



Engineering, Test & Technology
Boeing Research & Technology

Trends in Aerospace Manufacturing

Lane Ballard

Vice President of Materials & Manufacturing

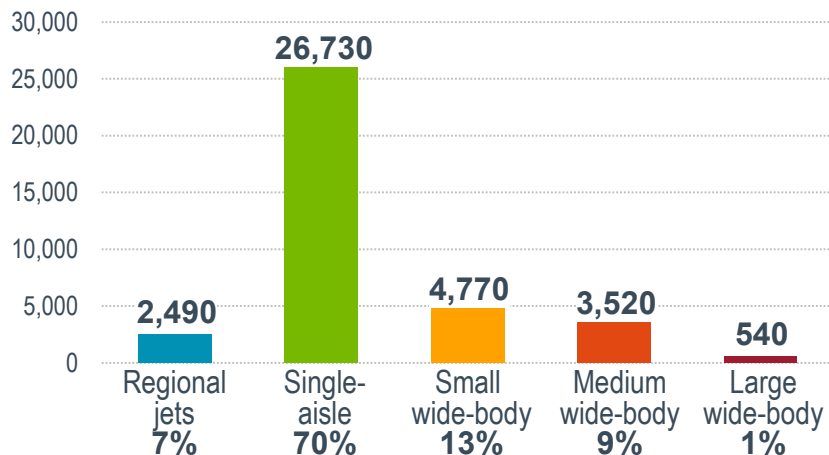
Boeing Research & Technology

Airlines will need 38,000 new airplanes valued at \$5.6 trillion



Airplane deliveries: 38,050

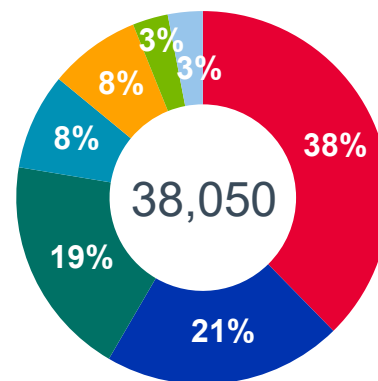
2015 - 2034



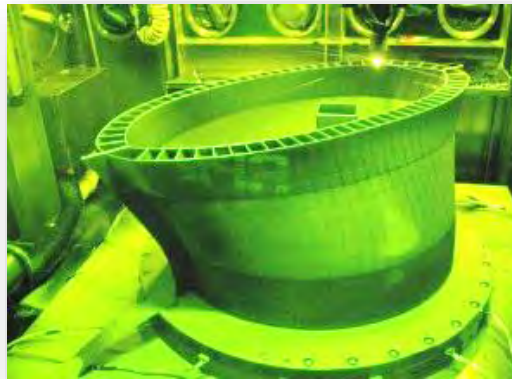
New airplane deliveries by region

2015 - 2034

Region	Airplanes
Asia	14,330
North America	7,890
Europe	7,310
Middle East	3,180
Latin America	3,020
Africa	1,170
C.I.S.	1,150
World Total	38,050



Beyond the 1st Century of Aerospace Manufacturing



Automated Composite Fab

Additive Manufacturing

Robotic Assembly

Industry Realities

June 12, 2015 6:28 pm

Boeing and Airbus face mammoth task to clear order backlog

Peggy Hollinger, Industry Editor

Honeywell cuts 2016 sales forecast on weak aerospace demand

BY ANKIT AJMERA

Production cut drives deeper loss at ATI

BY ALEXANDER | Tuesday, July 26, 2016, 9:21 a.m.

The movers and shakers of the aerospace industry this week are the Dow Jones Industrial Average and the Dow Jones Industrial Average.

Formidable challenges loom in Boeing's next century

Jon Talton / Columnist

AEROSPACE Doubts plague aerospace industry ahead of Farnborough Airshow

TIM HEPPER VICTORIA BRYAN
FARNBOROUGH, ENGLAND. — Reuters
Published Friday, Jul. 08, 2016 3:53PM EDT
Last updated: Jul. 08, 2016 4:00PM EDT

Rise in aircraft demand forces supply chain to modernise

Ross Tieman

Allegheny Technologies Inc. reported a bigger financial loss in the second quarter as the company cut production of its specialty steel business to deal with



GKN to cut jobs and redirect investment

Peggy Hollinger, Industry Editor

OBAMA URGES HOMEOWNERS TO PAY OFF THEIR HOUSE AT A CRUCIAL RATE

Should-Cost Review to Improve Affordability



The U.S. Department of Defense is experiencing unprecedented cost pressures as demands to reduce government spending rise. In this "doing more with the same—or less" environment, affordability of weapons programs and services is a hot topic.

Should-cost review is becoming the tool of choice to improve affordability. And for good reason. SCR, when implemented systematically, can reduce total system costs by 5 to 15 percent and subsystems costs by up to 40 percent.

The demand for affordability in the U.S. Department of Defense is underscored by the Under Secretary of Defense for Acquisition, Technology and Logistics. Dr. Ashton Carter, in a series of memos issued in 2010 and early 2011, stresses that a should-cost review (SCR) will serve as an important tool in attaining program affordability. He points out that should-cost targets are now required for all ACAT I, II and III programs and that progress toward these targets will be reviewed at major program milestones.



Jobs and investing in automation in a drive to trim costs as interim edge back and pension liabilities rise at the aerospace and equipment supplier.

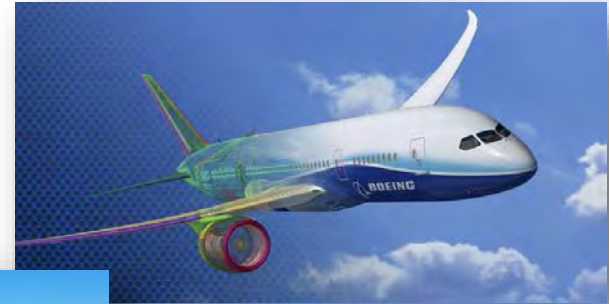


All aboard: Boeing 737 fuselages are delivered by train to a Boeing manufacturing site in Renton, Washington state. At the perimeter of Toulouse-Blagnac airport are rows of airliners, their wheels covered and doors taped over. An empty space beneath their wings betrays the supply chain hitch that caused this stockpile of aircraft, valued at more than \$2bn. For some, the Airbus A320neo (new engine option) became a no-engine option.

Industry customers are demanding more for less

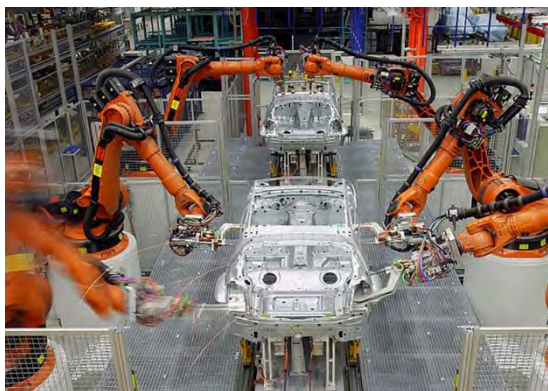
Market Challenges – What the Customers Want

- Safe
- Affordable
- Reliable
- Upgradeable
- Flexible
- Performance
- Environmentally responsible
- Available



Challenges & Opportunities Ahead

Design for Manufacturing –
Aerospace needs to leverage broader industry

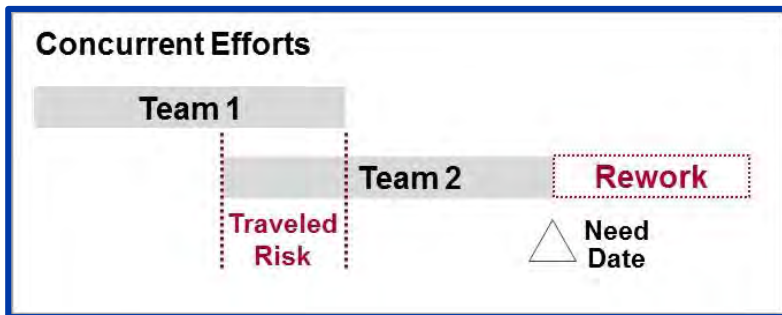


By KUKA Systems GmbH (KUKA Systems GmbH) [CC BY-SA 3.0], via [Wikimedia Commons](#)

Speed to Market –
More capability to customers – quicker



Traveled Risk –
Concurrency adds risk of rework



Modularity –
Enables Reuse & Customization



Advanced Materials

Top Business Outcomes

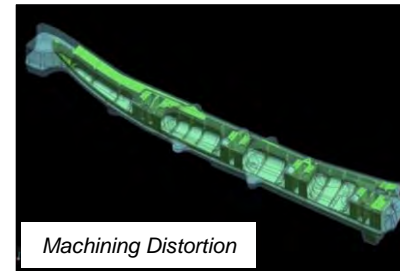
- Safe/Environmental/Ergonomic Processes
- Robust First Pass Quality
- High Rate Capability
- Reduced part count
- Optimized Weight AND Cost

Top Advanced Materials Applications

- Metallic Alloys
- Composites
- Sealants/Paints
- Ceramics

Enablers

- High rate processes
- Integrated materials modeling, fabrication processing and properties



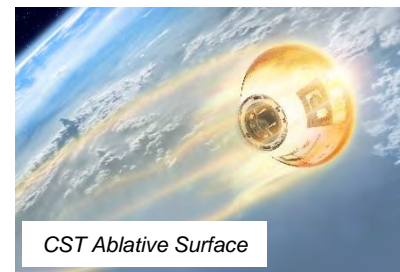
*Computational
Materials Models*



Reduced Part Count



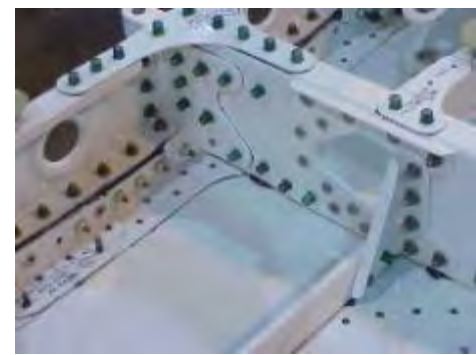
Robust Seal/Paint



*Materials for Extreme
Environments*

Product Performance & Production System Efficiency

Expanding capability for unitized machined components



Advanced modeling/machining technology critical – CMI helping

Automation Innovation

Top Business Outcomes

- Workplace Safety
- Product and Process Quality
- Flexibility / Factory Optimization
- Standardization / Replication

Top Automation Applications

- Drill/Fill
- Paint & Seal
- Composite Fabrication
- Material Movement

Enablers

- Networked Enabled Manufacturing
- In-Process Inspection
- TRL AND MRL



777 Fuselage Flex Tracks



737/787 Heatshield Line



787 Aft Robotic Drill/Fill

Innovative, Simple, Robust & Cost Effective

Additive Innovation

Top Business Outcomes

- Speed to Market
- Enhance Performance
- Cost Reduction Buy-to-Fly

Top Additive Applications

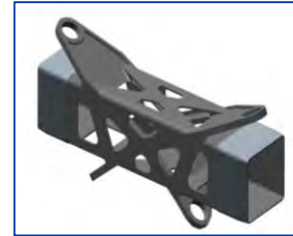
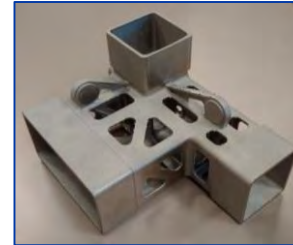
- Tools
- Interiors
- Structural Parts

Enablers

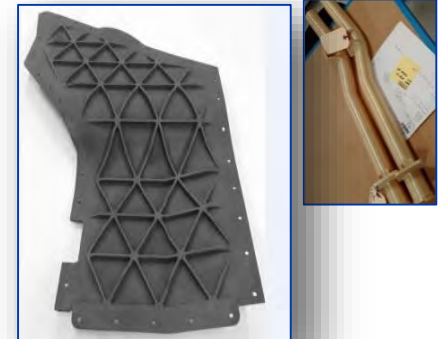
- Certification
- In-Process Inspection



Tooling



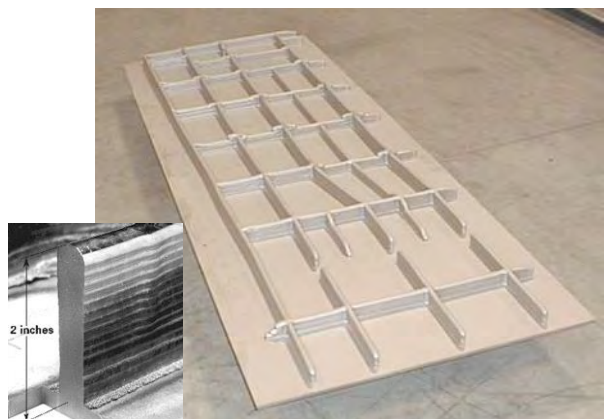
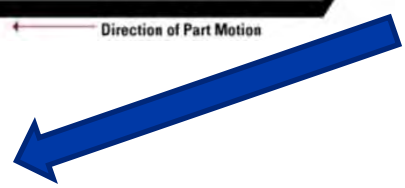
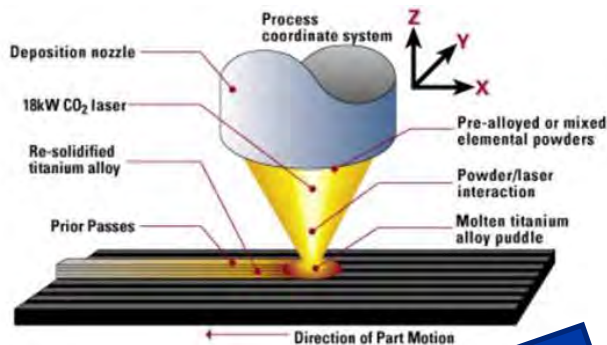
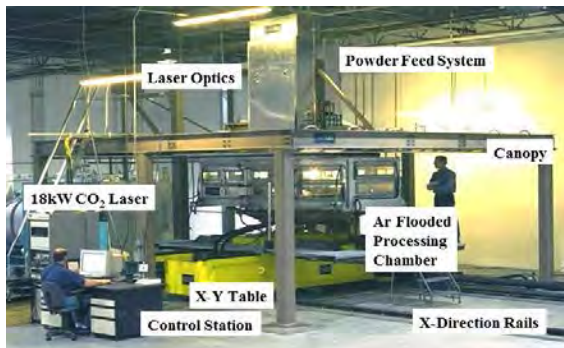
Metals



Polymers

Since 2002 more than 50,000 flyaway parts!

Titanium Additive/Subtractive Innovation



Complex to complex machining will continue to grow!

Manufacturing Analytics & Digital Threads

Top Business Outcomes

- Reduce Test & Evaluation / Rework 50%
- Affordable Manufacturing
- First Pass Quality
- Improved Factory Safety

Top Applications

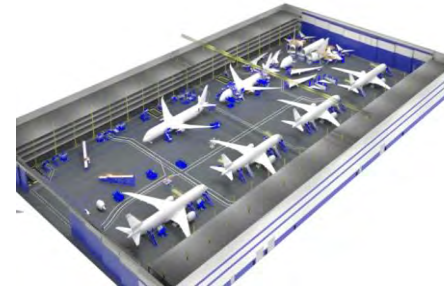
- Optimized Factory Flow
- Manufacturing Process Analytics
- Improved Automation Execution
- Robust Process & Material Specs

Enablers

- Analytics
- Advanced Modeling & Simulation
- Industry Standards
- Integrated Digital Factory

Production Simulation

Future Factory Concepts



Highest Impact Cells



On-Time Probability

Lateness - Plan		Lateness - Risk Analysis	
Value (Days)	Status	Expected (Days)	OnTime Probability
6.2060	Late	5.0774	21.22%
14.3339	Late	8.7516	21.22%
6.7277	Late	10.9023	21.22%
11.7132	Late	14.2971	21.22%

Integrated Digital Factory

The Complete Picture

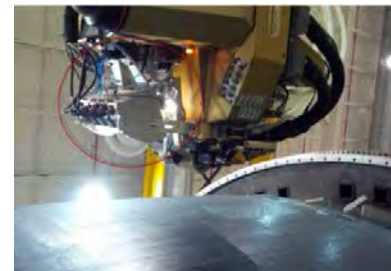
Real-Time Predictive Analytics



Process Automation



Computer Vision



Safety Analytics



Summary

- **Market challenges and industry realities are driving changes in the way the aerospace industry designs and builds products**
 - Cost
 - Speed to market
 - Performance
 - Environment
- **Advances in materials, automation, additive/subtractive manufacturing, and data analytics are leading the changes for the 2nd century of the aerospace industry**



BR&T Global Consortia

