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# Materials and the Aerospace Industry

Enhancing Innovation and Competitiveness Through  
Investments in Fundamental Research

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# Questions to Consider for Enhancing Innovation and Competitiveness

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- **Expanded federal investments in research and education and the impact**
- **Acceleration of ROI in basic research**
- **Collaboration models for research**
- **Specific areas of fundamental research**
- **Workforce challenges**

# Boeing Products

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**Commercial Airplanes Family**



**Integrated Defense Systems**

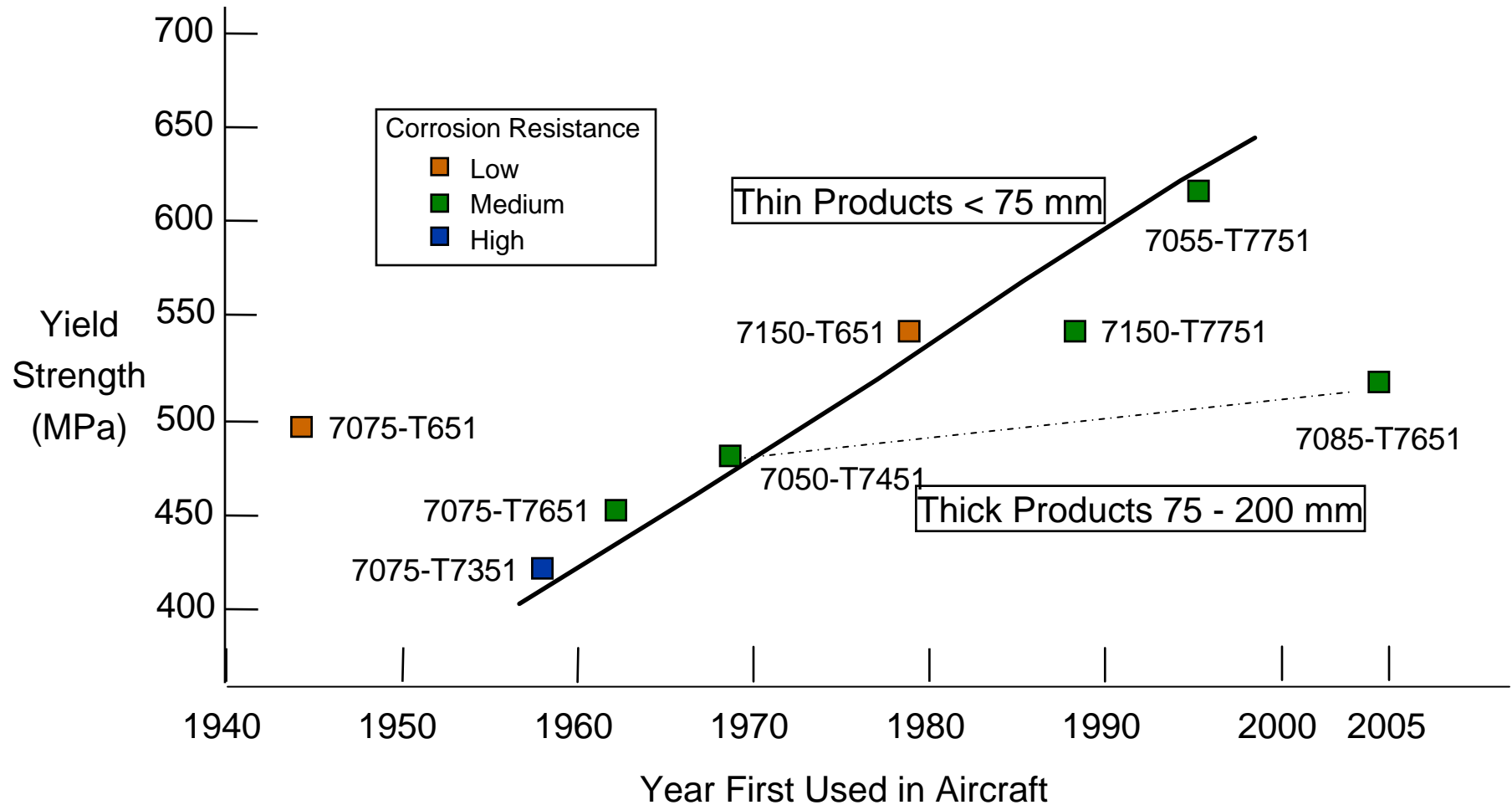
# Materials Research to Meet 21<sup>st</sup> Century Defense Needs DoD Sponsored, NRC/NMAB Study - 2003

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- **Revolutionary capabilities from R&D in**
  - **Structural and multifunctional materials**
  - **Energy and power materials**
  - **Electronic and photonic materials**
  - **Functional organic and hybrid materials**
  - **Bio-derived and bio-inspired materials**
  
- **Five recommendations made**
  - **Accelerate materials transition from concept to service**
  - **Computational modeling**
  - **Integrate research in various materials classes**
  - **Discover materials with substantially improved properties**
  - **Materials research from conception to service to retirement**

# Strength and Corrosion Resistance Improvements Relative to 7075-T651 in New 7XXX-Series Alloys



# Composition (Wt. %) of 7XXX Series Alloys

	7075	7050	7055	7085
Zn	5.6	6.2	8.0	7.5
Mg	2.5	2.3	2.0	1.5
Cu	1.6	2.3	2.3	1.6

# Industry Perspective

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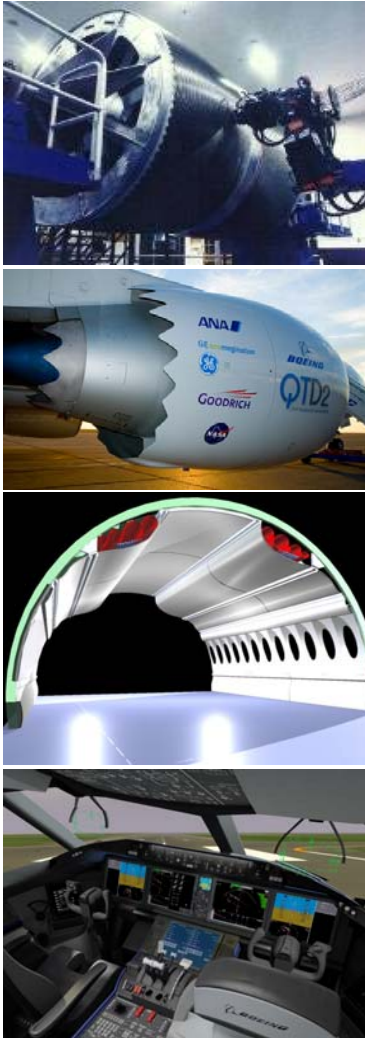
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- **Technologies fuel growth**
  - Products – 787 Dreamliner
  - Services – Expand the value of products to customers
- **Technologies reduce the bottom line**
  - Design – Enables more efficient structures
  - Manufacturing – Enables streamlined production
- **Breakthrough Technologies - What will the future bring?**
- **Fundamental research**
  - **What are the gaps and what is needed to close them?**
- **Workforce challenges**

# Growth: New Technologies Enable New Products and Services

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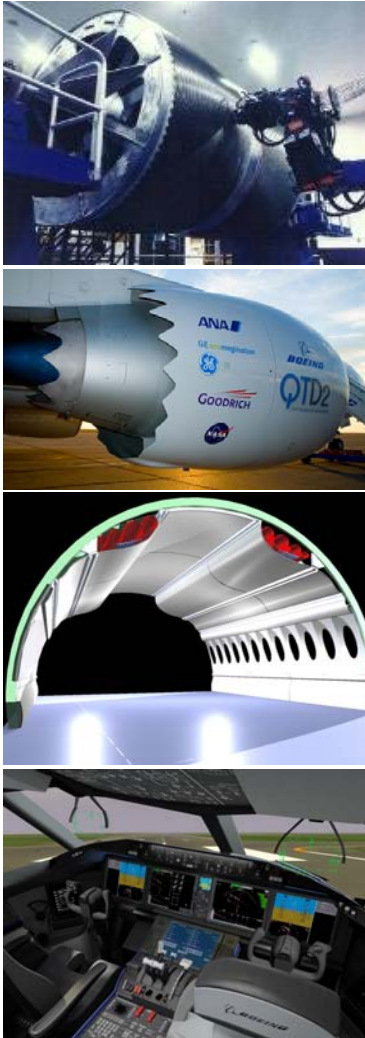


- Large-scale composite components
- Advanced manufacturing processes
- System health monitoring
- Next-generation engines
- More-electric power systems
- Enabling interior architecture
- Integrated avionics
- Advanced flight controls
- Wireless IFE and other technologies improve the cabin
- Noise reduction technologies
- Advanced Recycling Technologies for Airplanes

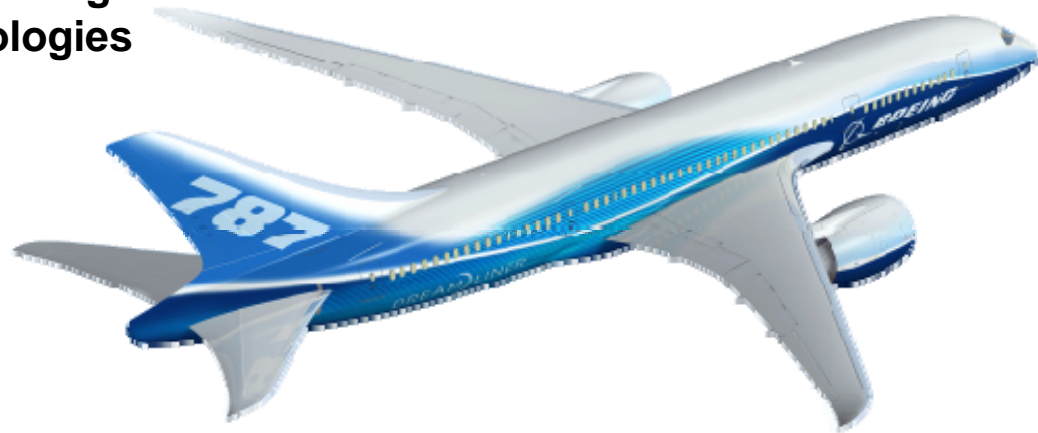
# Growth: New Technologies Enable New Products and Services

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**Integrating  
Breakthrough  
Technologies**

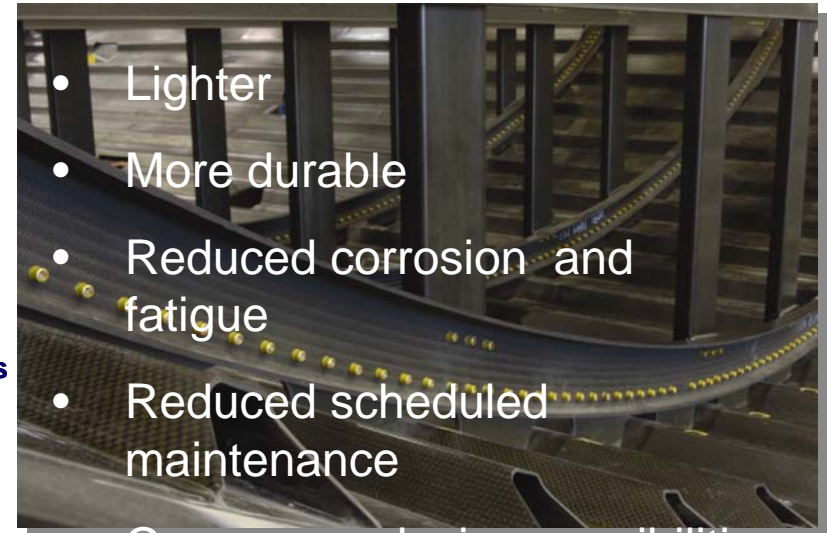
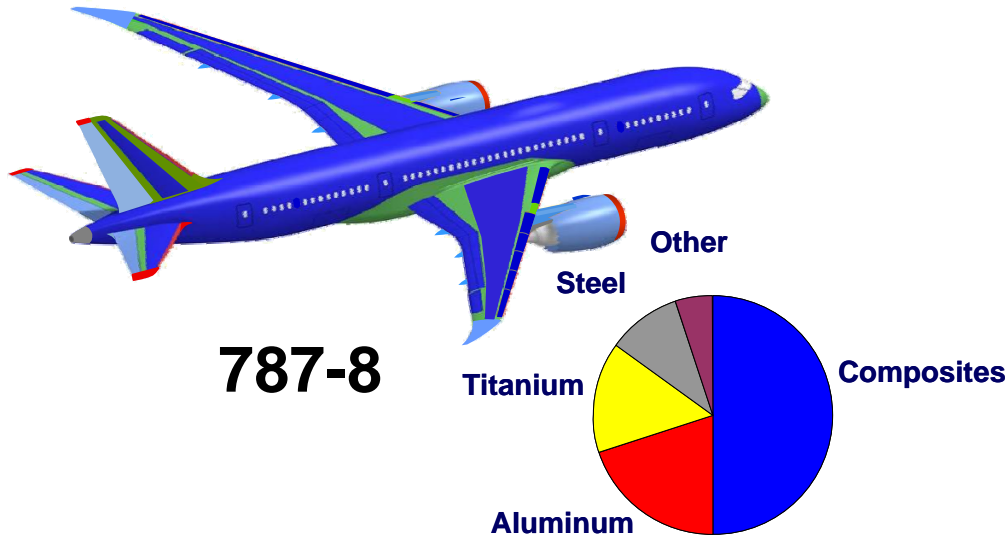


- **Best introduction of a new Boeing Commercial Airplane ever**

# Composites Serve as 787 Primary Structural Material

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**One Piece Fwd Fuselage**



**One Piece Barrel Section**

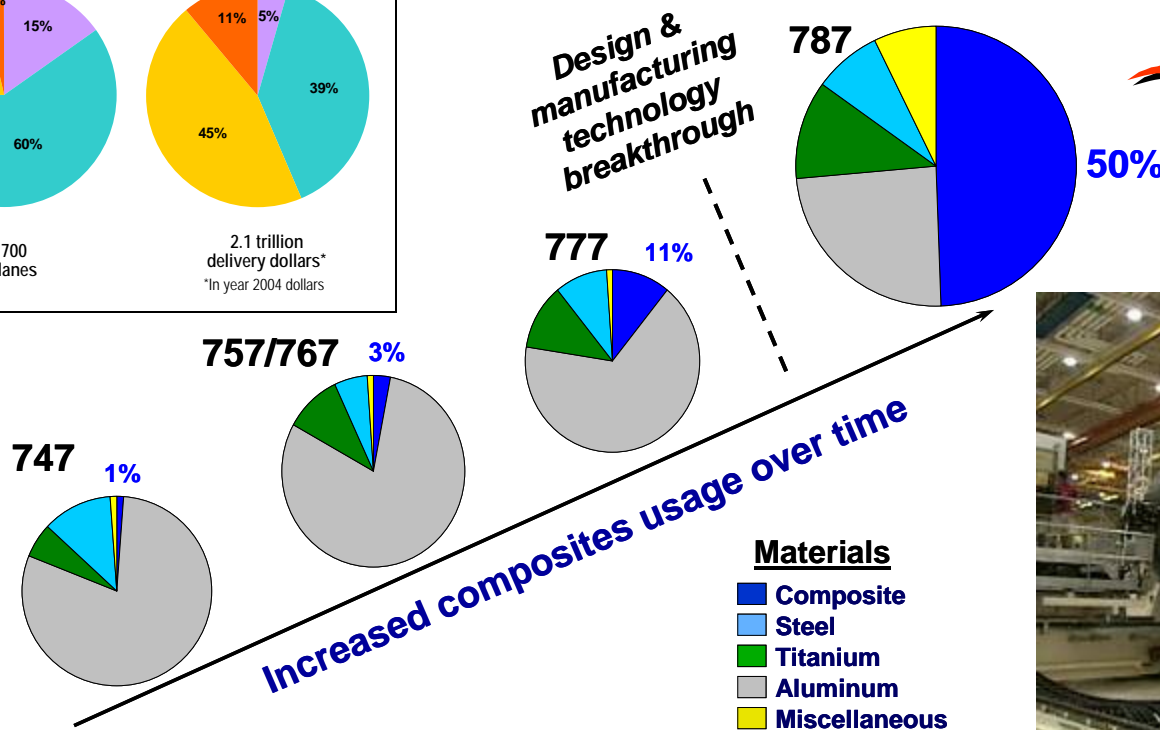
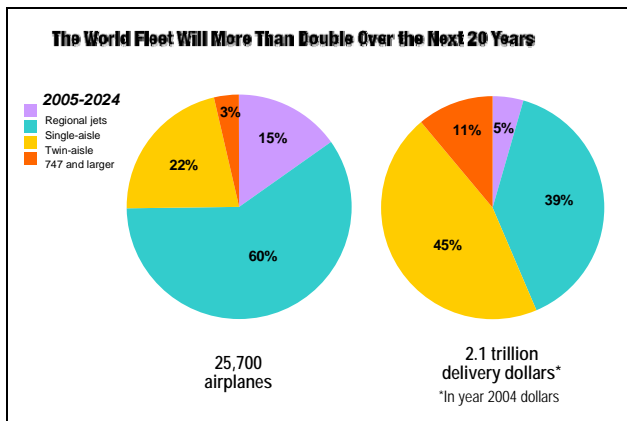


**Test Wing Box**

# The Future of Composites Enabling High Rate Production

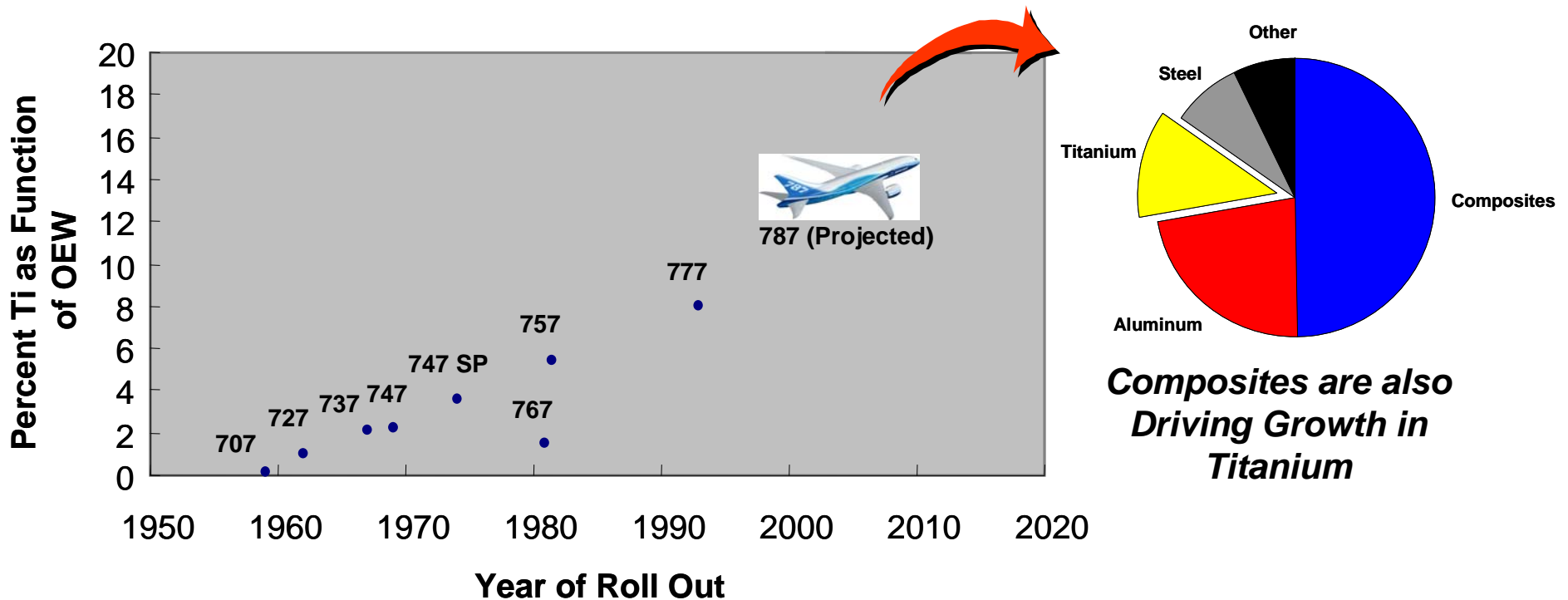
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**Continued Development of Advanced Composites Will Be Required to Affordability Satisfy High Rate Production Needs**

# Titanium Usage in Aircraft Has Been Increasing

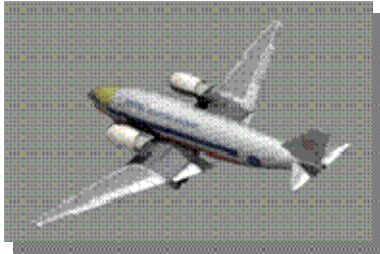


Continued Development of Improved Alloys Are Needed to Improve Performance, Manufacturability, and Affordability

# 7 Characteristics of Future Products, Processes & Services

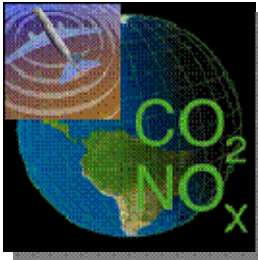
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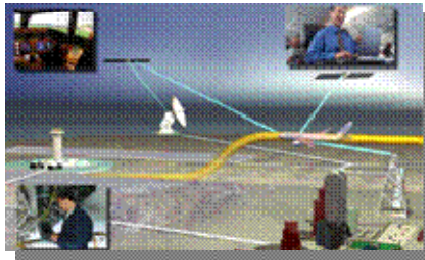
## Extreme Affordability

Cost improvements of factors from 2-100



## “Universally” Friendly

Minimal to no environmental impact of a product throughout its full lifecycle



## Network Centric

Multiple assets that collaborate on a network to optimize the system performance



## Super-Human Intelligence

Platforms and systems with decision making capabilities better than human

# 7 Characteristics of Future Products, Processes & Services



## Highly Integrated

Integration of many functions into a single component



## Breakthrough Performance

2 to 100-fold performance improvements



## Adaptability to Change

Easy to upgrade with the latest technological advancements

# Growth: New Technologies Enable New Products and Services

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## Product Support – Integrated Vehicle Health Management

Develop diagnostic/prognostic technologies that will allow us to monitor the performance of our products in the field to ensure optimum performance and maximum availability to our customers

**Monitor**

**Detect**

**Analyze**

**Plan**

**Manage**



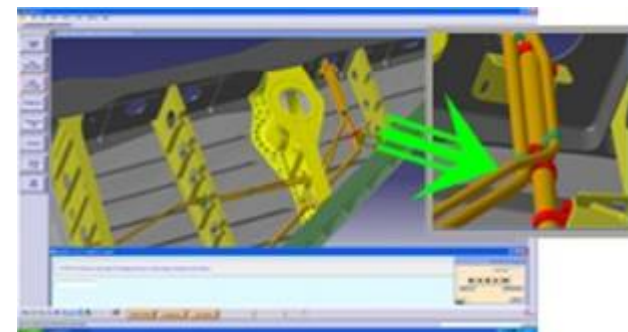
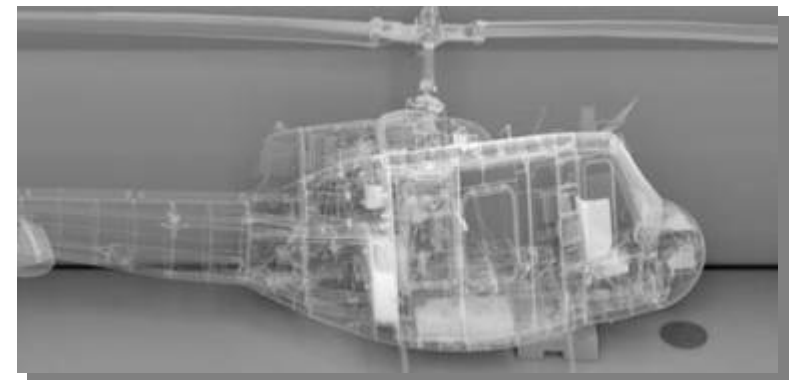
# Growth: New Technologies Enable New Products and Services

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## Product Support – Maintenance, Mods, & Repairs

Develop advanced technologies which will improve the quality and reduce the cost of Maintenance, Modifications and Repair



# Productivity Improvements: Design Technologies Enabling More Efficient Structures

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## Lower Cost & Lower Weight

Develop innovative structural concepts which will be lighter, easier to build and maintain, and cost less to fabricate and support



Fewer parts  
Fewer fasteners  
Less assembly  
Lower weight

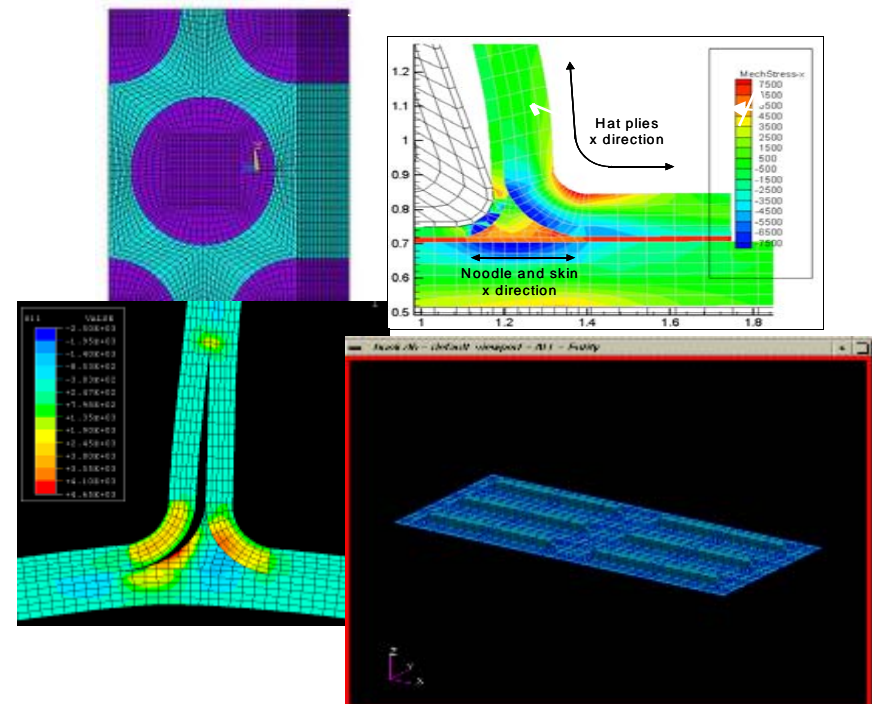
# Productivity Improvements: Design Technologies Enabling More Efficient Structures

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## Design & Analysis Tools

Develop the necessary analysis capabilities needed to support the advanced concepts and integrate those into common design tools and processes



Faster Designs  
More Iterations

# Productivity Improvements: Design Technologies Enabling More Efficient Structures

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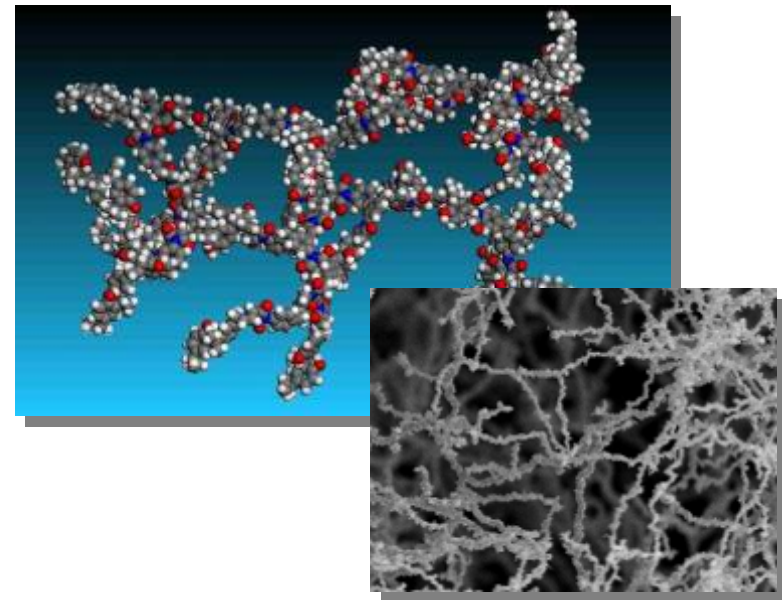
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## Materials by Design

Create high-performance materials and leverage with design concepts to improve performance and/or lower costs



- Materials by Trial and Error
- Lots of testing



- Architect the materials necessary to enable higher performance designs

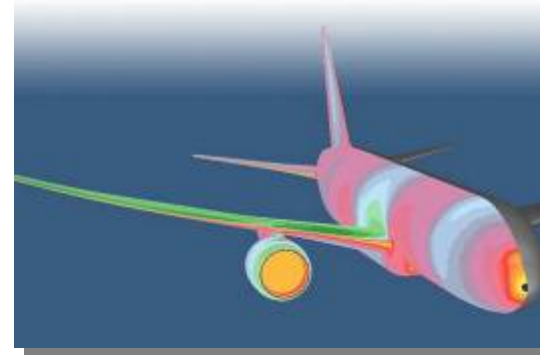
# Productivity Improvements: Design Technologies Enabling More Efficient Structures & Operations

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## Modeling and Simulation

Develop, design, and build multiple iterations virtually to reduce costs and speed development



Physical

Virtual

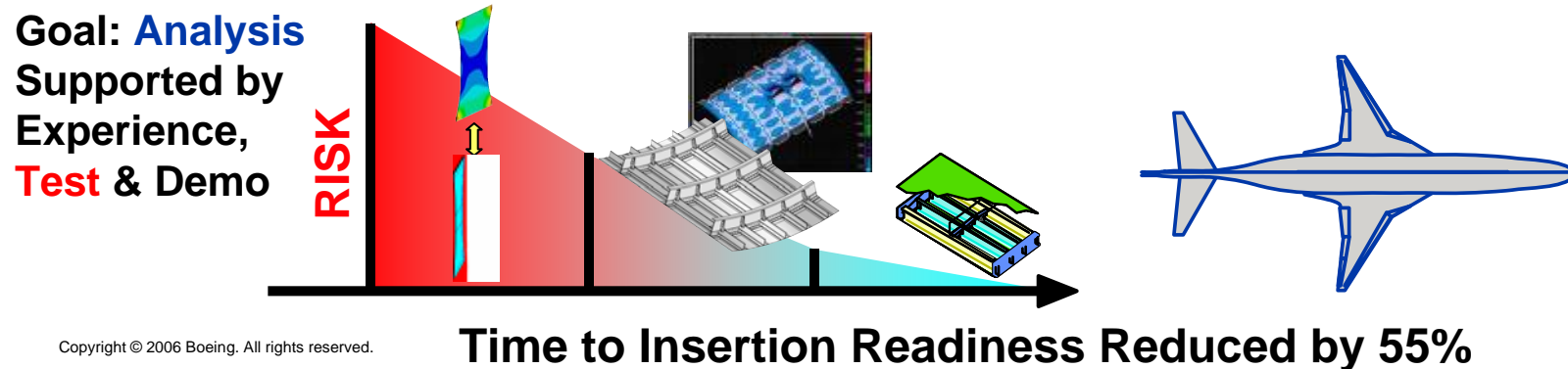
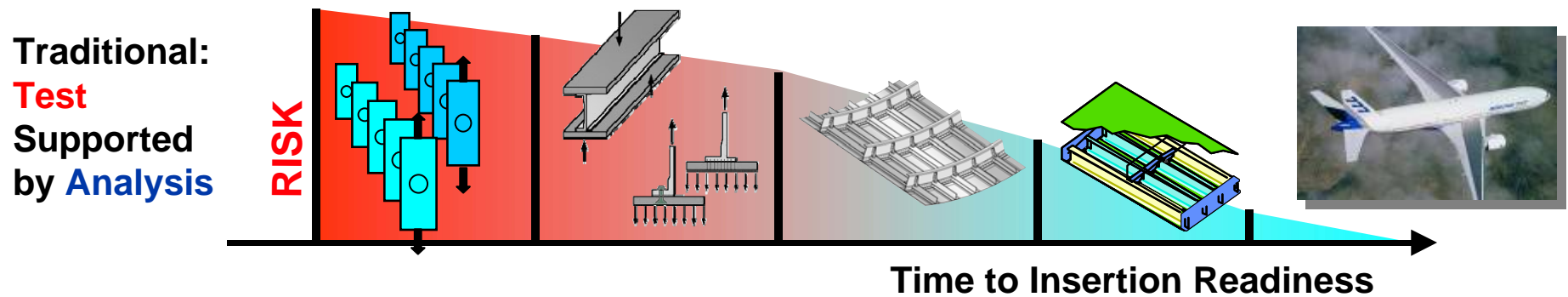
# Productivity Improvements: Design Technologies Enabling More Efficient Structures

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## Analytical Techniques Replace Empirical Testing

Develop methods to verify and certify new structural concepts and material forms to speed those advancements product lines



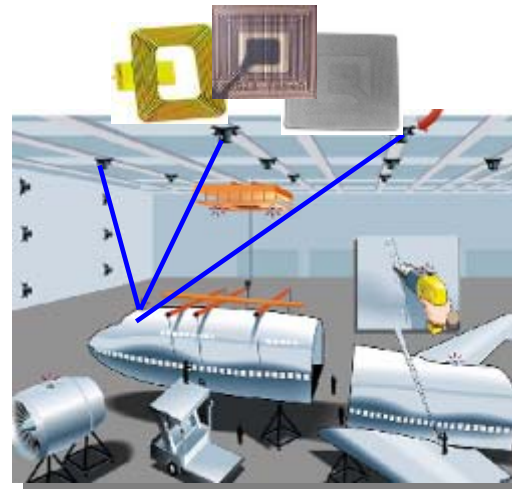
# Productivity Improvements: Technologies Enable Lower Cost Structures

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## Network Enabled Manufacturing

Develop open architecture model for linking system-of-systems, e.g., Indoor GPS, RFID, SmartTools, Laser Projection all linked to manufacturing work instructions and Quality Management System



NEM Converts today's aerospace factories where information collection and diagnostics are mostly manual to state-of-the-art automated information database resource in real time. This methodology is well adaptable to the future engineering work force who are familiar with intelligent computerized systems

# Aerospace Direction

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- Increased global sourcing of subcomponents and materials
- Global sourcing of assembly
  - Airbus to assemble planes in China (2006)
- Networked manufacturing
- “Materials by Design”
- Lean manufacturing
- “Green” materials and processes
- Networked aircraft, satellites, etc.

# Aerospace Workplace Needs

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- Educated Scientists and Engineers
  - Globally sourced
  - “Clearable” for Defense-related projects
  - Mathematical and Analytical capability
    - Probability and Statistics
  - *Communications* across various disciplines
    - Not just interdisciplinary studies, but interaction

Boeing invests significantly in employee training  
both in-house and at universities

# Fundamental Research Gaps and Needs

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- Modeling and simulation
  - Materials Informatics
  - Simulation of manufacturing processes
- Multi-functional materials
- Lower cost or affordable replacement for strategic materials
- Self assembled structures – “Grow the parts”
- In-service assessment of the health of materials
  - Diagnostics and prognostics

Materials are Key to Maintaining Competitiveness