Engine MRO Forecast & Industry Trends

October 31 – November 2, 2017: Singapore
COMPANY INTRODUCTION

Alton Aviation Consultancy is a boutique aviation consulting firm with deep domain expertise across the aviation value chain.

- Aircraft Leasing & Financing Advisory
- Airlines
- Aviation & Aerospace Investors
- Business & General Aviation
- Aerospace Manufacturers & Supply Chain
- MRO & Aftermarket
- Airports
- Specialty Projects

Alton supports a global client base from offices in the U.S., China, Hong Kong, and Tokyo, with additional associates worldwide

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TODAY’S AGENDA

1. Global Fleet Dynamics
2. The Power & Impact of “Little Data”
3. New Engine Technologies on the Horizon
Today’s commercial air transport fleet consists of approx. 27,000 aircraft, with Asia-Pacific recently surpassing North America.
Historically, fleet growth has been directly correlated to GDP...

![Fleet and GDP Growth by Region (1997 – 2017)](image)

Source: CAPA, USDA ERS, Alton analysis
...Perhaps a better determinant of future fleet growth is the so-called “Disneyland factor”; the growth rate of a country’s middle class.
Over the past 25 years, the global fleet has grown at a rate of 5.1%, with narrowbody aircraft accounting for over 55% of today’s fleet.


Engines by Manufacturer (1992 – 2017)

Source: CAPA, Alton analysis
Driven by narrowbody aircraft deliveries, the installed engine base in Asia-Pacific primarily consists of the CFM56-5/7 and V2500

**Installed Base by Engine Model**

(Asia-Pacific Region)

- ~ 9,400 engines

**Installed Base by Country**

(Top 10 by Volume; Asia-Pacific Region)

- OTHER
- GEnx
- CF34
- PW4000
- CF6
- GE90
- Trent 700
- PW100
- V2500
- CFM56-5
- CFM56-7

Source: CAPA, Alton analysis
Given the timing of aircraft deliveries, a massive bow wave of CFM56-5/7 and V2500 shop visits will occur over the coming decade.
Record high OEM backlog continues to drive investor interest, joint venture, and M&A activity in MRO providers and OEM supply chain.
There are already over 4,400 confirmed orders for the CFM LEAP & P&W Geared Turbo Fan (GTF) engines in the APAC region.

**Alton Insight**

- Both the CFM LEAP and P&W GTF are meeting fuel efficiency targets.
- Given the recent Airbus / Bombardier venture, analysts predict a potential doubling of previous C Series order estimates – great news for P&W!
- P&W has secured significant GTF MRO capacity in APAC via JVs with SAIEC (Eagle Services Asia in Singapore) and Air New Zealand (Christchurch Engine Center), IHI in Japan, and MTU Zuhai (China Southern JV).
- In APAC, GE plans to support the LEAP in its Singapore facility; MTU will also support the LEAP in its Zuhai, China facility.
Fleet retirements are down from peak levels

**Alton Insight**

- Typical aircraft life is approx. 25 years; there was a large spike in aircraft deliveries in the late 1980’s
- Increased retirements was also driven by high fuel prices and uneconomic 50-seat regional jets
- Low fuel prices and a strong traffic growth environment contributed to the slowdown in retirements rates
- The surge in aircraft retirements spawned the aircraft tear-down/part-out industry (very disruptive to OEM new parts sales)

Source: CAPA, Alton analysis
THE POWER & IMPACT OF “LITTLE DATA”
Little Data

**Noun: Little Data**

**Definition:** Life before “Big Data”...

Traditional, old school engineering design, planning, entrepreneurship, communication, and leadership
The MRO industry and aerospace supply chain continues to evolve, driven by technological, commercial, and geopolitical events.

### Pre-Globalization: Era of Self-Sufficiency
- Airlines build/operate own maintenance facilities
- Aircraft and inventory owned, limited leasing
- Manufacturers with fully integrated supply chains
- Limited international airline networks
- Rise of LCCs and PBH agreements

### Globalization 1.0: Era of Labor Cost Arbitrage
- Outsourcing non-core competencies
- New oil/gas drilling technology
- Rise of the BRICS
- End of cold war
- Open skies agreements
- NAFTA
- Global Financial Crisis
- Airline bankruptcies & consolidation

### Globalization 2.0: Era of Machine Learning
- U.S. energy revolution
- Supply chain rightshoring
- Cloud computing
- Global labor rate convergence
- Advanced manufacturing technology (robotics, automation, 3D printing)

Source: Alton Aviation Consultancy
The aviation & MRO industry benefits of “Little Data” have been substantive and impressive

<table>
<thead>
<tr>
<th>Alton Insight</th>
<th>Then</th>
<th>Now</th>
<th>Change</th>
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<tbody>
<tr>
<td>Engineering design and maintenance program development</td>
<td>1,700</td>
<td>258</td>
<td>84% ↓</td>
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<td>Business model structure and strategy (e.g. creation of LCC)</td>
<td>6,000</td>
<td>25,000</td>
<td>316% ↑</td>
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<td>Supply chain innovation (e.g. use of surplus material and PMA, strategic sourcing, consignment programs, etc.)</td>
<td>380,000</td>
<td>314,000</td>
<td>18% ↑</td>
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<td>Commercial innovation (e.g. cost per flight hour programs for engines and components)</td>
<td>10,900</td>
<td>1,350,000</td>
<td>12,000% ↑</td>
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<td>Creative financing (e.g. sale-leaseback programs)</td>
<td>0.020</td>
<td>0.008</td>
<td>60% ↓</td>
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NEW ENGINE TECHNOLOGIES ON THE HORIZON
Additive manufacturing (or 3D printing) is already transforming traditional engine design and production

Alton Insight

- GE’s new Advanced Turboprop is being touted as “the world’s most printed engine”
- The Advanced Turboprop will power Cessna’s new Denali aircraft
- Additive manufacturing replaces 855 normally made parts with just 12 “printed” components
- GE claims the engine is designed to achieve 20% better fuel burn with 10% more power than comparative engines
An army of tiny robots are on the march; with plans to disrupt engine MRO inspection and repair processes

Alton Insight

- OEMs are developing very small robots which can venture inside an engine to perform inspections and carry out any necessary repairs.

- The robots are small enough to navigate their way around all the various fan and turbine blades, taking video of everything they see, and will relay the pictures wirelessly to technicians.

- Once the video has been analyzed by technicians, the robots will be able to carry out certain repairs (at the gate between flights!)

Source: The Economist, September 2017
The Asia-Pacific region has become the engine MRO demand capital of the world.

Airbus’ C Series investment is an industry game changer.

While “Big Data” analytics will inevitably drive further industry improvements, “Little Data” has been, and will continue to be, the cornerstone of aviation & MRO innovation.

Emerging technologies including 3D printing and robotics are transforming engine manufacturing and MRO processes.