Today’s Agenda

- Bizarro Aviation
- MRO Forecast
- Trend Watch:
  - Aircraft Cabin Interiors
  - New Technology Aircraft
  - Virtual Reality
“Bizarro Aviation”
Four external macro-economic forces are having a significant impact on the aviation industry and the MRO supply chain.
The dramatic increase in oil & gas market supply and reduced demand for commodities has led to a strong US Dollar

**FOREX Impact**

- Partially offsets the positive impact of low fuel costs for operators
- Increases the cost of dollar based flight hour agreements (and parts/material in general)
- Cost of labor for in-country MROs is cheaper driving up margins for US dollar based contracts
- Buying/leasing aircraft becomes more expensive

*Source: USForex, ICF analysis*
Commercial aircraft OEM production backlog remains at historical record levels driven by:

- Emerging market growth
- Low interest rates
- Previously high oil and commodity prices
- Introduction of new technology aircraft/engines

Source: CAPA, ICF Analysis
Low fuel costs appear to be reversing aircraft retirements trends

**Industry Impact:**
- **MRO Suppliers** - Positive: Increased spend on older airframes & engines
- **Surplus Market** - Negative: Reduced part-out “feed stock”
  - OEMs: Improved new part sales
  - Distributors: Improved used part values / pricing
  - Operators: Increased material costs

Source: CAPA, Airline Monitor, ICF analysis
Airline return on invested capital (ROIC) is clearly correlated with the drop in fuel costs.

Fuel Price as a % of Airline Operating Expenses

Source: IATA, ICF Analysis
Airline return on invested capital (ROIC) is clearly correlated with the drop in fuel costs.

Source: IATA, ICF Analysis
Driven by low fuel costs and consolidation, airline the industry is on target to achieve record profitability in 2016 of almost $40B USD.

These are the “good old days: - for some airlines…

Global Airline Profitability, 1996 - 2016F

Source: IATA, ICF analysis
However, profit margin improvement has been largely limited to carriers in North America and Europe.

...but not all – many airlines continue to struggle

Global Airline EBIT Margin by Region

Source: IATA, ICF Analysis
Brexit has clearly had an impact on European airline stock performance; specifically UK based carriers.

Share Performance of European Airlines Since Brexit

23 June 2016 – 13 October 2016

-50%  -40%  -30%  -20%  -10%  0%

Easy Jet, -41.5%
IAG, -28.1%
Air France-KLM, -24.8%
Wizz, -23.2%
Norwegian, -16.5%
Ryan Air, -16.2%
Lufthansa, -15.2%
SAS, -6.3%

Source: Company websites
Follow the Money: Airlines are spending their hard earned profits in three primary areas

1. **Labor ~ 20%:**
   - Profit sharing
   - Wage increases

2. **Capex ~ 38%:**
   - Fleet renewal & cabin upgrades
   - Facilities, offices, lounges
   - Equity partner investments

3. **Investors ~ 42%:**
   - Stock buy-backs
   - Dividends
   - Debt repayment

Source: Company Reports, ICF Analysis
After positive signs in 2014, air cargo supply continues to exceed demand.

South Korea’s Hanjin Shipping Co., one of the world’s largest container shipping companies, has filed for bankruptcy protection.

Source: IATA, ICF Analysis
Amazon is very well positioned to lead a major disruption of the air cargo industry.

Amazon is investing in airplanes - takes ownership stake in two North American cargo carriers; Atlas Air & ATSG.

Amazon’s Growing Revenue & Shipping Costs

Amazon Quarterly Revenue

Shipping Costs as a Percentage of Revenue

Source: Amazon SEC Filings
March of the Middle East Titans:

Middle East carriers have been very effective in capturing valuable business passenger traffic from European secondary airports.

European Secondary Airports
Average Number of Seats per Departure in 2016

<table>
<thead>
<tr>
<th>City</th>
<th>Gulf Carriers</th>
<th>Non-Gulf Carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>363</td>
<td>180</td>
</tr>
<tr>
<td>Duesseldorf</td>
<td>408</td>
<td>148</td>
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<tr>
<td>Glasgow</td>
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<td>128</td>
</tr>
<tr>
<td>Hamburg</td>
<td>400</td>
<td>128</td>
</tr>
<tr>
<td>Lyon</td>
<td>394</td>
<td>146</td>
</tr>
<tr>
<td>Manchester</td>
<td>370</td>
<td>121</td>
</tr>
<tr>
<td>Munich</td>
<td>343</td>
<td>163</td>
</tr>
<tr>
<td>Nice</td>
<td>400</td>
<td>149</td>
</tr>
<tr>
<td>Newcastle</td>
<td>400</td>
<td>117</td>
</tr>
<tr>
<td>Venice</td>
<td>306</td>
<td>135</td>
</tr>
</tbody>
</table>

“…Lufthansa’s Frankfurt hub has lost nearly a 3rd of its market share on routes between Europe and Asia since 2005, with more than three million people now flying annually via Gulf hubs” – The Economist

Source: OAG Data, ICF Analysis
The current commercial air transport fleet consists of over 27K aircraft; over half are narrowbody aircraft.
The combination of strong air travel demand and the need to replace ageing aircraft will drive fleet growth at a healthy 3.4% annually.

10 Year Global Air Transport Fleet Growth

- **Africa**: 5% CAGR, 8% Avg.
- **Middle East**: 8% CAGR, 6% Avg.
- **Latin America**: 25% CAGR, 23% Avg.
- **Europe**: 27% CAGR, 32% Avg.
- **Asia Pacific**: 31% CAGR, 26% Avg.
- **North America**: 3.8% CAGR, 5.1% Avg.

Source: ICF analysis: CAPA 2015
Current commercial air transport MRO demand is $64.3B; with Asia equivalent to North America and Europe in market size.
The global MRO market is expected to grow by 4.1% per annum to $96B by 2025

- Engine and component MRO markets remain the largest segments
- Modifications market will see the strongest growth (e.g. interiors, connectivity)
- Airframe market slows due to reduced man-hour intensity and increased check intervals as new fleets are introduced

Source: ICF analysis; Forecast in 2015 $USD, exclusive of inflation
The current European fleet consists of over 6,700 aircraft; with almost 60% consisting of narrowbody.
The European MRO market is expected to grow to approx. $21.3B by 2025, at 2.3% per annum.

- Modifications is the fastest growing MRO segment in Europe.
- MRO spend on engines will experience the largest absolute growth.

Source: ICF analysis; Forecast in 2015 $USD, exclusive of inflation
Trend Watch: A New Golden Age of Aircraft Cabin Interiors
Modifications growth is driven by airlines seeking differentiation in the cabin and customer experience.

**MRO modification market growth drivers include:**
- Premium lie-flat seats are now the minimum standard
- Premium economy
- Wi-fi, on-board connectivity
- Coming soon: ADS-B Mod program
- Capacity (ASM/K) increase

Commercial Air Transport Modifications Forecast

- **2015**
  - AD/SB**: $0.3B
  - PTF Conversions*: $0.4B
  - Painting: $0.4B
  - Avionics Upgrades: $0.4B
  - Interiors: $0.6B
  - Total: $2.7B

- **2025**
  - AD/SB**: $0.5B
  - PTF Conversions*: $0.4B
  - Painting: $0.5B
  - Avionics Upgrades: $1.1B
  - Interiors: $4.9B
  - Total: $7.4B

**CAGR**
- AD/SB**: 3.6%
- PTF Conversions*: 0.0%
- Painting: 3.7%
- Avionics Upgrades: 6.9%
- Interiors: 5.9%
- 5.3% Avg.

Modifications demand includes labor and material spend

*Passenger-To-Freighter Conversions

**Airworthiness Directives / Service Bulletins

Source: ICF analysis, constant 2015 US$
Cabin “densification” has emerged as cost effective strategy for airlines to increase capacity and drive bottom line growth.

Cabin Upgrades:
- Slim seats
- Slim lavatories
- Slim galleys
- Slim coat closets

Source: ICF analysis, delta.com
Trend Watch: New Technology Aircraft
Over the next decade, the global fleet of new generation aircraft fleet will grow by approx. 531% to nearly 19,000 aircraft.

10-Year Fleet Forecast by Aircraft Generation

<table>
<thead>
<tr>
<th>Year</th>
<th>Global</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>22,212</td>
<td>2,993</td>
</tr>
<tr>
<td>2025</td>
<td>18,896</td>
<td>4,487</td>
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</table>

Old Gen: 727, 737 Classic, 747 Classic, DC10, L1011, A300
Mid Gen: 757, 767, 747-400, A320 Family, A330/A340, 737NG, 777, ERJ, CRJ

Source: ICF analysis
Over the next decade, MRO spend on new technology Airbus A350 & Boeing 787 aircraft will double every three years.

Source: ICF analysis; Forecast in 2015 $USD, exclusive of inflation, includes Boeing 787 and Airbus A350

10-Year MRO Spend for New Technology A350 and 787 Aircraft

$ USD Billions

- Africa
- Latin America
- Middle East
- North America
- Europe
- Asia Pacific

$0.5 $0.9 $1.0 $1.3 $3.3 $4.4 $5.8 $7.1 $8.4 $9.7 $11.1


+2000%
New technology aircraft challenge traditional MRO sourcing strategies

Return on investment challenges:
- Facilities
- Tooling & Equipment
- Training
- IT Systems

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### 12 Year Heavy Maintenance Schedule

<table>
<thead>
<tr>
<th>A/C Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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<tbody>
<tr>
<td>767</td>
<td></td>
<td></td>
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<td>H</td>
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<tr>
<td>787</td>
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</tr>
</tbody>
</table>

- **Light C-Check**
- **Heavy C-Check**

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Volume (C-checks)</th>
<th>Intensity (man-hours)</th>
<th>Days (Hangar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>767</td>
<td>8</td>
<td>95,000</td>
<td>136</td>
</tr>
<tr>
<td>787</td>
<td>4</td>
<td>33,000</td>
<td>47</td>
</tr>
</tbody>
</table>

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**Impact**

- **Cost Savings:** ~65% fewer routine airframe heavy maintenance man-hours drives an estimated savings of ~$3.5M
- **Asset Utilization:** ~90 additional available flying days enables increased revenue generation potential

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*Based on 4,000 FH/yr utilization
767 C-check = 18mo, 4C = 72mo; 787 C-check = 36mo, 4C = 144mo
Assumed industry standard labor man-hour rate
Aircraft out of Service (AooS) calculated for C/4C/8C checks assuming industry standard MRO hangar productivity
Source: ICF analysis
**Challenge:** How best to realize value from the disparate terabytes of data generated by new technology aircraft.

- **Stakeholder Battle:** Who will control and benefit most from the operating data IP?
  - Operators
  - Lessors
  - OEMs
  - MRO Suppliers

### Aircraft Health Monitoring Parameters

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>AHM Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>A320</td>
<td>15,000</td>
</tr>
<tr>
<td>B787</td>
<td>100,000</td>
</tr>
<tr>
<td>767</td>
<td>10,000</td>
</tr>
<tr>
<td>777</td>
<td>&lt; 1MB</td>
</tr>
<tr>
<td>787</td>
<td>~ 28MB</td>
</tr>
<tr>
<td>Yr 1</td>
<td>~11TB</td>
</tr>
<tr>
<td>Yr 10</td>
<td>~ 137TB</td>
</tr>
</tbody>
</table>

### Transmittable Data (MB/Flt)

- 777: < 1MB
- 787: ~ 28MB

### A/C Data Generated (TB/Year)

- 777: < 1MB
- 787: ~ 28MB
- Yr 1: ~11TB
- Yr 10: ~137TB

**Source:** ICF analysis
ICF believes that virtual reality (VR) technology will be as disruptive to MRO training as 3D-printing is to parts manufacturing.
THANK YOU!

For questions regarding this presentation, please contact:

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- Airline Maintenance Benchmarking
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- OEM Aftermarket Strategy
- Aviation Asset Valuations & Appraisals
- MRO Information Technology (IT) Advisory
- Strategic Sourcing & Supply Chain Mgt.
- LEAN Continuous Process Improvement
- Military Aircraft Sustainment
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- 80+ professional staff
  - Dedicated exclusively to aviation and aerospace
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