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Aerospace Production & Supply Chain Outlook

October 5, 2015 – Orlando, FL
Today’s Agenda:

- Aerospace Demand Outlook
- Key Supply Chain Trends
- Conclusions
Today’s Agenda

- Aerospace Demand Outlook
- Key Supply Chain Trends
- Conclusions
AEROSPACE DEMAND OUTLOOK

Total aircraft production in 2014 is 4,976 units; air transport aircraft account for 61% of value

2014 Aircraft Production by Market

By Units
- Air Transport: 33%
- Civil Rotary Wing: 21%
- Military Fixed Wing: 9%
- Military Rotary Wing: 15%
- Business Aviation: 22%

By Value
- Air Transport: 61%
- Military Fixed Wing: 11%
- Civil Rotary Wing: 11%
- Business Aviation: 13%
- Military Fixed Wing: 9%

Source: ICF analysis
AEROSPACE DEMAND OUTLOOK

Annual production value is expected to reach more than $200B, with unit production eclipsing 6,000 aircraft by 2024

Aircraft Production 2014-2024
By Market Segment

# Aircraft

<table>
<thead>
<tr>
<th>Year</th>
<th>Military Fixed Wing</th>
<th>Military Rotary Wing</th>
<th>Civil Rotary Wing</th>
<th>Business Aviation</th>
<th>Air Transport</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>3,500</td>
<td>1,500</td>
<td>1,000</td>
<td>2,000</td>
<td>2,000</td>
<td>8,000</td>
</tr>
<tr>
<td>2019</td>
<td>4,000</td>
<td>1,800</td>
<td>1,200</td>
<td>2,200</td>
<td>2,200</td>
<td>9,400</td>
</tr>
<tr>
<td>2024</td>
<td>4,500</td>
<td>2,000</td>
<td>1,400</td>
<td>2,400</td>
<td>2,400</td>
<td>10,300</td>
</tr>
</tbody>
</table>

$B USD*

<table>
<thead>
<tr>
<th>Year</th>
<th>Military Fixed Wing</th>
<th>Military Rotary Wing</th>
<th>Civil Rotary Wing</th>
<th>Business Aviation</th>
<th>Air Transport</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>$100</td>
<td>$150</td>
<td>$100</td>
<td>$80</td>
<td>$150</td>
<td>$460</td>
</tr>
<tr>
<td>2019</td>
<td>$120</td>
<td>$180</td>
<td>$120</td>
<td>$88</td>
<td>$180</td>
<td>$578</td>
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<tr>
<td>2024</td>
<td>$140</td>
<td>$200</td>
<td>$140</td>
<td>$96</td>
<td>$200</td>
<td>$662</td>
</tr>
</tbody>
</table>

Source: ICF analysis

* Constant 2014 US$
Overall raw material demand has increased slightly with the latest update to ICF’s production forecast.

### Changes in Production Rates & Raw Material Demand

**V.S. Previous Year’s Forecast**

<table>
<thead>
<tr>
<th>Platform</th>
<th>2015-2023 Net Production Rate Δ (vs Previous Forecast)</th>
<th>2015-2023 Net Material Demand lbs Δ (vs Previous Forecast)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A330neo</td>
<td>+100</td>
<td>+61M</td>
<td>• A330neo launched in July 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Changed forecast as more information about rates emerged</td>
</tr>
<tr>
<td>A330</td>
<td>-64</td>
<td>-39M</td>
<td>• As A330neo plans firmed up, A330ceo rate cut was announced</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• New rates expected to remain firm until A330neo EIS</td>
</tr>
<tr>
<td>737NG/MAX</td>
<td>+312</td>
<td>+44M</td>
<td>• 737NG sales have continued, and further detail on MAX ramp-up announced</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Some technical risk remains for 737MAX on-time EIS</td>
</tr>
<tr>
<td>777</td>
<td>-40</td>
<td>-27M</td>
<td>• With 777X EIS in 2019/2020, Boeing has had trouble filling in the 777-300ER backlog</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• A production rate cut is expected later in the decade</td>
</tr>
<tr>
<td>E170/190 / E2</td>
<td>-135</td>
<td>-17M</td>
<td>• Lowered estimates compared to previous forecast</td>
</tr>
<tr>
<td>A380</td>
<td>-12</td>
<td>-13M</td>
<td>• Uncertainty over potential updates to A380 and several prominent customer cancellations and deferrals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• A decision on the launch of the A380neo is expected to be made within a year</td>
</tr>
<tr>
<td>Air Transport Total (Net)</td>
<td>+256</td>
<td>+8.3M</td>
<td></td>
</tr>
</tbody>
</table>

Source: ICF analysis
Aggregate aerospace raw material demand is 1.56B pounds

2015 Aircraft Raw Material Demand
By Material Type (buy weight)

- **Aluminum Alloys**: 47%
- **Steel Alloys**: 21%
- **Titanium Alloys**: 11%
- **Super Alloys**: 10%
- **Composites**: 5%
- **Other**: 6%

Total 1.56 B lbs

**ICF Insight**

- Aluminum alloys are nearly half of all total demand
- Steel alloys & titanium are large driver of demand due to their high buy to fly ratios
- Titanium is 11% of demand
- Composites are relatively small part of total demand at just 5% due to their light weight and relatively low buy to fly ratio

Source: ICF analysis
Boeing and Airbus aircraft account for nearly two-thirds of raw material demand

2015 Aircraft Raw Material Demand
By OEM (buy weight)

- **Boeing** 35%
- **Airbus** 30%
- **Bombardier** 5%
- **GE** 4%
- **CFM International** 4%
- **Rolls Royce** 4%
- **Pratt & Whitney** 2%
- **Embraer** 2%
- **Other** 14%

**Total 1.56 B lbs**

ICF Insight

- Boeing and Airbus aircraft models comprise 65% of demand
- With CSeries ramp up beginning in 2016, Bombardier is the next largest material consumer

Source: ICF Analysis
The total aerospace raw material market is worth over $12 billion

2014 Aircraft Raw Material Value
By Material Type

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Value ($Bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium Alloys</td>
<td>3.4</td>
</tr>
<tr>
<td>Aluminum Alloys</td>
<td>3.1</td>
</tr>
<tr>
<td>Composites</td>
<td>2.6</td>
</tr>
<tr>
<td>Super Alloys</td>
<td>1.9</td>
</tr>
<tr>
<td>Steel Alloys</td>
<td>1.1</td>
</tr>
<tr>
<td>Other</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$12.4B</strong></td>
</tr>
</tbody>
</table>

Source: ICF analysis

ICF Insight

- Titanium is the largest material market by value ($3.4B)
- With 787 production ramping up, and A350 long-lead items under production, composites are the third largest category at $2.6B
- The value of superalloys is $1.9B, driven by aero-engine production
Over the next decade aluminum demand will remain solid while composites & titanium will grow the fastest

2014 – 2019 Aerospace Raw Material Demand
By Material (buy weight)

<table>
<thead>
<tr>
<th>Material</th>
<th>Million Lbs 2014</th>
<th>Million Lbs 2019</th>
<th>Type, CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Materials</td>
<td>1,600</td>
<td>1,600</td>
<td>1.0%</td>
</tr>
<tr>
<td>Composites</td>
<td>1,400</td>
<td>1,700</td>
<td>6.2%</td>
</tr>
<tr>
<td>Super Alloys</td>
<td>1,200</td>
<td>1,300</td>
<td>2.0%</td>
</tr>
<tr>
<td>Titanium Alloys</td>
<td>1,000</td>
<td>1,100</td>
<td>3.4%</td>
</tr>
<tr>
<td>Steel Alloys</td>
<td>800</td>
<td>800</td>
<td>0.9%</td>
</tr>
<tr>
<td>Aluminum Alloys</td>
<td>600</td>
<td>700</td>
<td>(0.5%)</td>
</tr>
</tbody>
</table>

Total CAGR: 0.9%

ICF Insight

- 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 and titanium will be the fastest growing material categories
- Aluminum demand will decrease slightly, but will still represent over 40% of total demand in 2024

Source: ICF analysis
Today’s Agenda

- Aerospace Demand Outlook
- **Key Supply Chain Trends**
- Conclusions
Alcoa’s recent acquisition spree has continued the cycle of Tier 4 consolidation and vertical integration

**Firth Rixson (June 2014)**
- $1.0B in 2013 revenue; based in Sheffield, UK
- Leader in forged rolled rings, closed die forging, isothermal forging
- Primarily nickel and titanium
- Expanded Alcoa content on next generation engine platforms

**Tital (Dec 2014)**
- $96M in 2013 revenue
- Based in Germany
- Leader in airframe and engine castings
- More than half of revenues from Titanium castings
- Leader in casting design

**RTI International (July 2015)**
- Nearly $800M in 2014 revenue; based in US
- Fourth largest aerospace titanium supplier
- Capabilities in machining, additive manufacturing, extrusions, open die forging, newly expanded forging capability

**Implications**
- Increases aerospace revenue from $4.0B in 2013 to $5.6B pro forma revenue in 2014
- Adds capabilities in titanium raw material, powder metal, castings, additive manufacturing, forged rings, and finished parts
- Expands content on next generation engine and aircraft platforms

Sources: Secondary research, Alcoa
SUPPLY CHAIN TRENDS – IMPORTANT EVENTS SINCE 2014

Berkshire Hathaway’s $32B purchase of PCC is a vote of confidence in the strength of the aerospace backlog

**PROS**

- Relentless focus on productivity
- Highly profitable
- High entry barriers
- High revenue certainty
- Good timing – bought PCC stock on dip

**CONS**

- Who will succeed Mark Donegan?
- Supply chain strategies to counter PCC strength
- Focus on metallic parts limits growth potential
- Impact of disruptive technologies

- Berkshire Hathaway’s largest-ever investment
- Values PCC at $32.3B, 12X trailing EBITDA
- Deal announced August, 2015

**Our take**

- A good deal for Berkshire Hathaway shareholders assuming PCC grooms a CEO successor and prepares for disruptive technologies
- Will PCC’s focus shift from relentless growth through acquisition to cash generation?
Cost reduction will be important as aircraft OEMs target double-digit profitability

- Major aircraft OEMs are driving for double-digit profitability
- One initiative is to secure concessions from suppliers to ensure access to future programs
- OEMs are also expanding their influence and role in the aftermarket
- The implication is downward margin pressure on suppliers

“All of us have got religion. Every 25 years a big moonshot … and then produce a 707 or 787 – that’s the wrong way to pursue this business. The more-for-less world will not let you pursue moonshots.”

– Jim McNerney, Boeing CEO, Boeing Annual Investor Conference, May 2014

Figures are EBIT (Airbus) and Operating Profit (Boeing)
Source: Airbus, Boeing.
Aircraft development activity has been at an elevated level since 2010 – that pace will begin to decline in 2-3 years.

**Air Transport & BGA New Programs – Entries into Service 2015-2024**

- **Large WB**
  - 747-8
  - 787
  - A350 XWB
  - Superjet 100
- **RJ**
  - CRJ-1000
  - ARJ21
- **2010**
- **2015**
  - A320neo
  - A330neo
  - 737 MAX
  - CSeries
  - C919
  - MRJ
  - MS-21
- **2020**
  - A380neo*
  - 777X
  - E2
- **2025**

Source: ICF International
Aerospace suppliers need to prepare for the new reality

Deliver
- High service level = customer’s life made easier
- High service level -> win the right to bid on more work
- Improvements that increase factory throughput and reduce schedule variability frequently also have cost and yield benefits

De-Cost
- Get ahead of the curve
- Better positioned to address customer challenges
- Earn returns and make critical investments

Defend
- Identify and retain key engineering resources and technologies
- Retain aftermarket revenue streams

Source: ICF International
While the macro environment will change, the micro environment will continue to thrive – and be transformed.
This “revolution from below” presents both opportunities and threats to aerospace suppliers

<table>
<thead>
<tr>
<th>New Materials</th>
<th>Outlook</th>
<th>Implications for Supply Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing adoption of thermoplastic composites, titanium aluminide, and ceramic matrix composites</td>
<td>Part requalification presents opportunities to win new business …</td>
<td></td>
</tr>
<tr>
<td>… but fewer new programs means fewer new materials insertion opportunities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additive Manufacturing</th>
<th>Outlook</th>
<th>Implications for Supply Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faster laydown rates</td>
<td>Those not investing now will be 5+ years behind when early adopters are certifying parts</td>
<td></td>
</tr>
<tr>
<td>Better finished part mechanical properties</td>
<td>Lower mill volumes … but more expensive material forms</td>
<td></td>
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<tr>
<td>Certificated parts despite current challenges</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Automation</th>
<th>Outlook</th>
<th>Implications for Supply Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased manufacturing automation</td>
<td>Change in cost structure to higher fixed / lower variable cost</td>
<td></td>
</tr>
<tr>
<td>Continued assembly automation</td>
<td>Compatibility with assembly equipment can be a differentiator</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Faster Processing</th>
<th>Outlook</th>
<th>Implications for Supply Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing hard metal machining speeds</td>
<td>Increased investments in tools and equipment (i.e., more capital intensive)</td>
<td></td>
</tr>
</tbody>
</table>

Source: ICF International
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CONCLUSIONS

Aerospace Production & Supply Chain Outlook

- Aircraft production value will grow at 2.4% over the next ten years
- Titanium is expected to grow at 3.4% CAGR

- At the macro level, the market is shifting from technology for performance toward cost-out
  - Deliver, De-Cost, Defend

- At the micro level, the materials and process revolution will continue
Thank you!

For questions regarding this presentation, please contact:

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Peter.zimm@icfi.com
Through 2024, Boeing will increase production on a number of platforms, while also managing the transition to new programs.

*Boeing Air Transport Production Market 2011-2024*

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>B737NG</td>
<td>369</td>
<td>411</td>
<td>440</td>
<td>485</td>
<td>504</td>
<td>504</td>
<td>382</td>
<td>202</td>
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<td>0</td>
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<td>B737 MAX</td>
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<td>624</td>
<td>624</td>
<td>624</td>
<td>552</td>
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<tr>
<td>Narrowbody Total</td>
<td>369</td>
<td>411</td>
<td>440</td>
<td>485</td>
<td>504</td>
<td>504</td>
<td>564</td>
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<td>B777</td>
<td>73</td>
<td>83</td>
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<td>Widebody Total</td>
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<tr>
<td>TOTAL</td>
<td>474</td>
<td>597</td>
<td>648</td>
<td>723</td>
<td>753</td>
<td>751</td>
<td>809</td>
<td>846</td>
<td>836</td>
<td>838</td>
<td>862</td>
<td>896</td>
<td>830</td>
<td>830</td>
</tr>
</tbody>
</table>

Source: ICF Research & Analysis
Similarly, Airbus is also managing transitions to new engine programs, while also ramping up the A350XWB platform.

**Airbus Air Transport Production Market 2011-2024**

<table>
<thead>
<tr>
<th># Aircraft</th>
<th>Actuals</th>
<th>ICF projection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platform</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A320</td>
<td>421</td>
<td>447</td>
</tr>
<tr>
<td>A320 NEO</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Narrowbody Total</strong></td>
<td>421</td>
<td>447</td>
</tr>
<tr>
<td>A330</td>
<td>87</td>
<td>103</td>
</tr>
<tr>
<td>A330neo</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A350XWB</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A380</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td><strong>Widebody Total</strong></td>
<td>113</td>
<td>133</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>534</td>
<td>580</td>
</tr>
</tbody>
</table>

Source: ICF Research & Analysis
ICF AVIATION OVERVIEW

ICF is one of the world’s largest and most experienced aviation and aerospace consulting firms

- 52 years in business (founded 1963)
- 80+ professional staff
  - Dedicated exclusively to aviation and aerospace
  - Blend of consulting professionals and experienced aviation executives
- Specialized, focused expertise and proprietary knowledge
- Broad functional capabilities
- More than 10,000 private sector and public sector assignments
- Backed by parent ICF International (2014 revenue: 1.05 billion USD)
- Global presence — offices around the world

New York • Boston • Ann Arbor • London • Singapore • Beijing
ICF’s functional practices cover the breadth of aviation, offering our airline clients comprehensive insight into industry issues.

**Airlines**
Operational, strategic and transaction support to airlines and air transport businesses

**Aerospace & MRO**
Strategy, marketing, transaction support and Operations & Supply Chain services for manufacturers, MROs and investors

**Aircraft**
Industry-focused financial and technical support for aviation equipment transaction activities

**Airports**
Operational, strategic and transaction support to regulators, owners, operators, and developers

*ICF provides aircraft operators, manufacturers, financiers, lessors, and owners, maintainers, airports, and related businesses with world-class advisory, implementation, and improvement management consulting services.*