Aerospace Titanium In The More For Less Era

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AeroDynamic Advisory
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Agenda

The More For Less Era

Supplier Implications

Important Events Since 2015
The air transport production outlook is strong for single aisles

Air Transport Production Forecast

Air Transport Backlogs (years)

Sources: AeroDynamic Research, Boeing, Airbus, Bombardier, Embraer
Aircraft OEMs are focused on increased profitability; Boeing is targeting mid-teens margins

**EBITS: OEMs and Suppliers**

- **System and Aeroengine Suppliers**
  - 20.00%
  - 15.00%
  - 10.00%
  - 5.00%
  - 0.00%

- **Boeing Commercial**
  - 2010: 5.00%
  - 2011: 5.00%
  - 2012: 10.00%
  - 2013: 15.00%
  - 2014: 20.00%
  - 2015: 20.00%

- **Airbus Commercial**
  - 2010: 0.00%
  - 2011: 5.00%
  - 2012: 10.00%
  - 2013: 15.00%
  - 2014: 20.00%
  - 2015: 20.00%

**Boeing Commercial Airplane Group – Margin Goals**

**Increased Focus on Margin Expansion**
Consolidated Segment Margins

- **2013-2015**
  - 10.0%

- **Near-term focus**
  - Double Digit

- **Aspirational Goal**
  - Mid Teens

**Key Drivers / Areas of Focus**
- Delivering on backlog
- Supply chain efficiencies
- Development transition/efficiency
- First-time production quality
- Internal cost optimization
- Market conditions
- Competitive landscape

Sources: Airbus, Boeing, AeroDynamic estimates, May 2016 Boeing Investor Conference
Airbus and Boeing are very dependent on single aisles for profits

- Single aisles drive the vast majority of profits for Airbus and Boeing – thus the strong motivation for increasing production rates.
- The A330 and 777 are also critical profit generators.
- Services and parts are also important – but not to the same extent as for aeroengine and system OEMs.

* Assumes no profits for A380 or 787

Source: AeroDynamic analysis
Note: Assumes no profits for 787 and A380
Increased 737 profits will be partially offset by the 777X transition

Estimated Commercial Airplane Profits*

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* Assumes no profits for 787

+ 170 units = ~ $2.5 B profit

(50) units = ~ ($1.3 B) profit

Sources: Cannacord Genuity (production forecast); AeroDynamic - profits
Aircraft OEMs have several initiatives to improve profitability

OEM Initiatives To Increase Profitability

- Large revenue targets
- New services
- Automation
- Lean / six sigma

- Partnering For Success
- SCOPE +
- Best cost countries
- Internal competition
- Labor agreements

Source: AeroDynamic
OEMs are using a variety of tactics for aerostructures & materials

### Supplier Initiatives – Aerostructures & Materials

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<th>Initiative</th>
<th>Activity</th>
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| New commercial terms              | • *Unilateral price reductions and revised payment terms*  

- “No fly” lists for suppliers that don’t participate |
| Part redesigns                     | • Value engineering  

- Material substitution |
| New processes                    | • Shift to lower cost process  

- Leverage new processes |
| Selective vertical integration   | • Expand role in profitable product segments  

- Assume system integration role  

- Gain access to lucrative aftermarket revenue |
| Aggregation & Dual Sourcing       | • Aggregate fragmented segments (e.g. fasteners, interior parts)  

- Shift to dual sourcing |
| Capture revert                   | • Where possible, capture revert from suppliers  

- Work with supply chain integrators to close loop on material |

Source: AeroDynamic
The bottom line: expect more automotive-style operations and supply chain practices

The last decade was about innovation; the next will be about productivity
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The More For Less Era

Supplier Implications

Important Events Since 2015
The impact will be felt different ways through the supply chain

Aerospace Supply Chain

Typical # suppliers per program

- **30 - 60**
  - Tier 1
    - Systems Integration
  - Tier 2
    - Sub-assembly manufacture
  - Tier 3
    - Make-to-print components
  - Tier 4
    - Materials & Processes

- **100s**
  - Principal components

- **1,000s**
  - Sub-components

- **20 - 50**
  - Mill product, casting, forging, other

Source: AeroDynamic
Tier 1 suppliers will continue to consolidate as they face profitability headwinds

- Tier 1s are the primary targets of OEM supply chain initiatives

- Tier 1 challenges
  - OEM pricing pressure
  - Shifting aftermarket
  - Selective customer vertical integration
  - Short-termism

- Tier 1 outlook
  - Continued consolidation around systems/technologies
  - Focus on operations, supply chain and aftermarket strategic functions
  - Some Tier 1s may de-emphasize or leave air transport

Source: AeroDynamic
Tier 2 suppliers face a squeeze from consolidating Tier 1s & Tier 4s

- Many Tier 2s suppliers are being squeezed by consolidating Tier 1 and Tier 4 suppliers

- Tier 2 Challenges
  - Tier 1 and OEM vertical integration and sharper supply chain practices
  - Greater Tier 4 bargaining leverage as they consolidate
  - Defining “winning business model” & achieving competitive differentiation

- Outlook
  - Ongoing consolidation
  - Suppliers without design or process IP will be vulnerable

Source: AeroDynamic
There are far too many Tier 3 suppliers; attrition is a certainty

- There are thousands of “make to print” Tier 3 suppliers
- Private equity and strategic suppliers have consolidated many Tier 3s
- Tier 3 challenges
  - Tier 4 consolidation and vertical integration
  - Suppliers in “best cost” countries
  - Selecting “winning business models”
- Tier 3 outlook
  - Continued attrition and/or consolidation
  - Churning of ownership as private equity begins to exit
The consolidation of Tier 4 suppliers is nearly complete

Aerospace Supply Chain

- Tier 4 suppliers consolidated and vertically integrated over the last decade
- Challenges
  - Cost reduction – near net shape, lower cost materials, new processes
  - Additive manufacturing gaining traction
- Outlook
  - Consolidation is nearly complete
  - Growth in powder metallurgy
  - Will Tier 4s divest some downstream assets during next downturn?
2015 Aerospace raw material demand is 1.56 B pounds; titanium demand is 177 M pounds

2015 Aerospace Raw Material Buy Weight

- Aluminum Alloys: 47%
- Steel Alloys: 21%
- Super Alloys: 11%
- Composites: 10%
- Other: 6%
- Composites: 10%
- Engine: 14%
- MRO/Aftermarket: 6%
- Airframe: 79%

Aggregate “buy to fly” ratio is ~6
Aerospace titanium demand will grow at a 4% CAGR through 2020

2015 – 2020 Aerospace Raw Material Buy Weight

- Overall, raw material demand growth will be lower than aircraft unit growth
  - due to lower buy-to-fly ratios and
  - greater use of composites
- Composites (5.8%) and titanium (4.0%) will grow the fastest
- Aluminium demand will decrease slightly

Source: ICF International
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Supplier Implications

Important Events Since 2015

AeroDynamic
Boeing opened its composite wing center in Everett

777X Composite Wing Center

- $1 billion investment by Boeing in the 777X composite wing center
- Includes three autoclaves large enough to hold two 737 fuselages
- The upshot: Boeing is insourcing wing manufacturing after outsourcing for 787

Source: Boeing
Bombardier delivered the technology-rich CSeries to Swiss

The CSeries is loaded with new materials technology

It features the industry’s first Aluminium-Lithium fuselage

It is making its wings by a Resin Transfer Infusion process
- Upper and lower wing skins with embedded stringers are fabricated as single pieces
- Made in Bombardier’s Belfast facility

The upshot: significant material advances for single aisles; is this the future?
Norsk Titanium broke ground on two major additive manufacturing facilities…

- Norsk focuses on aerospace-grade, additive manufactured, structural titanium components
- Its New York investment will be the world’s first Rapid Plasma Deposition™ factory; it will open in 2017
- It also broke ground on a new European assembly & test center
- The upshot: additive manufacturing is being capitalized
...and earlier this month GE doubled down an additive manufacturing in purchasing two leading European suppliers

**Arcam AB**
- Based in Mölndal, Sweden
- Invented electron beam melting machining for metal-based additive manufacturing
- $68 million in revenue with 285 employees

**SLM Solutions Group**
- Based in Lübeck, Germany,
- Produces laser machines for metal-based additive manufacturing
- $74 million in revenue with 260 employees

Source: Arcam, SLM, GE Aviation
THANK YOU!