Aerospace Industry Trends

Implications For Titanium Suppliers

Presented by:
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Agenda

- Aerospace Industry Dynamics & Raw Material Demand
- Aerospace Supply Chain Trends
ICF SH&E projects 3.9% air travel growth over the next decade

### 2012 - 2022 Air Travel Demand Growth

**Annual RPM Growth**

- **Global Average Growth**: 3.9%
- **% global RPMs**: Africa 3.0%, Asia Pacific 29.5%, Europe 26.8%, Middle East 7.5%, N. America 27.9%, S. America 5.4%

- **Asia-Pacific**, now the largest market, grows >6% led by China
- **Solid growth in Africa, Middle East, and S America**, which comprise 16% of global market
- **Slow growth in Europe and North America**, which are 55% of global demand

Source: ICF SH&E analysis
Slow growth in N. America is a result of market maturity

**U.S. Enplanements Per Capita**

- US trips for capita peaked at 2.5 last decade and have since declined
- The US market, 35 years after deregulation, is mature with air travel comprising a shrinking share of the economy
- Europe will also be shaped by maturity, coupled with slow economic growth

Source: FAA

Source: ICF SH&E analysis
However, several other factors will drive a positive production outlook

**Factors Shaping Aircraft Production Rates**

**Positive**
- Decreasing A/C economic lives
- Escalating retirements
- Low cost of capital
- Introduction of new aircraft technology
- High cost of fuel

**Negative**
- Market maturity
- Slowing economic growth
- Increasing load factors
- Social-cultural factors
- Infrastructure

Source: ICF SH&E
There several key changes in ICF's production forecast since last year on important platforms

**Year Over Year Changes In ICF Forecast Notable Aircraft Unit Production**

<table>
<thead>
<tr>
<th>Platform</th>
<th>'13-'21 Total Production Difference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>B737</td>
<td>258</td>
<td>Near term production rates raised</td>
</tr>
<tr>
<td>A320</td>
<td>229</td>
<td>Near term production rates raised</td>
</tr>
<tr>
<td>EMB-170/190</td>
<td>188</td>
<td>Mid decade production rates raised</td>
</tr>
<tr>
<td>A330</td>
<td>126</td>
<td>Increased production rates; orders strong in light of 787 competition</td>
</tr>
<tr>
<td>C919</td>
<td>-30</td>
<td>Delays to program &amp; reduced program outlook</td>
</tr>
<tr>
<td>MRJ</td>
<td>-60</td>
<td>Delays to program</td>
</tr>
<tr>
<td>F-35</td>
<td>-214</td>
<td>Slower Ramp up</td>
</tr>
</tbody>
</table>

Source: ICF SH&E
ICF’s air transport forecast anticipates production rates approaching 1,800 by 2023.

Source: ICF SH&E Analysis
Nearly 50% of these deliveries will be for replacement, with more than 6,000 retirements anticipated.

Source: ICF SH&E Analysis
Note: includes turboprops and regional jets
Aircraft production in all markets is projected to reach 5,000 units by 2016.

The business & general aviation (BGA) market as at the bottom of a cycle and poised for recovery.

Military fixed wing and rotary wing production will be relatively flat.

Source: ICF SH&E
Aeroengines are 18% of the $151B aircraft production market

2012 Aircraft Production Market
Total = $151B

Source: ICF SH&E
Engines in the 20-50K thrust category are nearly half of the value of aeroengine production.

2012 Aeroengine Production Market
Total = $28B

By Market
- Civil RW: 2%
- Air Transport: 73%
- BGA: 10%
- Military: 16%

By Engine Thrust
- Geared Turbofan – LEAP-X battleground
- > 50k: 31%
- 20 - 50k: 47%
- < 20k: 13%

Source: ICF SH&E
GE is the market share leader with 28% of the aeroengine production market

2012 Aeroengine Production Market
Total = $28B

- GE has the largest market share with 28%
- Pratt & Whitney is the next largest OEM, bolstered by its military and BGA businesses
- Safran and Rolls-Royce both have ~20% market shares

Source: ICF SH&E, Company Annual Reports
Total aerospace material demand in buy weight is 1.44B pounds, led by the air transport sector.

2013 Aerospace Raw Material Buy Weight*

By Material Type

- Aluminum Alloys: 49%
- Other: 6%
- Composites: 4%
- Super Alloys: 9%
- Titanium Alloys: 10%
- Steel Alloys: 22%

- The total buy weight is 1.44B pounds….with an aggregate buy-to-fly ratio of 5.5
- Aluminum alloys, including Al-Li are 49% of demand
- Steel alloys are the next largest material category

* Fundamental Mill Demand; Maintenance, repair and overhaul (MRO) included in total
Source: ICF SH&E
Aerospace titanium buy weight is 145M lbs, led by the air transport sector

- Aerospace titanium demand is 145m lbs., a notable increase over the 2012 figure
- Air transport aircraft comprise more than 70% of titanium demand

Source: ICF SH&E Analysis
Airframe production now accounts for 66% of total titanium demand

- Airframe consumption is now two-thirds of demand
- The 787 now accounts for one-quarter of air transport airframe Ti demand
- The four next largest programs are the 737NG, 777, A380 and A320

Source: ICF SH&E Analysis
MRO – maintenance, repair, and overhaul
Adjustments in B777 production rates drive the largest increase in Ti demand versus last year’s forecast.

Year Over Year Changes In ICF Forecast
Sum of 2013-21 Ti Forecast*

Source: ICF SH&E Analysis
Titanium demand will grow at 4.6% through 2023, led by airframe production.

Aircraft Titanium Demand 2013-2023

Source: ICF SH&E Analysis

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- Aerospace Industry Dynamics & Raw Material Demand
- Aerospace Supply Chain Trends
There are five important aerospace trends that will influence titanium supply chains:

- **Additive Manufacturing**
- **Onshoring**
- **OEM Vertical Integration**
- **Tier 4 Consolidation**
- **Advanced Aeroengines**

Source: ICF SH&E
Airbus committed to a new A320 facility in Alabama...

- In July 2012 Airbus announced its plan to establish a new facility in Mobile, Alabama.
- The facility will focus on A320 production with first deliveries planned for 2016.
...which underscores the southeast us as one of the hottest manufacturing investment destinations...

Selected Aerospace Investments In The Southeast US

- ALCOA
  - Morristown: Expansion of Howmet facility
- Safran
  - Monroe: Engine parts manufacturing
- Timco
  - Wallburg: New manufacturing facility
- Greensboro: Honda's HQ and manufacturing facility
- Greensboro: Service Center
- EMBRAER
  - Nashville: Full service facility
- Boomardier
  - Memphis: Spare parts distribution center
- Boeing
  - Charleston: 787 Final Assembly and Delivery
  - North Charleston: JV to produce sub-assemblies for B787
- Gulfstream
  - Savannah: Gulfstream aircraft maintenance training facility
  - Savannah and Brunswick: Expansion of completions and service facilities
  - Palm Beach: New HQ, R&D center
- Chromalloy
  - Ft Lauderdale: Full service facility
  - Space Coast: Phenom Final Assembly Facility
  - Deerfield Beach: JV for landing gear MRO
  - Ft Lauderdale: Full service facility
- Airbus
  - Mobile: A320 final assembly line
  - Mobile: MRO facility
- SIFCO
  - Tampa: Component repair JV
  - Rolls-Royce Tampa: Casting foundry and ceramic core facility
- Dassault
  - Deerfield Beach: JV for landing gear MRO
- Chromalloy
  - Columbus: UH-72A final assembly line
- EADS
  - Auburn: New manufacturing facility for super alloys
- North Carolina
  - Orangeburg: Hondajet fuselage assembly
- Columbia Aerospace
  - Atlanta: Aerospace manufacturing facility

Source: ICF SH&E analysis
...and increasing interest in manufacturing “reshoring”

Manufacturing outsourcing cost index
% of US Cost

Companies’ intentions to change manufacturing source, worldwide, % of capacity

Source: Economics January 19 2013
PCC continued the trend of Tier 4 consolidation...
...and now has ~20% share of the aerospace titanium market

2012 Aerospace Titanium Demand

- Timet has a strong focus on engine related (rotary-grade) titanium
- 16% of Timet's total 2011 sales were to PCC

Source: ICF SH&E Analysis, PCC
The Embraer decision to re-engine the E-Jet series demonstrates the value of advanced engine designs

“G2” E-Jet

- In January 2013 Embraer selected Pratt’s GTF for is “G2” E-Jets
- Boeing is moving towards board approval of the 777-X, the fourth re-engining program in recent years
- Re-engining preserves legacy aerostructures materials in fuselage, delaying introduction of advanced materials

“Our enabling technology is now three times more valuable than it was a decade ago due to the price of fuel.”

Engine OEM Executive
...however aeroengine material trends are encroaching on titanium’s “sweet spot” in aeroengines

**CFM LEAP-X**

Composite fan and fan case introduced into single-aisle engines with LEAP-X → Titanium’s “sweet spot” in aeroengines → Nickel alloy moving forward in the High Pressure Compressor module

Source: CFM
OEMs are also pursuing vertical integration for advanced technologies and strategic components

**Recent GE Aviation Vertical Integration Activities**

<table>
<thead>
<tr>
<th>Partner</th>
<th>Year</th>
<th>Rationale</th>
</tr>
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<tbody>
<tr>
<td>SeaCast</td>
<td>2013</td>
<td>• Montana precision productions JV with SeaCast</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Will produce tubes, ducts and small structural castings</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>• Wins GE-9X wins 777-X competition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Includes CMC blades in baseline LPT configuration</td>
</tr>
<tr>
<td>Avio</td>
<td>2012</td>
<td>• Acquired Avio, a major low pressure turbine and gearbox supplier</td>
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<tr>
<td></td>
<td></td>
<td>• GE to invest $1.1B into Avio over the next 10 years</td>
</tr>
<tr>
<td>Morris</td>
<td>2012</td>
<td>• Acquired Morris Technologies and Rapid Quality Manufacturing</td>
</tr>
<tr>
<td>Technologies</td>
<td></td>
<td>• Expands GE’s additive manufacturing capabilities significantly</td>
</tr>
<tr>
<td>Parker</td>
<td>2012</td>
<td>• JV with Parker Aerospace to develop LEAP-X fuel nozzles</td>
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<tr>
<td></td>
<td></td>
<td>• Will use additive manufacturing</td>
</tr>
</tbody>
</table>

**Other OEMs engaged in vertical integration: Boeing, Roll-Royce, Bombardier**

Source: ICF research, GE Aviation
A long term trend to watch is additive manufacturing

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

- GE is committing $3.5B AM R&D over the next five years; most major OEMs have AM initiatives underway
- China is investigating ways to use AM for large parts in future military designs...and potentially the C919
- AM is unlikely to have an impact on Ti demand in the short-medium term, but needs to be monitored in the long run – particularly with Ti’s aggregate 6:1 buy-to-fly ratio!

Sources: RapidReady, China Northwest Polytechnical University
Thanks and Questions

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ICF SH&E OVERVIEW

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$841M  Revenues
4,500  Employees
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One of ICF's founders and its first president was a Tuskegee Airman. C.D. "Lucky" Lester flew more than 90 missions and earned the Distinguished Flying Cross. In 1969, "Lucky" and 3 DoD analysts founded the organization that is now ICF International.