Aerostructure equipment market

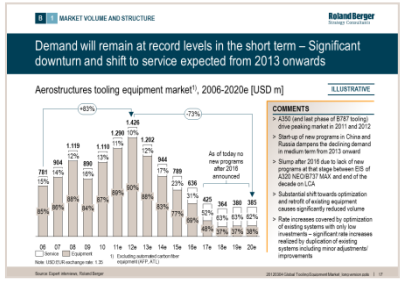
Study report

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

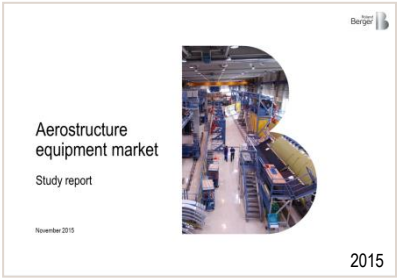
> Therefore, the key question was: **Has the expected downturn only been deferred or are we experiencing a sustainable long-term market stabilization?**

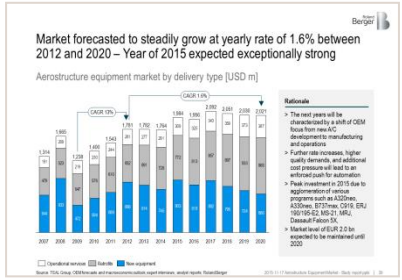
Objective

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 & competitors

The market for aerostructure equipment can be categorized in 6 segments – Metal parts production out of scope

Market segmentation

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

Metal parts production and related technologies are **out of scope**

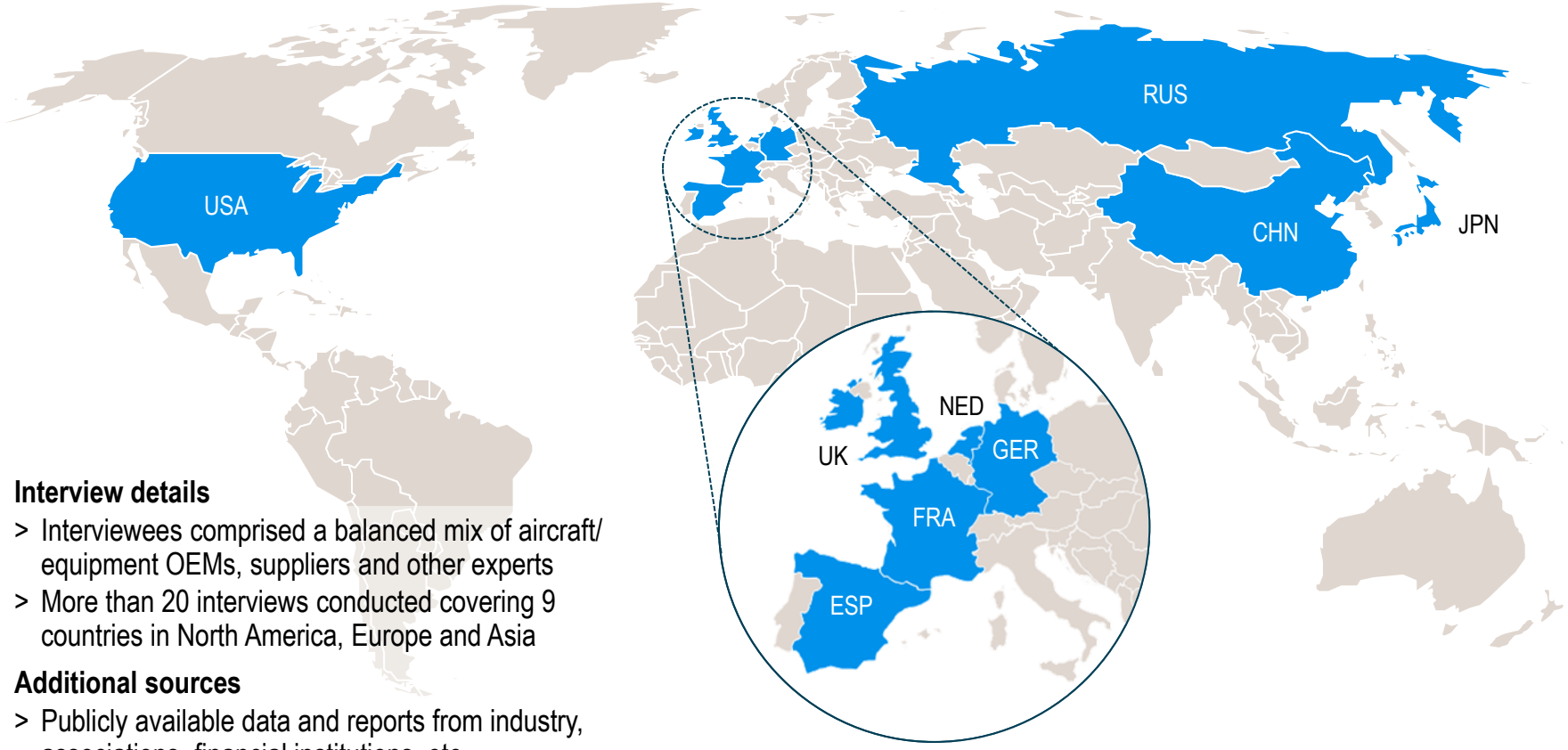
> Drilling
> Milling
> Turning
> Cutting
> Bending
> Drawing
> Forming
> Shaping
> …

1) Selection only, not exhaustive

Source: Roland Berger

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

Market	> **Market size and structure** – 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? > **Market development** – 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? > **Market volatility** – 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?
Products	> **Product segments** – 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? > **Product trends** – 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 "Industry 4.0" to influence the market? > **Services and service trends** - 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?
Customers	> **Product/ service requirements** – What are general requirements of customers regarding aerostructure equipment? How do requirements vary along customer segments and regions? > **Buying criteria** – What are key buying criteria (product features, price, service quality, brand, etc.)? How do buying criteria differ along customer/product segments and regions?
Suppliers	> **Supplier landscape** – 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? > **Supplier trends** – 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? > **Competition intensity** – 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?

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**

Topic	Findings	Impact
Constant growth	Industry experiences a boom driven by rate increases, new programs and automation push – Further growth expected until 2020	↑
The dip	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	↑
China	Growth opportunities in China for established players over the next 10 years as emerging OEMs lack respective equipment know-how	↑
USA	Increased demand for aerostructure tooling equipment supported by Boeing 737MAX	↑
Service market	Change towards automation and flexible production, high level of service to support OEMs – OEM outsourcing plans underpin the trend	↗
Japan	Mitsubishi's regional jet will trigger demand for tooling equipment in the upcoming years, but local players expected to increase know-how	→
Russia	Price/performance ratio seen as insufficient, geopolitical situation and financial sanctions currently limit further opportunities, "Buy Russian" policy as further constraint of Russia as key market	→

↑ Strong impact ↗ Average impact → Low impact

Interview quotes

"Due to geopolitical situations and economical sanctions, Russia is currently out of focus"
Equipment manufacturer

"There might be a plateau from 2018 until 2022"
Aerostructure Tier-1

"In general I agree with the forecast three years ago, although it was not applicable to us due to internal order income"
Aircraft OEM

"Within the next 10 years, the demand for tooling equipment should be secure due to lack of knowledge in China"
Equipment Tier-2

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**

Topic	Findings	Impact
Automation	Need for fully automated assembly lines in order to meet quality requirements when rates and share of composites increase	↑
Flexible production	In order to increase efficiency and decrease unit costs, manufacturing equipment should be universally deployable	↑
Incremental innovation	Incremental innovations secure sustainable demand for new tooling equipment, modifications and retrofits	↗
New technology	Joining methods will remain the same; glueing rather developing; importance of welding rises by time; sealing not explicitly highlighted	↗
New materials	Composites gain importance; wide range of research regarding CFK, GLARE and thermoplastics	↗
Industry 4.0	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	→
3D Printing	3D Printing could be the next game changer, although it is still too far away to have a major impact until 2025	→

↑ Strong impact ↗ Average impact → Low impact

Interview quotes

"Automation is the consequence of the high importance of quality standards"
Aircraft OEM

"Robotics for sure with potential, but need to be platform flexible"
Aerostructure Tier-1

"Promised advantages of thermoplastics have not be proven true in reality so far"
Equipment Tier-2

"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

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**

Topic	Findings	Impact
Desire for automation	Automation required to meet quality standards and target times; However, knowledge needs to be transferred by suppliers	↑
Outsourcing	Production/pre-assembly is being shifted towards supplier side; great chance for TIER-1s to benefit from increasing A/C production volume	↑
Industrial expansion	Established OEMs shift production sites and finishing centers towards emerging sales markets in order to meet local expectations	↑
Seek for integrators	OEMs want to have suppliers with turnkey capabilities to reduce total number of suppliers and share risks along the supply chain	↗
Emerging OEMs	Bombardier, Embraer and Mitsubishi are pushing into Single-Aisle A/C market; undecidedness about COMAC's impact on industry until 2025	↗
Dual sourcing	To decrease risk, OEMs start pursuing dual sourcing strategies; overall impact on tooling demand is negligible	→

↑ Strong impact ↗ Average impact → Low impact

Interview quotes

"COMAC's current A/C design is only allowed to fly in China, Laos, Africa etc. due to negligence of safety requirements"
Aircraft OEM

"Due to lagging production, we do not see COMAC within the next 10 years"
Equipment manufacturer

"Changes in outsourcing packages by Airbus and Boeing might require new tooling demands"
Equipment manufacturer

"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

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**

Topic	Findings	Impact
Consolidation	The ongoing merger & acquisition trend will most likely continue the upcoming years due to increased expectations from OEMs	↑
Turnkey capability	Since OEMs want to reduce total number of suppliers, turnkey and service provision combined with a global footprint gain importance	↑
Fragmentation	There are key suppliers in the market; Besides that, there are numerous small-sized companies with local focus	↗
Newcomer	Despite brand recognition as a market entry barrier, automation attracts automotive suppliers to establish themselves in the aerospace industry	↗
Core competencies	Key suppliers usually have developed their core competencies that give them a distinct position in the market	↗

↑ Strong impact ↗ Average impact → Low impact

Interview quotes

"Acquisitions have happened and will continue"
Equipment manufacturer

"We see a concentration process in the supplier market since OEMs want to collaborate with less Tier-1s than in the past"
Aerostructure Tier-1

"OEMs look particularly for international suppliers with automotive background to benefit from their automation knowledge"
Equipment manufacturer

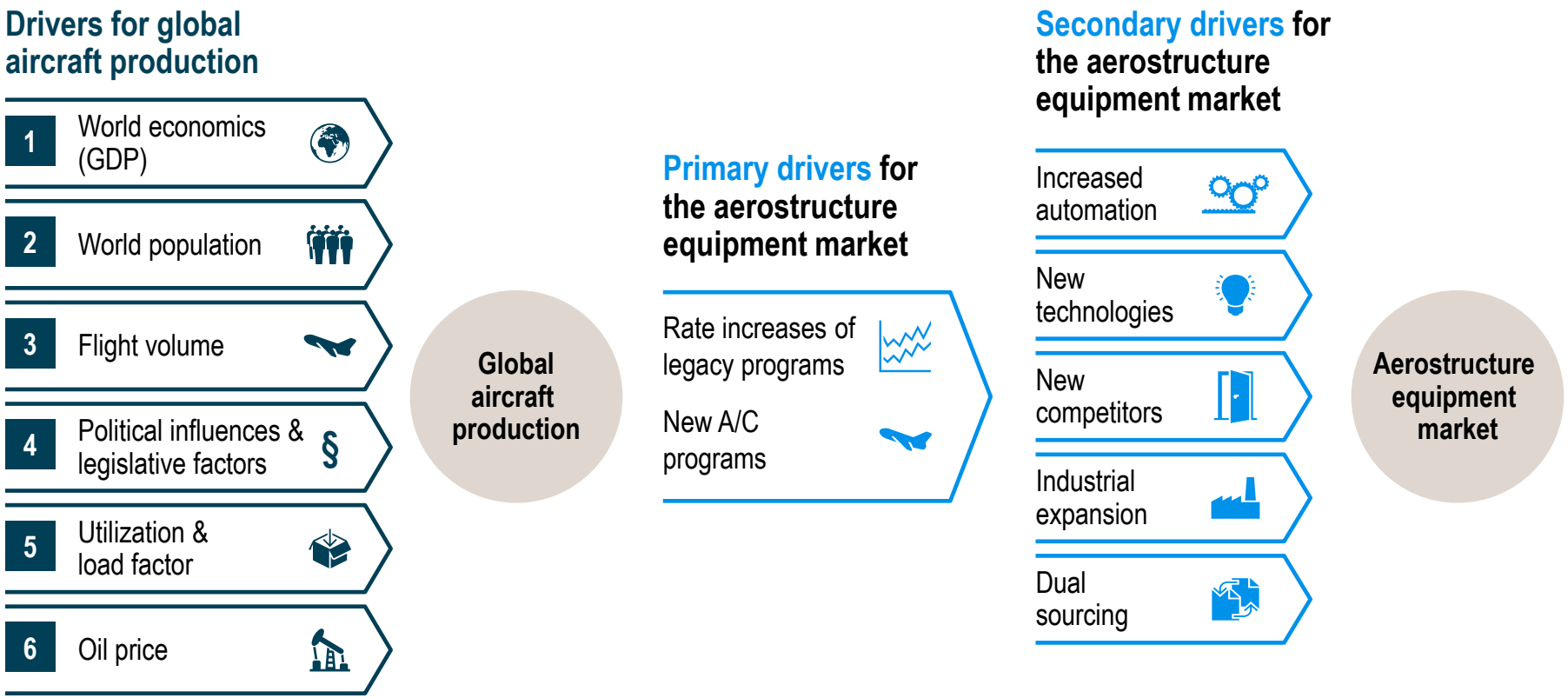
"There are high market entry barriers in the aerospace equipment supplier market due to brand recognition and high technological standards"
Equipment Tier-2

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



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

Civil aircraft

Large Commercial

Aircrafts with capacity 100+ seats

- AIRBUS
- BOEING
- COMAC 中国商飞
- BOMBARDIER the evolution of mobility
- IRKUT / ИРКУТ

Regional Jets

Aircrafts with capacity between 25 and 90 seats

- ATR PROPELLING THE NEXT CONNECTION
- EMBRAER
- BOEING
- SUKHOI
- MITSUBISHI HEAVY INDUSTRIES, LTD.

Business Jets

Passenger aircrafts with capacity < 25 seats

- BOMBARDIER the evolution of mobility
- Beechcraft [1]
- Cessna [1]
- DASSAULT AVIATION
- EMBRAER
- Gulfstream
- Hawker [1]

Military aircraft

Jet Fighter

Fixed-wing or variable-geometry wing armed aircrafts

- AIRBUS
- BOEING
- DASSAULT AVIATION
- LOCKHEED MARTIN
- SAAB AEROSPACE
- SUKHOI

Freighter

Transport aircrafts developed for military load transportation

- AIRBUS
- BOEING
- AleniaAeronautica A Finmeccanica Company
- LOCKHEED MARTIN

Rotorcraft

Helicopter

Rotorcrafts with vertical takeoff and landing ability

- AIRBUS HELICOPTERS
- AgustaWestland
- Bell Helicopter A Textron Company
- Sikorsky A United Technologies Company

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

Driver	Description	Driver impact[1] To date	Driver impact[1] In future
1 World economics (GDP)	> Long-term economic outlook for the global market remains bright > Demand and production of aircrafts is expected to grow accordingly	↗	↑
2 World population	> Wealth increase and population growth in emerging economies will drive the increased need for aircrafts	↗	→
3 Flight volume	> Flight volume has proven to be resilient to external shocks > Volume is estimated to double in next 15 years boosting aircraft production	↗	↑
4 Political influences & legislative factors	> Production will shift regionally to China and Mexico, and technologically to higher efficient aircraft types; production constraints in Russia and South America	→	↗
5 Utilization & load factor	> Aircraft production is constrained by utilization and load factors; improved loading, higher utilization and bigger aircrafts reduced aircraft demand in past	↘	→
6 Oil price	> 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	→	↗

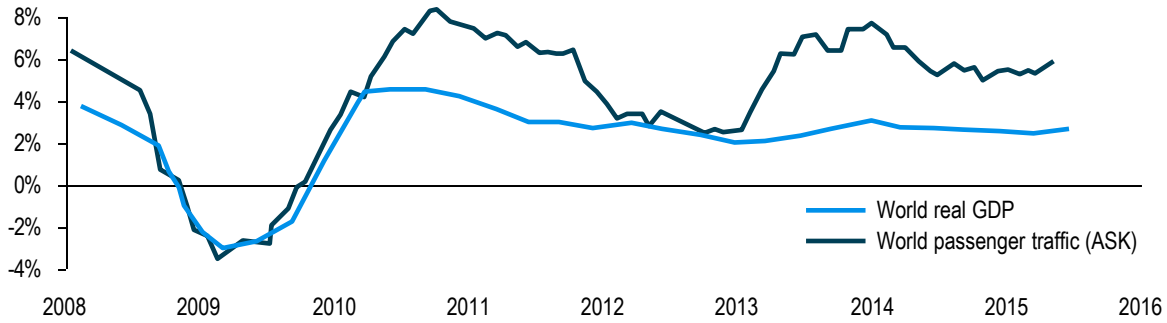
↑ Strong impact ↗ Average impact → Slow impact 1) General impact across multiple countries; exceptions in specific cases possible

Source: Roland Berger

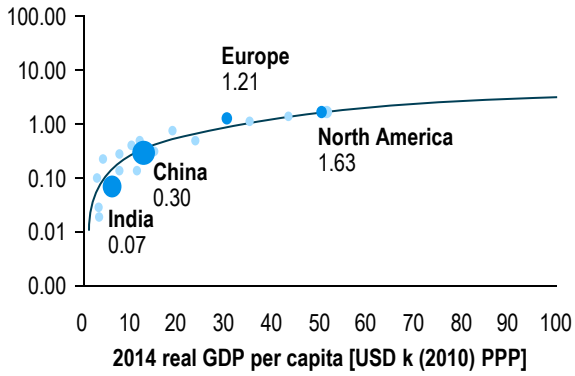
Overall, long-term economic outlook for the global market remains bright leading to an increasing demand and production of aircrafts

1 World economics (GDP)

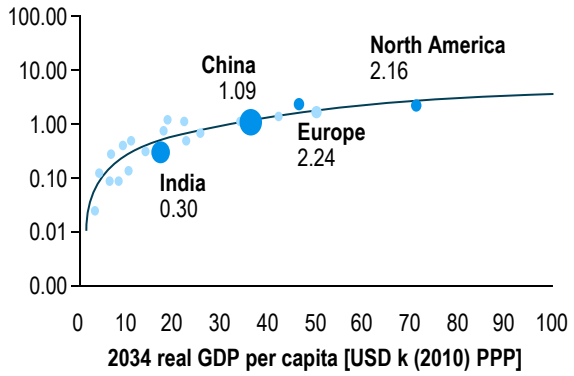
World real GDP/passenger traffic growth



2014 trips per capita [#]



2034 trips per capita [#]



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

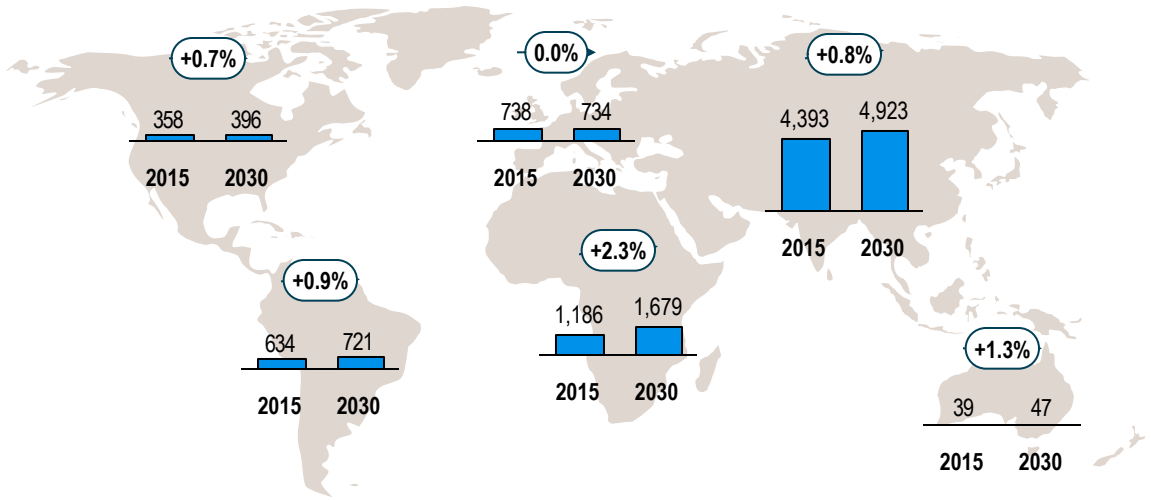
Impact to date **Impact in future**

Strong impact | Average impact | Slow impact

Source: Airbus; Boeing; Roland Berger

In conjunction with wealth increase and population growth, emerging economies will drive the increased need for aircrafts

2 World population [m]



CAGR 2015-2030	Population	RPK[1)]
Emerging markets	+1%	+6%
Mature markets	±0%	+4%

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

Impact to date **Impact in future**

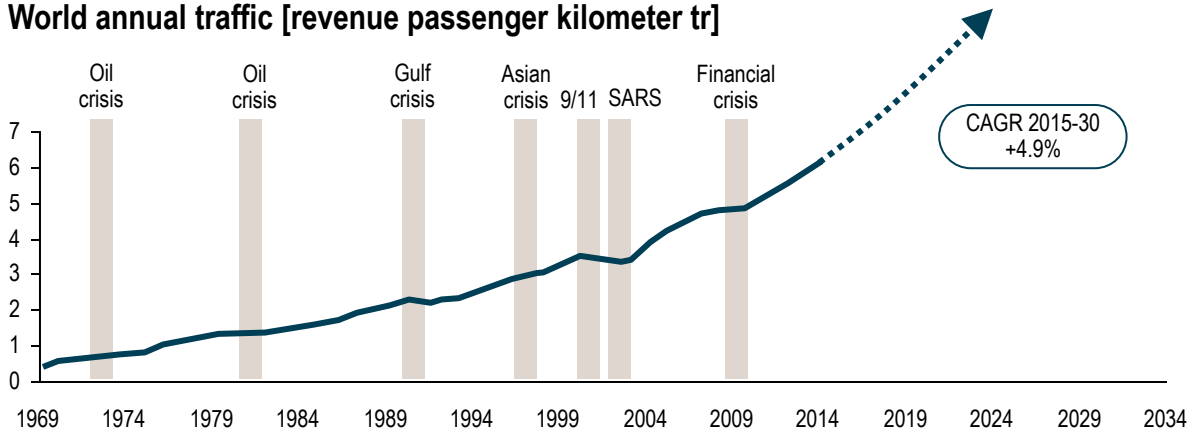
Strong impact | Average impact | Slow impact | 1) Revenue Passenger Kilometer

Source: United Nations, Department of Economic and Social Affair; Roland Berger

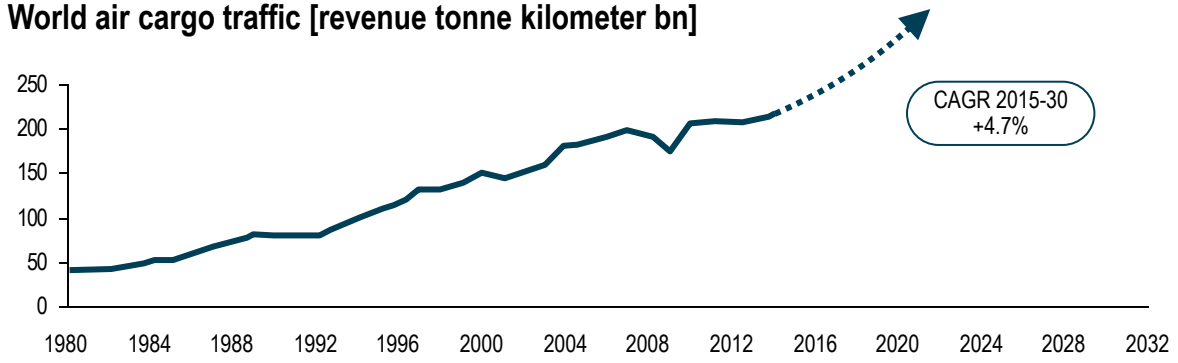
Flight volume has proven to be resilient to external shocks and is estimated to double in next 15 years boosting aircraft production

3 Flight volume

World annual traffic [revenue passenger kilometer tr]



World air cargo traffic [revenue tonne kilometer bn]



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

Impact to date **Impact in future**

Strong impact | Average impact | Slow impact

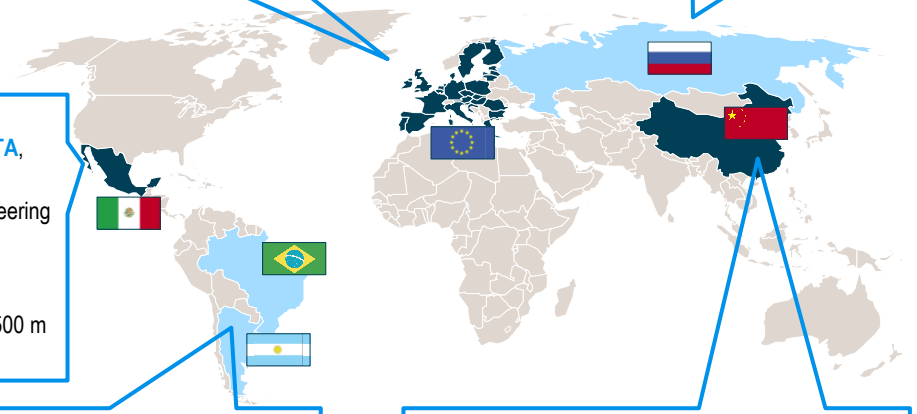
Source: IATA; ICAO (scheduled traffic); Airbus; Boeing; Roland Berger

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 CO_2-emissions** by 75% and **NO_x-emissions** by 90%[1] in air traffic
> Further **liberalization and deregulation** of air-space (Single European Sky)

> Import substitution strategy due to **geopolitical tension** with EU and US
> **Dependency** on **western made air components** for Russian aircraft projects



> 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

> **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

Impact to date → **Impact in future** ↗

Currently positive circumstances Currently constraining circumstances

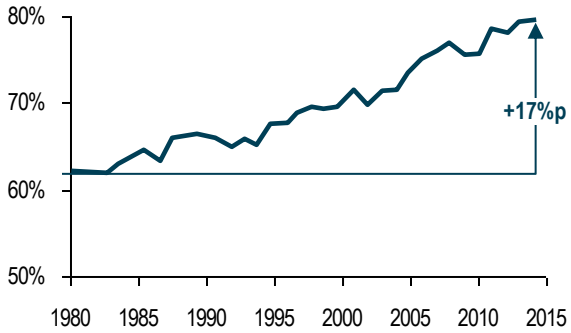
↑ Strong impact ↗ Average impact → Slow impact 1) Compared to 2000 2) Wassenaar Arrangement 3) Bilateral Aviation Safety Agreement

Source: Roland Berger

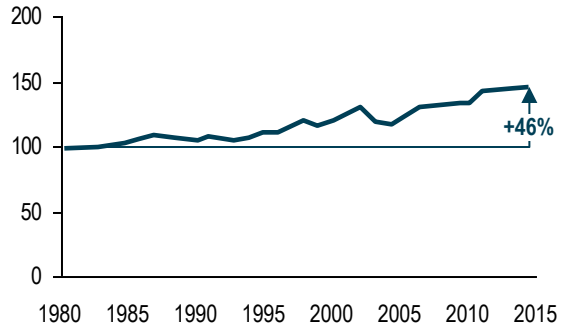
However, as aircraft utilization and load factors have risen, aircraft production logging behind growth in flight volume demand

5 Utilization & load factors

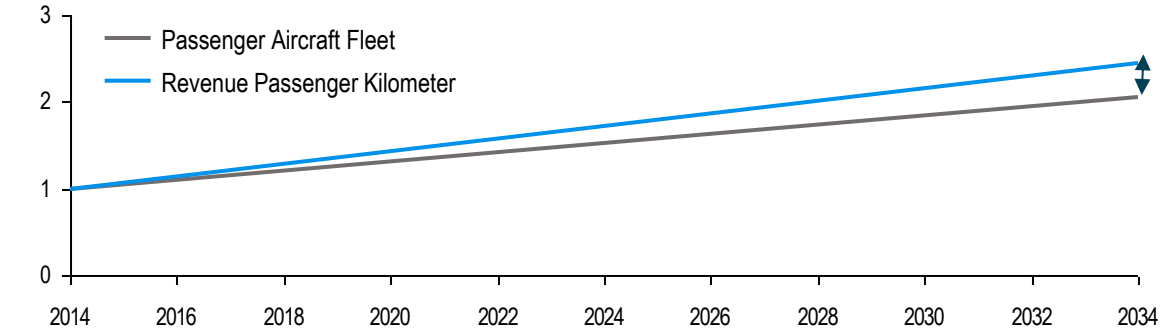
World passenger load factors [%]



Yearly offered seats per aircraft [# k]



World annual air traffic vs. aircraft fleet [2014 = 1]



Strong impact | Average impact | Slow impact

Source: OAG; Ascend; ICAO; Airbus; Boeing; Roland Berger

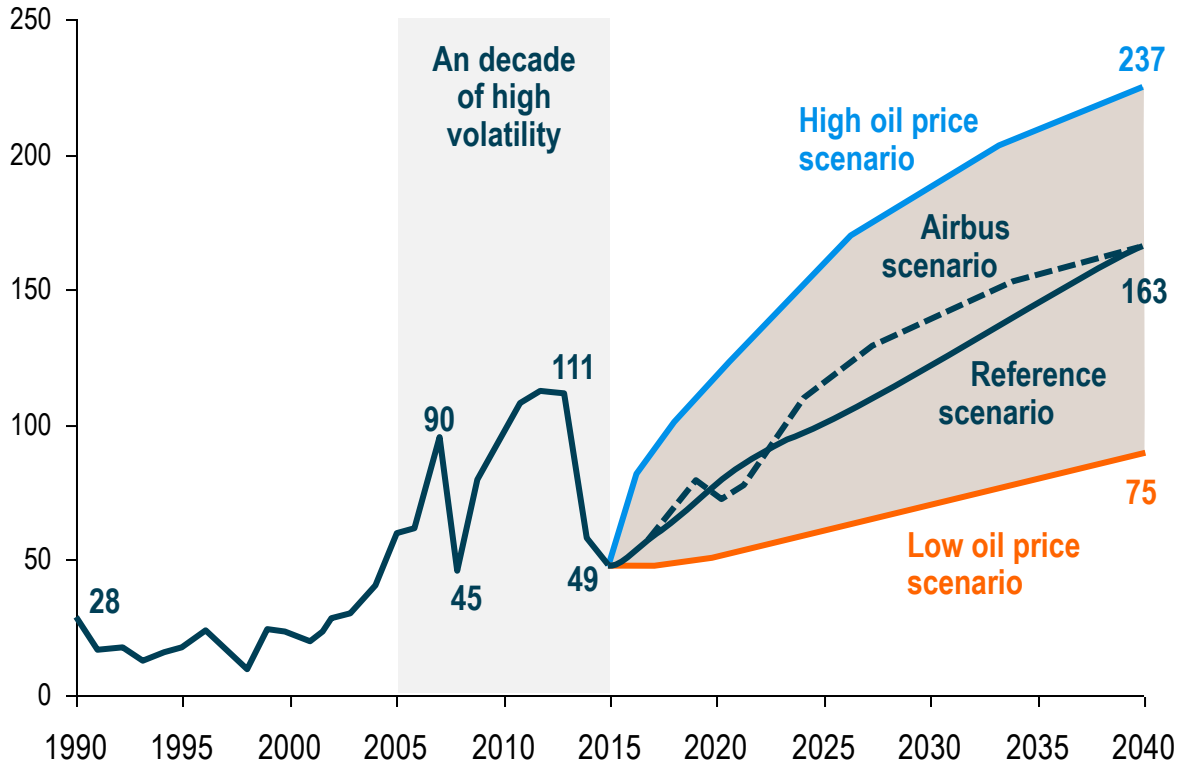
Impact on aircraft production

> 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

Impact to date ↘ **Impact in future** →

Oil price has gone through significant ups and downs in the past years – Long-term growth forecasted, but uncertainty increases

6 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

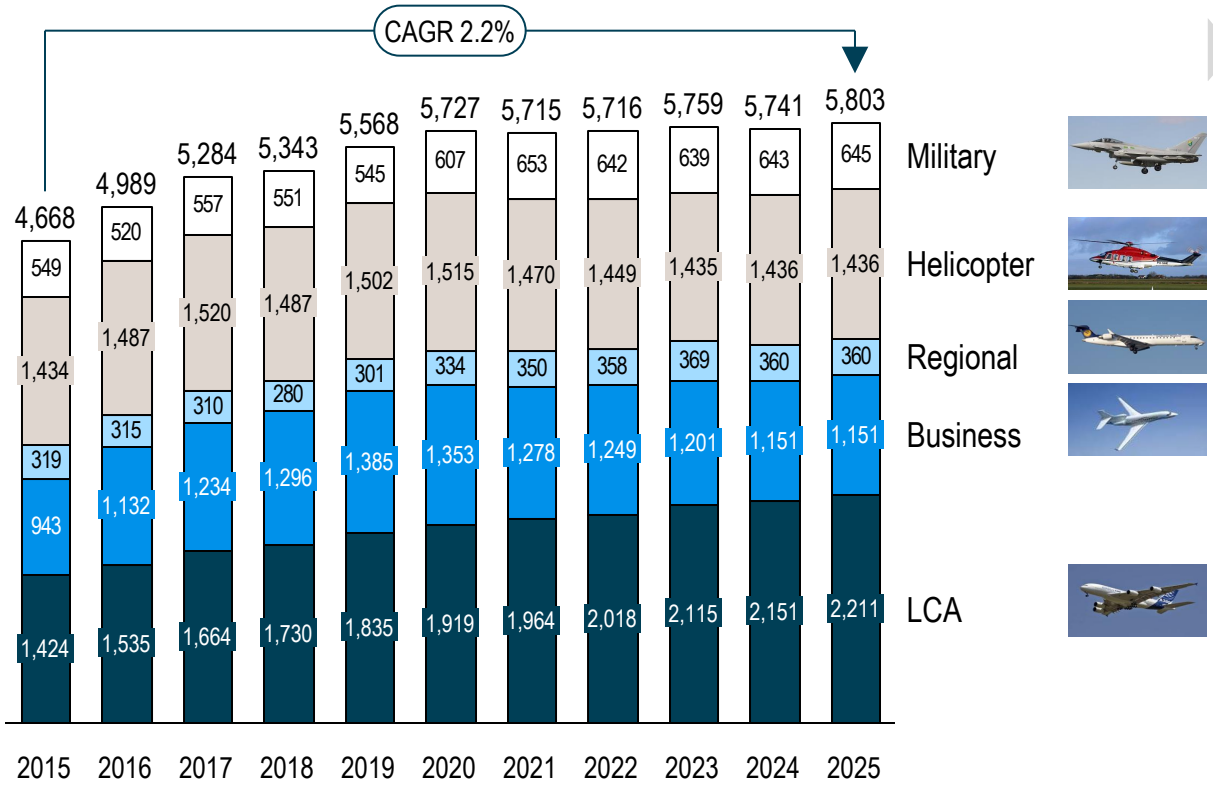
Impact to date → **Impact in future** ↗

↑ Strong impact ↗ Average impact → Slow impact

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]



Rationale

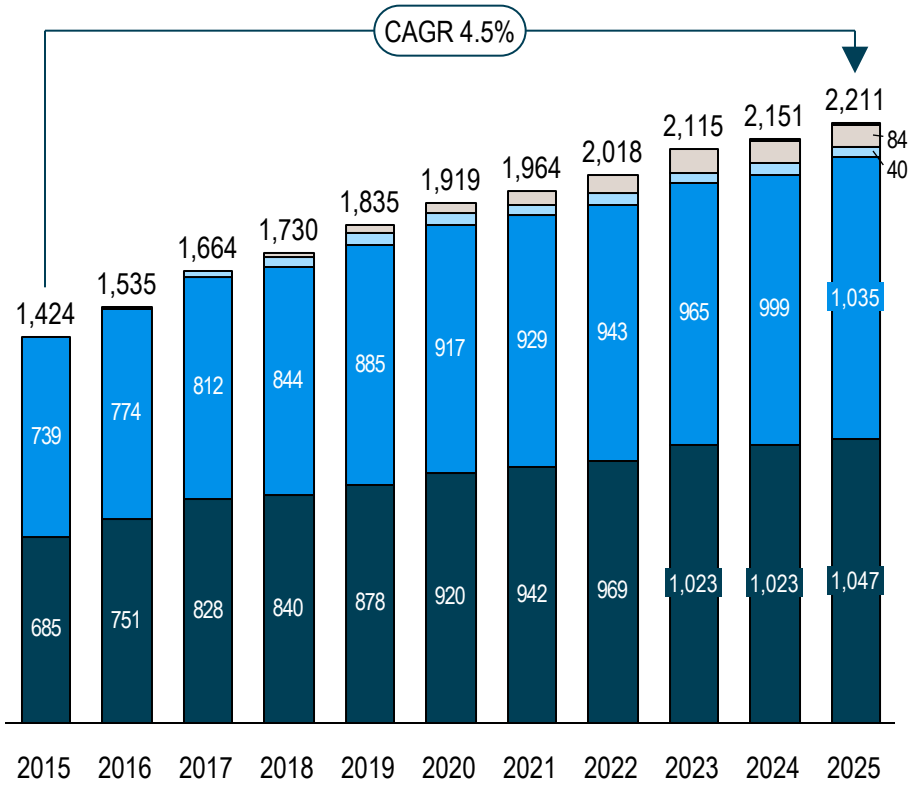
- Yearly rising air traffic volume reflected in overall A/C production CAGR of 2.2%
- Even higher rate increases fuel demand for aircrafts within next years
- Civil A/C production as main driver of market growth
- Both helicopters and military aircrafts forecast production downturn

Note: Rounding differences may occur

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

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]



IRKUT / ИРКУТ

BOMBARDIER the evolution of mobility

BOEING

AIRBUS

Rationale

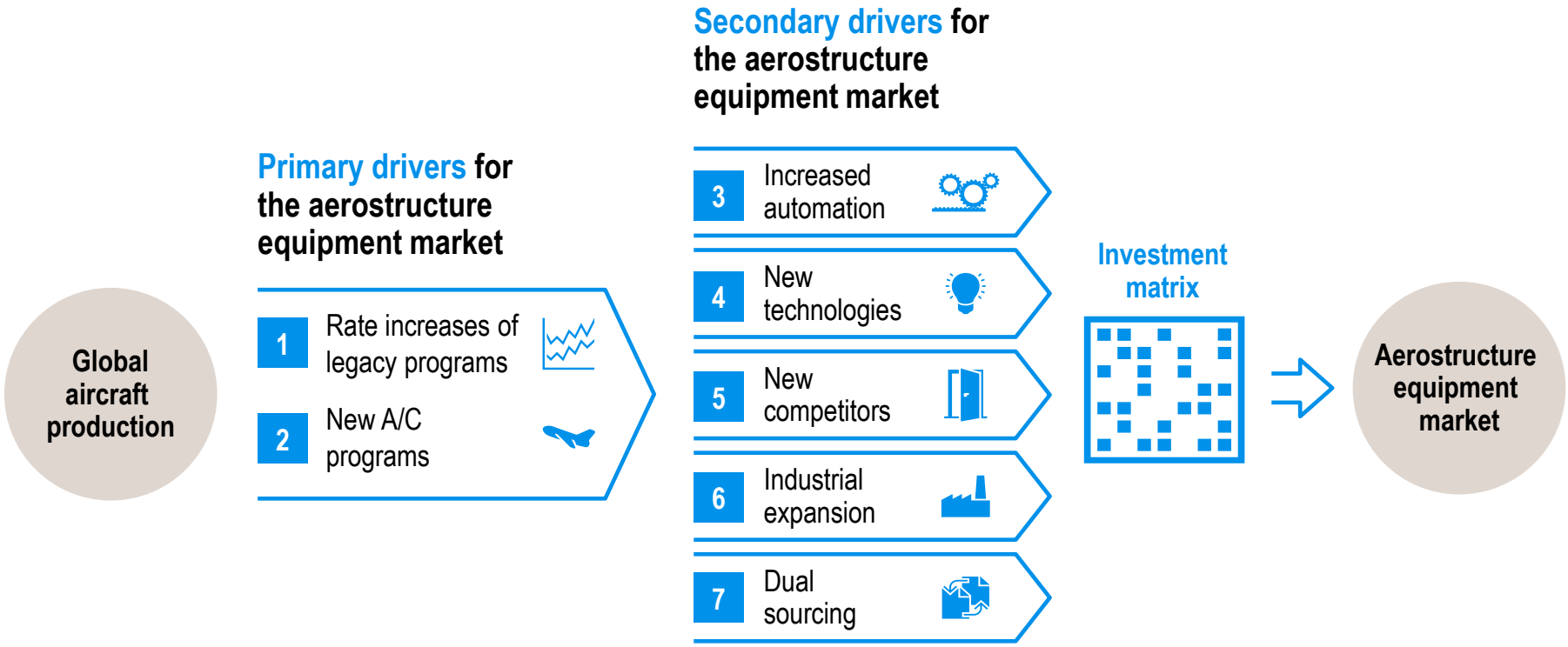
- LCA production by established OEMs Airbus and Boeing as key drivers for overall market growth
- Airbus with highest LCA production forecast
- A/C production by emerging OEMs mainly driven by Bombardier; However, overall market impact is negligible
- Irkut with estimated production volume of 84 MS-21 in 2025
- COMAC with estimated volume of 5 C919 in 2025

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

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



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

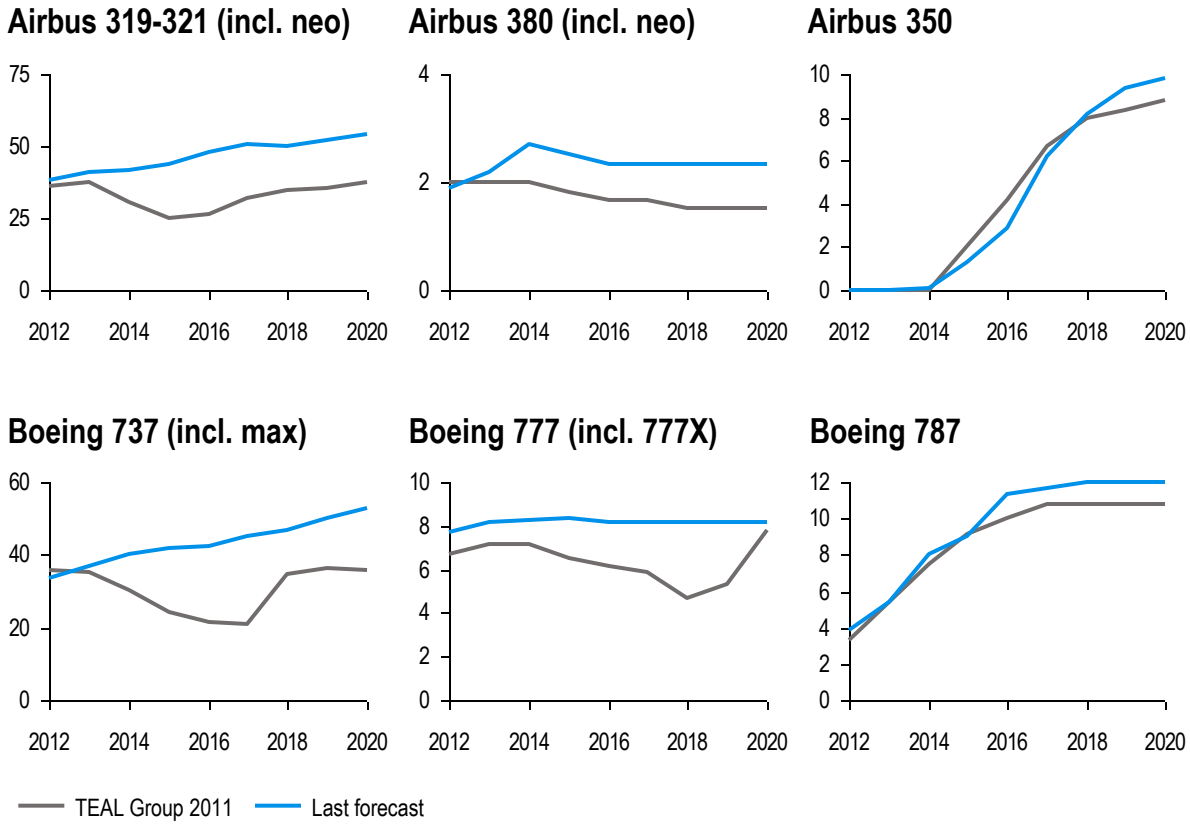
Driver	Description	Impact to date [1]	Future impact [1]
1 Rate increases of legacy programs	> Major legacy programs are expected to increase rates in the up-coming years, thus retrofits and services demand will not cave in	↗	↗
2 New A/C programs	> New aircraft programs will increase the need for additional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

↑ Strong impact ↗ Average impact → Slow impact 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]



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

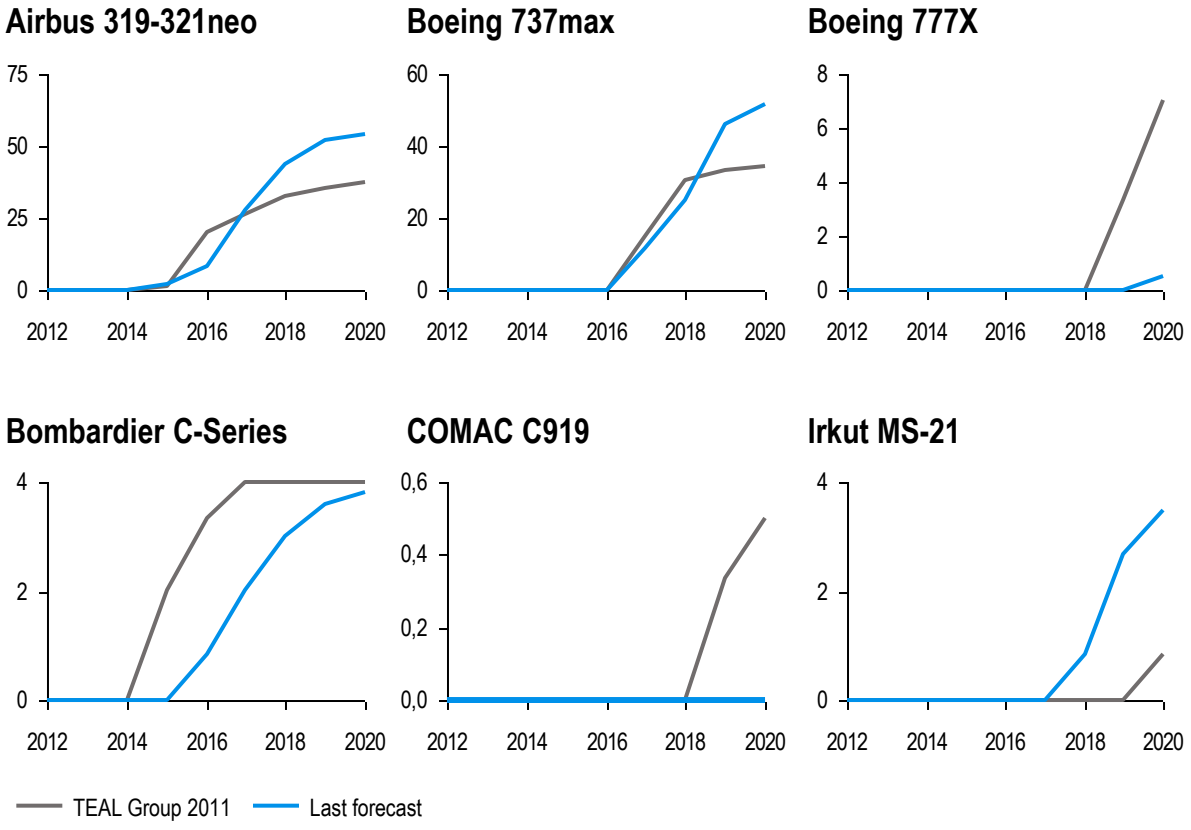
Impact to date ↗ **Impact in future** ↗

↑ Strong impact ↗ Average impact → Slow impact

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

2 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

Impact to date **Impact in future**

Strong impact | Average impact | Slow impact

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

4 New technologies

Robotics fastening

Impact to date ↗
Impact in future ↑

> 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

Impact to date →
Impact in future ↗

> 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

Impact to date →
Impact in future ↗

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

Glueing

Impact to date →
Impact in future →

> After successful introdruction 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

Impact to date ↗ **Impact in future** ↑

↑ Strong impact ↗ Average impact → Slow impact

Source: Roland Berger

Emerging OEM countries and newly entering competitors from other industries challenge established aerospace suppliers

5 New competitors

Russian protective measures

Impact to date →
Impact in future ↑

> Russia takes protective measures within the aerospace industry in order to support local companies and keep the value chain within its boarders
> The current geopolitical situation aggravates suppliers' position

Automotive integrators

Impact to date ↗
Impact in future ↗

> Increasing production rates, outsourcing trends and dual sourcing provide opportunities for new suppliers from other industries
> Aerospace requirements not easy to reach, but rising number of functional requirement based RFQs

Chinese knowledge transfer

Impact to date ↗
Impact in future →

> COMAC as the emerging Chinese OEM triggers demand for foreign aerospace tooling equipment due to the lack of required knowledge within China
> As soon as capabilities are built, decrease of demand expected

Frugal competitors

Impact to date →
Impact in future ↑

> Emerging OEMs in low cost countries require simple tooling equipment to meet price levels
> 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

Impact to date → Impact in future ↑

↑ Strong impact ↗ Average impact → Slow impact

Source: Roland Berger

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

6 Industrial expansion

China - Boeing finishing center

> Case: 2015, reaching deal to build 737 finishing center and along with selling 300 planes to Chinese companies

> Rationale: China starting to import know-how from developed countries in exchange for opening sales opportunities

Impact to date: →
Impact in future: ↑

Japan - Boeing wing production

> Case: Japanese engineers supporting design and construction of Boeing programs; Mitsubishi and Kawasaki suppliers of e.g. wings and fuselage sections

> Rationale: Boeing using Japanese engineering capabilities

Impact to date: ↗
Impact in future: ↗

USA - Airbus final assembly line

> Case: 2015, opening of final assembly line in Alabama, first time foreign manufacturer building jets on US soil

> Rationale: Low logistic and manufacturing costs, non-unionized workforce, as well as manufacturing in "Dollar-Zone"

Impact to date: ↗
Impact in future: →

Mexico – Production shift

> Case: Supportive political arrangements enabling production shift to Mexico, e.g. investments from Bombardier of USD 500 m in last 10 years

> Rationale: Strategic value of engineering expertise, quality and competitiveness Mexican workforce

Impact to date: ↗
Impact in future: ↑

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

Impact to date: ↗
Impact in future: ↑

↑ Strong impact ↗ Average impact → Slow impact

Source: Roland Berger

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

7 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

"We informed the International Association of Machinists of our plans to begin dual sourcing during the company/union discussions preceding our decision to place the second 787 line in South Carolina"
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** ↗

↑ Strong impact ↗ Average impact → Slow impact

Source: Web research; Roland Berger

The modelling logic builds on a wide range of parameters to define aerostructure tooling spend and distribution

Key assumptions

Market drivers

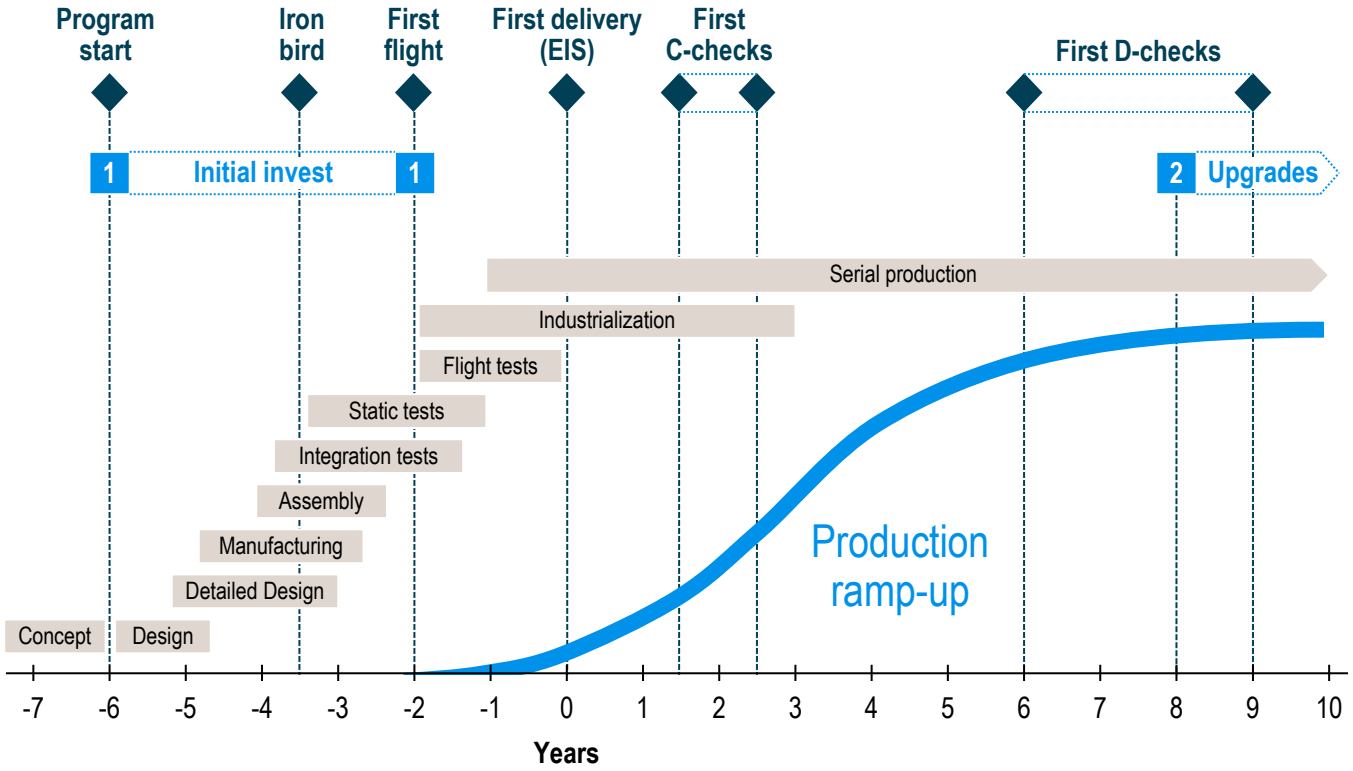
- Rate increases of legacy programs
- New A/C programs
- Increased automation
- New technologies
- New competitors
- Industrial expansion
- Dual sourcing

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

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

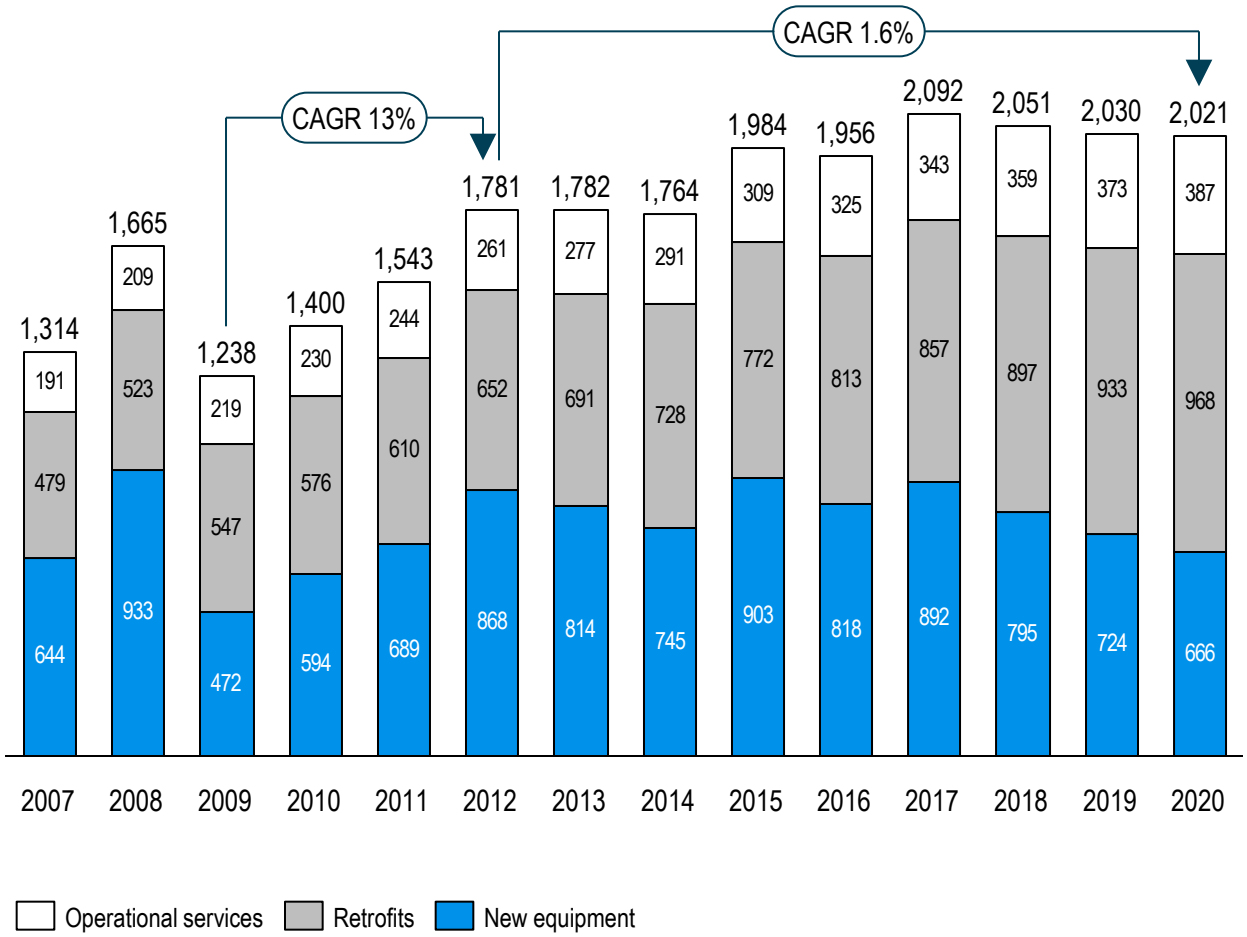
> First equipment upgrade 8-15 years after EIS

> Major driver for upgrades is productivity increase without new installment

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]



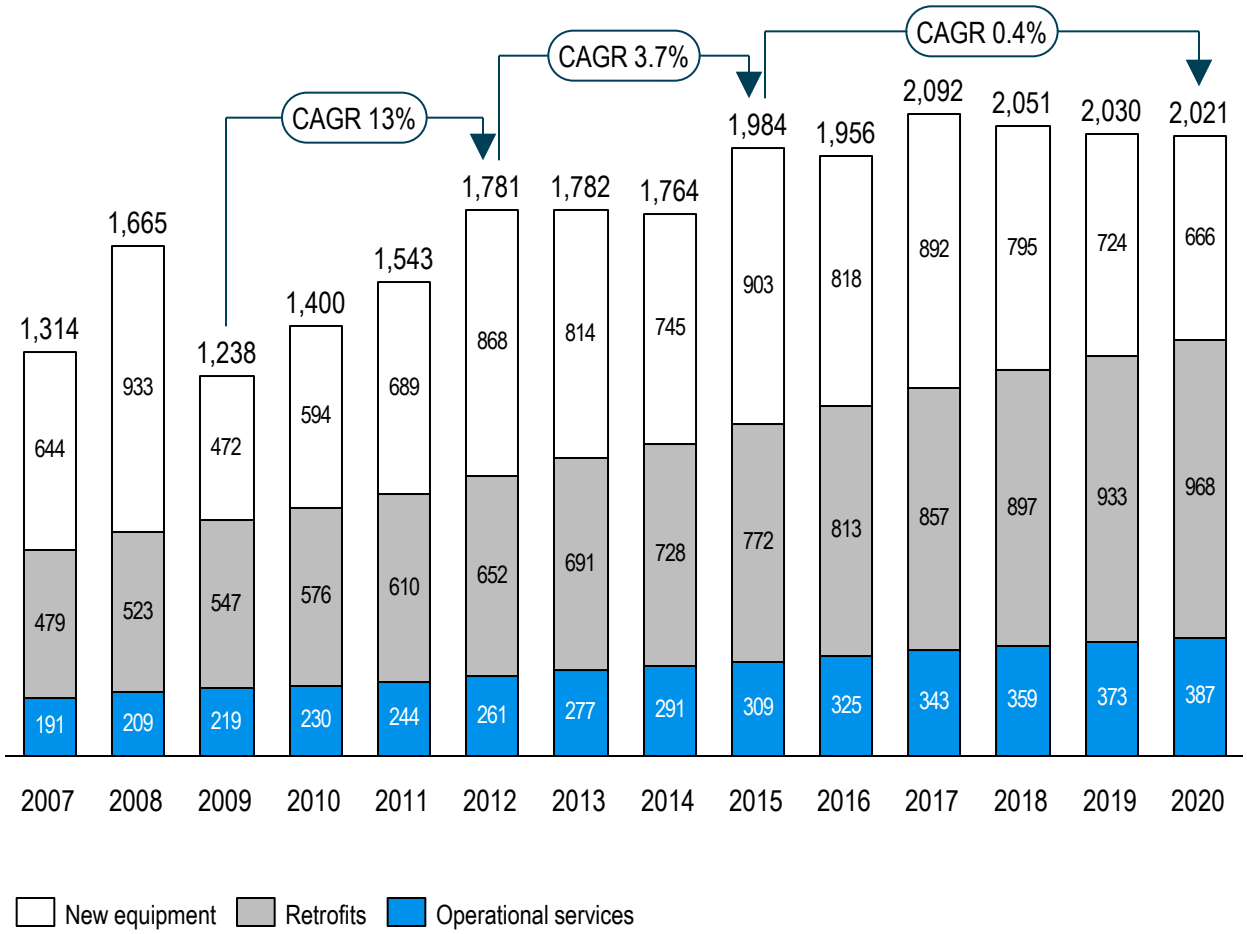
Rationale

- 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

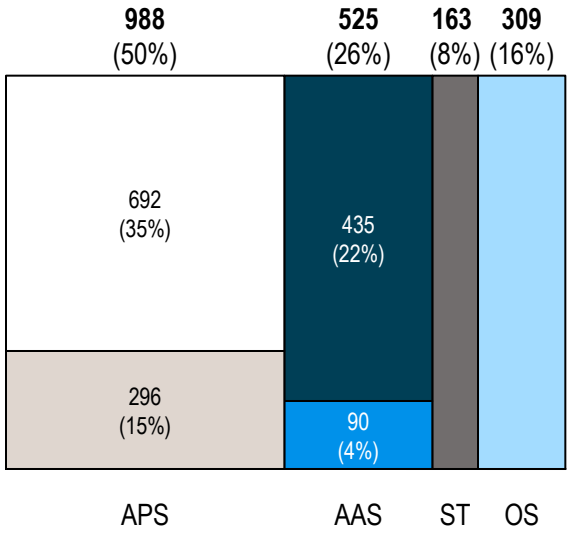
- Initial investments expected to be more balanced 2015 and 2020 but to decrease in overall terms
- Constantly growing installed base with high need for automation and rather short upgrade/retrofit cycles lead to overall constant market
- Upgrades/retrofit and service business expected to outperform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

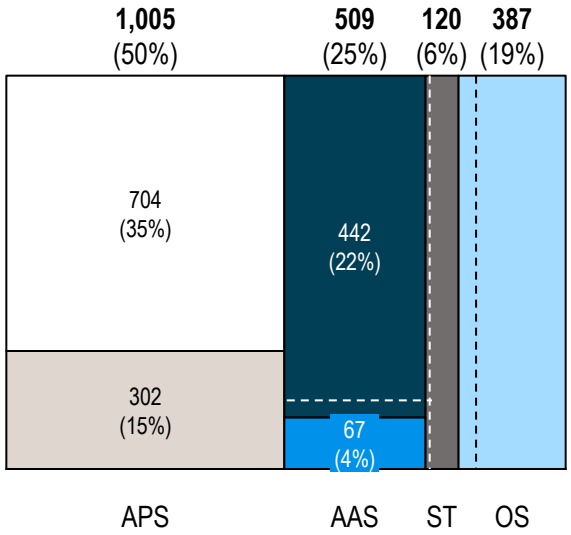
Global market for aerostructure equipment [EUR m]

2015 – Σ 1,984



> Automated production and assembly systems together account for almost 80% of the market

2020 – Σ 2,021



> Automated production systems grow with the market at a constant share of 50%
> Operational services share increases from 16% to 19%

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 loose 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

Fastening systems | Composite systems | Stations/Lines | Conveyor systems | Small tools | Operational services

Note: APS = Automated production systems, AAS = Automated assembly systems; ST = Small tools; OS = Operational services; Rounding differences may occur

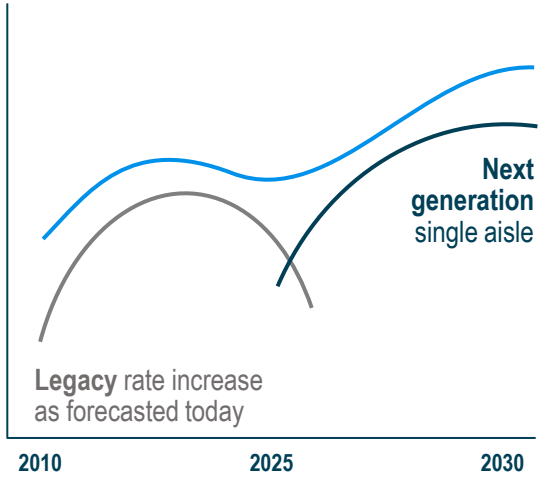
Source: TEAL Group; OEM forecasts and macroeconomic outlook; expert interviews; analyst reports; Roland Berger

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

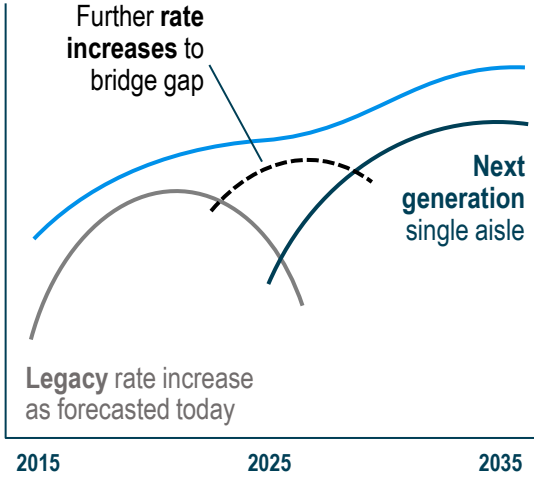
1 Scenario 1 The "dip"



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

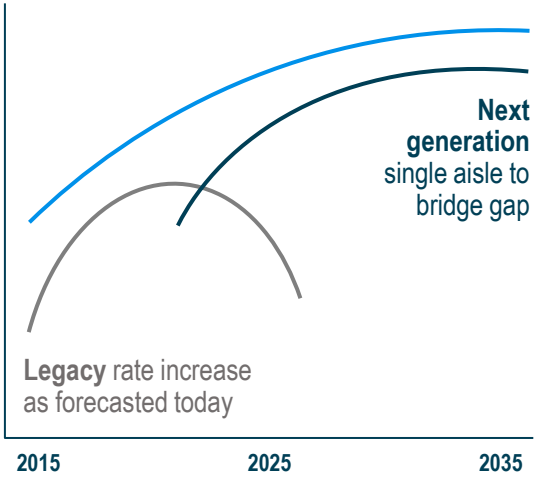
2 Scenario 2 Further rate increases



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



Scenario assumptions

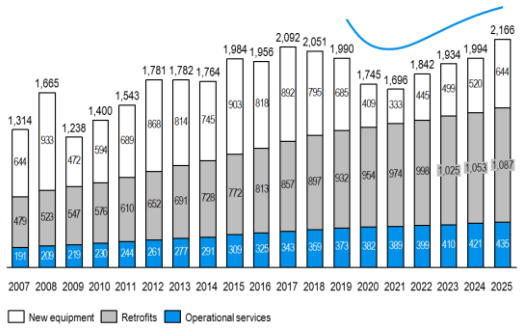
> Current MAX and neo generations are insufficient to satisfy client demand over 10+ years or sustain respective market share in duopolistic market

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

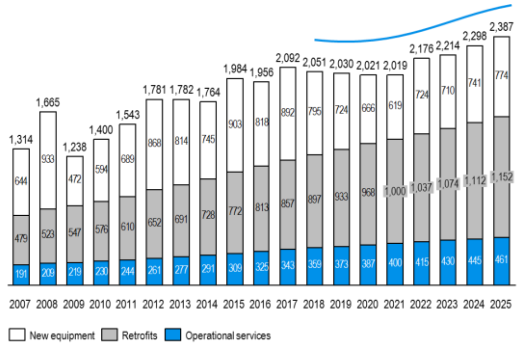
1 Scenario 1
The "dip"



Roland Berger hypothesis

> Unlikely case as cost pressures, rate increases, and quality assurance continue to call for higher productivity

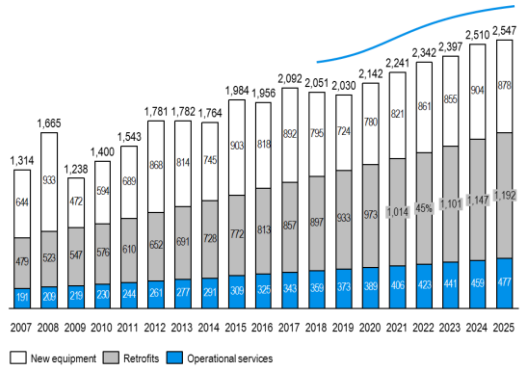
2 Scenario 2
Further rate increases



Roland Berger hypothesis

> 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
Early next generation



Roland Berger hypothesis

> 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

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> Services and support development strategy

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> Mergers & acquisitions/ alliances

> Corporate/BU organization redesign

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> Expertise of core and functional processes of the industry

> Experience based on more than 30 projects p.a. since 2000

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> Post merger integration

> R&D efficiency/product policy and innovation

> Program management efficiency

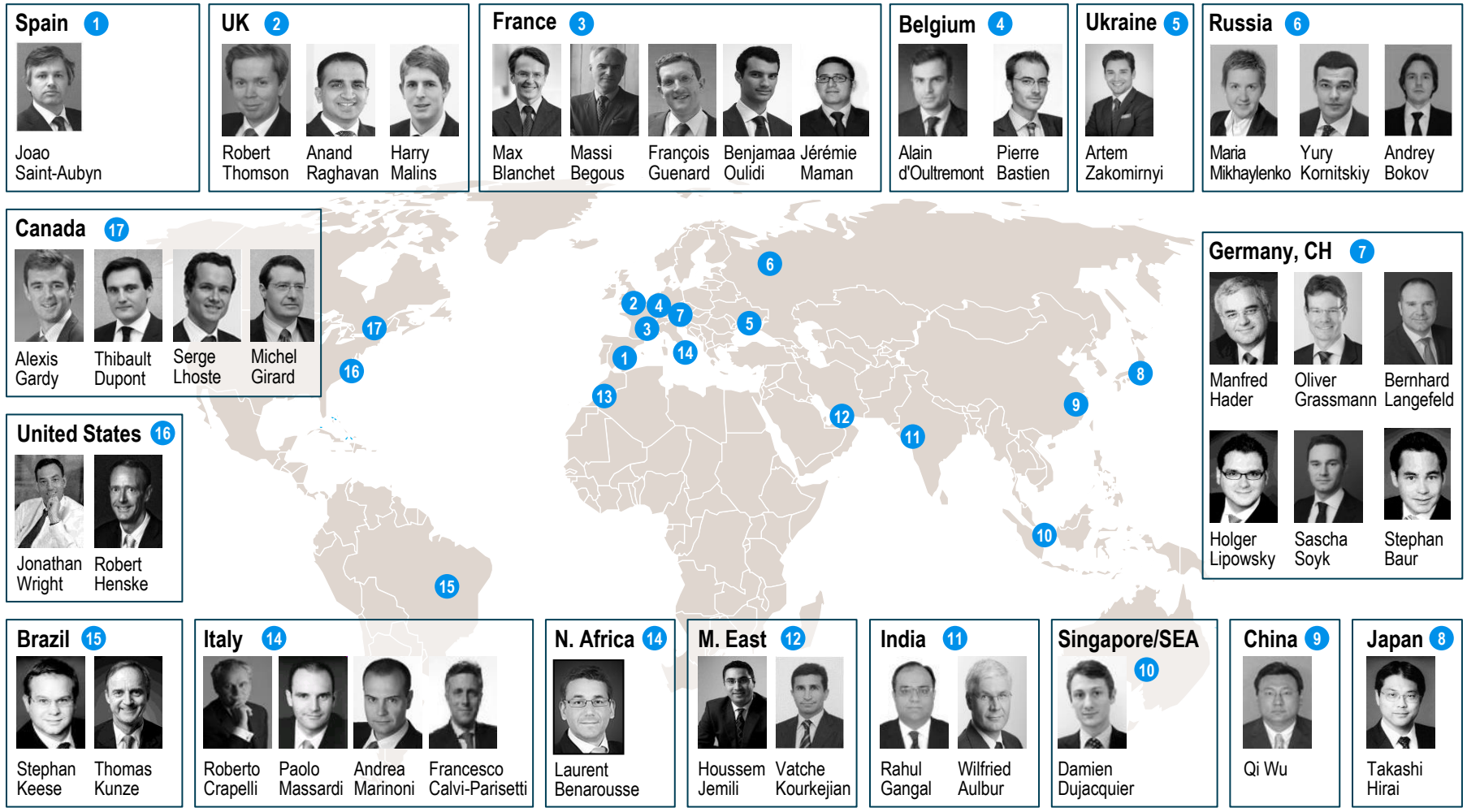
> Supply chain optimization

> Purchasing and supplier management optimization

> Manufacturing performance optimization

Source: Roland Berger

Our senior A&D specialists work with top management and operational teams on a global basis



Source: Roland Berger

Our A&D insights are based on a deep understanding of the industry across the entire value chain – Example of clients

OEM/prime contractors

Tier-1 players

Governments/institutions

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
Point of view

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

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Source: Roland Berger


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