The MRO Market & Key Trends

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Today’s Agenda

1. Industry Context
2. MRO Market
3. Trends to watch
Industry Context
The global airline industry is forecast to achieve a record profitability of over $38B USD in 2018.

Source: IATA/ICF Analysis
…but many airlines continue to struggle though North America has been a bright spot and was leading the way in 2017
Airlines are increasing their aircraft gauge by renewing their fleet...

**SOUTHWEST: AVERAGE SEATS PER AIRCRAFT (YEAR END AVERAGE)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>136</td>
</tr>
<tr>
<td>2013</td>
<td>141</td>
</tr>
<tr>
<td>2014</td>
<td>145</td>
</tr>
<tr>
<td>2015</td>
<td>146</td>
</tr>
<tr>
<td>2016</td>
<td>149</td>
</tr>
<tr>
<td>2017</td>
<td>152</td>
</tr>
</tbody>
</table>

**DELTA AIRLINES: AVERAGE AIRCRAFT GAUGE**

<table>
<thead>
<tr>
<th>Year</th>
<th>Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>131</td>
</tr>
<tr>
<td>2017</td>
<td>137</td>
</tr>
<tr>
<td>2020E</td>
<td>144</td>
</tr>
</tbody>
</table>

*Upgauging has driven nearly $1B in expense savings over the past 4 years from increased operational efficiency*
Commercial aircraft OEM production backlog remains at historical highs

**COMMERCIAL AIRCRAFT OEM PRODUCTION BACKLOG**

# of aircraft

<table>
<thead>
<tr>
<th>Year</th>
<th>Order Backlog</th>
<th>Backlog/% Active Fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>2,000</td>
<td>0%</td>
</tr>
<tr>
<td>2003</td>
<td>3,000</td>
<td>10%</td>
</tr>
<tr>
<td>2004</td>
<td>4,000</td>
<td>20%</td>
</tr>
<tr>
<td>2005</td>
<td>5,000</td>
<td>30%</td>
</tr>
<tr>
<td>2006</td>
<td>6,000</td>
<td>40%</td>
</tr>
<tr>
<td>2007</td>
<td>7,000</td>
<td>50%</td>
</tr>
<tr>
<td>2008</td>
<td>8,000</td>
<td>60%</td>
</tr>
<tr>
<td>2009</td>
<td>9,000</td>
<td>70%</td>
</tr>
<tr>
<td>2010</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>11,000</td>
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<td>2012</td>
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<tr>
<td>2015</td>
<td>15,000</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>16,000</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>17,000</td>
<td></td>
</tr>
</tbody>
</table>

**DRIVERS OF OEM BACKLOG**

- Backlog more than doubled between 2010 and 2014, driven by:
  - Emerging market growth
  - Very low interest rates and plentiful capital
  - High oil and commodity prices
  - Introduction of new technology aircraft/engines
- In 2017, total backlog decreased for the first time since 2009 as deliveries ramp-up and orders slowdown

Source: CAPA, ICF Analysis
Lower fuel costs are encouraging aircraft to remain in-service longer – causing retirements to fall

**COMMERCIAL AIR TRANSPORT ANNUAL AIRCRAFT RETIREMENTS**

- **MRO suppliers - positive:** increased spend on older airframes & engines
- **Surplus market suppliers - positive:** reduced part-out “feed stock”
  - OEMs: improved new part sales
  - Distributors: improved used part values / pricing
- ** Operators – negative:** increased material costs

**INDUSTRY CONTEXT**

Source: CAPA, ICF analysis
MRO Market
The current commercial air transport fleet consists of ~29,100 aircraft; ~8,500 are located in North America.

Source: ICF Analysis: CAPA 2017
The combination of strong air travel demand and the need to replace ageing aircraft will drive fleet growth at a healthy 3.1% p.a.

20 YEAR GLOBAL AIR TRANSPORT FLEET GROWTH

# Aircraft

<table>
<thead>
<tr>
<th>Year</th>
<th># Aircraft</th>
<th>Region, 10y CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>~29,100</td>
<td>Africa, 3.5%</td>
</tr>
<tr>
<td></td>
<td>~8,500</td>
<td>Middle East, 5.6%</td>
</tr>
<tr>
<td></td>
<td>~8,500</td>
<td>South America, 3.6%</td>
</tr>
<tr>
<td>2027</td>
<td>~39,600</td>
<td>Europe, 2.5%</td>
</tr>
<tr>
<td></td>
<td>~9,200</td>
<td>North America, 0.8%</td>
</tr>
<tr>
<td></td>
<td>~17,500</td>
<td>Asia Pacific, 5.0%</td>
</tr>
<tr>
<td>2037</td>
<td>~46,900</td>
<td>Total: 3.1%</td>
</tr>
</tbody>
</table>

Source: ICF Analysis: CAPA 2017
2017 commercial air transport MRO demand is $75.5B; Asia is now larger than North America and Europe in market size

2017 COMMERCIAL AIR TRANSPORT GLOBAL MRO DEMAND

BY MRO SEGMENT

- Airframe: 13%
- Line: 17%
- Components: 21%
- Modifications: 7%
- Engines: 42%

BY GLOBAL REGION

- Asia Pacific: 31%
- North America: 26%
- South America: 25%
- Europe: 21%
- Middle East: 8%
- Africa: 6%

Source: ICF Analysis: CAPA 2017
The global MRO market is expected to grow by 4.6% per annum to ~$118B by 2027.

**20 YEAR GLOBAL COMMERCIAL AIR TRANSPORT MRO DEMAND**

<table>
<thead>
<tr>
<th>Region</th>
<th>10y CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>6.1%</td>
</tr>
<tr>
<td>South America</td>
<td>5.7%</td>
</tr>
<tr>
<td>Middle East</td>
<td>7.9%</td>
</tr>
<tr>
<td>Europe</td>
<td>3.3%</td>
</tr>
<tr>
<td>North America</td>
<td>1.7%</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>6.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4.6%</td>
</tr>
</tbody>
</table>

Source: ICF Analysis: CAPA 2017, 2017 constant $
North American MRO spend exhibits marginal growth, increasing by 1.7% per annum to $22.9B by 2027

Source: ICF Analysis: CAPA 2017, 2017 constant $
North American MRO spend exhibits marginal growth, increasing by 1.7% per annum to $22.9B by 2027

10 YEAR NORTH AMERICAN COMMERCIAL AIR TRANSPORT MRO DEMAND

<table>
<thead>
<tr>
<th>Category</th>
<th>10y CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turboprop</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Regional Jet</td>
<td>-3.8%</td>
</tr>
<tr>
<td>Widebody Jet</td>
<td>1.5%</td>
</tr>
<tr>
<td>Narrowbody Jet</td>
<td>3.3%</td>
</tr>
<tr>
<td>Total: 1.7%</td>
<td></td>
</tr>
</tbody>
</table>

Source: ICF Analysis: CAPA 2017, 2017 constant $
By 2037, ~65% of the heavy airframe MRO spend in North America will be generated by next-gen technology aircraft.

ICF OBSERVATIONS

- Over the next decade and beyond the North American airframe MRO demand will migrate from older aircraft (MD80s, 757s, 767s) to composite and more-electrical aircraft (787s, A350s, 737 MAX, A320neo etc)
- Newer aircraft have extended check intervals and reduced man-hour requirements
- Implications for training, access to repairs and hangar utilization / capacity

Source: ICF Analysis: CAPA 2017, 2017 constant $
Trends To Watch
Consolidation continues among System OEMs

- **2016**: Rockwell Collins acquires B/E Aerospace
- **2017**: UTC plans to acquire Rockwell Collins
- **2017**: Safran acquires Zodiac
- **2017**: Honeywell splits off 2 divisions, keeps Aerospace
- **2018**: Melrose acquires GKN

**Next?**

- Acquisitions?
- Divestments?

**Others?**
There continues to be expansion of MRO Capacity…

- **Alaska**: 2 additional bays for 737 in Anchorage, Alaska.
- **MTU**: Added V2500 capability in Richmond, Canada.
- **StandardAero**: RB211 capability in San Antonio, Texas.
- **SAQ**: New widebody heavy maintenance in Saltillo, Mexico.
- **Southwest**: Additional 6 NB bays in Houston, Texas.
- **Mexicana MRO Services**: 2 additional NB bays in Mexico City.
- **IAI**: Conversion facility for 767s in Mexico City.
- **Avocet Aviation Group**: Opening a 200,000ft modification centre in Melbourne, Florida.
- **STS**: 26,000ft NB line and heavy maintenance in Lakeland, Florida.
- **AAR**: Heavy maintenance facility for 2 WB aircraft in Rockford, Illinois.
Impact of New Technology Aircraft
The fleet of e-enabled aircraft is set to more than double over the next decade

ICF IN-SERVICE AIR TRANSPORT FLEET FORECAST

**OBSERVATION**

- ICF expects ~23,500 aircraft will be equipped with Aircraft Health Monitoring (AHM) by 2027, growing at 10.4% CAGR
- This is driving a digitisation of aircraft operations, which will see high growth in the e-enabled services and further advances in health management

### AHM adoption, 2017 – 2027 CAGR

- Limited AHM, -2.7%
- AHM, 10.4%

**TOTAL = 3.0%**

**Source:** ICF
AHM can be viewed as a subset of data management value chain...

Aircraft Data Management Value Chain

**Aircraft Health Monitoring** is inferring the state of the aircraft.

**Aircraft Health Management** is extracting value from this information.

- **Diagnosis**
  - Determining whether the component is performing its function

- **Prognosis**
  - Predicting the remaining life of a component

**Diagnostic**
- Troubleshoot while the aircraft is in flight or after it lands

**Prognostic**
- Customize maintenance program to prevent unscheduled downtime

Aircraft Health Management goes beyond predicting and replacing components, it incorporates flight operations and helps airlines in fleet and inventory management.

Source: ICF
The race is on... new battlegrounds are emerging across the MRO market.
OEMs & MROs are embracing partnerships to cover the MRO data value chain...

DATA VALUE CHAIN PARTNERSHIP EXAMPLES

Acquisition & Synthesis → Transmission → Storage → Analysis → MRO Planning → MRO Action → Records Keeping

Engine Health Monitoring Partnership: SITAONAIR
Digital aviation applications partnership: Palantir, Microsoft Azure, AIRBUS

Source: ICF
... Though the level of partnership varies across the various parts of the data value chain

### OVERVIEW OF AIRCRAFT DATA VALUE CHAIN PARTNERSHIPS

<table>
<thead>
<tr>
<th>Acquisition &amp; Synthesis</th>
<th>Transmission</th>
<th>Storage</th>
<th>Analysis</th>
<th>MRO Planning</th>
<th>MRO Action</th>
<th>Records Keeping</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRBUS</td>
<td>Rockwell Collins</td>
<td>transatel</td>
<td>IBM</td>
<td>Palantir</td>
<td>AIRBUS</td>
<td>AIRBUS MRO Alliance</td>
</tr>
<tr>
<td>BOEING</td>
<td>TELEDYNE Honeywell</td>
<td>ACARS / Gate Wi-Fi</td>
<td>Microsoft Azure</td>
<td>BOEING AnalytX</td>
<td>BOEING</td>
<td>BOEING</td>
</tr>
<tr>
<td>Lufthansa Technik</td>
<td>-</td>
<td>ACARS / Gate Wi-Fi</td>
<td>IBM</td>
<td>IBM</td>
<td>Swiss AviationSoftware</td>
<td>Lufthansa Technik</td>
</tr>
<tr>
<td>AIRFRANCE INDUSTRIES</td>
<td>-</td>
<td>ACARS / Gate Wi-Fi</td>
<td>AIRFRANCE INDUSTRIES</td>
<td>AIRFRANCE INDUSTRIES</td>
<td>AIRFRANCE INDUSTRIES</td>
<td>AIRFRANCE INDUSTRIES</td>
</tr>
<tr>
<td>AAR</td>
<td>-</td>
<td>ACARS / Gate Wi-Fi</td>
<td>ORACLE</td>
<td>ORACLE</td>
<td>AAR</td>
<td>AAR</td>
</tr>
</tbody>
</table>

Source: ICF
Digitisation could enable airlines to save in excess of $5B/year through lower fuel, maintenance and delay costs

**Health Monitoring and Predictive Maintenance**

- Airline Industry savings: ~$3B \( (\text{conservative estimate}) \)
- Driven by improved dispatch reliability, No Fault Found reduction, Inventory reduction and Improved labour productivity

**Fuel Cost Savings**

- Airline Industry savings: ~$1.7B \( (\text{conservative estimate}) \)
- Continuous flight optimisation through live weather updates, speed and altitude optimisation…

**Delay Reduction**

- Airline Industry savings: ~$0.8B \( (\text{conservative estimate}) \)
- Improved turnaround process, in-flight routing optimisation

Source: ICF
Several airlines are seeing the first tangible benefits of their aircraft health monitoring trials

<table>
<thead>
<tr>
<th>Results of Delta’s Predictive Maintenance approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Engine Events</td>
</tr>
<tr>
<td>Delta achieved a 100% completion factor for 241 days in 2017, with a 98% reduction in maintenance-related cancellations</td>
</tr>
<tr>
<td>Cancellation reduction</td>
</tr>
<tr>
<td>98% (Over 2010 - 2016)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>easyJet</th>
<th>31 Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 instances of Skywise correctly predicting faults before they occurred in service, allowing the carrier to intervene and remove components before they failed</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cathay Pacific</th>
<th>51%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathay Pacific reduced APU-related delay minutes by 51% using Honeywell’s predictive maintenance trial program</td>
<td></td>
</tr>
</tbody>
</table>

Source: MRO-Network
Considerations
CONSIDERATIONS

In Conclusion…

• The Global Air Transport MRO market outlook remains robust at $76B growing to $118B over the next decade (an expected growth of 4.6% per annum)

• North America generates $19.4B of MRO demand and will grow to $23B by 2027

• New technology aircraft and engines are creating both new challenges and opportunities for aviation stakeholders including how best to leverage big data to reduce operator costs, help increase efficiency and increase reliability
Thank You!

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**ICF focuses on key aspects of the industry that drive value in both revenue growth and cost control.**

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