The changing MRO landscape

IATA Maintenance Cost Conference

Athens, Greece

19 September 2018

IATA 15th MAINTENANCE COST CONFERENCE GREECE

Agenda

- Global trends
- World fleet
- MRO trends
- The changing MRO landscape
- Summary

A Growing, Global Company **Since 1969**

Global professional, technology and marketing services firm

More than **5,000** People

Headquartered in Washington, D.C. with:

67 Offices

80 Nationalities

$1.2B In annual revenue

Speaking more than **70** Languages

Our History

Airports | Airlines | Aerospace & MRO | Asset Advisory

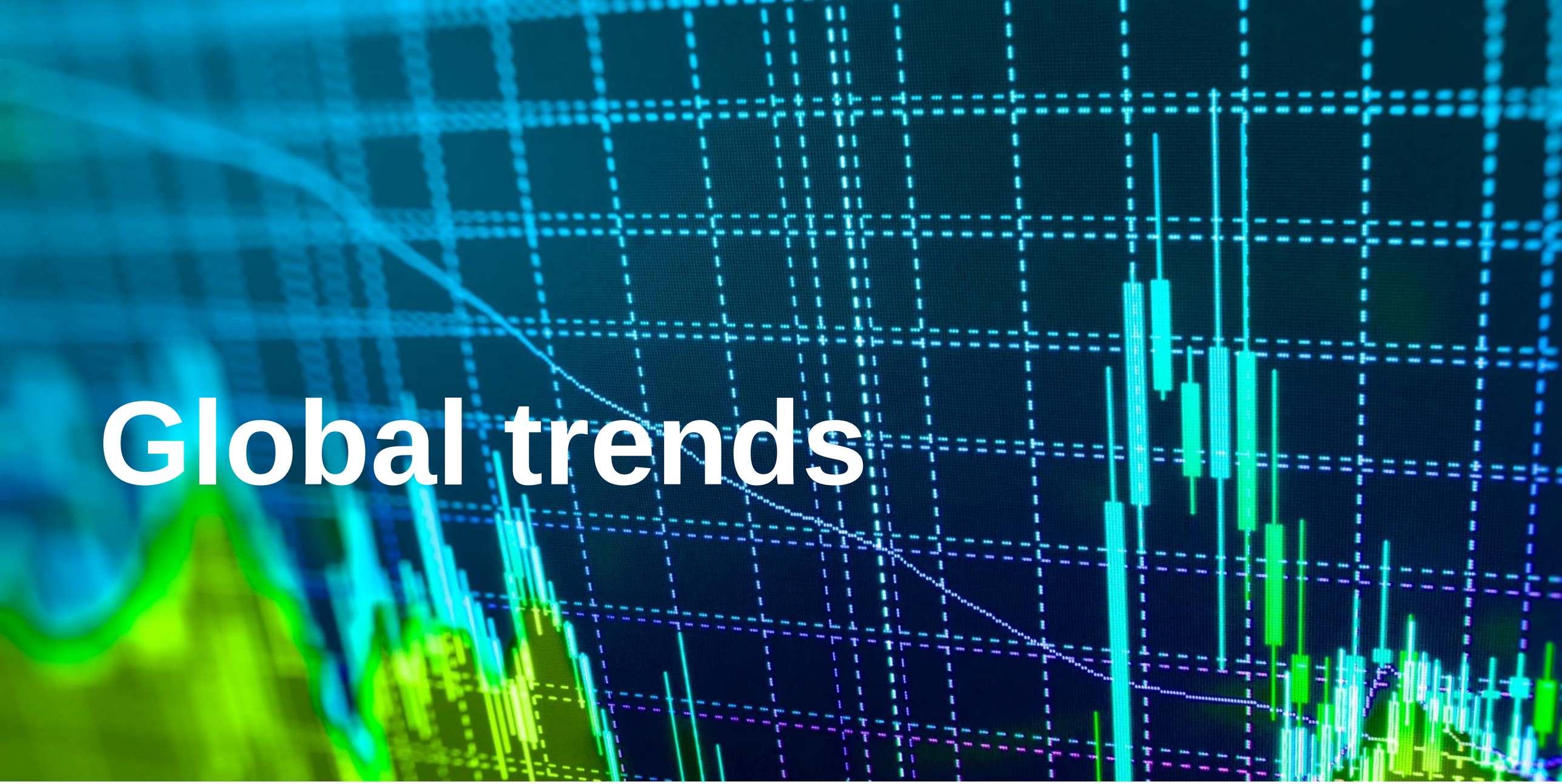
ICF is one of the world's largest and most experienced aviation and aerospace consulting firms

ICF → SH&E an ICF International Company joined in 2007 | AeroStrategy Management Consulting joined in 2011 | GHK joined in 2012 | OLSON joined in 2014

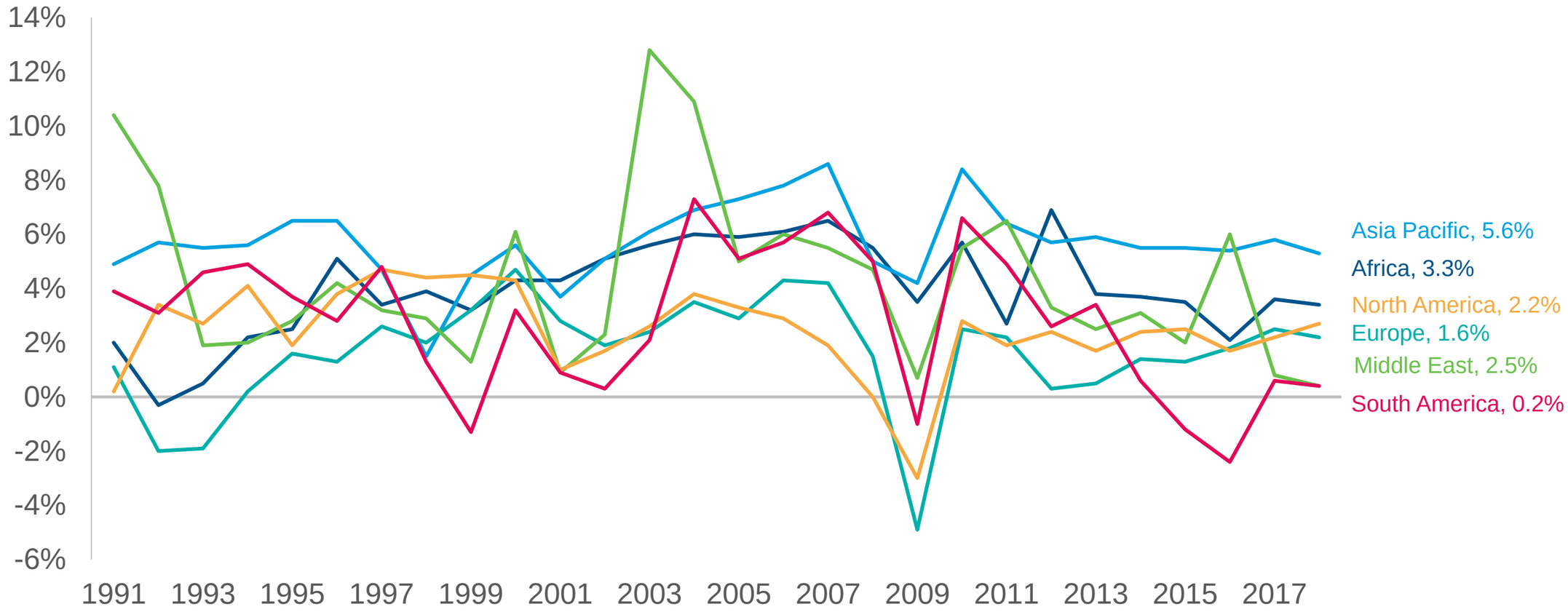
- **Founded in 1963**
- **100+ professional staff**
  - Dedicated exclusively to aviation and aerospace
  - Blend of consulting professionals and experienced aviation executives
- **Specialized, focused expertise and proprietary knowledge**
- **Broad functional capabilities**
- **More than 10,000 private sector and public sector assignments**
- **Backed by parent company ICF (2016 revenue: US$1.05 billion)**
- **Global presence — offices around the world**

New York | Boston | Washington D.C. | London | Singapore

Global trends

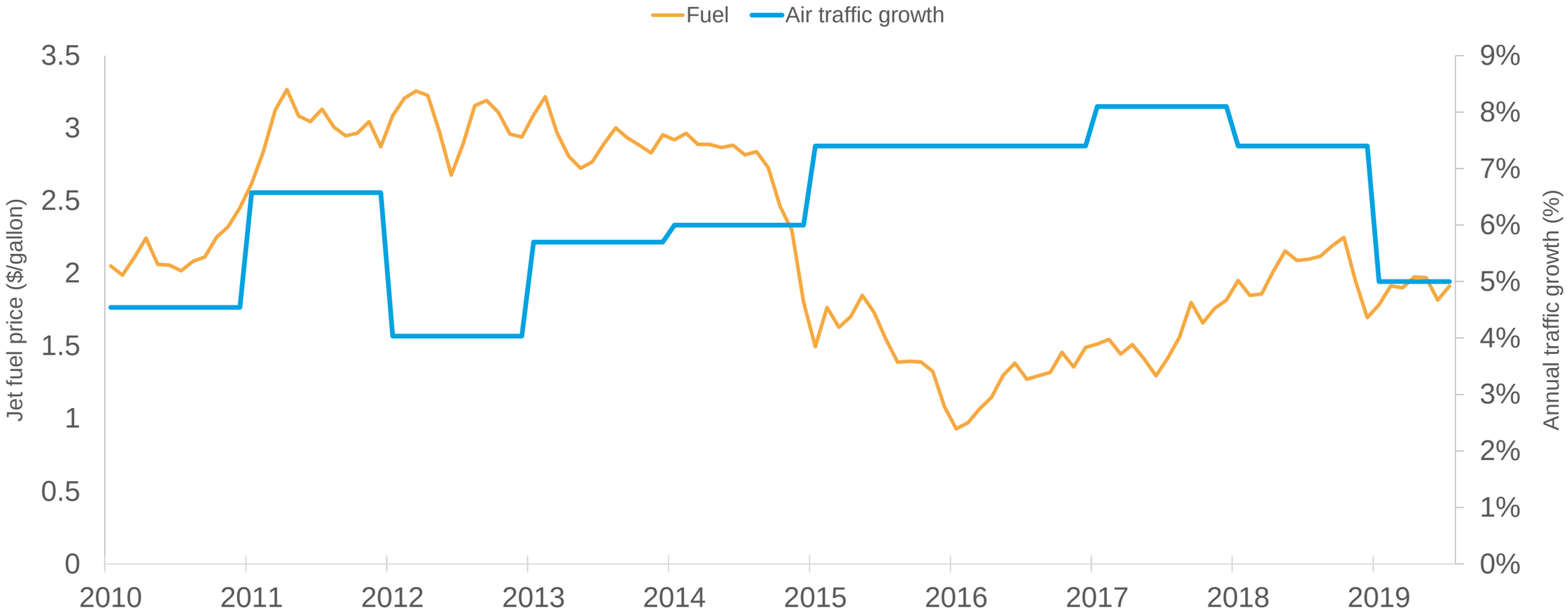


Asia Pacific, Middle East and Africa have been the fastest growing regions in the past five years



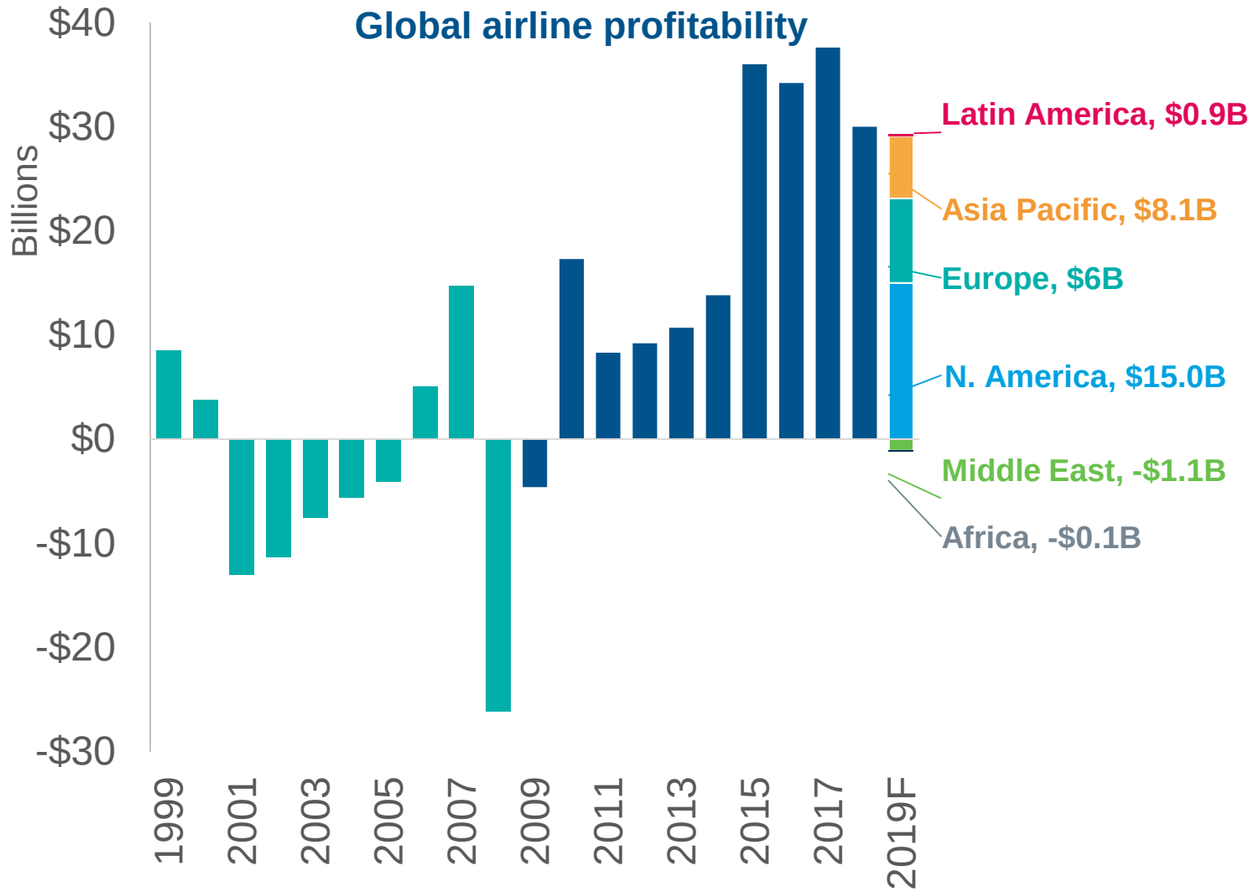
Source: World bank

Traffic growth, driven by increasing fuel prices, is slowly reversing as 2019 is forecast to shrink to ~5.0%



Source: ICF Analysis, IATA, EIA

Global airline industry achieved a record profitability in 2017, but this is estimated to decrease to $28.1B in 2019



Source: IATA, ICF Analysis

The European aviation industry is more fragmented than other markets

Number of airlines

Europe has a total of

195

Airlines

Europe has four large airlines & groups which are responsible for most of the European profits; Lufthansa Group, IAG, AFI-KLM and Ryanair

Whilst North America only has

98

Airlines

Europe **348 City pairs**

In Europe, it takes 348 city pairs to generate 25% of the inter-Europe passenger revenue, with 28 airlines holding approximately 80% of the available seating capacity

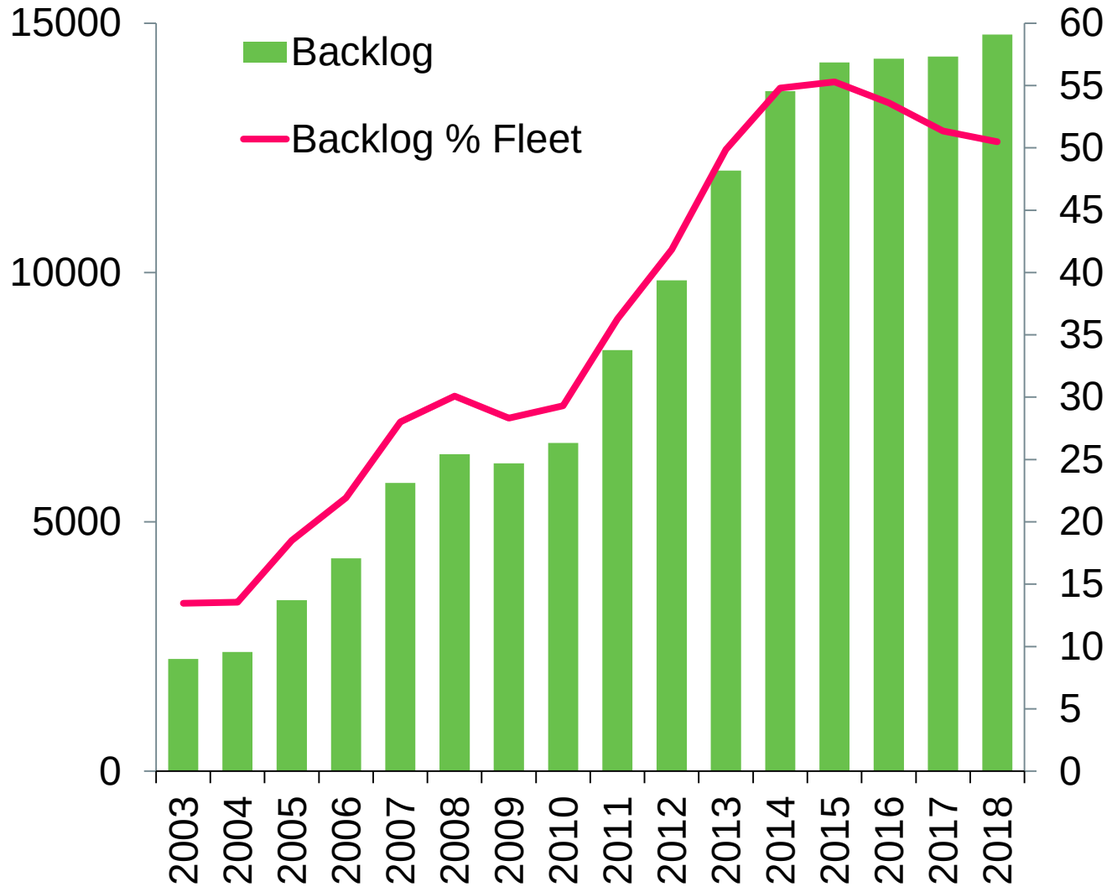
North America **167 City pairs**

In North America, the seven biggest airlines hold 80% of the of the available seat capacity and there are 167 city pairs needed to generate 25% of the

Source: PAXiS, IATA and ICF research

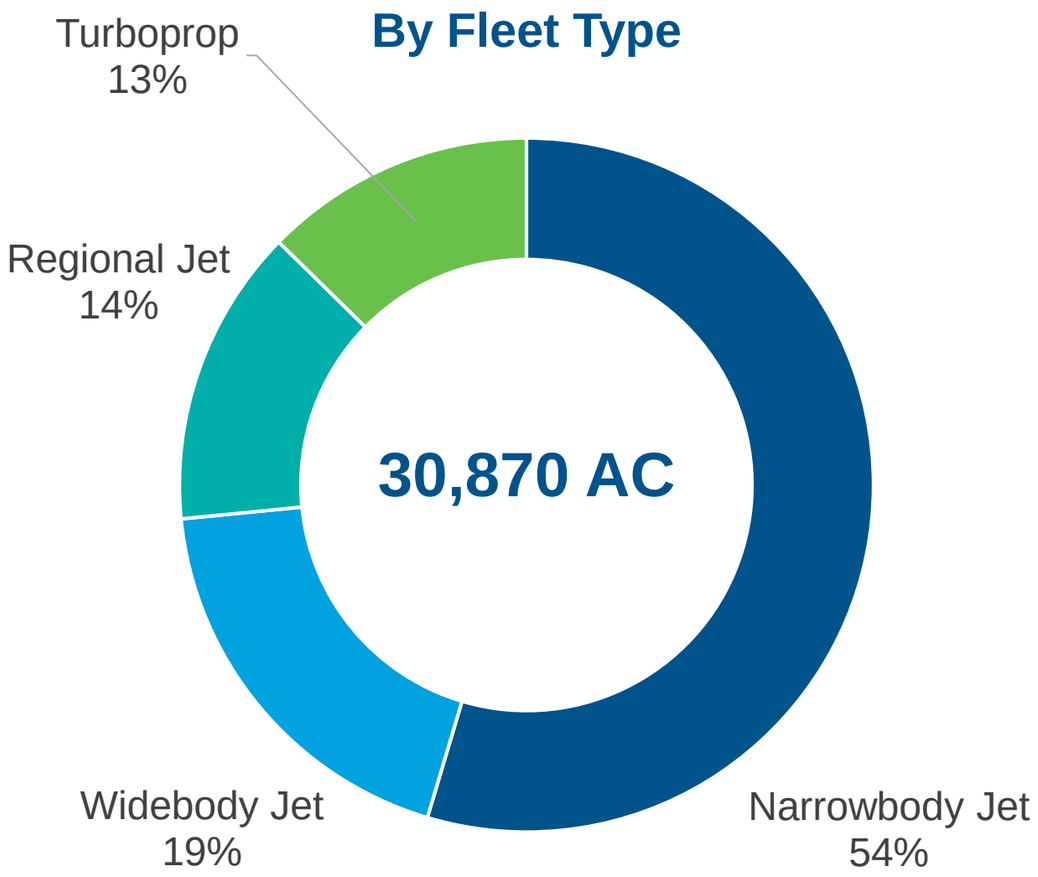
Commercial aircraft OEM production backlog remains at historical high, with nearly 7 years of production

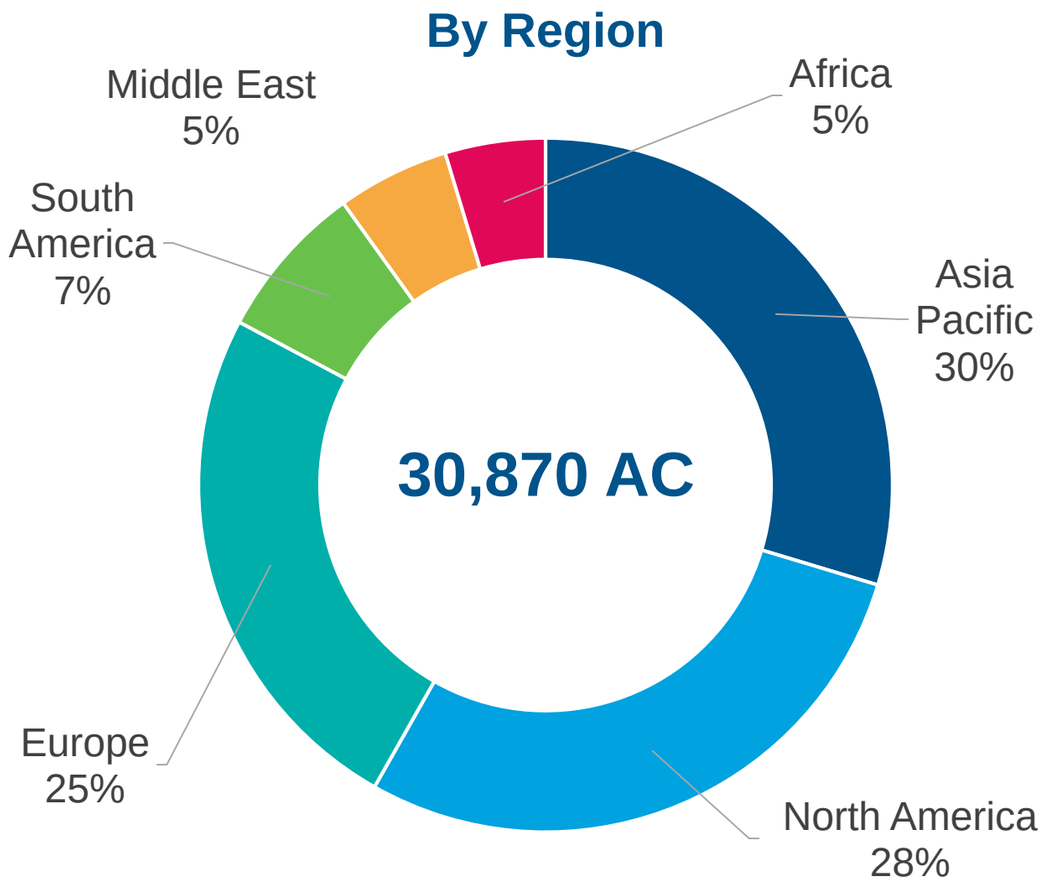
- **Backlog more than doubled between 2010 and 2014, due to:**
  - Growing global economy
  - Rapid growth of emerging markets
  - Very low interest rates and plentiful capital
  - High oil and commodity prices
  - Introduction of new technology aircraft/engines
- **Total backlog peaked in 2018 with almost 15,000 on firm order**



World fleet

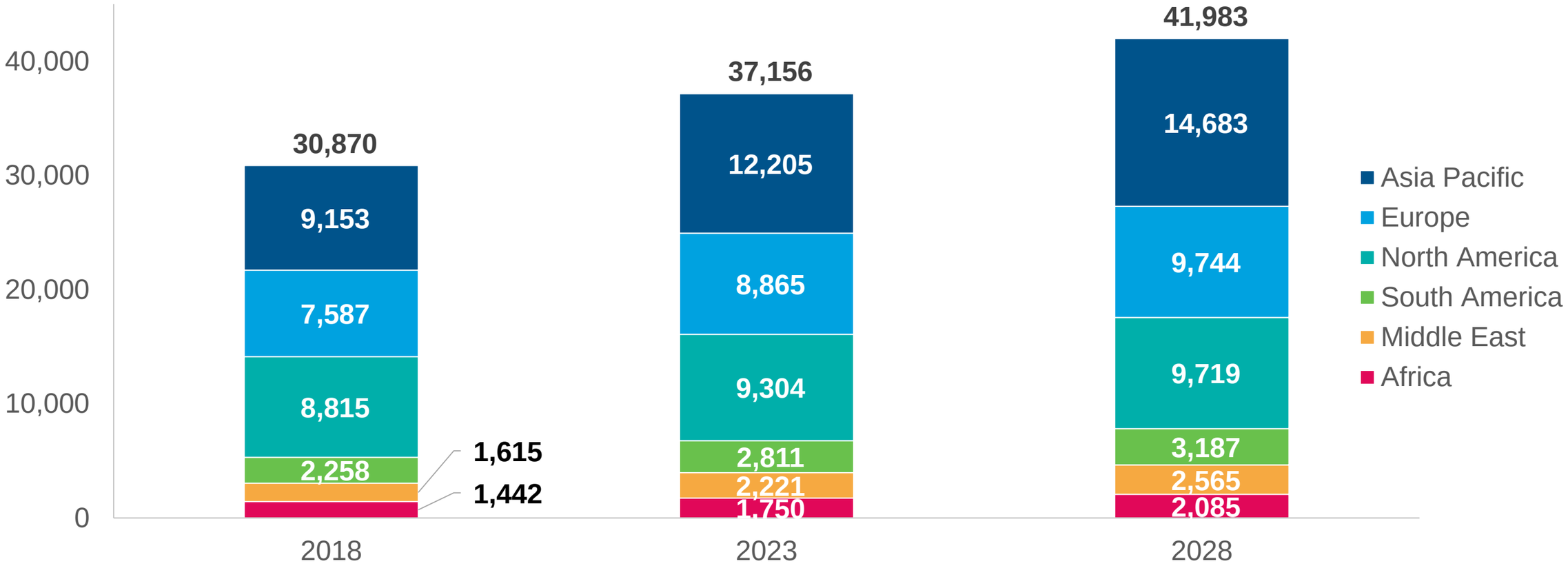
The current commercial air transport fleet consists of ~30,870 aircraft; ~7,500 are located in Europe





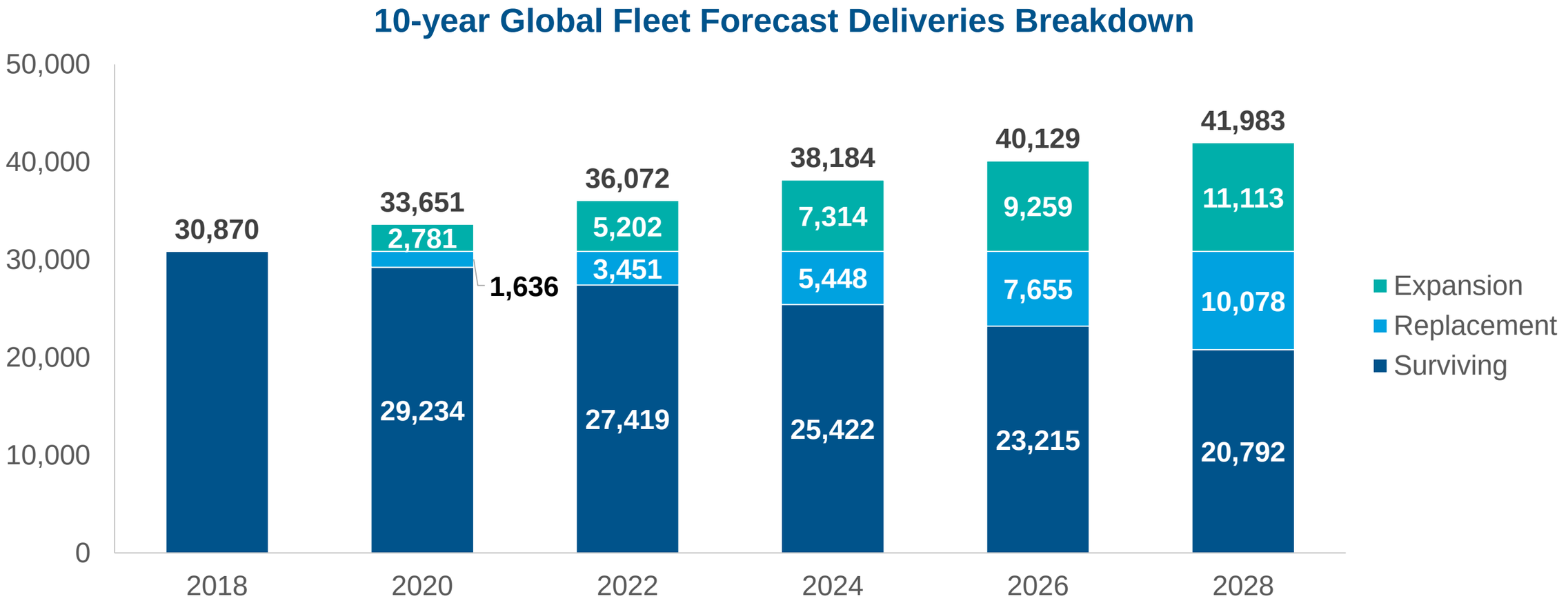
Source: ICF Analysis

Asia Pacific has surpassed North America and Europe in total fleet size, and will continue to grow to ~14,700 commercial aircraft by 2028



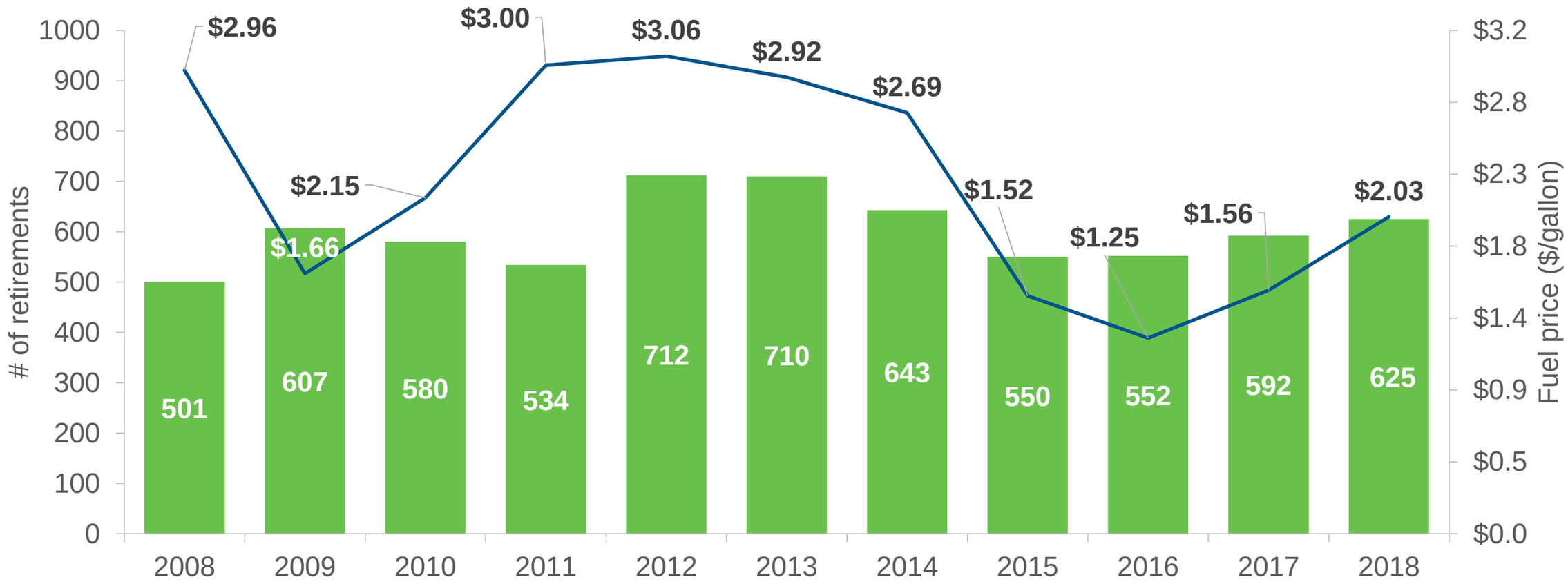
Source: ICF Analysis

New aircraft deliveries are for both expansion and replacement of retirement aircraft



Source: ICF Analysis

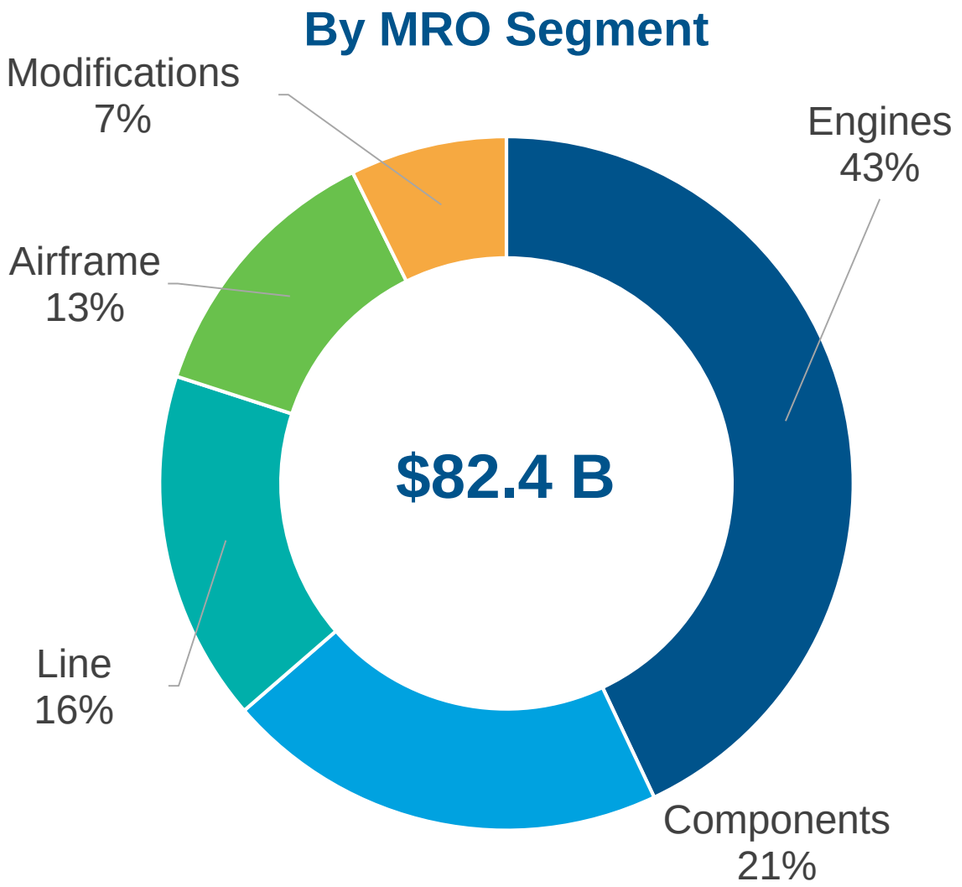
Aircraft retirements are influenced by many different elements

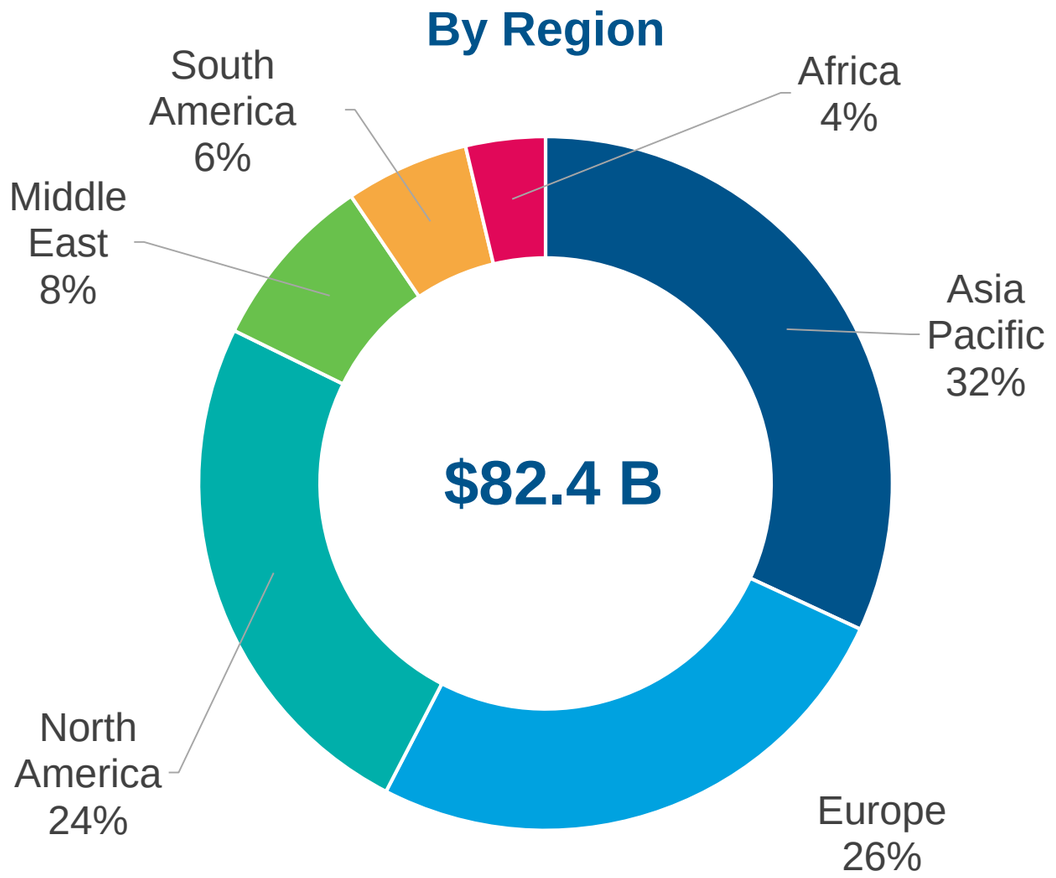


Source: ICF Analysis, CAPA, World bank

MRO trends

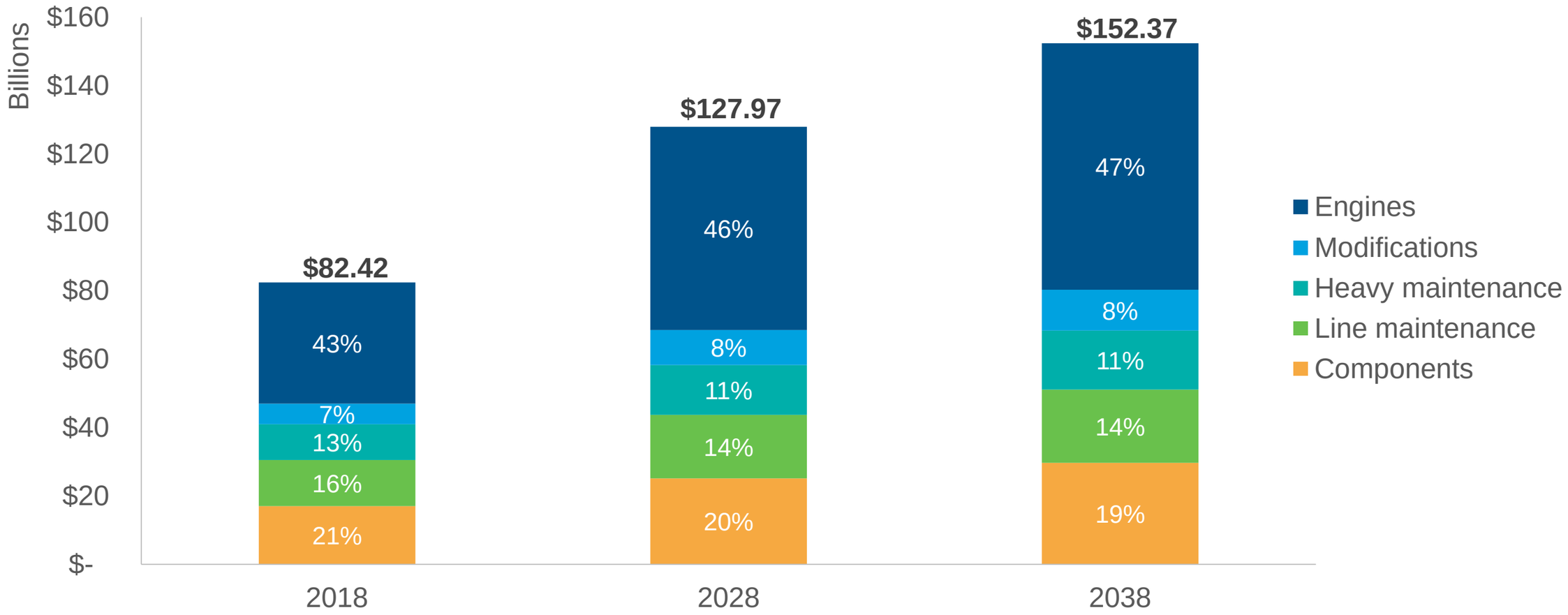
2018 commercial air transport MRO demand is $82.4B, with engines representing the largest share





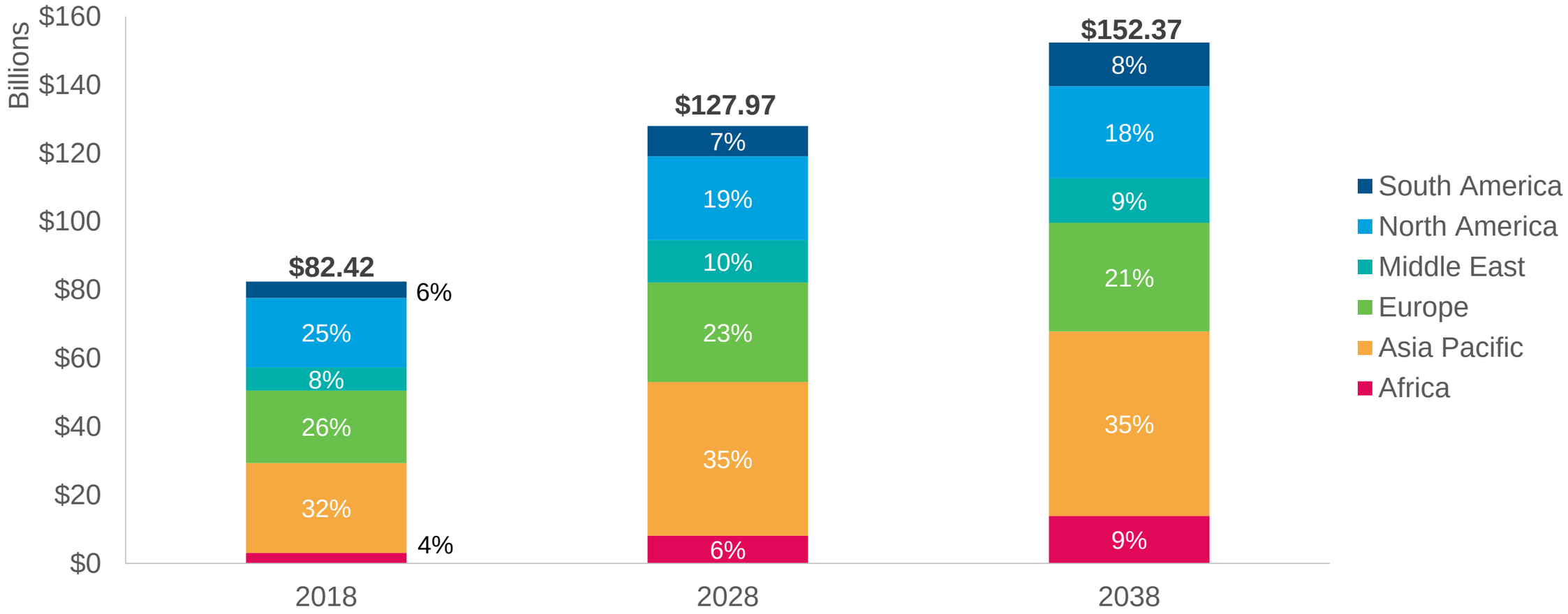
Source: ICF Analysis

The global MRO market is expected to grow to nearly $128 billion by 2028



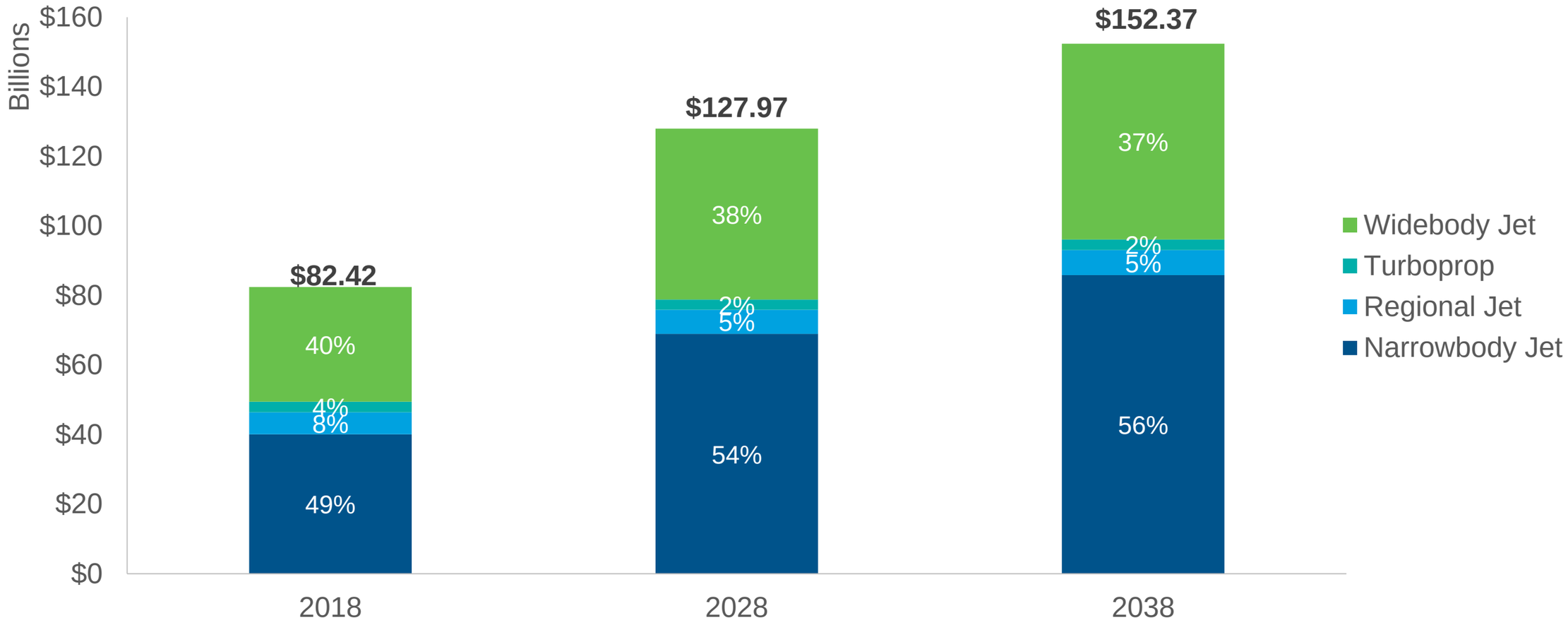
Source: ICF Analysis

Europe is the second largest region, with a total spend of $21 billion in 2018



Source: ICF Analysis

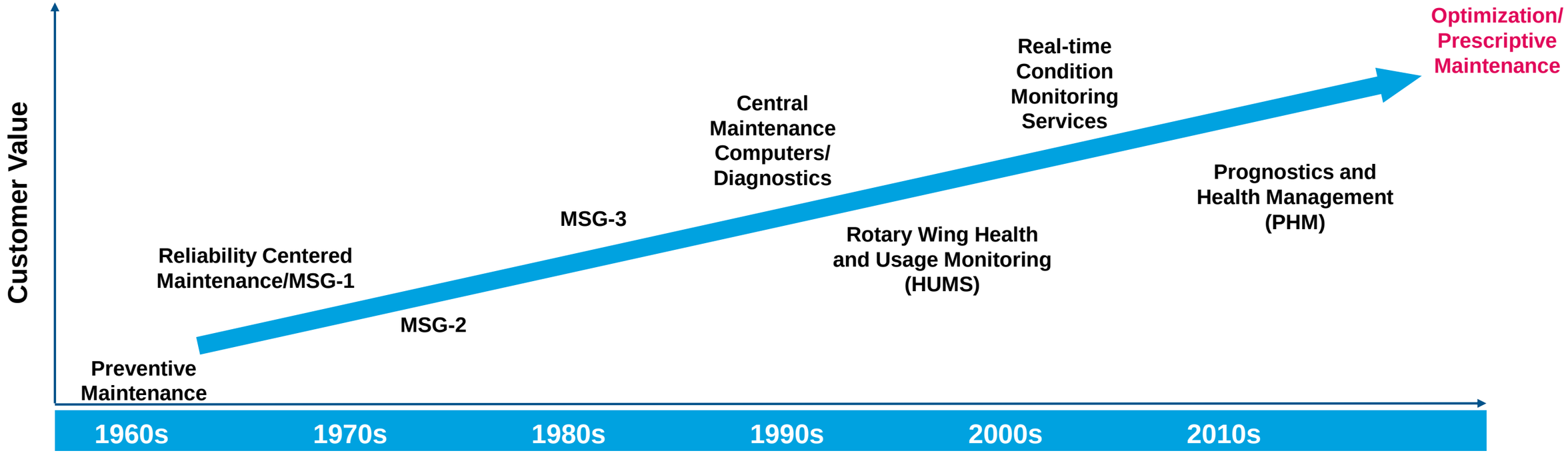
The total MRO spend for narrow body aircraft will grow from $40B in 2018 to nearly $86B in 2038



Source: ICF Analysis

The changing MRO landscape

Maintenance principles have evolved over time and continue to change, resulting in safer and more efficient maintenance programs



1968
Handbook "Maintenance Evaluation and Program Development" or MSG-1 developed

1970
MSG-1 updated to MSG-2

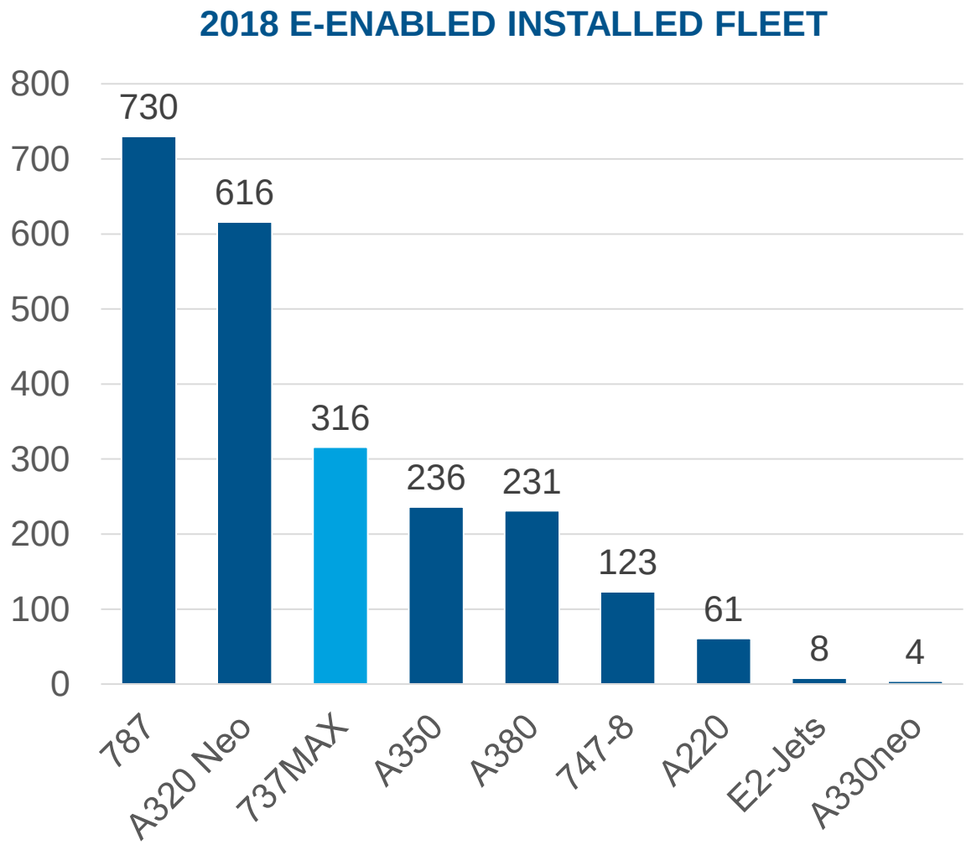
1979
Methodology for maintenance programs based on tested and proven airline practices or MSG-3

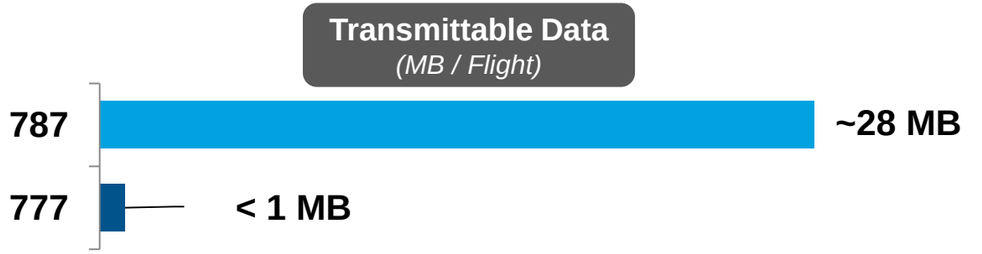
1999
Rolls-Royce starts its TotalCare program introducing extensive health monitoring services

2012
Boeing launches AHM and Airbus launches AiRTHM

2016 -2017
AFI KLM and LHT launch health management and prognostic products

New generation aircraft provide significant opportunities for airlines and MRO's alike



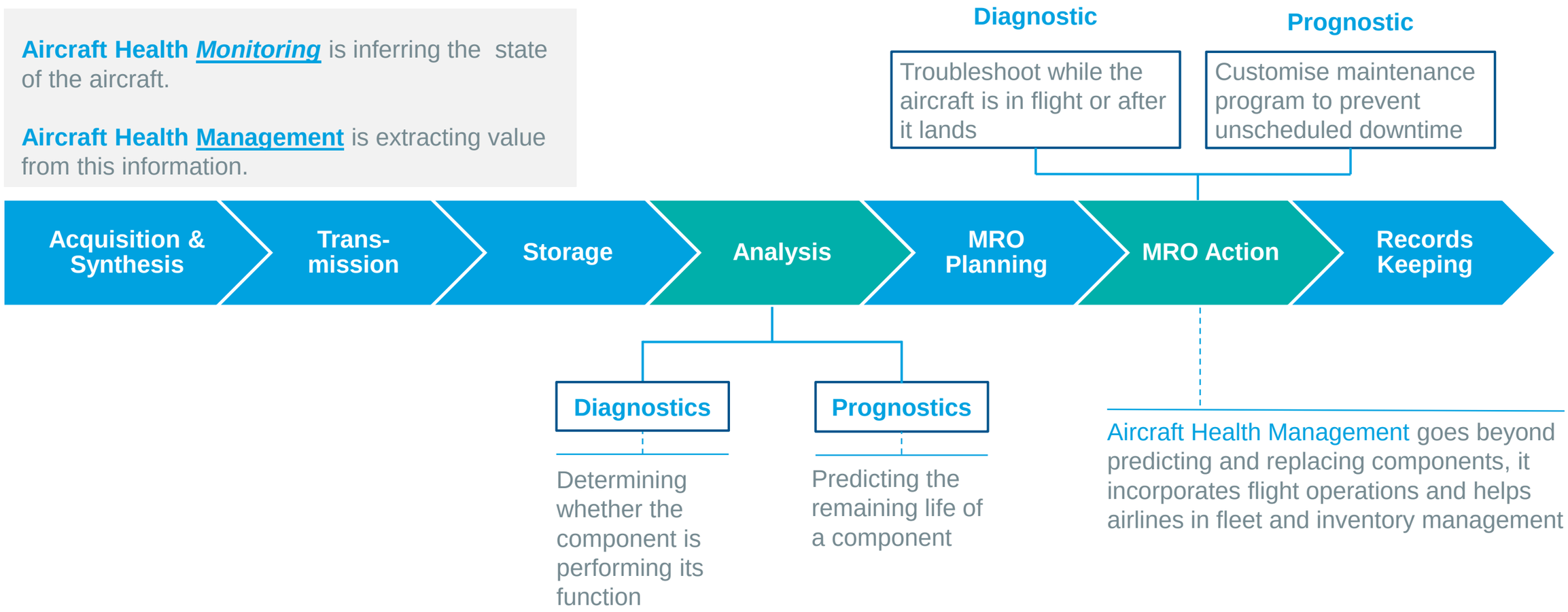


- New generation aircraft generate significantly more data compared to older types
- Aircraft health monitoring through the increased use of date will improve maintenance processes
- This will reduce maintenance cost and improve operational revenue

AHM can be viewed as a subset of data management value chain

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

Aircraft Health Management is extracting value from this information.



But AHM needs several building blocks for it to be an efficient and effective system

Access to Hardware and Infrastructure

- Hardware on Aircraft
- In-Flight Transmission
- Ground-based Transmission
- Cleaning
- Storage
- Web Portal or Other Interface

Intellectual Property

- Aircraft Health Data
- Flight Operations and Environmental Data
- OEM Documentation of Aircraft & Systems
- Maintenance Manuals
- Historic MRO data

Analytics

- Technical Expertise
- Diagnostics
- Prognostics

Aircraft Expertise

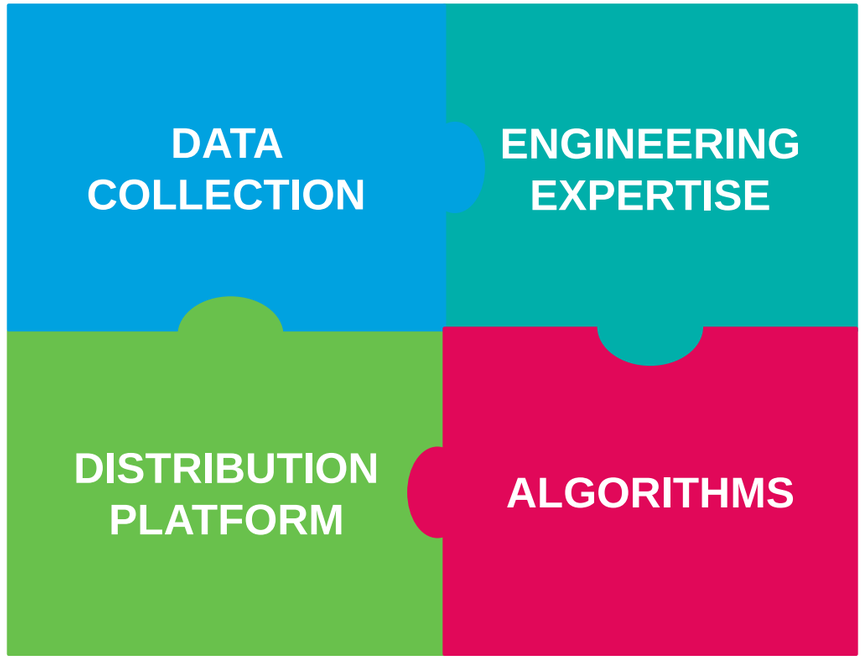
- Maintenance Expertise
- OE Design Expertise
- Integration with MRO software

Customer Support

- Processes for Validating and Communicating Outcomes to Customers
- Technical Support Centre

It is becoming clear that only a handful of players have the expertise to succeed in this market

Building blocks



Main candidates

skywise.

Prognos®

PREDIX

AVIATAR
Join the future of aviation

BOEING ANALYTX
boeing.com/analytx

R² Data Labs

IKON

"Large airlines may well decide to do it in-house as their scale make this option viable and they have the engineering expertise to do it.

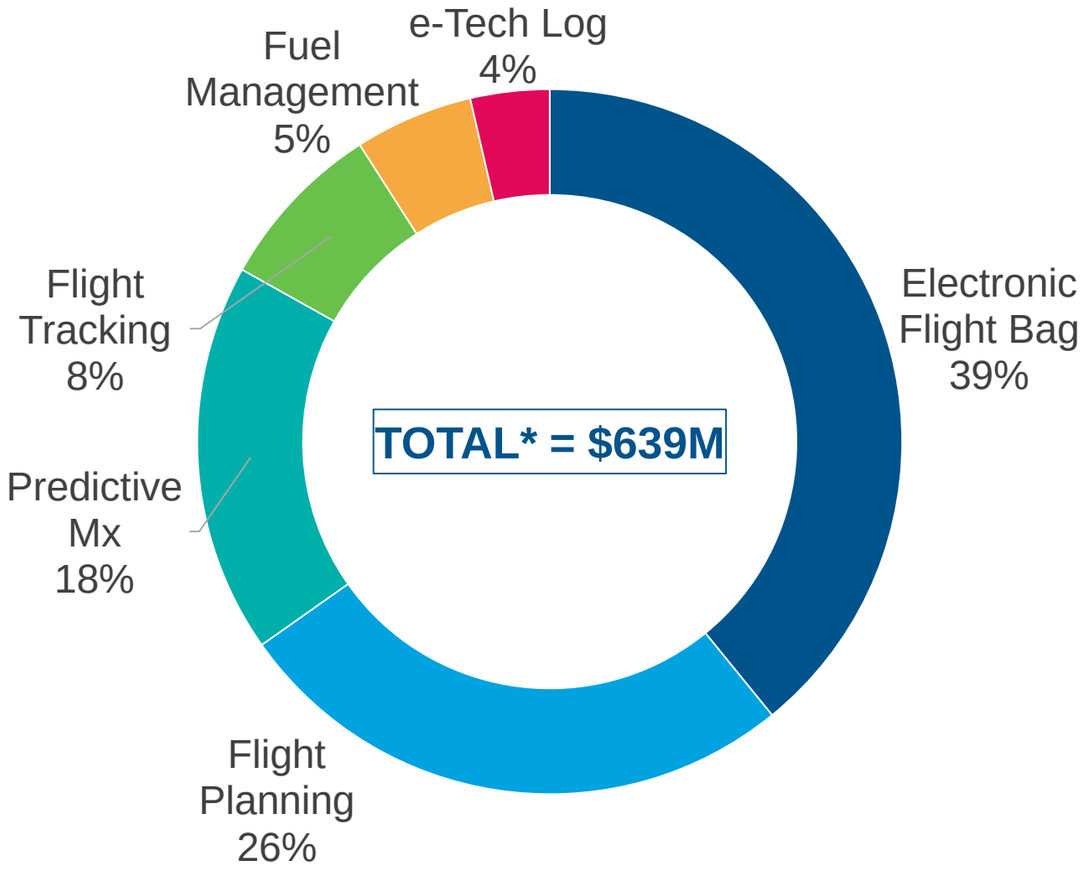
However, if you don't already have the engineering expertise and have limited scale, don't waste time hiring data scientists"
- Predictive Maintenance provider

There is a large variation in the predictive capability of the available systems

Solution	Strengths	Weaknesses
skywise	•Data acquisition monopoly on FOMAX equipped Airbus fleet •High airline & supplier adoption	•Less MRO expertise •Limited to Airbus aircraft
AnalytX	•Market penetration through offset •Wide coverage and multiple value propositions	•Less MRO expertise •Limited to Boeing Aircraft
AVIATAR AVIATION DataHub	•Open and independent platform with multiple solutions •High MRO expertise (LHT and LHT group)	•Limited customer adoption
Prognos®	•Covers all major Airbus and Boeing platforms •High MRO expertise (AFI KLM E&M)	•Currently limited to aircraft under AFI KLM E&M service •Scope of services is narrower than other products
PREDIX	•Platform covering more industries than aviation •Decades of engine data processing	•Limited airframe and component MRO expertise •Engine focused expertise & limited to GE engines
R2 Data Labs	•Platform covering more industries than aviation •Decades of engine data processing	•Limited airframe and component MRO expertise •Engine focused expertise & limited to RR engines
EMBRAER IKON	•Potential monopoly on Embraer aircraft •Integrated with Amazon Web Services	•Late entry limited to E2 jets & only 2 customers so far •Total in-service and on order fleet <300 aircraft

ICF estimates that in 2018 airline operation digital market to be $639M

- EFBs are ~40% of the airline spend given the high cost associated with it and high adoption
- Predictive maintenance solutions are the third largest spend for airlines
- The e-Tech log market, currently at 4% of the total spend, will grow as more airlines adopt the solution



*Note: This doesn't include regular IT spend on network planning, crew planning software etc
Source: ICF Analysis

Digitisation could enable airlines to save in excess of $5B/year

Maintenance cost

~ $3B

From AHM and predictive maintenance

- Driven by improved dispatch reliability, No Fault Found reduction, Inventory reduction and Improved labour productivity

Fuel saving

~ $1.7B

From flight optimisation

- Continuous flight optimisation through live weather updates, speed and altitude optimisation…

Delay reduction

~ $0.8B

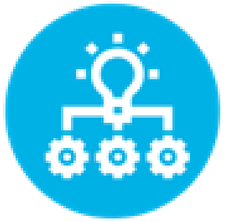
From improved operational processes

- Improved turnaround process, in-flight routing optimisation

Summary and conclusion

There is significant opportunity for predictive maintenance to grow further and mature

- **The MRO market will continue to grow to $128B by 2028**



- **Solutions for predictive maintenance need to mature further, so that all systems line up**

- **At around ~$5B, the benefits for the airlines are significant**

Digitisation of aircraft operations continues to develop at a fast pace, but still has a long way to go.

Aircraft OEMs have significant aftermarket service revenue ambitions and are seeing digitalisation of aircraft operations as a an avenue to grow their service business line.

Full integration of the predictive maintenance solutions into existing and future MRO software is required to support all the airline's business processes

QUESTIONS?

www.icf.com/aviation
joost.groenenboom@icf.com

Four specialized practices collaborate together and with our clients to effectively address business challenges




Airline Advisory

Operational, strategic, and transaction support for airlines and air transport businesses

Airports

Operational and strategic support for owners, operators, regulators, and developers

Aircraft

Industry-focused support for aviation equipment transaction activities

Aerospace & MRO

Strategy and marketing advisory, and transaction support for OEMs, MROs, and investors

ICF provides aircraft operators, manufacturers, financiers, lessors, owners, maintainers, airports, and related businesses with world-class advisory, implementation, and improvement management consulting services.

Serving the Aviation Community Since 1963

ICF Aviation Comprehensive Services:

Airlines - Fleet and network planning, pricing and revenue management, OTP and operational efficiency

Airports - Strategic planning, policy, route development, concessions planning

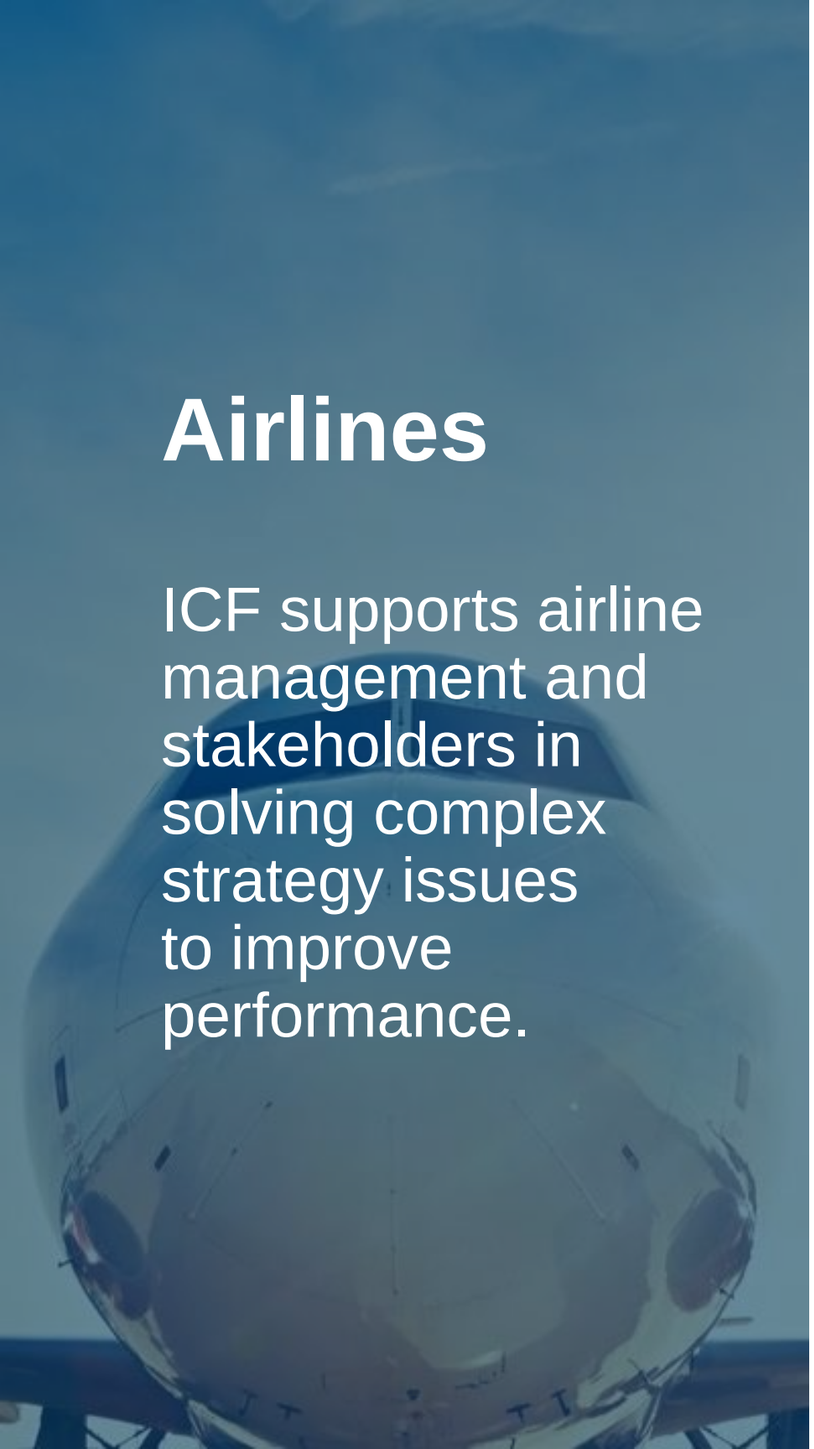
Aircraft - Valuations, cash flow forecasts, portfolio due diligence, market analysis, technical services

Aerospace & MRO - Operations assessment, M&A support, marketing analysis

BROAD PERSPECTIVE. **COMPELLING RESULTS.**

ICF offers our team of nearly 100 aviation experts dedicated to strategic and operations consulting for the aviation industry. Our aviation practice was founded as SH&E in 1963 and, after being acquired by ICF in 2007, we further expanded with the acquisition of AeroStrategy in 2011. Today we are one of the world's largest aviation consulting organizations. We provide objective, independent commercial, financial, technical, and regulatory guidance to aviation clients, including airlines, airports, lessors, financial institutions, manufacturers, governments, and VIPs. From our offices around the globe, ICF helps aviation clients manage assets and operations, mitigate risk, and maximize return on investment. **Visit us online at icf.com/aviation.**

ICF is a proud member of both ISTAT and the IATA Strategic Partnerships Program.



Airlines

ICF supports airline management and stakeholders in solving complex strategy issues to improve performance.

ICF provides strategic and operational advice to airline management and related stakeholders throughout the world. We help our clients navigate key business challenges by leveraging decades of global industry experience and a suite of proprietary models and databases. Below, we briefly describe our core airline advisory services and proprietary supporting products.

Airline Products
ICF's suite of proprietary airline tools, models, and databases offers a data-driven approach to help management and stakeholders navigate key business challenges to their advantage.

NetWorks® Planning Software
ICF provides its network and schedule analysis/systems to longstanding clients and for use in consulting assignments.

RM100/500/750 Revenue Management Software
Partnering with SITA, ICF has been the developer and technical support for SITA's multi-product RMS suite.

Airline Fleet Planning Model
Developed to give airlines a strong decision support product, ICF's model offers speed and clarity.

Planning
Whether in network, fleet, revenue management, alliances, loyalty, distribution, catering, maintenance, or expense planning, ICF has experience with carriers globally, large and small, legacy and low cost.

Strategy
As airlines assess long-term success criteria, alliance pros and cons, the changing competitive landscape, and areas of defensible advantage, ICF can help with strategic studies.

Operations
ICF supports airlines in turn-time reduction, OTP improvement, cost reduction, operations control, crew productivity, and MRO programs.

Finance
From bankruptcy and turn-around situations to cash-flow forecasting, transaction modeling, and financial planning, ICF has worked with airline CFOs, investors, and creditors.

Airports

ICF supports airports and industry participants across a range of expertise-based engagements.

ICF advises airport management, governments, civil aviation authorities, and buyers & sellers of airport assets throughout the world. Our long-term relationships with these entities make us a trusted guide through today's complex, competitive landscape. Below, we briefly describe our core airport advisory services and proprietary supporting products.

Airport Products
ICF's suite of proprietary airport tools, models, and databases helps management and stakeholders navigate key business challenges to their advantage.

NetWorks® Planning Software
ICF provides its network and schedule analysis/systems to longstanding clients and for use in consulting assignments.

Commercial Revenue Database
This premier assembly of expected revenue-generation values guides commercial planning.

Airline Fleet Planning Model
ICF's own, independent traffic demand forecast gives planners an unbiased point of view.

Strategic Planning
ICF brings airport planners with decades of expertise from hundreds of assignments to deliver the insight, attention to detail, and multi-faceted thinking needed for success.

Transaction Advisory
ICF has participated in almost every major airport asset transaction around the world in the past 20 years—and continues to be a trusted, objective, impartial advisor in every engagement.

Policy and Regulation
Some of the best-known consultants in policy and regulation are with ICF, helping airport directors, governing boards, and agencies determine the right framework for each distinct need.

Operations Improvement
Recognizing the power of integrated IT systems, the complexities of hub turn-times, and the environmental cost of non-sustainable operations, ICF can help improve both costs and efficiency.

Aircraft

ICF supports investors in aviation hard assets and provides asset management and remarketing to aircraft owners, lenders, and operators.

Lessors, operators, and investors count on ICF for integrity, flawless analysis, and expert technical support with aviation deals—from a single aircraft to the world's largest lease portfolio. Our certified ISTAT appraisers value aircraft and aviation assets worth billions of dollars each year, provide due diligence to buyers and sellers, and offer a full range of financial services. Below, we briefly describe our aircraft services and proprietary supporting products.

Aircraft Products
ICF's suite of proprietary asset advisory tools, models, and databases helps stakeholders navigate key business challenges to their advantage.

Maintenance Cash Flow Forecast
Our proprietary model builds portfolio cash flows from each discrete maintenance event.

TrueBook Valuations
Aircraft and engine bluebooks forecast residual values built up from component value over time.

Spare Parts Inventory Appraisals
Millions of transactions for spare parts support valuation and benchmarks.

Aircraft Transactions
Across the lifecycle—acquisition, inspection, transition, default management, and remarketing—ICF's experienced aircraft advisors deliver the specialized expertise where and when needed.

Financial Services
Recognized as best-in-class for maintenance cash flow projections and modeling for capital markets and P/E firms, ICF is able to support complex structures and transactions of aircraft lease portfolios and securitizations.

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ICF's ISTAT-certified appraisers routinely value aircraft, engines, spare parts, simulators, plus intangible assets like routes, slots, and gates—backed by ICF's best-in-class methodology and models.

Due Diligence
ICF provides aircraft trading due diligence services for single aircraft or full portfolios, and for investors or lessors during M&A or IPO transactions—combining our analytical expertise with our team's executive experience with lessors, airlines, and MRO providers.

Aerospace and MRO

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

ICF guides manufacturers, airlines, independent MROs, suppliers, and the financial community through every step of the aerospace and MRO supply chain to realize value and develop strategies that drive growth. We understand and focus on the key aspects of the industry, and have the proprietary tools necessary for successful operations. Below, we briefly describe our core aerospace & MRO services and proprietary supporting products.

Aerospace and MRO Products
ICF's suite of proprietary asset advisory tools, models, and databases helps stakeholders navigate key business challenges to their advantage.

Fleet & MRO Forecasts
Proprietary, independent forecasts for commercial and business aviation, industrial gas turbine, and military markets.

Value Database
Production value breakdown by component category and raw material content across the aerospace supply chain.

MRO Best Practices and Benchmarks
Comprehensive, proprietary databases on processes, costs, and organization.

Strategy Development
Leveraging years of aerospace and MRO advisory experience as well as proprietary market intelligence, ICF delivers data-driven, objective insight to underpin sustainable strategies.

Transaction Support
For clients' investment decisions, ICF combines global thought leadership in aerospace and MRO supply chain with accurate market intelligence, operations expertise, and unparalleled industry contacts.

Operations and Supply Chain
ICF's proven tools and methodologies offer improved performance and cost reduction across manufacturing, operations, and all phases of make-buy supply chain planning and execution.

MRO Business Improvement
For airlines, OEMs, and independent MROs, ICF has deep experience in comprehensive operational and financial diagnostics based on extensive proprietary benchmarks, followed by results-oriented improvement programs.