A New Era Dawns
Outlook For The Aerospace Supply Chain
And Raw Materials

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Agenda

- Evolving Supply Chain Strategies
- Outlook For Aerospace Raw Materials
These Are The Best Of Times For Aircraft Manufacturing

Aerospace Production History And Forecast (in 2006 US$B)

Source: Teal Group

The Aeroengine Production Market Will Nearly Triple Over The Next Two Decades, Led By The Air Transport Sector

Aeroengine Production Forecast – All Markets: 2006 – 2026 ($B)

Sources: AeroStrategy, Teal Group, Forecast International
Notes: IGT = Generation, Mechanical Drive, Marine Power, and other
Assumes 70% of value for electrical generation units is for gas turbines
Figures in 2006 dollars
Total Gas Turbine Production Is Worth $26B In 2006; Aeroengines Are $16.7B (64%) Of This Total

2006 Global Gas Turbine Production Market

By Value:
2006 Total = $26.1B

By Units
2006 Total = 12,380

The Aerospace Supply Chain Faces Numerous Challenges Despite The Rosy Outlook
As A Result, OEMs Are Pursuing New Supply Chain Strategies

1. Supplier reduction
2. Greater dependence on Tier I
3. Low cost poles
4. Aerostructures outsourcing
5. Increased transparency

Supplier Reduction Is A Key Supply Chain Trend...

1. SUPPLIER REDUCTION

Embraer - Number of Suppliers
- EMB 145 (1999): 350 suppliers
- EMB 170/190 (2004): 38 suppliers

Rolls-Royce: Number of Suppliers
- RB211-524 (1977): 400 suppliers
- Trent 500 (2002): 250 suppliers
- Trent 900 (2004): 140 suppliers
- Trent 1000 (2008): 75 suppliers
- Next Generation Narrow Body: 25-35 suppliers

Sources: Embraer, Rolls-Royce
...Such That The Primary OEMs Are Becoming More Dependent On Tier I Suppliers

GREATER DEPENDENCE ON TIER I SUPPLIERS

Aircraft Production Supply Chain

Raw Material Suppliers → Tier 2 Suppliers → Tier 3 Suppliers → Tier 1 Suppliers → Aircraft And Engine OEM Final Assembly

Aircraft / Engine OEM Internal Production

Changing OEM supply chain strategies

- More focused on systems integration
- Less internal production capability
- Desire to work with a smaller number of Tier I primes
- Significantly reduce direct dealings with Tier 2 and Tier 3 suppliers

OEMs Are Also Shifting Work To Low Cost Poles...

LOW COST POLES

Low Cost Poles

- As a result of globalization, OEMs have a richer portfolio of supplier alternatives than in the 1990s

- OEMs are shifting labor intensive work to three key regions
  - East Asia
  - Eastern Europe
  - Latin America
...There Are Several Recent Examples Of Shifting Activity To Low Cost Poles

S76D Fuselage in Czech Republic

Major production facilities in Mexico

Production, R&D, & assembly in Poland

Fuselage production in Poland

Aerostructures Outsourcing Is Poised To Grow

AEROSTRUCTURES OUTSOURCING

Outsourcing Matrix

- Aerostructures work is increasingly viewed as non-core for aircraft OEMs
- OEMs are less competitive in aerostructures
  - High labor costs
  - Broad array of suppliers
- As a result, they are pursuing aerostructures outsourcing on new aircraft programs – particularly in the air transport and rotary wing segments
Business Aviation OEMs Have Different Aerostructures Approaches

Aerostructures Outsourcing

- Mostly in-house for fuselage
- Some wing, empennage outsourcing
- Moderate levels of outsourcing
- Fuselage, wings and empennage
- Mostly in-house (Shorts, DeHavilland)
- Global Express is the exception
- Mostly in-house
- Mostly in-house
- Significant outsourcing on 7X

Will the emergence of large, global aerostructures firms facilitate more outsourcing?

Supply Chain Transparency Is Rapidly Improving

INCREASED TRANSPARENCY

Aircraft Production Supply Chain

- The focus of most suppliers in the late 1990s and early 2000s was “lean” – often accompanied with ERP system implementations
- Now the focus is on supply chain productivity, particularly with the greater focus on outsourcing
- New systems and communications channels are creating significantly enhanced supply chain transparency
The Recent Airbus Power8 Restructuring Initiative Highlights Evolving OEM Supply Chain Strategies

The Power8 Initiative aims to improve financial returns, cycle times and overall efficiency.

Airbus plans to shift from seven, mostly national centers of excellence to four transnational centers of excellence by the end of 2007.

- "…reshaping and consolidation of our supply base, and the building of a network of strong Risk Sharing Partners to Tier 1 suppliers…"

- "We will turn Airbus into an extended enterprise. The A350 XWB will draw on this new business model, as we assign large work packages to Tier 1 suppliers …"

- "…about 50 per cent of aerostructure work will be outsourced to risk-sharing partners…” which can help address launch aid and political issues.

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Agenda

- Evolving Supply Chain Strategies
- Outlook For Aerospace Raw Materials
The Material Composition Of Air Transport Aircraft Is Changing Significantly...

Air Transport Aircraft Material Composition

% of structural weight

- Composites
- Titanium
- Steel
- Aluminum
- Other

737 747 A300 A320 A330 777 787 A350XWB

Most business and regional aircraft are < 10% composite

Exception: some VLJ models, Hawker Beechcraft

...Leading A Transition To Higher Composite Content Aircraft...

Composite Content

% of structural weight

...Business Aviation OEMs, With The Exception Of Hawker Beechcraft, Are Conservative Users Of Composites

<table>
<thead>
<tr>
<th>OEM</th>
<th>Usage/Adopt of Composites</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawker</td>
<td>HIGH</td>
<td>• Pioneered composite fuselage with ill-fated Beech Starship • Now producing composite fuselages for Premier and Hawker 4000 • Usage of composites for other components is relatively modest</td>
</tr>
<tr>
<td>Gulfstream</td>
<td>MEDIUM</td>
<td>• Most usage for larger aircraft - G300 and larger • Composites weight for G550 exceeds 1,700 lbs</td>
</tr>
<tr>
<td>Cessna</td>
<td>LOW</td>
<td>• Learjets and Challengers feature limited composites integration • Key composite components include radomes and interiors</td>
</tr>
<tr>
<td>Cessna</td>
<td>LOW-MEDIUM</td>
<td>• Generally conservative in integrating composite components into designs • Citation jets have less than 200 lbs of composites • Citation X has most composites by weight: approx. 1,200 lbs</td>
</tr>
<tr>
<td>Dassault</td>
<td>LOW</td>
<td>• Use of composites in secondary structures on the Phenom</td>
</tr>
<tr>
<td>Dassault</td>
<td>LOW-MEDIUM</td>
<td>• Older models have generally low composite content • Dassault 7X has an all-composite empennage</td>
</tr>
</tbody>
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Nickel, Titanium, And Steel Will Continue To Be Dominant Aeroengine Materials...

Typical Aeroengine Material Content

- Titanium, Nickel and Steel are the dominant materials in aeroengine designs
- Titanium aluminide and ceramic matrix composites are two materials technologies with near-term potential for aeroengine introduction
- Thermal and environmental coatings also continue to improve

Source: Merrill Lynch
...Although Composites Are Becoming More Prevalent In Aeroengine Designs

- Military aeroengine designs have historically pioneered integration of advanced composites
- In civil markets, GE has aggressively introduced composites in the GE90 and GEnx models – including fan blades and fan cases

World Titanium Demand Is Expected To Nearly Double Over The Next Decade

World Titanium Demand Forecast (Millions of Pounds)
2006 - 2015
In Response, Major Titanium Sponge Producers Are Planning Significant Capacity Expansion

Major Global Titanium Sponge Producers Capacity
Thousands Of Tons

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>2006 Capacity</th>
<th>2010 Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSMPO-AVISMA</td>
<td></td>
<td>32.0</td>
<td>44.0</td>
</tr>
<tr>
<td>Sumitomo Titanium</td>
<td></td>
<td>24.0</td>
<td>38.0</td>
</tr>
<tr>
<td>Ust-Kamenogorsk</td>
<td></td>
<td>23.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Toho Titanium</td>
<td></td>
<td>15.0</td>
<td>28.0</td>
</tr>
<tr>
<td>Zunyi Titanium</td>
<td></td>
<td>10.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Titanium Metals (Timet)</td>
<td></td>
<td>8.6</td>
<td>12.0</td>
</tr>
<tr>
<td>Zaporozhye</td>
<td></td>
<td>8.5</td>
<td>12.0</td>
</tr>
<tr>
<td>ATI Alivac (Allegheny)</td>
<td></td>
<td>3.4</td>
<td>20.0</td>
</tr>
</tbody>
</table>

- The largest sponge producers have announced capacity expansion of nearly 60%
- Only two of the top eight producers are based in the USA
- As recently as 2003, the consensus was that there would never again be a major expansion of U.S. sponge capacity...now two greenfield US facilities are planned

124.5 197.6 +58%

The Outlook For The Aerospace Aluminum Market Will Be Highly Influenced By Next Generation Material Choices

Aerospace Aluminum Plate Demand Forecast - Davenport & Company
(millions of lbs)

Davenport & Co. Conclusions
- Aluminum market characterized by boom-bust cycles
- Market appears very tight through 2011
- Cycle softness projected in 2012-2013 followed by rebound
- Next generation aircraft material choices critical for 2015-2025 Al market
  - Major shortage if next generation designs use high Al content
  - Market in modest surplus with high composite content

Source: Lloyd O'Carroll, Davenport & Company
Some Raw Materials Suppliers Are Changing Market Dynamics Through Vertical Integration Strategies

**VSMPO AVISMA**
- During the 1990s, Russia was the largest source of sponge shipments to the U.S.
- In the late 1990s, Russian ingot supplier VSMPO took over the Avisma sponge works...resulting in decreased Russian sponge availability to outside suppliers.
- VSMPO Avisma has since expanded its focus to higher value products including forgings and machined parts.
- In 2006, VSMPO and Boeing formed a joint-venture to produce titanium parts for the 787.

**Precision Castparts**
- In 2005, PCC acquired Special Metals Corporation (SMC), a world leader in the production of high-performance nickel-based alloys and super alloys.
- SMC provides an internal supply of nickel-based billet for its Forged Products operations, enabling it to manage its overall value stream more cost effectively from raw material to forged component.

Composite Raw Material Suppliers Are Also Vertically Integrated...And Consolidated

Commercial Aircraft OEM – Composite Supplier Relationships

**1980s**
- Boeing
- DASA
- Douglas
- BAE
- McDonnell
- Martin Marietta
- Lockheed
- General Dynamics
- American Cyanamid
- ICI Fiberite
- BASF
- Hercules
- DuPont
- BP
- Hexcel
- Cytec
- Hercules
- BASF
- Amaco
- Toho
- Toray
- Akao

**TODAY**
- Boeing
- Airbus
- Cytec
- Hexcel
- Toray
- Toho

**Materials (prepreg)**
- Fiber

Sources: VSMPO Avisma and PCC

Note: Tier 1 and Tier 2 suppliers not depicted.
Key Messages

- The aerospace supply chain faces numerous challenges despite a strong production outlook
- As a result, OEMs are pursuing several significant supply chain initiatives
  - Supplier reduction
  - More dependence on Tier I integrators
  - Low cost poles
  - Aerostructures outsourcing
  - Increased transparency
- The volume and mix of raw materials will change considerably as a result of new generation aircraft designs

Thanks For Your Attention!

- AeroStrategy is a premier management consulting firm devoted to aviation and aerospace sectors with offices in Ann Arbor and Amersham, U.K.
- White papers highlighting trends in the aerospace supply chain and the aerospace composites market can be downloaded at http://www.aerostrategy.com/commentary.cgi
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