Aerospace Supply Chain & Raw Material Outlook

Presented by:

Peter C. Zimm
Principal
Agenda

- Aerospace Demand Outlook
- Aerospace Supply Chain Trends
Total aircraft production in 2014 is 4,972 units; air transport aircraft account for 62% of value

2014 Aircraft Production
By Market

By Units
4,972

By Value
$171B

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

*Source: ICF analysis*  
* Constant 2014 US$

Aircraft Production 2014-2024
By Market Segment

Type, CAGR

<table>
<thead>
<tr>
<th>Year</th>
<th>Civil RW</th>
<th>Military RW</th>
<th>BGA</th>
<th>Air Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1,250</td>
<td>90</td>
<td>255</td>
<td>2,750</td>
</tr>
<tr>
<td>2019</td>
<td>1,290</td>
<td>95</td>
<td>260</td>
<td>2,800</td>
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<tr>
<td>2024</td>
<td>1,330</td>
<td>84</td>
<td>265</td>
<td>2,860</td>
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Total CAGR = 2.2%

$B USD*

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<tr>
<td>2014</td>
<td>250</td>
<td>20</td>
<td>25</td>
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</tr>
<tr>
<td>2019</td>
<td>260</td>
<td>21</td>
<td>26</td>
<td>260</td>
</tr>
<tr>
<td>2024</td>
<td>270</td>
<td>23</td>
<td>27</td>
<td>270</td>
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Total CAGR = 2.3%
Aggregate aerospace raw material demand is 1.55B pounds

- Aluminum alloys are nearly half of all total demand
- Steel alloys & titanium also are large driver of demand due to their high buy to fly ratios
- Composites are relatively small part of total demand at just 4% due to their lightness of weight and their relatively low buy to fly ratio

Aggregate “Buy to fly” ratio is ~ 6

Source: ICF analysis
Boeing and Airbus aircraft account for nearly 70% of raw material demand

2014 Aircraft Raw Material Demand
By OEM (buy weight)

- Boeing and Airbus aircraft models comprise 67% of demand
- GE is the next largest consumer – 7% when including its share of CFM

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

- Aluminum and titanium are the largest material markets by value – both are worth just over $3B
- With 787 production ramping up, and A350 long-lead items under production, composites are the third largest category at $2.3B
- The value of superalloys is $1.8B, driven by aero-engine production

Source: ICF analysis
AEROSPACE DEMAND OUTLOOK

Over the next decade, composites and titanium will grow significantly while aluminum demand will remain solid

2014–2023 Aerospace Raw Material Demand
By 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 and titanium will be the fastest growing material categories
- Aluminum demand will be relatively flat

Source: ICF analysis
Agenda

- Aerospace Demand Outlook
- Aerospace Supply Chain Trends
There are several important aerospace trends that are shaping aerospace supply chains:

- **Additive Manufacturing**
- **“Right Shoring”**
- **OEM Vertical Integration**
- **Supply Chain Transparency & Control**
- **Advanced Aeroengines**
- **OEMs Push For Cost Reduction**

Source: ICF
### SUPPLY CHAIN TRENDS – COST REDUCTION

#### OEMs are utilizing a variety of cost reduction initiatives...

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>New commercial terms</td>
<td>• Unilateral price reductions and revised terms&lt;br&gt;• “No fly” lists for suppliers that don’t participate</td>
</tr>
<tr>
<td>Part redesigns</td>
<td>• Value engineering&lt;br&gt;• Material substitution</td>
</tr>
<tr>
<td>New processes</td>
<td>• Shift to lower cost process&lt;br&gt;• Leverage new processes</td>
</tr>
<tr>
<td>Capture revert</td>
<td>• Where possible, capture revert from suppliers&lt;br&gt;• Work with supply chain integrators to close loop on material</td>
</tr>
</tbody>
</table>

Source: ICF analysis
SUPPLY CHAIN TRENDS – COST REDUCTION

…and 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

Source: ICF analysis, Wall Street Journal
The push to deploy advanced technology underpins recent re-engining decisions – more are likely

“G2” E-jet

- In January 2013 Embraer selected Pratt’s GTF for its “G2” E-Jets
- Boeing announced the B777-X with GE9X aeroengines in November 2013
- Airbus announced the A330neo with the Trent 7000 at Farnborough 2014 for 2018EIS
- A future re-engining possibility includes the A380

“Every 25 years a big moonshot …— that’s the wrong way to pursue this business. The more-for-less world will not let you pursue moonshots.”

Jim McNerny – CEO, Boeing

Photo credits: Embraer, Boeing, Airbus
...however aeroengine material trends are encroaching on titanium’s “sweet spot” in aeroengines

CFM LEAP-X

Winning Materials

- Composites
- Powder Metals
- Advanced super alloys
- Titanium Aluminide

Composite fan and fan cases increasingly popular

Titanium’s “sweet spot” in aeroengines

Nickel alloy moving forward in the High Pressure Compressor module

Source: CFM, ICF analysis
Supply chain transparency and control is growing in importance

- Customers (driven by OEMs) demanding increased visibility into supply chain
- This contributes to the use of latest technology (physical control centers and software) for 'early alerts'
- There is also growing use of data analytics
- Sub-tier suppliers are being asked to provide utilization and ramp-up plans
Additive manufacturing represents a potential step-change in cost and part design capability

- Additive manufacturing (AM) “builds up” parts with material deposition, rather than removing material through machining
- There are many types of additive manufacturing processes and little industry standardization

Sources: ICF analysis
Several OEMs are trialing additive manufacturing on a range of production and aftermarket parts

**Examples of Additive Manufacturing Adoption**

- **GKN** is using AM on aerostructures for Falcon 5X
  - Driver is cost reduction

- **Boeing** is currently using AM for polymer ducting on F-18 & 787
  - Part consolidation & cost driver

- **GE** using AM for Leap-X fuel nozzles in Parker Aerospace JV
  - Performance is main driver of adoption

Source: ICF analysis, GKN, GE Aviation, Airbus, Boeing
In addition to adoption on certain parts, OEMs and suppliers are announcing substantial investments in AM

**RTI Acquires Directed Manufacturing**
- RTI acquired Direct Manufacturing for $23M to enhance production capabilities in medical devices and aerospace
- Makes full rate production parts for UAVs

**GE Expands Auburn AL**
- GE will expand Auburn facility starting in late 2014
- 10 machines in 2015 with capability for 50
- Will handle full rate production of all AM parts, including Leap fuel nozzles

**Carpenter Powder Facility in Athens, AL**
- Facility will be located adjacent to current mill facility in Athens
- Will produce superalloy powders for isothermal forging and additive manufacturing

Source: RTI, GE, Carpenter Technology, ICF analysis
A long term trend to watch is the penetration of additive manufacturing and its impact on buy-to-fly ratios

*Ti Wing Beam Concept*  
*(China Northwest Polytechnical Univ.)*

- The industry aggregate buy-to-fly ratio based on subtractive manufacturing is ~6:1; for some parts it is >15:1
- In contrast, the buy to fly ratio for additive manufacturing is very low
- Early application of AM will be in unmanned systems, experimental aircraft, space, and military sustainment
- In the long term, AM will impact mainstream aerospace production and raw material demand

Sources: RapidReady, China Northwest Polytechnical University
A Wildcard to watch: political crises with Russia and Ukraine could drastically impact aerospace supply chains

2014 Aerospace Titanium Market

- Over 30% of aerospace titanium is supplied by VSMPO
- Ukraine is a key supplier of nearly all titanium concentrates to VSMPO
- Some OEMs are stockpiling titanium as a contingency

Source: ICF analysis, Wall Street Journal
Thanks and Questions

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