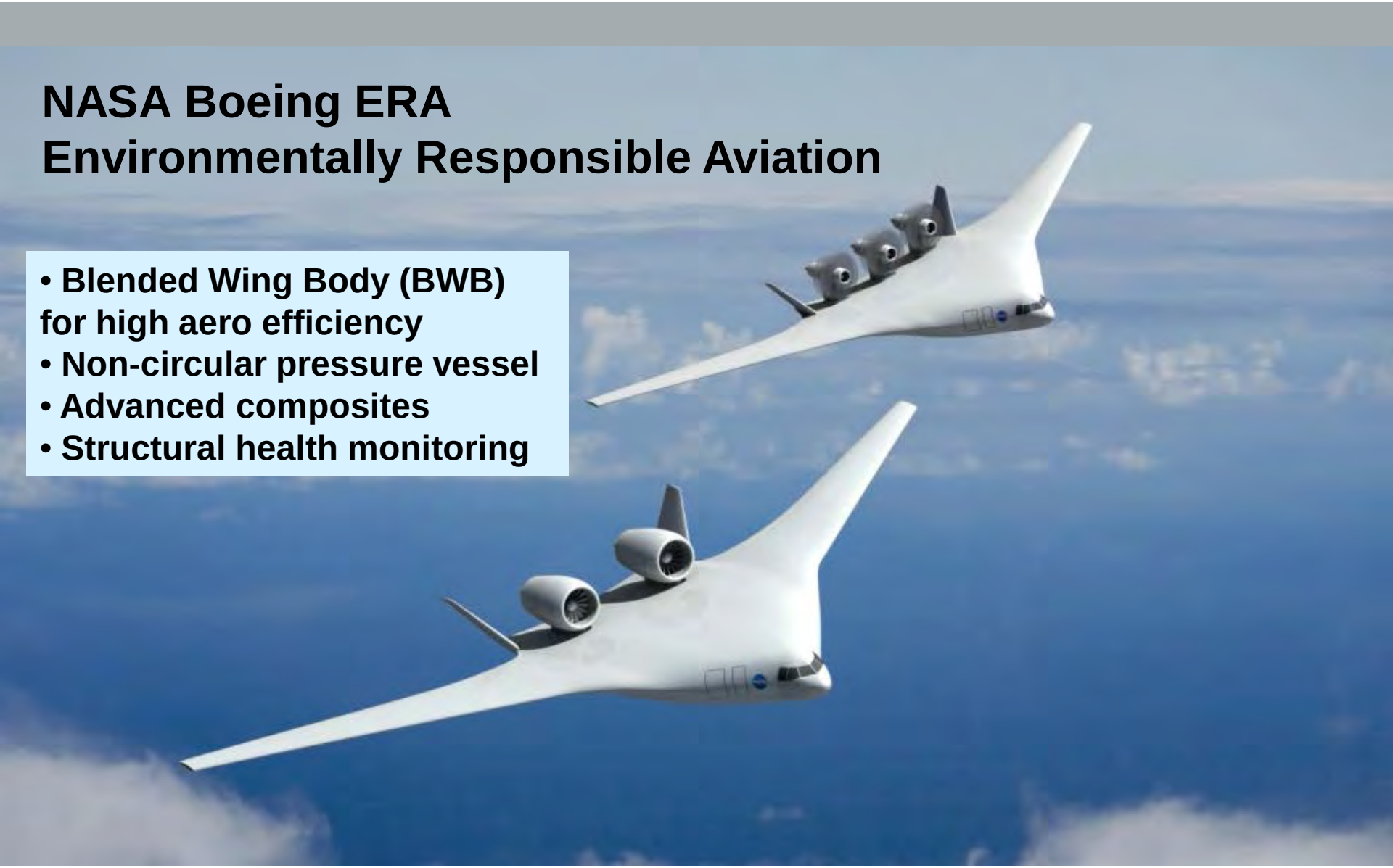
Materials Challenges In Future Concepts



NASA Boeing ERA
Environmentally Responsible Aviation

- Blended Wing Body (BWB) for high aero efficiency
- Non-circular pressure vessel
- Advanced composites
- Structural health monitoring

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Knowledge Base

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