Aerostructure equipment market

Study report

December 2015
Since 2012 the aerostructure equipment market developed much more positive than projected – Update of the forecast needed

Study rationale and objective

**Initial situation**

> In 2012, a significant decline in the aerostructure tooling equipment market was forecasted, primarily due to a lack of major new programs in the pipeline after the industrialization of the A350 and the B787

> Nevertheless, in the last two years the market developed much more positive – driven by new programs and rate increases of legacy programs

> Therefore, the key question was: Has the expected downturn only been deferred or are we experiencing a sustainable long-term market stabilization?

**Objective**

A. The first step of the study was to validate assumptions and understand changes in the market over the past three years

B. The second step was to update the market model for aerostructure equipment covering 2015-2020

C. Finally, selected scenarios have been assessed to reflect different options for the market's future development beyond 2020

Source: Roland Berger
### Contents

| A | Market assessment | Interviews with market experts confirmed that key drivers for global aerostructure tooling equipment demand include rate increases, new A/C programs, and an increased need for automation – Composite parts production became a major segment of the market |
| B | Market forecast 2020 | The global market for aerostructure equipment is estimated at USD 1.8 bn in 2014 and projected to increase to USD 2.0 bn in 2020 – Key drivers are rate increases of legacy programs, new program launches and upgrade/retrofit business to increase efficiency of installed base in order to cope with production ramp-up |
| C | Forecast scenarios beyond 2020 | In order to gain a better understanding of the significance of key market drivers and various possible options for future development, three alternative scenarios have been modeled – Worst case scenario yields market size of USD 2.2 bn in 2025, best case scenario results in forecast of USD 2.5 bn in 2025 |
A. Market & competitors
The market for aerostructure equipment can be categorized in 6 segments – Metal parts production out of scope

Market segmentation

<table>
<thead>
<tr>
<th>Segment</th>
<th>Sub-segment</th>
<th>Description</th>
<th>Technologies ¹</th>
<th>Key suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated production systems</td>
<td>Fastening systems</td>
<td>Automated and semi-automated fastening systems and equipment</td>
<td>&gt; Drilling</td>
<td>&gt; Broetje</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Riveting</td>
<td>&gt; Gemcor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Robotics</td>
<td>&gt; Loxin</td>
</tr>
<tr>
<td>Composite systems</td>
<td></td>
<td>Automated systems and machines for manufacturing of CFRP parts</td>
<td>&gt; Fiber placement</td>
<td>&gt; ElectroImpact</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Tape laying</td>
<td>&gt; MTorres</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; …</td>
<td>&gt; Sener</td>
</tr>
<tr>
<td>Automated assembly systems</td>
<td>Stations/ Lines</td>
<td>Automated and semi-automated station line equipment</td>
<td>&gt; Positioning</td>
<td>&gt; AIT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Measurement</td>
<td>&gt; Broetje</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; …</td>
<td>&gt; MTorres</td>
</tr>
<tr>
<td></td>
<td>Conveyors systems</td>
<td>Automated and manual systems for conveying, handling and storage</td>
<td>&gt; Conveyors</td>
<td>&gt; Reel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Jigs</td>
<td>&gt; CTi</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; …</td>
<td></td>
</tr>
<tr>
<td>Small tools</td>
<td></td>
<td>Hand power and manual tools in aerostructure equipment manufacturing and assembly</td>
<td>&gt; Hand power tools</td>
<td>&gt; All OEMs, aerostructures and equipment suppliers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Manual tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; …</td>
<td></td>
</tr>
<tr>
<td>Service offerings</td>
<td></td>
<td>All services related to aerostructure equipment including third parties</td>
<td>&gt; Maintenance</td>
<td>&gt; All OEMs, aerostructures and equipment suppliers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Engineering</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Spares</td>
<td></td>
</tr>
</tbody>
</table>

¹) Selection only, not exhaustive

Source: Roland Berger

Metal parts production and related technologies are out of scope

- Drilling
- Milling
- Turning
- Cutting
- Bending
- Drawing
- Forming
- Shaping
In order to assess the market from all angles, we conducted interviews with experts across the globe covering main A&D regions.

Geographical interview coverage

**Interview details**
- Interviewees comprised a balanced mix of aircraft/equipment OEMs, suppliers and other experts
- More than 20 interviews conducted covering 9 countries in North America, Europe and Asia

**Additional sources**
- Publicly available data and reports from industry, associations, financial institutions, etc.

Source: Roland Berger
"Golden age" of the industry – There is strong consensus that the current investment boom will last for some more years

Highlight quotes

"It will take another 10 years for China to really catch up with knowledge"
Equipment Tier-2

"We expect the current investment boom in the industry to last at least another 5 years"
Equipment manufacturer

"This is the golden age of aerostructure equipment and the market will keep rising until 2020"
Aircraft OEM

"Introduction of new technologies such as robotics or welding will happen and we will see different technologies in parallel within the next 5-10 years"
Aircraft OEM

"Composite is here to stay and tooling in that segment will remain on the rise"
Aircraft OEM

"Three years ago we strongly shared the pessimistic market outlook. Things have significantly changed since then and we didn't see the SA rate increase coming"
Aircraft OEM

"We see a balanced view between A320neo and B737max. We don't expect Boeing to launch their SA next generation a lot earlier than Airbus"
Aerostructure Tier-1

Source: Interviews; Roland Berger
Our external interviews followed a defined guideline – Focus of the questions is adjusted according to the interviewees' background

Guiding questions and panel objectives

<table>
<thead>
<tr>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market size and structure</strong> – What's your view on the overall market size? Which market segmentation do you recommend? Did you observe any changes in the market structure in the last 3 years?</td>
</tr>
<tr>
<td><strong>Market development</strong> – How do you expect the overall market size to develop until 2025? Which key growth drivers do you perceive? What changes in the forecast did you observe over the last 3 years?</td>
</tr>
<tr>
<td><strong>Market volatility</strong> – How do you rate stability of the market in general? Do you expect high volatility of the forecast for the next 3-5 years? How does the market react to potential volatility?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product segments</strong> – We propose to segment the market in automated production systems, assembly systems, composite systems, manual tools and service offerings. Which segmentation are you used to? Which market segments are expected to show the strongest growth?</td>
</tr>
<tr>
<td><strong>Product trends</strong> – Which are the key products in the market? Which technological differentiators exist? Where do you see the focus of innovation in the future? Do you perceive increased automation to boost the industry? Do you expect other &quot;Industry 4.0&quot; to influence the market?</td>
</tr>
<tr>
<td><strong>Services and service trends</strong> - How important are service offerings in general in the market? Which services are demanded/offered? How are services delivered? Which service trends do you perceive?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product/service requirements</strong> – What are general requirements of customers regarding aerostructure equipment? How do requirements vary along customer segments and regions?</td>
</tr>
<tr>
<td><strong>Buying criteria</strong> – What are key buying criteria (product features, price, service quality, brand, etc.)? How do buying criteria differ along customer/product segments and regions?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supplier landscape</strong> – Who are the main suppliers of aerostructure equipment? Can you estimate their revenue level? What are their perceived strengths/weaknesses? Are there any recent/potential entrants?</td>
</tr>
<tr>
<td><strong>Supplier trends</strong> – Do you see any trends in the supplier development, e.g. partnerships with OEMs? Do you expect a regional shift of production? Do you see a focus on core competencies at suppliers?</td>
</tr>
<tr>
<td><strong>Competition intensity</strong> – Is price development an issue for established players? Which development do you expect for the future? What drives price trends in the respective equipment segments?</td>
</tr>
</tbody>
</table>

**Key objectives**

> Derive views from key market participants on the market structure, its development and the competitor landscape

> Identify technological challenges and differentiating parameters along the key processing steps

> Integrate the customer perspective to identify potential for improvement and growth along the entire value chain of aerostructure equipment

Source: Roland Berger
Market experts expect further growth until 2020 and plateau phase until next single aisle generation will lead to market push

### Key findings – Market

<table>
<thead>
<tr>
<th>Topic</th>
<th>Findings</th>
<th>Impact</th>
<th>Interview quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant growth</td>
<td>Industry experiences a boom driven by rate increases, new programs and automation push – Further growth expected until 2020</td>
<td>↑</td>
<td>“Due to geopolitical situations and economical sanctions, Russia is currently out of focus”&lt;br&gt;Equipment manufacturer</td>
</tr>
<tr>
<td>The dip</td>
<td>Growth until 2020 expected to bridge the gap to the next generation of single aisle A/C – Plateau from 2020 to 2025 most probable scenario</td>
<td>↑</td>
<td>“There might be a plateau from 2018 until 2022”&lt;br&gt;Aerostructure Tier-1</td>
</tr>
<tr>
<td>China</td>
<td>Growth opportunities in China for established players over the next 10 years as emerging OEMs lack respective equipment know-how</td>
<td>↑</td>
<td>“In general I agree with the forecast three years ago, although it was not applicable to us due to internal order income”&lt;br&gt;Aircraft OEM</td>
</tr>
<tr>
<td>USA</td>
<td>Increased demand for aerostructure tooling equipment supported by Boeing 737MAX</td>
<td>↑</td>
<td>&quot;Within the next 10 years, the demand for tooling equipment should be secure due to lack of knowledge in China&quot;&lt;br&gt;Equipment Tier-2</td>
</tr>
<tr>
<td>Service market</td>
<td>Change towards automation and flexible production, high level of service to support OEMs – OEM outsourcing plans underpin the trend</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>Mitsubishi's regional jet will trigger demand for tooling equipment in the upcoming years, but local players expected to increase know-how</td>
<td>→</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>Price/performance ratio seen as insufficient, geopolitical situation and financial sanctions currently limit further opportunities, &quot;Buy Russian&quot; policy as further constraint of Russia as key market</td>
<td>→</td>
<td></td>
</tr>
</tbody>
</table>

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Source: Interviews; analyst reports; Roland Berger
With regard to product trends and developments, automation remains a key topic despite comparably low production volumes.

Key findings – Products

<table>
<thead>
<tr>
<th>Topic</th>
<th>Findings</th>
<th>Impact</th>
<th>Interview quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Need for fully automated assembly lines in order to meet quality requirements when rates and share of composites increase</td>
<td>↑</td>
<td>“Automation is the consequence of the high importance of quality standards” Aircraft OEM</td>
</tr>
<tr>
<td>Flexible production</td>
<td>In order to increase efficiency and decrease unit costs, manufacturing equipment should be universally deployable</td>
<td>↑</td>
<td>“Robotics for sure with potential, but need to be platform flexible” Aerostructure Tier-1</td>
</tr>
<tr>
<td>Incremental innovation</td>
<td>Incremental innovations secure sustainable demand for new tooling equipment, modifications and retrofits</td>
<td>↑</td>
<td>“Promised advantages of thermoplastics have not be proven true in reality so far” Equipment Tier-2</td>
</tr>
<tr>
<td>New technology</td>
<td>Joining methods will remain the same; glueing rather developing; importance of welding rises by time; sealing not explicitly highlighted</td>
<td>↓</td>
<td>“3D part printing could be the next big thing in aerospace parts production. Today, we see limited impact on the aerostructure equipment market” Equipment manufacturer</td>
</tr>
<tr>
<td>New materials</td>
<td>Composites gain importance; wide range of research regarding CFK, GLARE and thermoplastics</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Industry 4.0</td>
<td>Without a certain level of automation, “Industry 4.0” without major impact on A/C production industry; So far not a big topic in aerospace</td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td>3D Printing</td>
<td>3D Printing could be the next game changer, although it is still too far away to have a major impact until 2025</td>
<td>←</td>
<td></td>
</tr>
</tbody>
</table>

Source: Interviews; analyst reports; Roland Berger
OEMs' focus on core business opens new potential for integrators and service units – Additionally, new OEMs trigger overall demand

### Key findings – Customer

<table>
<thead>
<tr>
<th>Topic</th>
<th>Findings</th>
<th>Impact</th>
<th>Interview quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desire for automation</td>
<td>Automation required to meet quality standards and target times; However, knowledge needs to be transferred by suppliers</td>
<td></td>
<td>“COMAC’s current A/C design is only allowed to fly in China, Laos, Africa etc. due to negligence of safety requirements” Aircraft OEM</td>
</tr>
<tr>
<td>Outsourcing</td>
<td>Production/pre-assembly is being shifted towards supplier side; great chance for TIER-1s to benefit from increasing A/C production volume</td>
<td></td>
<td>“Due to lagging production, we do not see COMAC within the next 10 years” Equipment manufacturer</td>
</tr>
<tr>
<td>Industrial expansion</td>
<td>Established OEMs shift production sites and finishing centers towards emerging sales markets in order to meet local expectations</td>
<td></td>
<td>“Changes in outsourcing packages by Airbus and Boeing might require new tooling demands” Equipment manufacturer</td>
</tr>
<tr>
<td>Seek for integrators</td>
<td>OEMs want to have suppliers with turnkey capabilities to reduce total number of suppliers and share risks along the supply chain</td>
<td></td>
<td>“Market for tooling equipment will face constant growth the next ten years due to the introduction of automation and rate increases by A/C manufacturers” Equipment manufacturer</td>
</tr>
<tr>
<td>Emerging OEMs</td>
<td>Bombardier, Embraer and Mitsubishi are pushing into Single-Aisle A/C market; undecidedness about COMAC’s impact on industry until 2025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual sourcing</td>
<td>To decrease risk, OEMs start pursuing dual sourcing strategies; overall impact on tooling demand is negligible</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Interviews; analyst reports; Roland Berger
Market experts see turnkey capabilities as one of the most important assets of aerospace suppliers due to reduction of TIER-1s by OEMs

Key findings – Supplier

<table>
<thead>
<tr>
<th>Topic</th>
<th>Findings</th>
<th>Impact</th>
<th>Interview quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consolidation</td>
<td>The ongoing merger &amp; acquisition trend will most likely continue the upcoming years due to increased expectations from OEMs</td>
<td></td>
<td>&quot;Acquisitions have happened and will continue&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Equipment manufacturer</td>
</tr>
<tr>
<td>Turnkey capability</td>
<td>Since OEMs want to reduce total number of suppliers, turnkey and service provision combined with a global footprint gain importance</td>
<td></td>
<td>&quot;We see a concentration process in the supplier market since OEMs want to collaborate with less Tier-1s than in the past&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aerostructure Tier-1</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>There are key suppliers in the market; Besides that, there are numerous small-sized companies with local focus</td>
<td></td>
<td>&quot;OEMs look particularly for international suppliers with automotive background to benefit from their automation knowledge&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Equipment manufacturer</td>
</tr>
<tr>
<td>Newcomer</td>
<td>Despite brand recognition as a market entry barrier, automation attracts automotive suppliers to establish themselves in the aerospace industry</td>
<td></td>
<td>&quot;There are high market entry barriers in the aerospace equipment supplier market due to brand recognition and high technological standards&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Equipment Tier-2</td>
</tr>
<tr>
<td>Core competencies</td>
<td>Key suppliers usually have developed their core competencies that give them a distinct position in the market</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Interviews; analyst reports; Roland Berger
B. Market model
The aerostructure equipment market is driven by global aircraft production – Key drivers are new programs and rate increases

Macroeconomic view on markets and drivers

**Drivers for global aircraft production**
- 1. World economics (GDP)
- 2. World population
- 3. Flight volume
- 4. Political influences & legislative factors
- 5. Utilization & load factor
- 6. Oil price

**Secondary drivers for the aerostructure equipment market**
- Increased automation
- New technologies
- New competitors
- Industrial expansion
- Dual sourcing

**Primary drivers for the aerostructure equipment market**
- Rate increases of legacy programs
- New A/C programs

Source: Roland Berger
The market estimation is based on civil and military A/C comprising LCA, regional & business jets, jet fighters, freighters, and helicopters.

### Definition of aircraft segments in scope

<table>
<thead>
<tr>
<th>Civil aircraft</th>
<th>Military aircraft</th>
<th>Rotorcraft</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Large Commercial</strong></td>
<td><strong>Jet Fighter</strong></td>
<td><strong>Helicopter</strong></td>
</tr>
<tr>
<td>Aircrafts with capacity 100+ seats</td>
<td>Fixed-wing or variable-geometry wing armed aircrafts</td>
<td>Rotorcrafts with vertical takeoff and landing ability</td>
</tr>
<tr>
<td><strong>Regional Jets</strong></td>
<td><strong>Freighter</strong></td>
<td></td>
</tr>
<tr>
<td>Aircrafts with capacity between 25 and 90 seats</td>
<td>Transport aircrafts developed for military load transportation</td>
<td></td>
</tr>
<tr>
<td><strong>Business Jets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger aircrafts with capacity &lt; 25 seats</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Part of Textron Aviation

Source: Roland Berger
Growing world economy, population and demand for passenger and cargo air traffic are the key drivers for increased aircraft production

### Drivers for global aircraft production

<table>
<thead>
<tr>
<th>Driver</th>
<th>Description</th>
<th>Driver impact&lt;sup&gt;1)&lt;/sup&gt;</th>
<th>To date</th>
<th>In future</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 World economics (GDP)</td>
<td>&gt; Long-term economic outlook for the global market remains bright</td>
<td>↗</td>
<td></td>
<td>↗</td>
</tr>
<tr>
<td></td>
<td>&gt; Demand and production of aircrafts is expected to grow accordingly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 World population</td>
<td>&gt; Wealth increase and population growth in emerging economies will drive the increased need for aircrafts</td>
<td>↗</td>
<td></td>
<td>❯</td>
</tr>
<tr>
<td>3 Flight volume</td>
<td>&gt; Flight volume has proven to be resilient to external shocks</td>
<td>↗</td>
<td></td>
<td>↑</td>
</tr>
<tr>
<td></td>
<td>&gt; Volume is estimated to double in next 15 years boosting aircraft production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Political influences &amp; legislative factors</td>
<td>&gt; Production will shift regionally to China and Mexico, and technologically to higher efficient aircraft types; production constraints in Russia and South America</td>
<td>↗</td>
<td></td>
<td>❯</td>
</tr>
<tr>
<td>5 Utilization &amp; load factor</td>
<td>&gt; Aircraft production is constrained by utilization and load factors; improved loading, higher utilization and bigger aircrafts reduced aircraft demand in past</td>
<td>↘</td>
<td></td>
<td>❯</td>
</tr>
<tr>
<td>6 Oil price</td>
<td>&gt; Short-term low oil prices boost airline profitability, long-term future rise in oil price will promote demand for higher efficient aircrafts and early replacements</td>
<td>↗</td>
<td></td>
<td>❯</td>
</tr>
</tbody>
</table>

<sup>1)</sup> General impact across multiple countries; exceptions in specific cases possible

Source: Roland Berger
Overall, long-term economic outlook for the global market remains bright leading to an increasing demand and production of aircrafts.

**World economics (GDP)**

**World real GDP/passenger traffic growth**

<table>
<thead>
<tr>
<th>Year</th>
<th>World real GDP</th>
<th>World passenger traffic (ASK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>2009</td>
<td>-2%</td>
<td>0%</td>
</tr>
<tr>
<td>2010</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>2011</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>2012</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>2013</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>2014</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>2015</td>
<td>11%</td>
<td>13%</td>
</tr>
<tr>
<td>2016</td>
<td>13%</td>
<td>15%</td>
</tr>
</tbody>
</table>

**Impact on aircraft production**

- Personal income influencing propensity to travel
- GDP growth enabling world passenger traffic (Available Seat Kilometers); over-performance in the last years
- Growing wealth in emerging markets triggering accessibility of air traffic
- Global economy catalyzing urbanization and emergence of middle class, which both are key to expansion of airline industry
- Shift of demand and production to emerging markets

**2014 trips per capita [#]**

- India: 0.30
- China: 0.30
- Europe: 1.21
- North America: 1.63

**2034 trips per capita [#]**

- India: 0.30
- China: 1.09
- Europe: 2.24
- North America: 2.16

Source: Airbus; Boeing; Roland Berger
In conjunction with wealth increase and population growth, emerging economies will drive the increased need for aircrafts.

World population [m]

<table>
<thead>
<tr>
<th>CAGR 2015-2030</th>
<th>Population</th>
<th>RPK&lt;sup&gt;1)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emerging markets</td>
<td>+1%</td>
<td>+6%</td>
</tr>
<tr>
<td>Mature markets</td>
<td>±0%</td>
<td>+4%</td>
</tr>
</tbody>
</table>

Impact on aircraft production

- Growing global population increasing potential passengers, need for air cargo, and thus demand for additional aircrafts
- Private consumption becoming important growth driver in emerging markets
- Emerging markets with high populations showing high Revenue Passenger Kilometer growth rates

Source: United Nations, Department of Economic and Social Affairs; Roland Berger
Flight volume has proven to be resilient to external shocks and is estimated to double in next 15 years boosting aircraft production.

**World annual traffic [revenue passenger kilometer tr]**

- Oil crisis
- Oil crisis
- Gulf crisis
- Asian crisis
- 9/11 SARS
- Financial crisis

Impact on aircraft production:

> Despite external shocks, air travels and air cargo resilient to ruptures; always returning to its historical trend over the long term.

> Continuous Revenue Passenger Kilometer (RPK) and Revenue Tonne Kilometer (RTK) growth of 4.5 – 5.0% p.a.; flight volume will more than double in next 15 years.

> Asian and Middle East air volume gaining more importance.

> Overall reliable growth of airplane demand expected.

**World air cargo traffic [revenue tonne kilometer bn]**

Source: IATA; ICAO (scheduled traffic); Airbus; Boeing; Roland Berger

- Strong impact
- Average impact
- Slow impact
Political and legislative changes also shape the market – Shift in production countries; trend to lower fuel burn aircrafts

4 Political influences & legislative factors

- „Flight Path 2050“ to reduce CO₂-emissions by 75% and NO₂-emissions by 90%[1] in air traffic
- Further liberalization and deregulation of airspace (Single European Sky)
- Supportive political arrangements, e.g. NAFTA, WA[2], BASA[3]
- Strategic value of engineering expertise, quality and competitiveness of workforce
- Investments, e.g. USD 500 m Bombardier 2005-2015
- Aggravating market for foreigners due to complex tax, tariffs, customs and legal system
- Infrastructure projects for Olympic Games 2016
- WTO pressure to lift trade restrictions
- Import substitution strategy due to geopolitical tension with EU and US
- Dependency on western made air components for Russian aircraft projects
- Government investment of USD 80 bn in aviation infrastructure projects 2015
- Financial framework agreement providing COMAC USD 8 bn for R&D, manufacturing & sales support

Impact on aircraft production

- Political crises and tensions effecting air space; limitations in short- and mid-term
- Benefited from supportive politics and subventions, aircraft production shifting to East Asia and Mexico
- Lower fuel burn and emission requirements, especially in the EU, boosting trend of more efficient aircraft types and economical engines
- Protectionism in Brazil and Argentina under pressure of developed countries and WTO

1) Compared to 2000  2) Wassenaar Arrangement  3) Bilateral Aviation Safety Agreement

Source: Roland Berger
However, as aircraft utilization and load factors have risen, aircraft production logging behind growth in flight volume demand.

**Utilization & load factors**

- **World passenger load factors [%]**
  - 1980: 50%
  - 1985: 55%
  - 1990: 60%
  - 1995: 65%
  - 2000: 70%
  - 2005: 75%
  - 2010: 80%
  - 2015: +17%

- **Yearly offered seats per aircraft [# k]**
  - 1980: 100
  - 1985: 110
  - 1990: 120
  - 1995: 130
  - 2000: 140
  - 2005: 150
  - 2010: 160
  - 2015: +46%

- **World annual air traffic vs. aircraft fleet [2014 = 1]**
  - Passenger Aircraft Fleet
  - Revenue Passenger Kilometer
  - 2014: 1
  - 2016: 2
  - 2018: 3
  - 2020: 4
  - 2022: 5
  - 2024: 6
  - 2026: 7
  - 2028: 8
  - 2030: 9
  - 2032: 10
  - 2034: +46%

**Impact on aircraft production**

- Aircraft production constrained by further increase of utilization and load factors; past drivers:
  - Launch of jumbo widebody jets (A380-800, 747-8)
  - Consolidation of routes through airline alliances
  - Process and maintenance improvements
Oil price has gone through significant ups and downs in the past years – Long-term growth forecasted, but uncertainty increases

Oil price [USD/barrel, average]

Impact on aircraft production

> Fuel price averaging 25-30% of airline cost structure
> Despite low oil prices, airlines further focusing on cost reduction and producers launching new enhanced models of current families (e.g. Airbus A320neo, Boeing 737 MAX 8)
> Future rise in oil price promoting demand for higher efficient aircrafts and early replacements

Source: Bloomberg, IMF; Airbus; Roland Berger
The resulting forecast for aircraft production shows 60,300 units of new aircraft to be produced between 2015 and 2025

Global aircraft production forecast [units]

Note: Rounding differences may occur

Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger

Rationale

> Yearly rising air traffic volume reflected in overall A/C production CAGR of 2.2%
> Even higher rate increases fuel demand for aircrafts within next years
> Civil A/C production as main driver of market growth
> Both helicopters and military aircrafts forecast production downturn
The resulting forecast for large commercial aircraft production shows 20,500 new LCAs to be produced between 2015 and 2025.

Global LCA production forecast [units]

Note: Rounding differences may occur; COMAC with annual production volumes of up to 5 A/C and Irkut with up to 84 A/C and therefore below 1% (excluded for presentation purposes)

Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger

Rationale

> LCA production by established OEMs Airbus and Boeing as key drivers for overall market growth
> Airbus with highest LCA production forecast
> A/C production by emerging OEMs mainly driven by Bombardier; However, overall market impact is negligible
> Irkut with estimated production volume of 84 MS-21 in 2025
> COMAC with estimated volume of 5 C919 in 2025
The aerostructure equipment market is driven by global aircraft production – Key drivers are new programs and rate increases

Drivers and modeling of global aerostructures equipment market

**Primary drivers for the aerostructure equipment market**

1. Rate increases of legacy programs
2. New A/C programs

**Secondary drivers for the aerostructure equipment market**

3. Increased automation
4. New technologies
5. New competitors
6. Industrial expansion
7. Dual sourcing

**Investment matrix**

Source: Roland Berger
Rate increases and new A/C programs are the key trigger for investments into aerostructure production equipment

Drivers for aerostructure equipment market

<table>
<thead>
<tr>
<th>Driver</th>
<th>Description</th>
<th>Impact to date ¹)</th>
<th>Future impact ¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rate increases of legacy programs</td>
<td>&gt; Major legacy programs are expected to increase rates in the upcoming years, thus retrofits and services demand will not cave in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 New A/C programs</td>
<td>&gt; New aircraft programs will increase the need for additional tooling machinery and engineering services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Increased automation</td>
<td>&gt; The current production lines still have automation opportunities; reducing &quot;touch labor&quot; to increase quality and cost efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 New technologies</td>
<td>&gt; New technologies on the rise since established OEMs need meet new cost targets and quality requirements to remain competitive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 New competitors</td>
<td>&gt; Emerging OEM countries and newly entering competitors from other industries challenge established aerospace suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Industrial expansion</td>
<td>&gt; First projects have shown trend of OEMs to build up production in emerging markets opening new chances for equipment industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Dual sourcing</td>
<td>&gt; New procurement strategies by major OEMs will most likely result in both benefits and drawbacks for equipment suppliers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹) General impact across multiple countries; exceptions in specific cases possible

Source: Roland Berger
Major legacy programs are expected to increase rates in the upcoming years, thus retrofits and services demand will not cave in.

1. Rate increases of legacy programs [A/C per month]

![Graphs showing rate increases of legacy programs for Airbus 319-321 (incl. neo), Airbus 380 (incl. neo), Airbus 350, Boeing 737 (incl. max), Boeing 777 (incl. 777X), and Boeing 787.]

**Impact on equipment market**

- According to increase of aircraft demand growing production of major legacy programs in total expected.
- Demand for retrofit of machinery and additional services staying stable or even growing.

Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger
New aircraft programs will increase the need for additional tooling machinery and engineering services

New aircraft programs [A/C per month]

**Impact on equipment market**

- All major players launching new or advanced aircraft programs in the upcoming five years
- Along with new aircraft programs building of new fabrication lines
- Developing enhanced and adapted machinery to new production requirements
- Requiring services for the design, development and implementation of the new production lines, turnkey and engineering capabilities getting more important

Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger
The current production lines still have automation opportunities – Reducing "touch labor" to increase quality and cost efficiency

3 Increased automation

- Automated guided drilling/riveting robots in assembly lines
- Time, cost and quality improvements

- Fuselage assembly for future programs
- Increasing overall quality and workers safety and reducing cost

- Movable robotic platform for flexible applications
- Development of human and robot collaborative applications

Impact on equipment market

- Further automation effort of OEMs driving demand of automated tooling machinery
  - Developing new enhanced tooling machinery
  - Developing low-price, functional tooling machinery for smaller OEMs
- Need for building up further engineering capabilities and core competencies to develop these advanced machinery
- Solution still under development, further testing and capability for industrialization to be proven

Impact to date ➤ Impact in future ➤

Strong impact ➤ Average impact ➤ Slow impact

Source: Boeing; Broetje Automation; Cranfield University; Comau; Roland Berger
New technologies on the rise since established OEMs need meet new cost targets and quality requirements to remain competitive

New technologies

Robotics fastening

- Desire for automation in order to meet quality requirements and reduce touch labor
- Introduction of a high degree of robotic application at A/C manufacturing expected

Welding

- In order to reduce costs and decrease quality variances, companies expend R&D effort on new joining methods such as friction stir welding
- Riveting as major fastening method could be replaced at minor important parts

Sealing

- Sealing will gain importance in aerostructure tooling equipment applications as consequence of automation efforts

Glueing

- After successful introduction in other industries (e.g. automotive), aerospace manufacturers consider glueing as an alternative joining method
- Large temperature differences still challenge glueing as applicable joining method

Impact on equipment market

- Research on and first introductions of alternative fastening methods shorten replacement cycles of existing machinery
- Importance of robotic applications will increase order to meet industry need to implement automation
- As soon as benefits of automation have proven true, market for equipment will most likely experience strong demand for fully-automated solutions

Source: Roland Berger
Emerging OEM countries and newly entering competitors from other industries challenge established aerospace suppliers

New competitors

**Russian protective measures**
- Impact to date: Russia takes protective measures within the aerospace industry in order to support local companies and keep the value chain within its borders.
- Impact in future: The current geopolitical situation aggravates suppliers' position.

**Chinese knowledge transfer**
- Impact to date: COMAC as the emerging Chinese OEM triggers demand for foreign aerospace tooling equipment due to the lack of required knowledge within China.
- Impact in future: As soon as capabilities are built, decrease of demand expected.

**Automotive integrators**
- Impact to date: Increasing production rates, outsourcing trends and dual sourcing provide opportunities for new suppliers from other industries.
- Impact in future: Aerospace requirements not easy to reach, but rising number of functional requirement based RFQs.

**Frugal competitors**
- Impact to date: Emerging OEMs in low cost countries require simple tooling equipment to meet price levels.
- Impact in future: Opportunities of strategic reorientation for existing suppliers and the chance for newcomers to enter the market will arise.

**Impact on equipment market**
- Favorable situation for new suppliers to enter the aerospace tooling equipment market.
- Good chance for equipment suppliers that do not meet high end technology requirements to serve emerging markets.
- Upcoming OEMs establish new sales markets.
- Degree of protectionism of newly established OEM countries needs to be reviewed carefully in order to evaluate impact on the worldwide equipment market.

---

Source: Roland Berger
First projects have shown trend of OEMs to build up production in Emerging markets opening new chances for equipment industry

**Industrial expansion**

**China - Boeing finishing center**
- Impact to date
  - Case: 2015, reaching deal to build 737 finishing center and along with selling 300 planes to Chinese companies
- Impact in future
  - Rationale: China starting to import know-how from developed countries in exchange for opening sales opportunities

**Japan - Boeing wing production**
- Impact to date
  - Case: Japanese engineers supporting design and construction of Boeing programs; Mitsubishi and Kawasaki suppliers of e.g. wings and fuselage sections
- Impact in future
  - Rationale: Boeing using Japanese engineering capabilities

**USA - Airbus final assembly line**
- Impact to date
  - Case: 2015, opening of final assembly line in Alabama, first time foreign manufacturer building jets on US soil
- Impact in future
  - Rationale: Low logistic and manufacturing costs, non-unionized workforce, as well as manufacturing in “Dollar-Zone”

**Mexico – Production shift**
- Impact to date
  - Case: Supportive political arrangements enabling production shift to Mexico, e.g. investments from Bombardier of USD 500 m in last 10 years
- Impact in future
  - Rationale: Strategic value of engineering expertise, quality and competitiveness Mexican workforce

**Impact on equipment market**
- Production of aircraft shifting to East Asia and Americas due to increased demand in emerging markets and competitive production advantages
- Opening of new sales potentials for European aerostructure market industry
- In the long run, developing of own capabilities and know-how in emerging markets; rising new competitors

Source: Roland Berger
New procurement strategies by major OEMs will most likely result in both benefits and drawbacks for equipment suppliers

Dual sourcing

"Airbus has decided to accelerate dual-sourcing for the single-aisle A320, and where needed to maintain backup facilities or limited buffer stocks"

Aircraft OEM

"Airbus has told suppliers that the prospect of increased volumes and a longer lifespan for its best-selling jet ... it is time to "review all options" in its supply chain. This includes a fresh look at the company’s procurement strategy that could include extra use of dual sourcing for crucial parts: a strategy designed both to reduce costs and to reduce the risks of shortfalls as production increases."

Thomson Reuters

"The dual-sourcing [plan] is about business continuity and getting better commercial terms where we can. There are certainly suppliers who have taken advantage of a unique position in the supply chain and used it, I think, to earn unreasonable profits"

Aircraft OEM

Positive market impacts

- Higher production rates force OEMs to broaden their supplier range
- Dual sourcing applied in order to mitigate risk regarding supply chain

Negative market impacts

- Resulting competition will cut current price levels
- Chance of business continuity decreases due to direct comparison to key competitors

Impact
to date

Impact in future

Source: Web research; Roland Berger
The modelling logic builds on a wide range of parameters to define aerostructure tooling spend and distribution

### Key assumptions

<table>
<thead>
<tr>
<th>Market drivers</th>
<th>Key parameters</th>
<th>Rationale</th>
<th>Input range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate increases of legacy programs</td>
<td>&gt; Production volume [units]</td>
<td>&gt; 2015 Teal Group data modified by Roland Berger insights, interviews and desk research</td>
<td>&gt; 0-63 units/month</td>
</tr>
<tr>
<td>New A/C programs</td>
<td>&gt; Program tooling spend [USD m]</td>
<td>&gt; Total aerostructure tooling spend per A/C program as a function of empty operating weight, performance, and predecessor history</td>
<td>&gt; USD 9-3,045 m</td>
</tr>
<tr>
<td>Increased automation</td>
<td>&gt; Investment lead time [yrs]</td>
<td>&gt; Production ramp-up requires lead time for investment and production setup</td>
<td>&gt; 2-6 years</td>
</tr>
<tr>
<td>New technologies</td>
<td>&gt; Replacement cycles [yrs]</td>
<td>&gt; Forecast of retrofit cycles for defined segment of installed base</td>
<td>&gt; 8-15 years</td>
</tr>
<tr>
<td>New competitors</td>
<td>&gt; Replacement value [%]</td>
<td>&gt; Retrofit value undercuts original investment</td>
<td>&gt; 30-50%</td>
</tr>
<tr>
<td>Industrial expansion</td>
<td>&gt; Efficiency increase through upgrades/retrofit [%]</td>
<td>&gt; Cost savings from efficiency increase in retrofit compared to installed base</td>
<td>&gt; 10% on average</td>
</tr>
<tr>
<td>Dual sourcing</td>
<td>&gt; Efficiency increase through learning effects [%]</td>
<td>&gt; Cost savings from production experience</td>
<td>&gt; 3% of recurring costs/unit</td>
</tr>
<tr>
<td></td>
<td>&gt; Segment shares per A/C program [%]</td>
<td>&gt; Share of predefined market segments in tooling changes for respective A/C programs</td>
<td>&gt; 5-50%</td>
</tr>
<tr>
<td></td>
<td>&gt; Service content/value [%]</td>
<td>&gt; Service potential differentiating between operational services and turnkey/integration</td>
<td>&gt; 3% annually</td>
</tr>
</tbody>
</table>

Source: Roland Berger
Investment modeled along production ramp-up – Initial invest 2-6 years prior to EIS, first upgrades and retrofits 8 years after EIS

Investment and decision timeline

**Equipment invest**

1. **Initial invest**
   - First installation of production equipment for new A/C programs
   - 2-6 years prior to EIS of the first A/C
   - Equipment ramp-up generally follows production ramp-up with a bias towards first installments

2. **Upgrades/retrofit**
   - First equipment upgrade 8-15 years after EIS
   - Major driver for upgrades is productivity increase without new installation

Source: Roland Berger
Market forecasted to steadily grow at yearly rate of 1.6% between 2012 and 2020 – Year of 2015 expected exceptionally strong

Aerostructure equipment market by delivery type [USD m]

Rationale

> The next years will be characterized by a shift of OEM focus from new A/C development to manufacturing and operations
> Further rate increases, higher quality demands, and additional cost pressure will lead to an enforced push for automation
> Peak investment in 2015 due to agglomeration of various programs such as A320neo, A330neo, B737max, C919, ERJ 190/195-E2, MS-21, MRJ, Dassault Falcon 5X,
> Market level of EUR 2.0 bn expected to be maintained until 2020

Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger
Market volatility driven by investment schedules – Upgrades/retrofits and service with stable growth due to increasing installed base

Aerostructure equipment market by delivery type [USD m]

Rationale

> Initial investments expected to be more balanced 2015 and 2020 but to decrease in overall terms
> Constantly growing installed base with high need for automation and rather short upgrade/retrofit cycles lead to overall constant market
> Upgrades/retrofit and service business expected to outperform overall growth with estimated annual growth rates of 5-6%

Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger
Regarding market segments we expect stable growth of APS and growth of Stations/Lines due to higher automation in that area

Global market for aerostructure equipment [EUR m]

<table>
<thead>
<tr>
<th>2015 – Σ 1,984</th>
<th>2020 – Σ 2,021</th>
</tr>
</thead>
<tbody>
<tr>
<td>988 (50%)</td>
<td>1,005 (50%)</td>
</tr>
<tr>
<td>525 (26%)</td>
<td>509 (25%)</td>
</tr>
<tr>
<td>163 (8%)</td>
<td>120 (6%)</td>
</tr>
<tr>
<td>309 (16%)</td>
<td>387 (19%)</td>
</tr>
</tbody>
</table>

Impact on equipment market

> Automated production systems represent the solid foundation of the market with a constant share of 50%
> Conveyor systems and small tools lose some importance as their automation level is low per definition
> Service will gain importance driven by increased installed base and new service offerings such as increased use of integrated data and remote surveillance
> Stations/Lines with slight increase due to automation push

Note: APS = Automated production systems, AAS = Automated assembly systems; ST = Small tools; OS = Operational services; Rounding differences may occur
C. Forecast scenarios
3 scenarios are used to describe the uncertainties in the market – Key modelling parameter is production rate of new/legacy programs

Scenario overview

1. Scenario 1  
   The "dip"
   - Legacy rate increase as forecasted today
   - Next generation single aisle
   - Scenario assumptions:
     > Lack of major new A/C programs will stall demand for tooling equipment
     > No major changes in production rates
     > Currently installed base is sufficient to cover forecasted demand

2. Scenario 2  
   Further rate increases
   - Legacy rate increase as forecasted today
   - Next generation single aisle
   - Further rate increases to bridge gap
   - Scenario assumptions:
     > Currently high demand will further intensify
     > Automation and more efficient assembly lines are required to cope with output, cost, and quality levels

3. Scenario 3  
   Early next generation
   - Legacy rate increase as forecasted today
   - Next generation single aisle to bridge gap
   - Scenario assumptions:
     > Current MAX and neo generations are insufficient to satisfy client demand over 10+ years or sustain respective market share in duopolistic market

Source: Roland Berger
We support the market believe in further rate increases to fulfill the projected traffic need – Automation will be the second key driver

Scenario assessment

1. **Scenario 1**
   - The "dip"

2. **Scenario 2**
   - Further rate increases

3. **Scenario 3**
   - Early next generation

**Roland Berger hypothesis**

1. **Scenario 1**
   - Unlikely case as cost pressures, rate increases, and quality assurance continue to call for higher productivity

2. **Scenario 2**
   - Most likely scenario (already materializing with Airbus' ambitious A320 rate of 63 A/C per month) as limited technological innovation requires significant new developments

3. **Scenario 3**
   - Current ramp-ups of mass-volume programs A320neo and 737MAX do not indicate need for next generation within the next 10 years (contrary to A380 case)

Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger
D. Roland Berger in Aerospace & Defense
We support Aerospace & Defense clients with strategic and operational transformations

<table>
<thead>
<tr>
<th>Strategy/M&amp;A</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Corporate strategy and portfolio management</td>
<td>&gt; Post merger integration</td>
</tr>
<tr>
<td>&gt; Services and support development strategy</td>
<td>&gt; R&amp;D efficiency/product policy and innovation</td>
</tr>
<tr>
<td>&gt; Marketing/business capture</td>
<td>&gt; Program management efficiency</td>
</tr>
<tr>
<td>&gt; Mergers &amp; acquisitions/alliances</td>
<td>&gt; Supply chain optimization</td>
</tr>
<tr>
<td>&gt; Corporate/BU organization redesign</td>
<td>&gt; Purchasing and supplier management optimization</td>
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<tr>
<td>A&amp;D Practice</td>
<td>&gt; Manufacturing performance optimization</td>
</tr>
<tr>
<td>&gt; 30+ senior industry experts</td>
<td></td>
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<tr>
<td>&gt; Coverage of civil and Defense sectors</td>
<td></td>
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<tr>
<td>&gt; Ability to work with top management and operational teams</td>
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<tr>
<td>&gt; Expertise of core and functional processes of the industry</td>
<td></td>
</tr>
<tr>
<td>&gt; Experience based on more than 30 projects p.a. since 2000</td>
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</tr>
</tbody>
</table>

Source: Roland Berger
Our senior A&D specialists work with top management and operational teams on a global basis
Our A&D insights are based on a deep understanding of the industry across the entire value chain – Example of clients

**OEM/prime contractors**

- AIRBUS
- SAFRAN
- THALES
- AIRBUS DEFENCE & SPACE
- BAE SYSTEMS
- UAC
- AIRBUS HELICOPTERS
- NEXTER
- TATA MOTORS
- Kongsberg Defence & Aerospace
- MBDA
- Navantia
- EMBRAER
- OHB
- Finmeccanica
- Odebrecht

**Tier-1 players**

- MT AEROSPACE
- SELEX
- Zodiac Aerospace
- MTU
- DASA
- EADS
- Thales
- Airbus Military
- Safran
- Leonardo
- Alenia Aermacchi
- ALESTIS
- TATI
- STELIA
- DISHL
- SERCO
- RUAG
- Eureonico
- ESG
- Rolls-Royce
- Spirit Aerosystems
- QinetiQ
- Cobham
- GE Aviation
- FFG
- Aerospatiale
- Aérospatiale

**Governments/institutions**

- ESA
- COMMISSION EUROPEENNE
- DGA
- EUROPEAN DEFENCE AGENCY
- European GNSS Agency
- SATELLITE EUROPE
- DEPARTMENT OF DEFENCE
- MINISTRY OF DEFENCE
- DLR
- BDI

Source: Roland Berger
In parallel to our project work, we continuously scan trends of the industry to help our clients anticipate evolutions and revolutions.

Selected recent studies:

- A&D Program Management
- A&D Management Issue Radar Study
- Cyber security Point of view
- Transfer of Technology Speech
- European Defense Quo vadis? Point of view
- European A&D industry Study
- Indian A&D opportunity Point of view

Source: Roland Berger
We are happy to offer you a more detailed review of the study results and to discuss any further related topics with you.

Your contacts

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CC Engineered Products & High Tech  
Expert in Aerospace

Source: Roland Berger