# Reviving the Commercial Aircraft Supply Chain

What's holding back the commercial aircraft supply chain — and where to go from here

OliverWyman | IATA

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# Contents

# Foreword

Aviation cannot function without a reliable supply chain. Yet today, grounded aircraft, delayed deliveries, and escalating maintenance and leasing costs are clear symptoms of a system under strain. Airlines face long waits for engines and components, while OEMs, MROs, and suppliers are challenged by capacity and labor constraints, as well as fragile supply chains.

Aircraft certification delays and engine reliability issues are compounding backlogs and extending delivery times. At the same time, the aviation economic model has become unbalanced, with engine and equipment system OEMs receiving a growing share of profitability from aftermarket repairs and spare parts, rather than new equipment sales.

Timely access to serviceable parts and maintenance is essential to keep aircraft flying and avoid unnecessary groundings. This requires restoring standard supply lead times and repair turnaround times. A stronger supply chain also depends on transparency and collaboration across the value chain. Without decisive action, these bottlenecks risk constraining aviation growth and sustainability.

This joint IATA-Oliver Wyman report sets out the scale of the challenge and provides practical steps for improvement. Expanding capacity, opening up the MRO aftermarket, improving forecasting and data visibility, and fostering competition and alternative solutions will be critical. Reviving the supply chain is not optional; it is essential for the future of aviation.

# Executive Summary

Supply chain challenges are one of the most pressing issues facing the commercial aviation industry today, with airlines waiting longer for both aircraft and parts. As a result, airlines have been forced to reevaluate fleet plans and, in many cases, keep older aircraft flying longer, which has created even more complications in the aftermarket.

By our estimate, these challenges could cost the airline industry more than $11 billion[1] in 2025, driven by a mix of delayed fuel cost savings, higher maintenance costs, and increased spares inventory. But this represents only a portion of the economic and operational impacts facing the aviation industry due to supply chain challenges; others include delayed expansion of service, impacted aircraft and asset lease rates, and more/longer operational disruptions.

In this report, we provide a detailed look at the current structure of the commercial aerospace supply chain, challenges and their root causes, impacts on airlines, and some potential actions for moving the industry forward.

## Aircraft market outlook — and backlog

The aircraft market has not quite fully recovered to its pre-pandemic size but is on track to do so by 2027. The problem? The highly consolidated, tiered structure of the commercial aircraft industry has found it difficult to absorb multiple recent and overlapping market shocks — from the disarray caused by the COVID-19 pandemic to geopolitical conflict-driven material shortages and tight labor markets. As a result, airlines are waiting for new aircraft with lower fuel consumption, while facing higher maintenance and repair costs for an aging fleet.

## Industry structure and challenges

The current commercial aerospace industry structure began to take form in the 1980s, evolving through waves of consolidation in successive decades. At the same time, the airline industry opened new markets, stimulated demand, and improved profitability; and original equipment manufacturers (OEMs) delivered significant improvements in aircraft technology while keeping upfront aircraft acquisition costs relatively competitive. Today, many aircraft components are sole sourced by original aircraft program specifications. The maintenance, repair, and overhaul (MRO) supply chain has consolidated as well, with OEMs aiming to increasingly participate in the engine and component aftermarkets.

1 All dollar amounts in this report are in US dollars

Ongoing aviation industry challenges, from widespread supply chain volatility and price increases to aircraft and parts delivery delays, are being exacerbated by the current structure of the aircraft production and aftermarket supply chains and their associated business models — undermining airline operations.

## Root causes of supply chain friction

The root causes of current supply chain challenges center on three main issues. The first is that the overall aerospace economic model has resulted in an unbalanced situation where OEMs aim to generate a larger portion of their profitability in the aftermarket (repairs and spare parts) versus new equipment sales.

A second issue is supply chain disruption, including geopolitical instability, raw material shortages, and greater demand for military/business jets — which share supply chain touchpoints with commercial aircraft. While some level of external pressures and supply chain volatility is always present, a series of global crises in recent years have overlapped one another, creating a bigger "hole," slowing investment in new capacity, and making it more difficult for the aerospace industry to climb out.

Finally, the aerospace industry is being deeply constrained by tight labor markets. As a large wave continues of older workers retiring, industry participants are struggling to recruit, retain, and train sufficient skilled workers from younger generations.

## Impact on airlines

Although supply chain challenges affect airlines in various ways, we have identified four primary impacts that together could cost airlines more than $11 billion in 2025. The largest cost bucket is delayed fuel efficiency (~$4.2 billion), due to airlines having to operate older, less efficient aircraft while waiting for the new aircraft backlog to ease. Next is additional maintenance cost ($3.1 billion), as the global fleet is older than it should be, and older aircraft are more costly to maintain. Third, excess engine leasing costs are estimated at $2.6 billion for 2025, as more engines must be leased (to make up for engines spending longer on the ground when they require maintenance). This is in addition to aircraft lease rates, which have increased by 20-30% from 2019 to the end of 2024. Finally, excess inventory holding costs for 2025 are estimated at $1.4 billion, as airlines have increased spares inventory to make up for unpredictable parts supply.

## Actions for industry

While there is no quick fix for the problems the commercial aerospace industry faces, we believe there are steps that airlines, OEMs, lessors, and suppliers can take to begin addressing the current supply-demand imbalance and build in greater resilience for the future. These include:

**Ramp up collaboration** to improve schedule stability and early insight into supply chain problems, as well as to develop early warning and joint contingency planning tailored to specific risk areas. Airlines also could consider sharing best practices and exploring the benefits of further standardization.

**Improve supply chain insight** through end-to-end supply chain mapping and visibility, thus revealing potential bottlenecks and hidden risks. This also could enable better collaboration and innovation, such as the integration of digital tools for real-time track and trace.

**Better leverage inventory and maintenance data:** Airlines possess a wealth of data, and through open industry forums, etc. could leverage it for virtual "parts pooling"[2] to optimize parts access and inventory, as well as to develop predictive tools. This also could include central repositories for aircraft maintenance data to serve as a shared knowledge base.

**Expand maintenance and parts supply** by increasing the ability to repair materials, and the use of Parts Manufacturer Approval (PMA) arrangements and Used Serviceable Materials (USM).[3] With OEM and MRO provider support, these actions would free up production capacity to focus on critical parts in short supply. Airlines also could better leverage warranty/performance terms in existing agreements.

**Open up aftermarket best practices**, which would include supporting MROs being less constrained by OEM-driven commercial licensing models, and encouraging the rise of new, independent MRO programs (as well as access to alternative sourcing of materials and services). This could be accomplished through a variety of existing industry enablers, such as active use of used serviceable materials (USM), development of EASA Part 21 and/or FAA DER repair instructions, STC retrofit solutions, broader deployment of PMAs, etc.

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2 An example of this is the International Airlines Technical Pool.

3 Note: PMA — generic replacement parts approved by aviation authorities as alternatives to OEM parts. USM — previously installed parts that have been certified by an approved Part 145 organization (following repair, overhaul and/or inspection tests) to be serviceable, and therefore available for reuse.

**Leverage existing contractual enablers** to increase competition. This includes frameworks which already exist and are accessible to all airlines and their MROs. For example, the Airbus Supplier Support Conditions (SSC) and Boeing Product Support and Assurance Agreement (PSAA) frameworks with their delegation mechanism, the IATA-CFM Agreement on Engine Maintenance and IATA and Rolls Royce Statement on Best Practices for Maintaining Competition in Aerospace Markets, the FAA Order 8110.54A for unrestricted access to Instructions of Continued Airworthiness (ICAs), etc.

**Support the current and future workforce** through innovation in training, incentives, and recruiting. The five generations now in the workforce have different learning styles, technology exposure, and work-life values — workforce programs and outreach efforts need to recognize this.

We believe that present commercial aerospace supply chain challenges are not intractable. A broader, united industry response that is more proactive, flexible, and strategic could help all participants better prepare for and be ready to respond to supply chain threats, while ramping up efficiency and driving down costs over the long term.

SECTION I.

# Aircraft Market Size and Outlook

The commercial aerospace market is forecast to surpass $230 billion in 2025. Although this is below the $278 billion peak reached in 2019, the market is on track to fully recover from its pandemic-induced downturn by 2027.

Over the next decade, the market is projected to grow by an average of 5% per year, with the original equipment manufacturer (OEM) market growing by more than double the pace of maintenance, repair, and overhaul (MRO) (Exhibit 1).

The worldwide commercial backlog reached a historic high of more than 17,000 aircraft in 2024, significantly higher than the 2010 to 2019 backlog of around 13,000 aircraft per year. Despite strong order books, the OEM market has not yet seen a recovery to 2019 levels, with 2024 deliveries totaling 1,226 aircraft, compared to 1,374 in 2019 (a 10% decrease), highlighting production capacity constraints. This bottleneck is forcing airlines to extend the operational life of their current fleet, as well as delaying fleet renewal and, in some cases, expansion plans.

The MRO market, which typically accounts for more than 40% of the total aerospace market, has recovered faster than manufacturing. The MRO market is set to reach nearly $120 billion in 2025 and exceed $150 billion by 2030. This growth is being driven by the dual forces of an aging fleet, which requires more maintenance, and the maintenance needs of new aircraft, which are experiencing teething issues — especially, but not exclusively, in the form of costly engine visits that are occurring earlier than expected.

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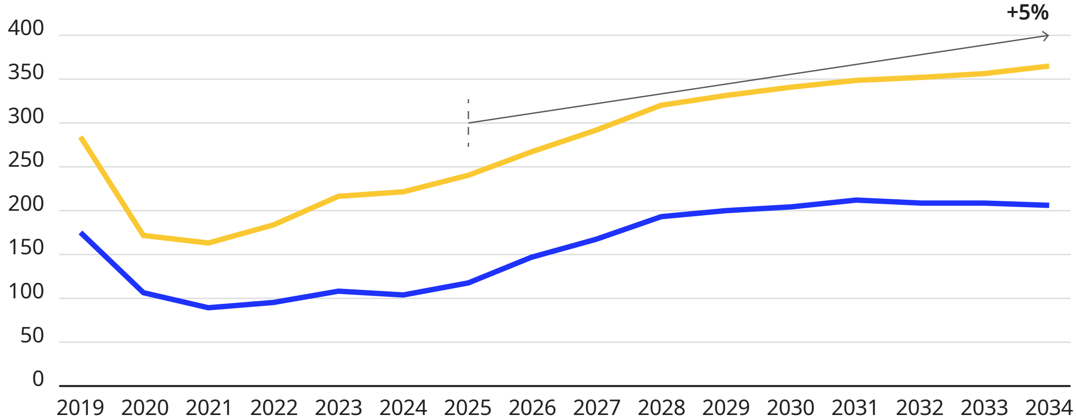
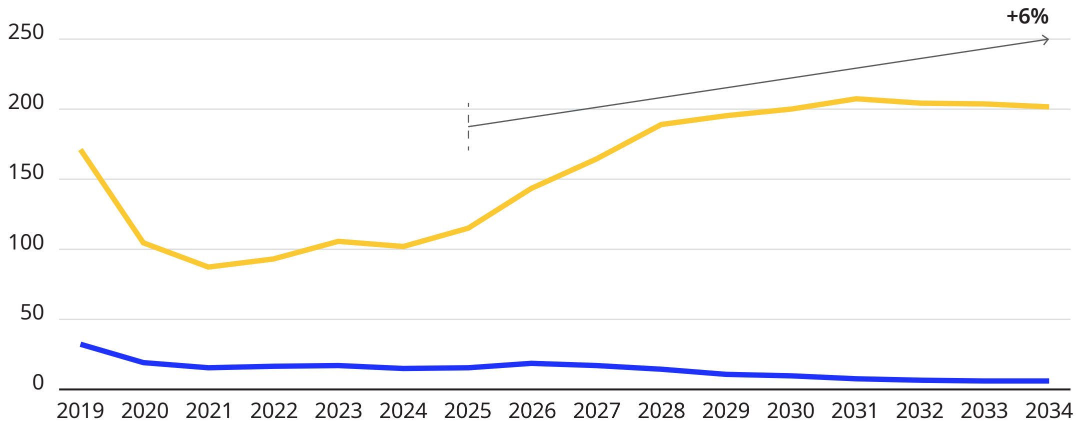
**Exhibit 1: Global commercial aerospace, OEM, and MRO market value, 2019-2034**
$ billions, CAGRs

Global commercial aerospace market



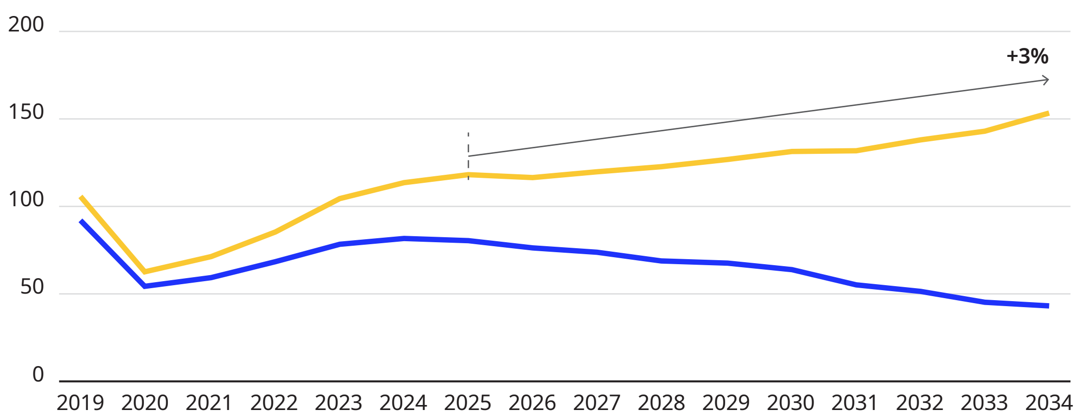

**CAGR 2019–2034:** OEM +1% MRO +3%

Global OEM market




**CAGR 2019–2034:** Legacy -11% Modern +2%

Global MRO market




**CAGR 2019–2034:** Legacy -5% Modern +15%

Source: Oliver Wyman analysis and Global Fleet and MRO Forecast

SECTION II.

# Key Supply Chain Structures

This section explores production and aftermarket supply chain structures and provides context for supply chain issues explored in subsequent sections. Experienced industry participants who are already cognizant of these structures may wish to continue on to supply chain challenges in Section III.

The aerospace value chain today is a tiered structure with a diverse range of organizations — each with a role to play in the industry (Exhibit 2). Suppliers at various tiers produce critical components, which airframers then assemble into finished aircraft.[4] These aircraft are then certified by various regulatory agencies before airlines and lessors put them into service. Throughout the aircraft lifecycle, airlines and MROs work to keep aircraft airworthy and ensure they retain their asset value. This section describes the market structure and key dynamics for OEMs (suppliers and airframers) and MROs.

## Airlines and MROs work to keep aircraft airworthy and ensure they retain value throughout their lifecycle.

4 Airframers are aircraft manufacturers such as Boeing, Airbus, COMAC, Embraer, and ATR that design and carry out final aircraft assembly.

**Exhibit 2: The commercial aerospace value chain**

Not exhaustive

### Suppliers

**Tier 1.**
**Aerostructures and main assembly**

**Engine OEMs**
- Rolls Royce
- CFM
- GE
- Pratt & Whitney

**Others**
- Honeywell
- Collins
- GKN
- Spirit
- Safran
- Aernnova

**Tier 2.**
**Components and subassemblies**
- Magellan
- Barnes
- Karman
- Latecoere
- Montana Aero
- Sonaca

**Tier 3.**
**Detailed parts and basic components**
- Cadence Aero
- Greene-Tweed
- Korry
- Moeller Aero
- Silcoms
- SKF

**Tier 4.**
**Raw material, castings, and forgings**
- ATI
- Doncasters
- CPP
- Howmet Aero
- PCC

### Airframers

**Boeing**

**Airbus**

**COMAC**

**MHIRJ**

**Embraer**

**ATR**

**DHC**

### Owners and operators

**Passenger airlines**
- Air France-KLM Group
- American
- China Eastern
- Emirates
- IAG Group
- IndiGo
- Qantas
- Ryanair
- Southwest

**Cargo airlines**
- FedEx Express
- UPS Air
- Cargolux
- Atlas Air
- Qatar Airways Cargo
- DHL Aviation

**Lessors**
- AerCap
- BOC Aviation
- AVOLON
- Air Lease Corp.
- BBAM

### Maintenance, repair, and overhaul (MRO)

**Engine, airframe, line, and component MRO**

**OEMs**
- Rolls Royce
- GE
- CFM
- Safran
- Embraer

**Airline MROs**
- Delta TechOps
- Lufthansa Technik
- Turkish Technic
- AFI KLM

**Independents**
- SR Technics
- AAR
- StandardAero
- ATS

**Joint ventures**
- MTU Zhuhai
- SAESL
- Evergreen Aviation
- STAECO

**Trading and distribution**
- AerSale
- AJW Aviation
- Avair
- DASI
- AerFin
- APOC
- Avtrade

### Regulators and industry bodies

- International Civil Aviation Organization
- International Air Transport Association
- European Aviation Safety Agency
- Federal Aviation Administration
- Civil Aviation Administration of China

Source: Oliver Wyman analysis

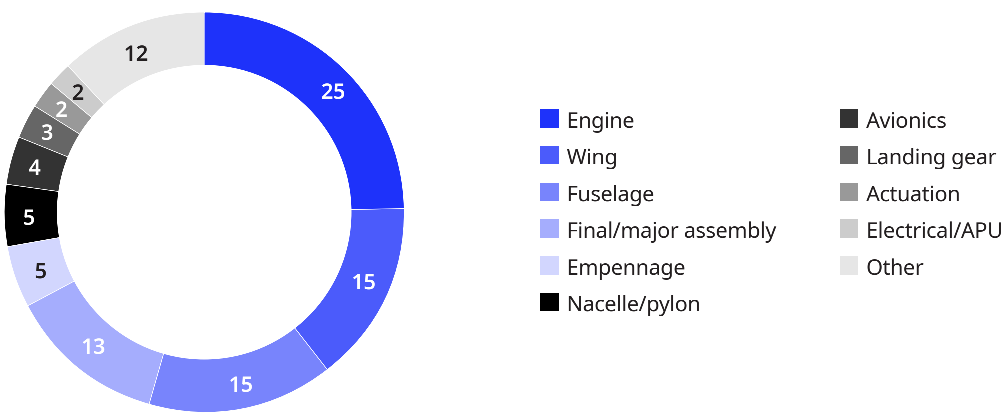
# Evolution and Structure of the OEM Value Chain

The current OEM market structure encompasses all players involved in the research, development, design, and manufacture of new aircraft. This market includes airframers and producers of major systems such as engines, aerostructures (for example, wings and fuselage), avionics, auxiliary power units (APUs), landing gear, and cabin interiors. The relative value of each of these systems for a newly built aircraft is shown in Exhibit 3.

Most of these segments are highly concentrated and served by just a few Tier 1 and Tier 2 suppliers (Exhibit 4). The OEM market structure plays a pivotal role in understanding the complexities around airframer backlogs and parts constraints.

**Exhibit 3: Share of average new build commercial aircraft value by system, 2024**

In percent

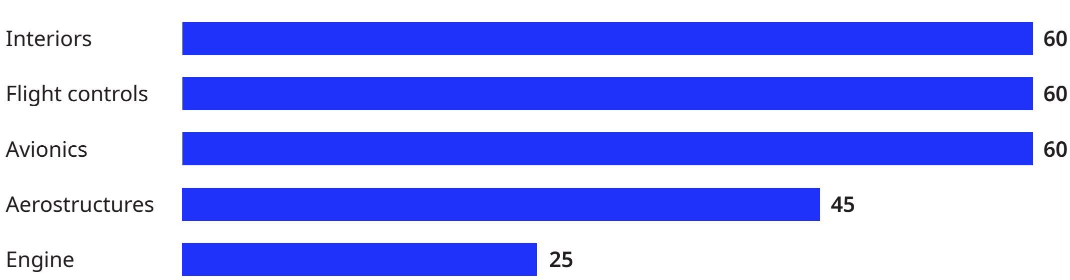



Note: OEM non-recurring engineering (NRE) costs and margins (as a percent of new build value) are excluded to isolate major system values

Source: Oliver Wyman analysis

**Exhibit 4: Market share of top five suppliers (T1 and T2) by segment**

Percent of respective market revenues, excluding airframers and engine OEMs




Source: Janes Capital Partners, Counterpoint Research, Oliver Wyman analysis

## Airframers

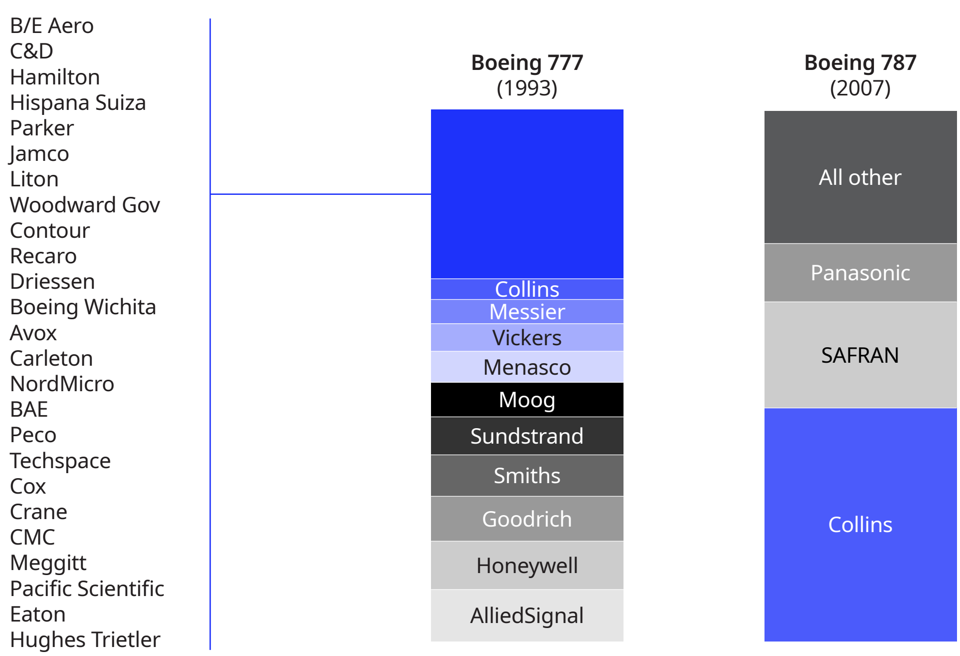
In the 1960s and 1970s, airframers maintained vertically integrated operations that kept control in-house and enabled visibility across the value chain. Major companies such as Boeing and Douglas Aircraft manufactured aerostructures, major systems, and interiors in-house, with tens of thousands of engineers and production workers co-located near final assembly lines. Suppliers mainly focused on manufacturing individual parts and subassemblies, with limited engineering involvement.

The end of the Cold War and trade liberalization (such as through the 1980 World Trade Organization Agreement on Civil Aircraft) opened up new markets and low-cost labor pools in China, Eastern Europe, and beyond. Concurrently, advances in digital design and global collaboration tools enabled airframers to coordinate complex projects across international boundaries. These developments made it both practical and economically advantageous for airframers to consolidate their supplier bases and delegate greater responsibility to a select group of Tier 1 suppliers.

Bombardier and Embraer pioneered this approach in the 1990s by transferring significant engineering and financial risk to Tier 1 partners, thus reducing their own development costs. This model soon became the industry standard, fundamentally reshaping the aerospace supply chain, as shown in Exhibit 5.

**Exhibit 5: Supplier consolidation example: component MRO spend for the B777 vs. B787**

Percent share of spend




Source: Oliver Wyman analysis

Today, Boeing and Airbus are the leading global airframers, representing 86% of all aircraft deliveries in 2024. This leadership is expected to continue over the next decade, although their combined share is expected to decline slightly, to 80%. Emerging manufacturers, such as the Commercial Aircraft Corporation of China (COMAC), [5] are projected to capture approximately 8% of the market by 2034. The remaining 12% of the market is expected to be captured by smaller airframers, such as Embraer and ATR.

## Engines

Engines represent the largest single component of new aircraft value, due to their technological complexity and use of advanced materials. The commercial aerospace engine market is split among four companies: CFM International (a 50/50 joint venture between GE and Safran), Pratt & Whitney, Rolls-Royce, and GE Aerospace.

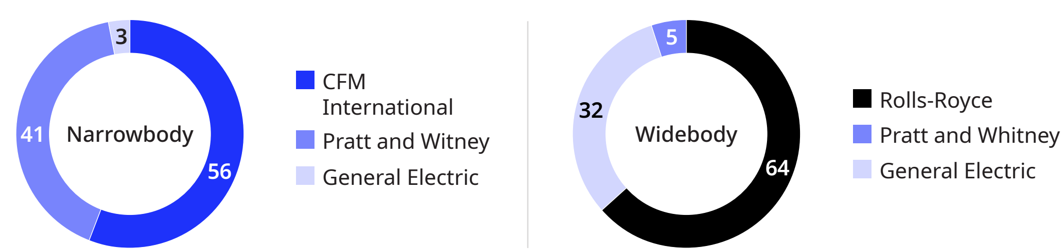
As shown in Exhibit 6, CFM and Pratt & Whitney primarily focus on narrowbody aircraft engines, with the CFM56, LEAP, and Geared Turbofan (GTF) powering the majority of narrowbody fleets. Rolls-Royce and GE specialize in widebody engines, with the Trent XWB series and the GEnx, GE9X, and GE90.

Both airframers and engine OEMs offer significant discounts compared to list prices on the initial sale of aircraft and engines. Discounts on engines vary widely but can be up to 80% or more. Engine OEMs then expect to recoup this investment through MRO services, including spare parts sales and scheduled maintenance, which can represent over half of total engine-related revenues. For example, in 2024, GE's and Rolls Royce's MRO services accounted for 74% and 66% of their total commercial revenue, respectively. Gross margins for engine OEMs are typically -5% to 10% on the manufacturing side and 20 to 35% on the MRO side.

Engine choice varies based on aircraft type (Exhibit 7). The A320 is the only major narrowbody platform in production with an engine choice (LEAP or PW1000G). On widebodies, the 787 is the only platform in production with an engine option (GEnx or Trent 1000).

**Exhibit 6: Narrowbody and widebody new build turbofan engine market, 2024**

Percent share by OEM




Note: Percentages based on share of total new build value in US dollars

Source: Oliver Wyman analysis

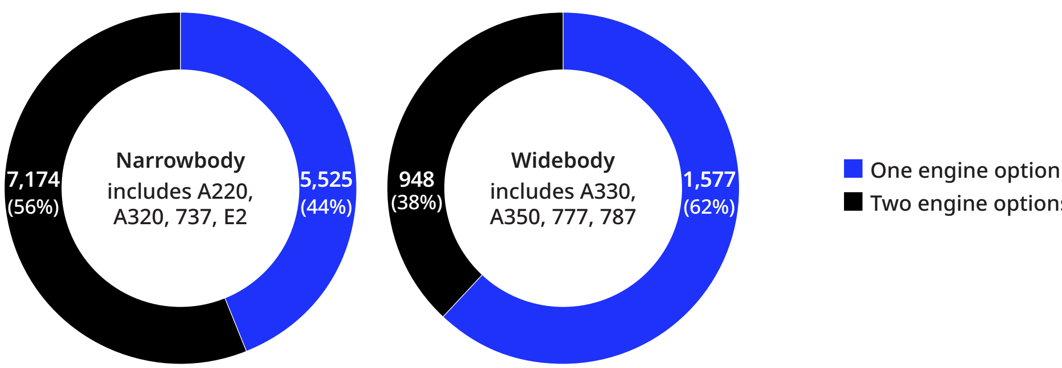
5 The COMAC C919 is expected to make up an increasing portion of Chinese airlines' fleets, with deliveries planned to exceed 200 aircraft per year by 2030. The C919 has seen just 16 total deliveries so far as of 2024, however, due to significant production ramp up hurdles

Decisions around engine choice, where available, are typically based on airline preferences around performance characteristics (such as fuel burn and thrust) and maintenance costs (maintenance agreements and spare engine/part pricing). Owners also occasionally consider supporting regional champions when making their engine decisions, with European airlines choosing CFM or Rolls Royce and North American airlines choosing Pratt & Whitney or GE.

Although engine options are predetermined by the airframer and included in the aircraft Type Certificate, owners will negotiate directly with engine manufacturers on performance guarantees, warranties, and other product support elements. The results of these negotiations impact the final engine price. Where the owner has a choice in engine platforms, it will conduct an engine selection campaign and sign purchase and service agreements with the engine OEM directly. If no choice is available, owners will do their best to negotiate with the airframer and the engine OEM for discounts on engine acquisition costs and performance guarantees, warranties, and other product support elements.

**Exhibit 7: Backlog distribution by engine choice for aircraft**

Percent of backlog as of May 2025




Note: Aircraft with two engine options are the A320 and the 787

Source: Oliver Wyman analysis

## Aerostructures

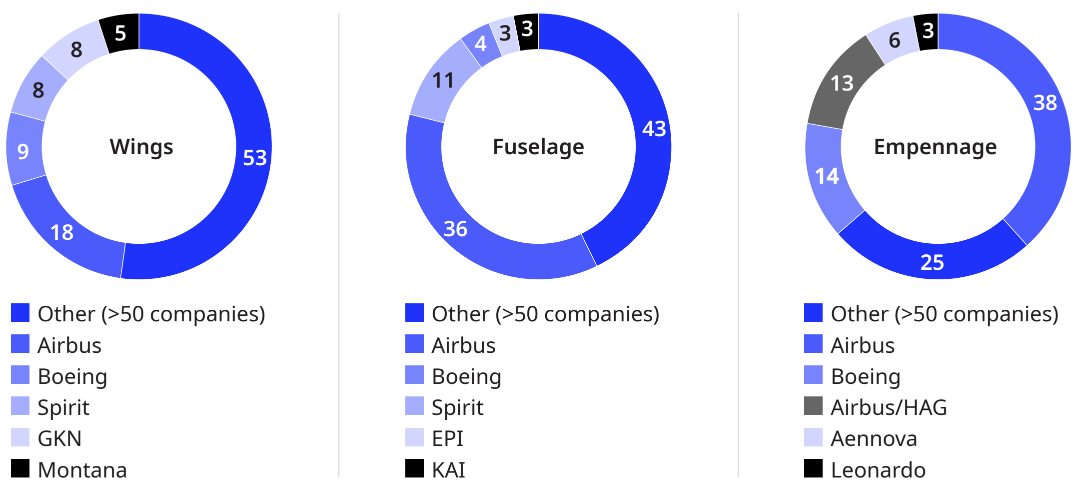
The aerostructures market encompasses the design and manufacture of critical aircraft components such as fuselage sections, wings, doors, nacelles, and thrust reversers. The market landscape is mixed: At the Tier 1 level, a few large suppliers are responsible for the production of major aerostructure assemblies (Exhibit 8). At lower tiers of the supply chain, the aerostructures market is highly fragmented, with thousands of players globally, primarily producing less complex machined parts, sheet metal details, and secondary interiors.

The current structure is the result of significant consolidation over the past two decades. In the late 1990s and continuing into the 2000s, airframers divested their in-house aerostructures facilities, creating opportunities for larger scale Tier 1 suppliers to emerge as they acquired and consolidated smaller Tier 1 companies and Tier 2 suppliers, reshaping the aerostructures supply base into a more concentrated network (Exhibit 9).

Strategic approaches to aerostructures sourcing differ for major airframers. Since 2005, Boeing historically outsourced much of its aerostructure manufacturing to suppliers such as Spirit AeroSystems. Recently, Boeing has moved to reintegrate Spirit into its operations, with a definitive merger agreement set to close in 2025.

**Exhibit 8: New build market shares by firm for select aerostructures, 2024**

Percent share

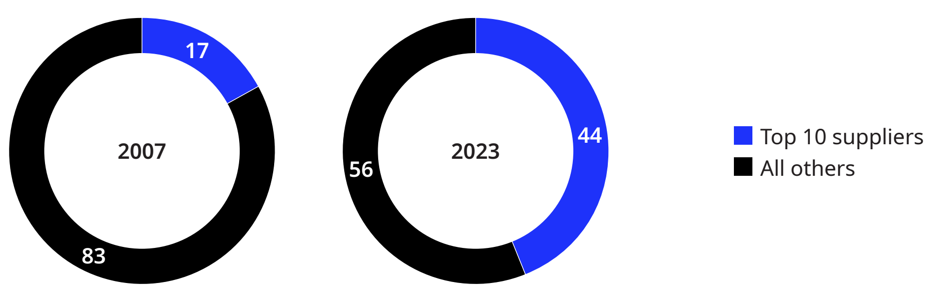



Note: Percentages based on share of total new build value in US dollars

Source: Oliver Wyman analysis

**Exhibit 9: Aerostructures Tier 2 consolidation over time**

Percent of total Tier 2 revenues




Source: Janes Capital Partners, Counterpoint Research, Oliver Wyman analysis

Airbus has been pursuing a vertical integration and consolidation strategy, bringing in-house the manufacturing and assembly of fuselages and wings, among other components, to gain control of the value chain and improve quality. This follows a 2021 declaration by CEO Guillaume Faury that aerostructures would be a "core activity of Airbus." Airbus has created two integrated aerostructures assembly business units centered around Stelia Aerospace and Premium Aerotec.

Aerostructures are typically standard features and airlines have little to no optionality. The contractual relationship exists between the airframer and supplier. These parts are typically sole sourced from suppliers through partnership and cost-sharing agreements and are included in the airframe price. Airframers are responsible for ensuring timely production from their suppliers and enforcing the relevant terms and conditions of their contracts.

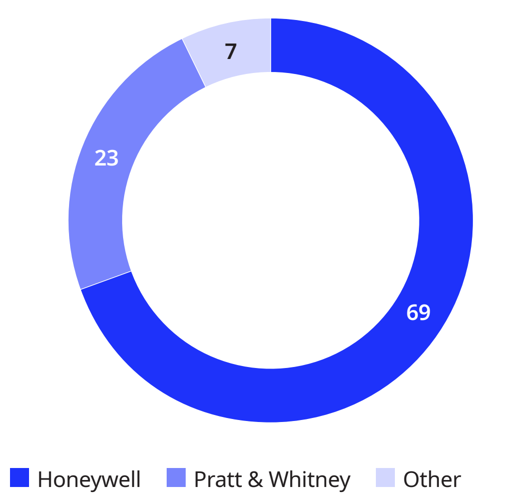
## Auxiliary Power Units (APUs)

The APU market is concentrated: Honeywell accounts for nearly 70%, supplying the A320 family (including neo), A350XWB, 737 MAX, 777, and A220; Pratt & Whitney (RTX) accounts for 23% and supplies the A380, 787, and A320 family (Exhibit 10). Boeing and Safran attempted to introduce additional competition to the market through the Initium joint venture in 2019 but were unable to gain traction and the effort was put on hold. Airlines currently have optionality for only one aircraft in production, the A320, between Honeywell and Pratt & Whitney. APUs are considered seller-furnished equipment (SFE).

APU suppliers work directly with the airframer and follow a contract and warranty model similar to that for aerostructures (described above), even on platforms where owners have an option. Warranties and performance guarantees provided in SSC or PSAA for key components like APUs are often supplemented by additional Commitment Letters signed between the airline and the OEM. Similar to engines, OEMs and their licensed MRO partners have an advantage in the APU MRO aftermarket, due to the high dependency of APU overhauls on parts replacement.

**Exhibit 10: APU market share of in-service fleet, 2024**

Percent share




Note: Percentage of in-service aircraft with the above APU suppliers, based on major widebody, narrowbody, and regional jet aircraft

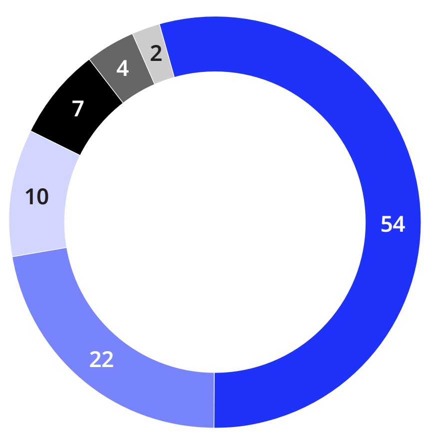
Source: Oliver Wyman analysis

## Landing Gear

The landing gear new build supply market is similarly concentrated, with Tier 1 suppliers providing landing gear systems directly to airframers under long-term agreements. Like aerostructures and APUs, landing gear is SFE and follows a similar contract and warranty model.

Safran is the largest provider, supplying the A320, A350, and 787; followed by Collins (777, 787, and E2 jets); Liebherr (737 MAX); and Heroux Devtek (regional jets and 777/777X) (Exhibit 11). High barriers to entry — including long design and certification cycles (5-8 years), significant tooling investments, special processes, and close partnerships with Boeing and Airbus — have prevented any new Western Tier 1s from entering the market for more than 20 years.

**Exhibit 11: Landing gear new build supply market share by firm, 2024**
Percent share




Note: Percentages based on share of total new build value in US dollars

Source: Oliver Wyman analysis

## Avionics

The avionics industry consolidated in the 1980s, shrinking to five leading suppliers by 1990. AlliedSignal expanded in the United States through its acquisition of Honeywell, and Collins became more entrenched with Boeing after merging with Rockwell. Smiths (now GE Aerospace) grew in Europe, and France's Sextant Avionique (now Thales) aligned closely with Airbus. By the 2010s, four major suppliers — Thales, GE, Honeywell, and Collins — each specialized in distinct avionics areas.

Today, these suppliers provide an integrated avionics suite and work closely with airframers' new platform development cycles to ensure system compatibility and certification compliance. Market players at lower tiers address specific customer requirements (such as displays, communications, navigation, and weather radar) and are integrated into the supply chain through direct airframer relationships or Tier 1 subcontracts.

Given the wide range of equipment in avionics, there is a range of optionality and approaches. Core safety-critical avionics components of an aircraft (such as auto flight packages, and certain communications and navigation equipment) are often standard features or SFE and sole sourced by the airframer. For certain SFE avionics equipment, owners may be able to choose from a set of options, like they do for engines and APUs. Airframers manage the relationship with suppliers and ensure timely delivery of equipment for production.

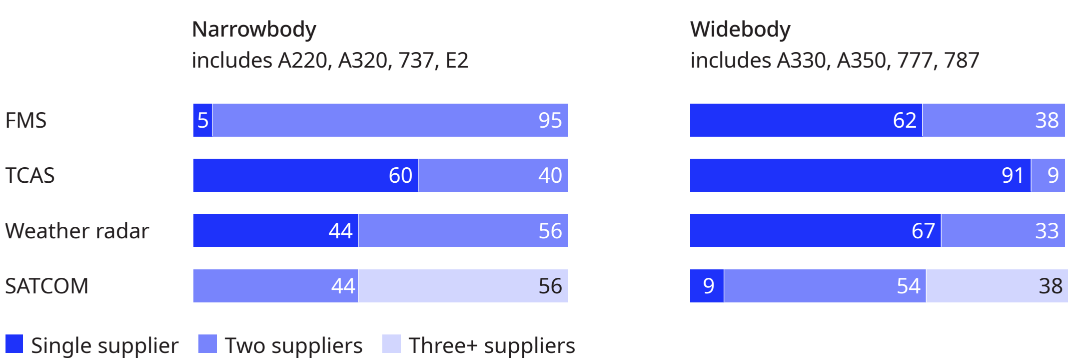
Other avionics systems are buyer-furnished equipment (BFE).[6] In avionics, BFE equipment includes flight management systems, weather radar, SATCOM options, and cabin connectivity servers, among others. BFE contracts are managed between owners and suppliers, with owners negotiating directly with suppliers. Owners hold contractual responsibility for selecting the appropriate equipment and ensuring its timely delivery. Airframers provide guidance on available suppliers/configurations through aircraft customization catalogues. Additionally, BFE is typically excluded from the airframe price.

According to Aircraft Monitor, by part quantity, [7] the BFE elements of an aircraft account for only a small portion of equipment (~20% of narrowbodies and ~30% of widebodies), with the rest being SFE. Of the BFE elements, ~70% is the cabin interior, with the rest being avionics and oxygen systems. BFE represents only 2-5% of the base price of a narrowbody aircraft (including engines) and 8-12% of the price of a widebody.

Supplier fragmentation varies across system types and class of aircraft (Exhibit 12). For example, satellite communication systems (SATCOM) tend to have more options (2-3+) compared to traffic collision avoidance systems (TCAS), where there is often only one option. Flight management systems (FMS) vary, with less optionality on widebodies than narrowbodies. Generally, there is more optionality on narrowbody systems than widebody.

**Exhibit 12: Avionics supplier fragmentation by system and aircraft class**

Percent of backlog as of May 2025




Note: Based on known avionics suppliers by platform as reported by airframer. FMS = flight management system, TCAS = traffic collision avoidance system, and SATCOM = satellite communications

Source: Oliver Wyman analysis

6 BFE is fitted on new aircraft deliveries, as defined by each aircraft manufacturer for each aircraft platform.

7 Based on the quantity of Master Part Numbers (MPNs).

## Cabin Interiors

In line with the broader market, the aircraft interiors supply chain has consolidated, starting in 1987 with B/E Aerospace's acquisitions. Zodiac Aerospace followed a similar path. Regulatory changes and airline industry demand for lighter, safer cabins accelerated this pattern in the 1990s and 2000s. By 2014, Zodiac and B/E had completed dozens of acquisitions. This trend continued with Safran's 2018 acquisition of Zodiac and B/E's integration into Collins Aerospace.

As a result, today's cabin interior market is concentrated, with only a handful of leading players, including Safran, Collins, Honeywell, Thales, and Jamco. These suppliers produce a wide range of products across key segments, including seating, in-flight entertainment systems, overhead bins, carpets, and galleys. For certain specialized segments, there are a few other specialized suppliers, as the market is being expanded due to airlines' need to maintain and modernize cabin interiors to meet passenger expectations.

Cabin interiors are mostly BFE, and follow the BFE contract model, as discussed in the prior section. The percentage of selectable interior cabin equipment in an aircraft depends on the type of aircraft: widebodies are traditionally more customizable than narrowbodies. Widebody aircraft are typically configured to offer distinct aircraft classes (such as economy, economy plus, business, and first), and this requires a higher amount of cabin interior materials. In designing narrowbody aircraft, airlines, lessors, and OEMs prioritize cost and efficiency, although increased customization (such as lie-flat seats) is gaining momentum for longer-haul flights.

Owners select interior BFE components from catalogs of manufacturer-approved suppliers, negotiating directly with suppliers on price, delivery schedules, and customization options. Airlines typically prefer fleet-wide standardization to simplify spare parts management and crew training, while also ensuring choices align with branding and passenger comfort objectives. Lessors prefer aircraft with standardized BFE configurations to maintain higher residual values and facilitate less costly aircraft transitions.

Airframers have tried to move toward greater standardization and simplification of interior BFE, with programs like Boeing's Dreamliner Gallery and Airbus's Contract Supplier initiative. These efforts aimed to reduce complexity for the airframers to certify and integrate interiors to reduce lead times. But this approach swung too far in limiting airline choice, and airframers had to ease back on restrictions, particularly as airlines began to demand more customization for their aircraft, including bespoke business class seats that are differentiated from their competitors. As a result, airframers now offer a "controlled customization" approach to balance complexity and customer needs.

Airlines typically prefer fleet-wide standardization to simplify spare parts management and crew training

# MRO Market Structure

The aerospace MRO market is divided into four main MRO service categories: engines, airframes (including modifications), components, and line maintenance (Exhibit 13).

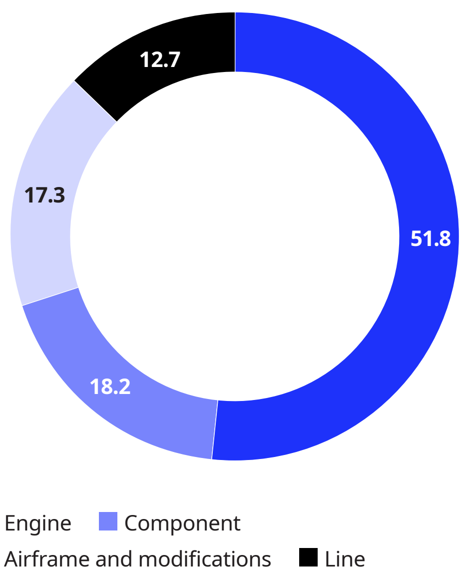
Engine MRO is the largest MRO segment. It is growing as a proportion of MRO spend, as new engine technologies undergo their first shop visits and older fleets remain active longer, thus aging into costly shop visits. Engine MRO has grown from 48% of the market in 2019 to 52% in 2025. Engine MRO can be divided into engine overhauls, piece part repair, and accessory repair. Overhauls are typically highly predictable, interval-based maintenance events.

Component MRO is the second largest segment and involves the maintenance of all non-structural elements of the aircraft outside of the engines (Exhibit 14). This includes avionics, landing gear, wheels, tires, brakes, APUs, cabin systems, hydraulics, etc. The largest categories in this segment are wheels and brakes, APUs, and avionics. The maintenance approach varies by category and at the individual part level; it can be on-condition or based on utilization or calendar intervals.

Airframe MRO (including modifications and upgrades) is the third largest category and involves scheduled, hangar-based inspections and rectifications to ensure the structural soundness of aircraft. These checks typically occur at regular calendar intervals but also can be driven by utilization of the aircraft.

Line maintenance, the smallest segment, consists of mainly labor-intensive, routine, day-to-day checks and minor repairs typically performed in-house by airlines (at airline-critical hubs) or by contract maintenance at outstations.

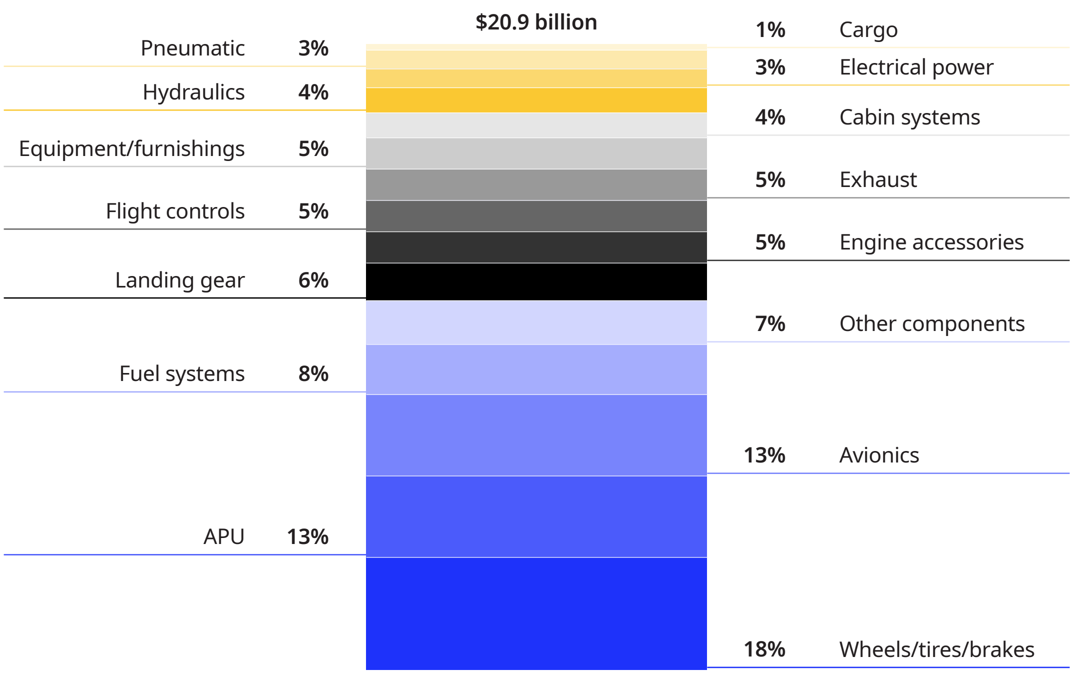
**Exhibit 13: MRO expenditure by segment, 2024**
Percent of spend




Source: Oliver Wyman Global Fleet and MRO Forecast, 2025-2035

Engine MRO has grown from 48% of the market in 2019 to 52% in 2025.

**Exhibit 14: Component MRO expenditure by Air Transport Association (ATA) Chapter, 2024**




Source: Oliver Wyman Global Fleet and MRO Forecast, 2025-2035

## Labor and Materials Content

The degree of value attributable to materials vs. labor in MRO is a key driver of what types of businesses participate in each market segment. Labor-intensive tasks (disassembly, inspection, etc.) generally have less intellectual property (IP) barriers associated with them than materials and repairs. Intellectual property refers to legal rights IP holders have to patents/designs (such as for parts), copyrights (such as for technical manuals and software), and trade secrets (such as proprietary manufacturing and repair processes and customer data).[8]

Materials content is highest in engine and component maintenance (60%+), while much lower for airframe and line maintenance (20% or less). In engine and component maintenance, labor is concentrated in disassembly, inspection, test, and reassembly. These steps are more straightforward for engines and individual components than for the entire aircraft (as in the case of airframe maintenance). In addition, materials in engine and component maintenance are often replaced after inspection and are of higher value than in airframe maintenance. Interior components (that is, equipment and furnishings) are

8 More broadly, intellectual property refers to the intangible assets that IP holders have legal rights to, including inventions, designs, symbols, and other creations of the mind. These rights allow the IP holder to control how its IP is used, shared, and exploited by others, and, in some cases, to benefit from it through licensing or sale. This includes patents, copyrights, proprietary technology, know-how, and trade secrets.

particularly exposed to high material costs as they are BFE, highly customized to individual owners, and have limited repairs available from OEMs.

The degree of IP required for maintenance or overhaul of components (such as engines, APUs, landing gear, avionics, and electrical systems) is a key advantage for OEMs to capture aftermarket revenues. In their role as manufacturers, OEMs have the design details, technical publications, repair instructions, test equipment, and spare parts required to effectively participate in the aftermarket. In segments like engine and component maintenance, where there is limited commoditized labor content, repair processes are complex, and spare piece parts are critical, OEMs have an advantage. OEMs have leveraged their IP advantage in a variety of ways, directly competing in the aftermarket and granting access to program enablers to other MRO repair providers of their choice through commercial licenses and royalties. This may not always be widely known among airline procurement teams, who may not easily recognize embedded license/royalty costs (as well as other related limitations) when seeking external MRO services, in particular on new "sunrise" aircraft platforms.

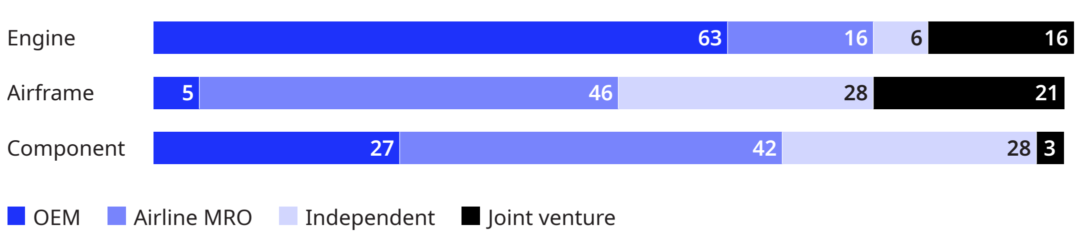
Despite the OEMs' IP advantage, there are structures in place to help create a more level playing field. For example, airlines can leverage the Boeing PSAA and Airbus SSC product support frameworks and, where applicable, delegate access to those support provisions to third party MROs of their own choice. Regulatory frameworks such as FAA Order 8110.54A and Policy Statement PS-AIR-21.50-01 also have clarified Design Approval Holders' (including OEMs) obligations, requiring them to make Instructions for Continued Airworthiness (ICAs) available to airlines and their designated MROs in a timely manner. There also is ongoing debate within the industry on what level of information should be made available within ICAs.

## Market Participation

The level of fragmentation in each MRO segment varies widely (Exhibit 15). Engine MRO, especially engine overhauls, is typically the most concentrated market, while airframe and component MRO are more fragmented. OEM participation in component MRO is strongest in higher value, more technically complex categories, like nacelles/thrust reversers, avionics equipment, landing gear, and APUs. Other less complex categories are performed by a wide range of suppliers, including in-house by airlines.

**Exhibit 15: MRO market participation by segment, 2024**

Percent share by firm type




Note: Joint ventures include OEM + OEM partnerships, as well as OEM + airline partnerships

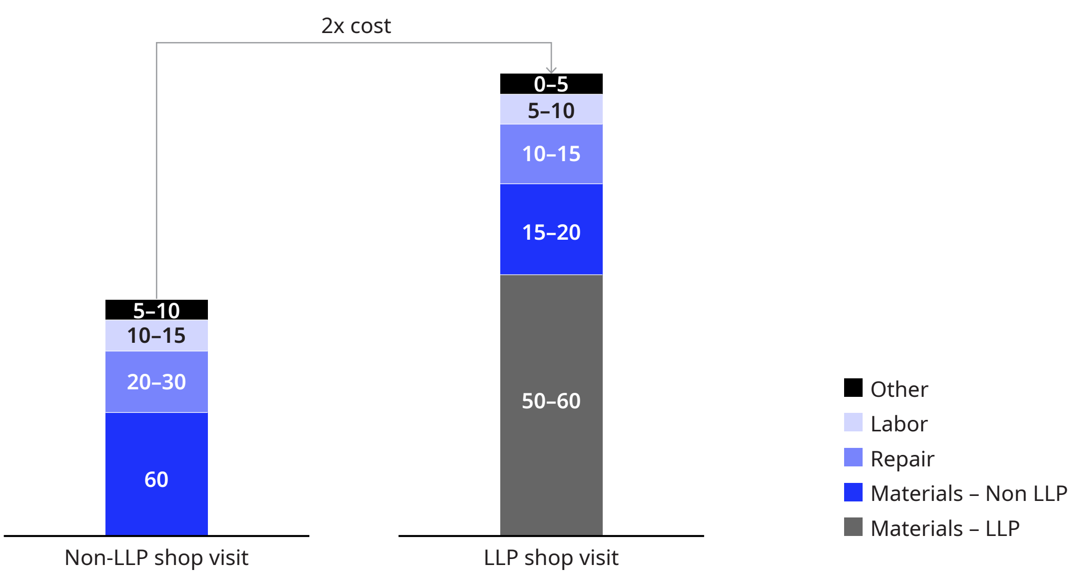
Source: Oliver Wyman analysis

## Engine MRO

Engine OEMs conduct overhauls and repairs themselves as well as through joint ventures and licensed overhaul shops. The direct costs to MRO providers of a typical narrowbody engine maintenance overhaul is ~60% materials and another 20-30% repairs. If life-limited parts (LLPs) are replaced in significant quantities, the direct costs to MROs of a shop visit could double or more, and the LLPs would drive total materials to 65-80% of overhaul costs (Exhibit 16).

OEM licenses are a particularly important factor in engine maintenance costs, as they are used to manage access to IP. Through licenses, OEMs provide access to discounted materials, test equipment, manuals and repair instructions, and marketing support. These elements affect the competitiveness of individual MROs, by impacting the materials and repair costs of licensed MROs. Licensed MROs (as opposed to independent shops) typically receive discounts on materials and can perform more repairs internally, giving them the ability to better control their internal costs. Access to OEM repair instructions has become more important as the complexity of materials and repair processes has increased over time. However, licensed MROs are typically restricted by OEM commercial license terms from using other approved repairs (such as EASA Part 21 and/or FAA DERs), PMAs, and even USM. Independent MROs do not face these restrictions and can use other approved repairs, PMAs, and USM to increase competitiveness, provided their customers (airlines and lessors) are receptive.

**Exhibit 16: Engine MRO cost share for LLP and non-LLP shop visits**
Turbofan focus (not exhaustive)




Note: LLP = life-limited part. Other includes line replaceable unit (LRU), Service Bulletin (SB), transport, and fuel. Labor excludes internal repairs

Source: Oliver Wyman analysis

Across the engine lifecycle, licenses are most restrictive at the beginning of a platform's life. Over time, unlicensed providers develop lower-cost repair options and have easier access to used parts trading to feed their workshops with serviceable parts, without depending on OEM repairs and materials.

Engine overhaul workshops subcontract certain piece part repairs to third-party providers, although OEMs typically perform higher value piece part repairs (Exhibit 17). Many engine accessories are not produced by engine OEMs. OEMs often offer accessory MRO solutions but offload repairs to different providers.

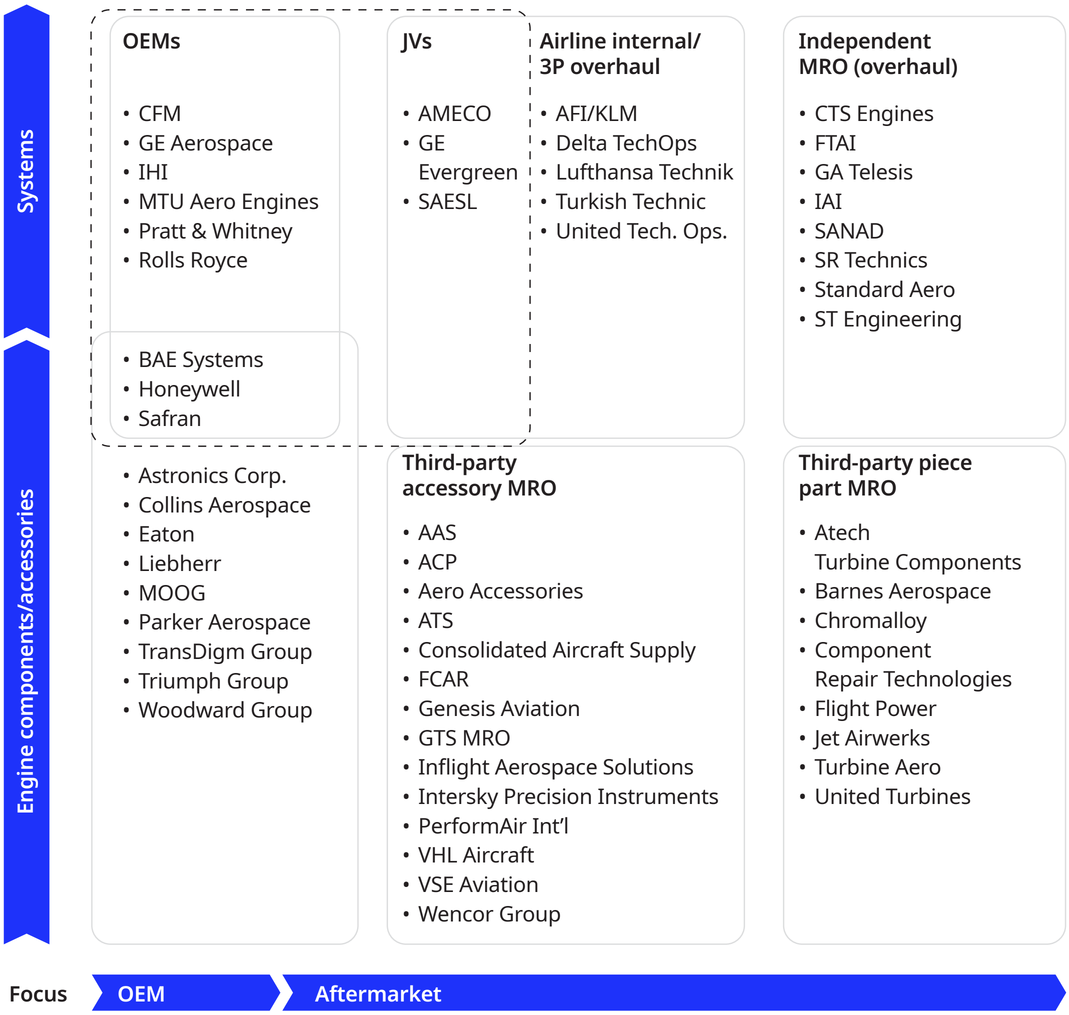
Engine MRO contracts primarily fall into three categories: power-by-hour (PBH), fixed pricing, and time and materials (T&M). PBH contracts charge airlines a negotiated rate per flight hour, providing predictable, recurring expenses to airlines and cash flow to MRO providers. These long-term agreements (8-12 years) typically cover all maintenance and can have the option to add on extra coverage for spare engines and transport. Fixed pricing contracts are priced per event, with pre-negotiated fees for a specified work scope. These contracts are usually 5-8 years in length, with LLPs typically sourced and paid for by an airline. T&M contracts price work based on actual labor and materials used and are generally short-term or one-off agreements (1-3 years), with airlines sourcing from multiple providers.

Market participation varies over an engine platform's lifecycle (Exhibit 18). The first phase, engine entry into service (EIS), is mostly led by OEMs. They are well positioned early in the platform lifecycle, as they can offer risk transfer agreements (for example, cost per flight hour agreements) to airlines, given their knowledge of the platform and stronger financial positions. This allows OEMs to recoup research and development expenditures early in the lifecycle, although recouping these costs can be stymied by early engine durability/reliability issues that the OEM must address. In this first phase, airline third parties and independent MRO companies focus on securing access to MRO enablers (such as repair instructions, manuals, test equipment) through, for example, commercial agreements (such as licenses) granted by OEMs. Industry initiatives, such as the IATA-CFM Agreement on Engine Maintenance and IATA and Rolls Royce Statement on Best Practices for Maintaining Competition in Aerospace Markets also aim to create a more level playing field.

Access to OEM repair instructions has become more important as the complexity of materials and repair processes has increased over time.

**Exhibit 17: Engine aftermarket competitive landscape**

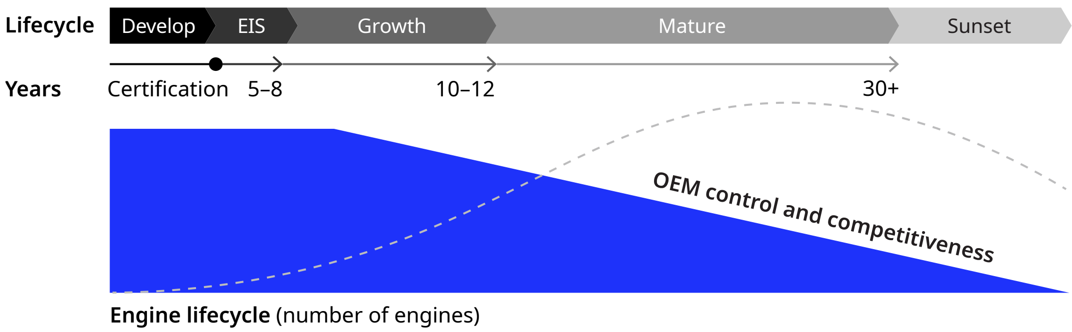
Turbofan focus (not exhaustive)




Source: Oliver Wyman analysis

As the total number of engine deliveries increases for a specific model (second phase), OEMs increase maintenance supply, offering licensing agreements to a network of MRO firms, launching joint ventures, and expanding OEM capacity. As the engine matures (next to last phase), the MRO network typically opens up and services can be sourced from a broad range of MROs. As the platform sunsets, the market gradually becomes more focused on parts repair and harvesting, as the usage of USM and PMA become good alternatives to new OEM parts.

**Exhibit 18: OEM involvement over engine lifecycle**




Source: Oliver Wyman analysis

## Component MRO

Component MRO involves the maintenance of all systems excluding the engine (e.g., wheels, tires, brakes, APU, avionics, fuel systems, landing gear, cabin equipment, hydraulics, electrical systems).

Component MRO is more fragmented than engine MRO (Exhibit 19). Competitors range widely in geographic focus and ATA chapter coverage, from large global integrators that play across component categories to “end-of-runway” shops focused on one or two customers and one or two categories.

As is the case with engine MRO, OEMs such as Honeywell, Collins, and Safran participate in the component MRO market by leveraging access to repair instructions, materials, and test equipment, together with engineering capabilities. OEM participation tends to be stronger in higher value categories with greater complexity, such as avionics, landing gear, thrust reversers, etc., and lower in less complex categories, such as hydraulics.

As outlined above, airframe systems components are a combination of BFE and SFE. Terms of product support for BFE equipment (e.g., cabin equipment), are defined under bilateral agreements negotiated directly between an airline (or the owner, usually the lessor that leads aircraft linefit customization), and OEMs. For SFE airframe systems equipment (such as APUs, wheels and brakes, hydraulics, fuel systems, electrical, air conditioning equipment, etc.) that are not the airframers’ proprietary parts, comprehensive terms of product support are typically already available to owners and airlines through frameworks such as the SSC and PSAA. These SFE product support frameworks are secured and made available by the airframers when originally selecting the OEM vendors for new aircraft programs. They provide product support protections on SFE airframe systems vendors part numbers and designate both aircraft owners and operators as co-beneficiaries of those protections. Airline procurement teams may then, at their discretion, decide to use those existing provisions (or to negotiate better ones individually) when discussing MRO services with the SFE systems OEMs. Airlines also can delegate those provisions to third-party MROs of their choice, enabling a more level playing field for independent MROs.

**Exhibit 19: Component competitive landscape**

Notably environmental control (heat exchange), fuel systems, landing gear, and avionics (not exhaustive)

**Systems**

**OEMs**

- BAE Systems
- GE Aerospace
- Heroux Devtek
- Honeywell
- Safran
- ONTIC
- Thales
- Pratt & Whitney

**Airline internal/ 3P overhaul**

- AFI/KLM
- Delta TechOps
- Lufthansa Technik
- Turkish Technic
- United Tech. Ops.

**Independent MRO**

- AAR
- GA Telesis
- HAECO
- MRO Holdings
- SANAD
- ST Engineering Aerospace

**Components**

- Barnes Aerospace
- Collins Aerospace
- Eaton
- Liebherr
- MOOG
- Parker Aerospace
- TransDigm Group
- Triumph Group
- Woodward Group

**OEM subcomponent providers**

- AllProtect Aviation
- American Polarizers
- Astronics Corp.
- Lee Aerospace

**Third-party component MRO**

- Aero Accessories
- AerSale
- AeroRepair
- AMETEK MRO
- ATS
- Aventure Aviation
- Desser Aerospace
- GTS MRO
- HEICO
- Revima
- SK AeroSafety
- Sunvair Aerospace
- VSE Aviation
- Wencor Group

**Third-party piece part MRO**

- ACP
- Aero Instruments and Avionics
- AeroMod
- Commercial Jet
- Eirtech Aviation
- EPCOR
- Galaxy International
- Genesis Aviation
- Marana Aerospace Solutions
- Meridiana Maintenance
- Professional Aircraft Accessories
- Regent Aerospace

Focus: OEM → Aftermarket

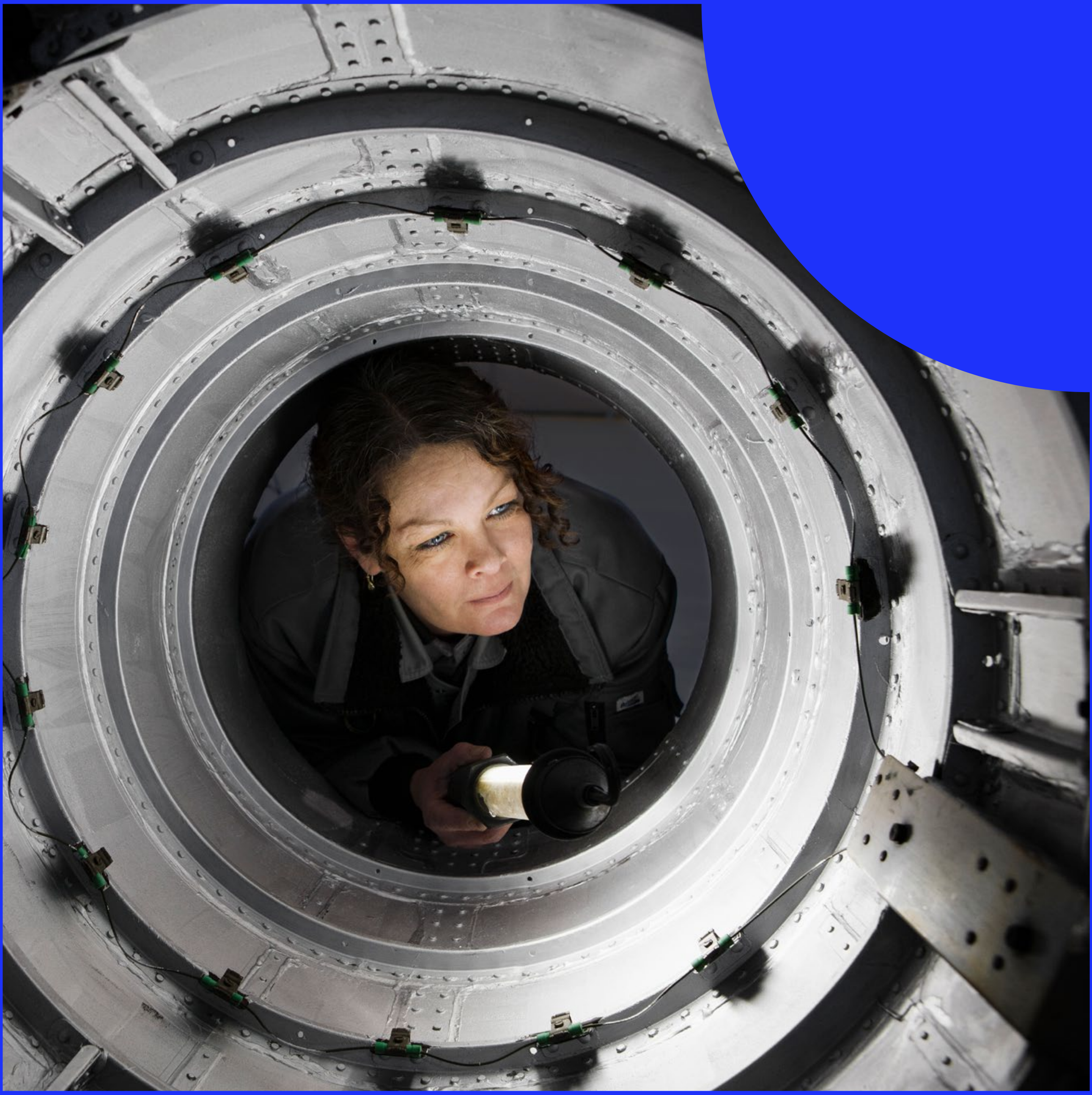
Source: Oliver Wyman analysis

## Airframe MRO

Airframe MRO is fragmented, and airlines and independent providers have the largest shares in this segment. Competitors range widely in size from single-hangar operations capable of serving one or two aircraft at a time to global providers with large hangar sites across regions. Regional market variations also exist: Joint ventures are prominent in Asia (such as GAMECO and HAECO), while in North America, consolidation over the past decade has led to fewer, larger firms, such as AAR, ATS, and MRO Holdings.

OEM share of airframe MRO is low, as much of the work involves labor-intensive disassembly, inspection, and reassembly of the airframe structure. OEMs do not have an advantage here, given their labor pools are primarily in higher-cost locations such as the US and Europe. Additionally, required repairs typically involve the airframe structure or structural components, where IP/proprietary technology and repairs are lower.

The one exception is the regional jet market, where Embraer and MHIRJ together support over 70% of airframe demand. This is primarily due to the concentration of the regional jet fleet in North America, where competitive capacity has been prioritized toward narrowbodies and widebodies. Furthermore, due to the relatively smaller installed base and simpler airframe of regional jets, manufacturers tend to be more directly involved to bring necessary levels of support to airlines.



SECTION III.

# Supply Chain Challenges

A history of consolidation has led to the structure of today's commercial aerospace market. But this structure has not been able to keep up with market demand in recent years. As a result, problems such as widespread volatility, price increases, aircraft and parts delivery delays, and longer maintenance turnaround times (TATs) have mounted. Collectively, these challenges undermine airline operations, by forcing airlines to operate aging fleets, absorb rising costs, and contend with market volatility that complicates strategy and fleet planning.

## Industry Volatility

The aviation industry faces a significant challenge stemming from supply and demand volatility, which has contributed to a lack of trust within the supply chain. Large airframers establish production targets based on projected aircraft demand combined with throughput, then suppliers align their output accordingly to meet these goals. However, when airframers are unable to ensure that the entire supply chain can consistently achieve these targets — or when actual demand falls short of forecasts — production objectives can become compromised (Exhibit 20).

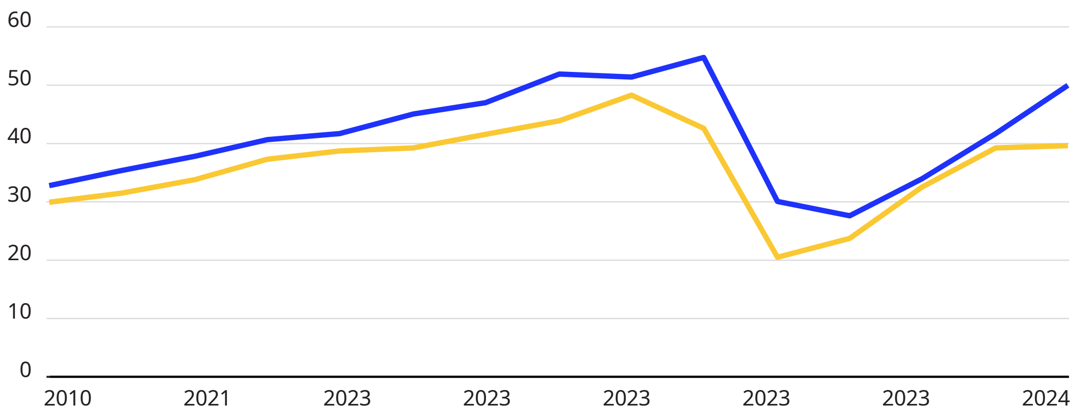
Without reliable airframer production forecasts, suppliers often develop their own independent forecasts based on their predictions and capacity, resulting in a fragmented landscape where projected and actual production rates vary widely across the supply chain.

When forecasts swing unpredictably, suppliers often ramp up production and invest heavily in material to meet anticipated demand, only to risk sudden cancellations or delays. This mismatch erodes supplier confidence in OEM commitments, straining relationships across the supply chain and undermining collaborative planning efforts. Lack of clarity on production levels also makes it more challenging to confidently invest in production capacity expansion. This volatility is especially challenging for smaller suppliers, as they do not have the ability to absorb such changes or float their inventories and for Tier 4 (e.g., raw material suppliers) where lead times are longer. The result of this volatility is mismatched supply/demand for components up and down the supply chain, resulting in delayed production and a lack of sufficient spare parts for the aftermarket.

**Exhibit 20: Aircraft stated vs. actual production rates, 2010-2024**

Units per month

**Narrowbodies**

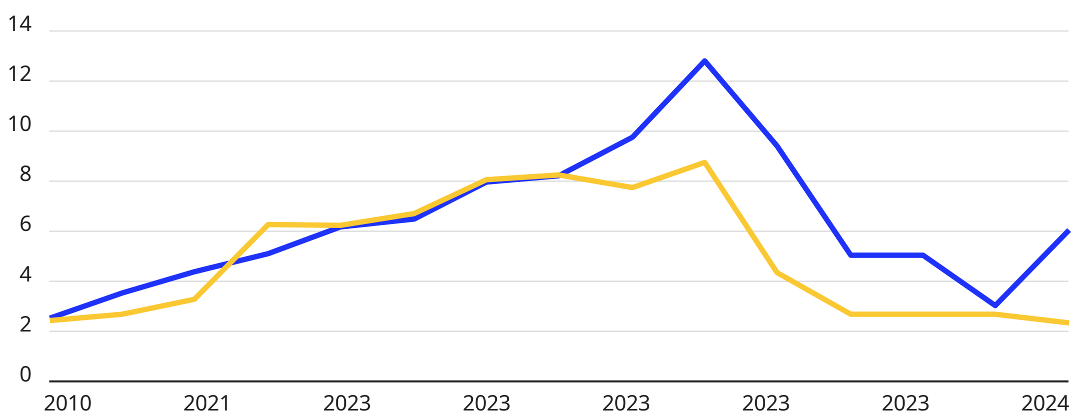



Gap in stated vs. actual production

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | 4 | 3 | 6 | 3 | 10 | 1 | 11 |

Stated production rate  Actual production rate

**Widebodies**




Gap in stated vs. actual production

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 2 | 5 | 2 | 4 |

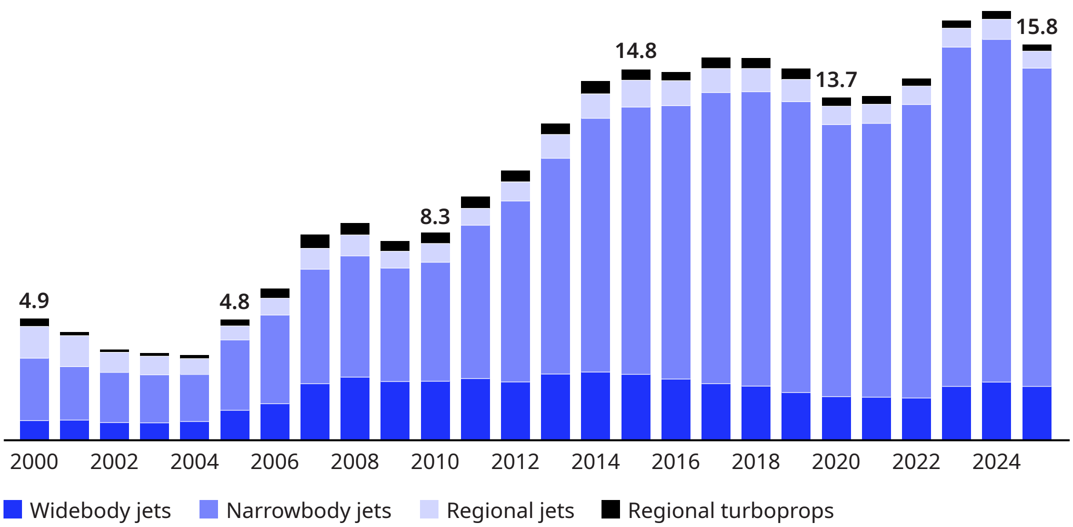
Stated production rate  Actual production rate

Source: Boeing and Airbus press releases, Oliver Wyman analysis

# Aircraft and Parts Delivery Delays

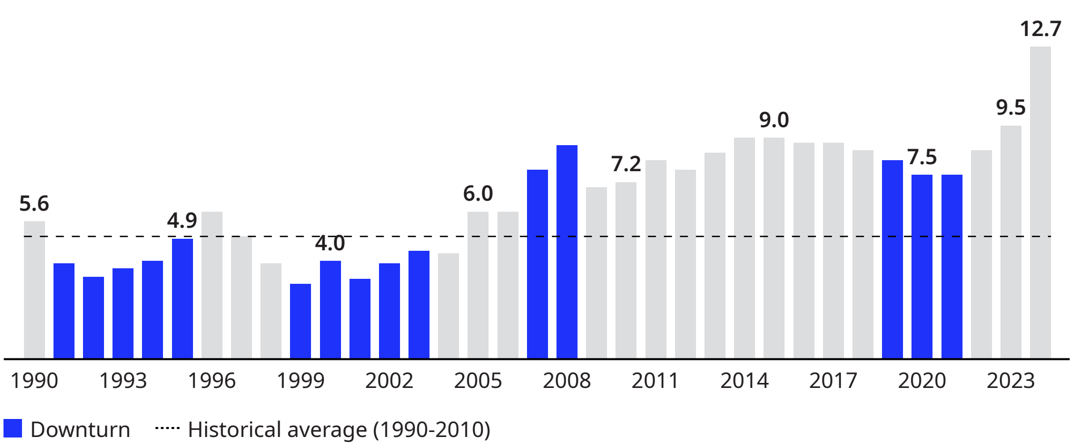
In 2024, commercial aircraft backlogs hit historic highs, with over 17,000 aircraft on order, equivalent to more than 12 years of production at current rates (Exhibit 21 and Exhibit 22). The backlog and time to work through it have increased significantly since the early 2000s and has further increased post-pandemic. Despite strong demand, the major airframers remain far below their peak annual deliveries: Airbus delivered 766 aircraft in 2024 (down from a 2019 high of 863), while Boeing's deliveries dropped sharply, from 806 in 2018 to 348 aircraft in 2024.

**Exhibit 21: Commercial aircraft backlog by aircraft type, 2000-2025**
In thousands




Source: Cirium, Oliver Wyman analysis

**Exhibit 22: Commercial aircraft backlog in years of production, 2000-2024**



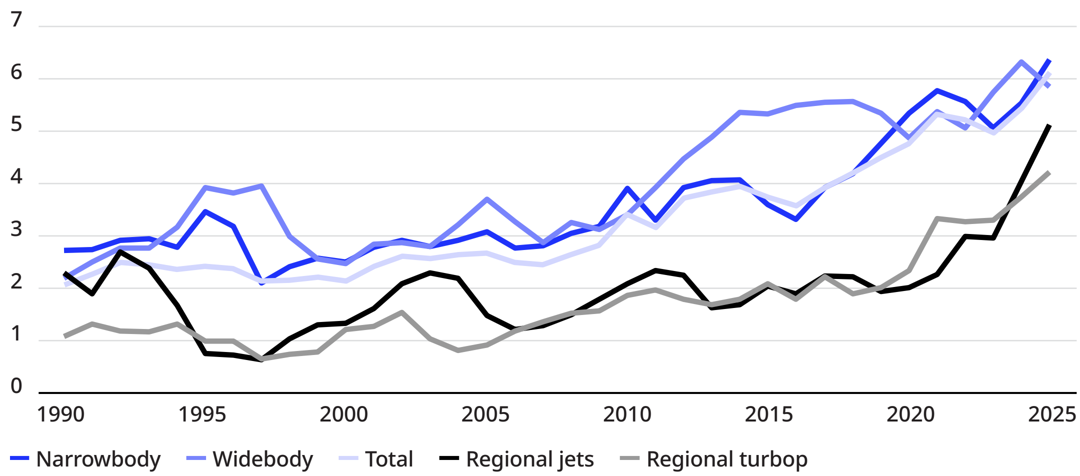

Note: Based on OEM full rate production statements for each respective year; 2024 based on total backlog divided by 2025 total aircraft production

Source: Cirium, Oliver Wyman analysis

The existing backlog, coupled with lower production rates, has resulted in longer overall lead times. Aircraft delivered in 2024 took 6.8 years to make it to the airlines, up from 4.5 years in 2018 (Exhibit 23). For airlines, this means delayed fleet renewal plans and constrained capacity growth. This has led to older aircraft remaining in service longer than planned, delaying retirements and increasing operational costs.

**Exhibit 23: Aircraft average delivery times, 1990-2025**

In years




Note: Delivery time is the length of time from the date of order to the date of delivery of the aircraft

Source: IATA Sustainability and Economics, Cirium, Oliver Wyman analysis

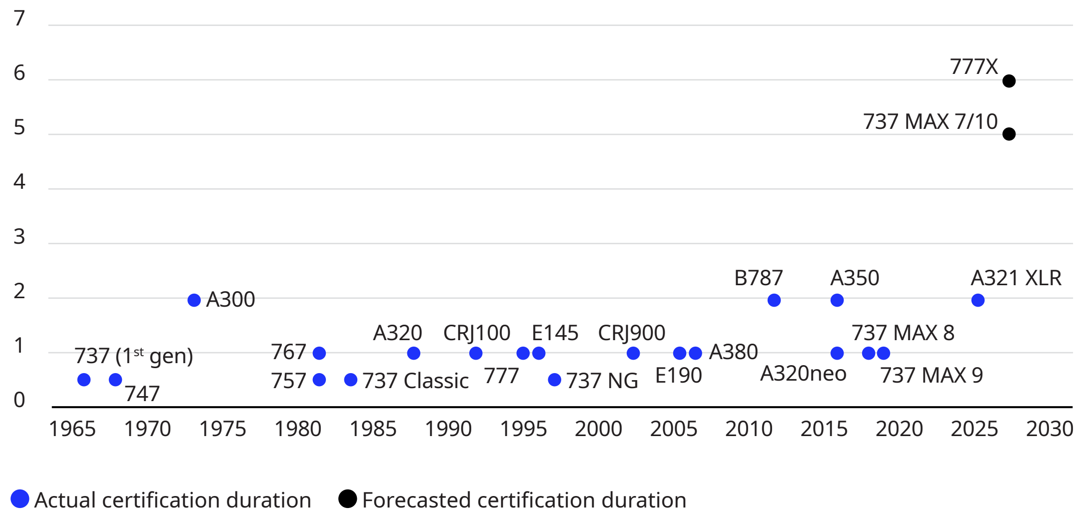
One of the drivers of the backlog is the increasing length of time for aircraft certification. Historically, certification times ranged between 1 and 2 years (Exhibit 24). Newer generation platforms have tended to be at the higher end of this range, but noticeably, Boeing certifications of the 737 MAX 7/10 and 777x are now in their fourth and fifth years, respectively, and it could take until 2026 for these platforms to be certified. These platforms account for 14% and 24% of the narrowbody and widebody orderbooks, respectively.

Several issues collectively may be impacting certification timelines, including but not limited to OEM design changes, airline interior customization, and regulator capacity. Many regulators, including the Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA), are facing staffing shortages and challenges in attracting specialized talent. For example, in 2023, a reported 40% of FAA certification engineers had less than two years of experience.[9] FAA processes also frequently require paper documentation, as opposed to digital copies. In addition, evolving regulations require more comprehensive documentation and substantiation, compelling manufacturers to revisit previous work.

9 According to the General Aviation Manufacturer Association (GAMA).

**Exhibit 24: Certification timeline for select aircraft type, 1965-2030**

From first flight to certification, in years




Source: Oliver Wyman analysis

Attempts to reduce aircraft and parts delivery delays are further complicated by the lack of leverage that both airframers and airlines have over suppliers. Since 2010, only four "new" or "clean-sheet" platforms have been put into production — the 787, A350, A220, and C919. The remainder have been incremental upgrades over older designs (such as the A320 and 737).

The lack of truly new platforms reduces airframer leverage to penalize suppliers for poor performance, which previously took the form of potential exclusion from future programs. And swapping out known poorly performing suppliers is challenging, given the costs and regulatory burdens associated with approving new major components and systems.

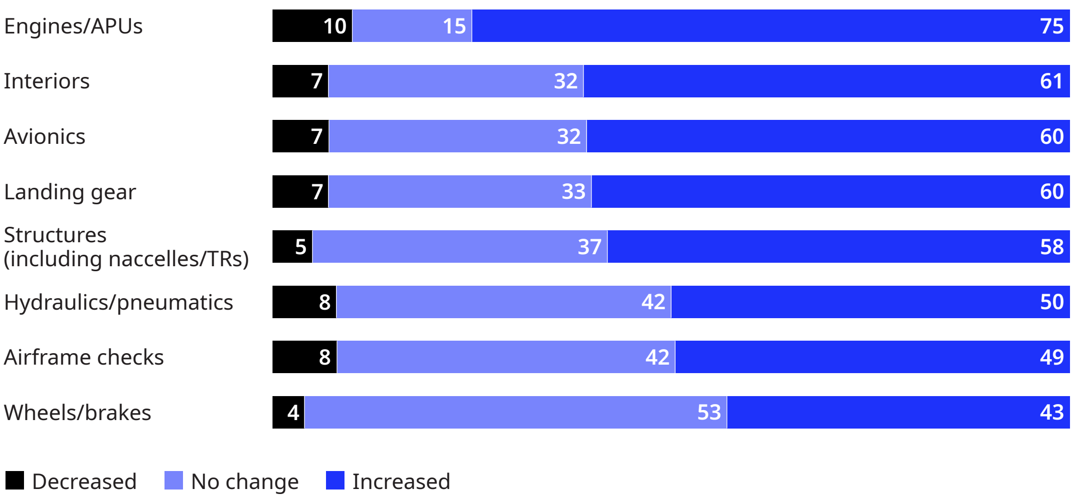
Airlines have less leverage over suppliers due to their smaller aircraft orders and limited sway over the market relative to airframers. As a result, poorly performing suppliers remain entrenched in the supply chain, compounding overall delays for aircraft and parts deliveries.

# Increased Maintenance Turnaround Times

Following the surge in aircraft backlogs and extended delivery times, the industry is facing widespread increases in TATs, further constraining airline operations. Oliver Wyman's 2025 MRO Survey found that more than 75% of survey respondents reported longer engine maintenance TATs between 2024 and 2025, with more than 60% noting similar delays for interiors, avionics, and landing gear (Exhibit 25).

**Exhibit 25: Changes to turnaround times in the past year**

Percent of MRO Survey respondents selecting each option




Note: TR = thrust reverser

Source: Oliver Wyman 2025 MRO Survey

For engines in particular, turnaround times have seen sharp increases from the industry standard of 30 to 60 days. Shop visits are lasting upward of 300 days in some instances, with full overhauls around 75 days and quick turns around 50 days. Similarly, landing gear overhauls typically lasting 45 days under normal conditions are now taking 90 to 120 days, and this trend can be seen across numerous other components, including APUs.

Parts shortages, especially for airlines with older fleets, play a role in TAT increases. When asked why TATs have increased, 80% of respondents to Oliver Wyman's 2025 MRO industry survey indicated piece part availability was the top issue — outpacing supply/demand imbalances, insufficient labor, and OEM control of key repairs. This shortage in turn is driving greater demand for USM and PMAs as cost-effective, reliable options.

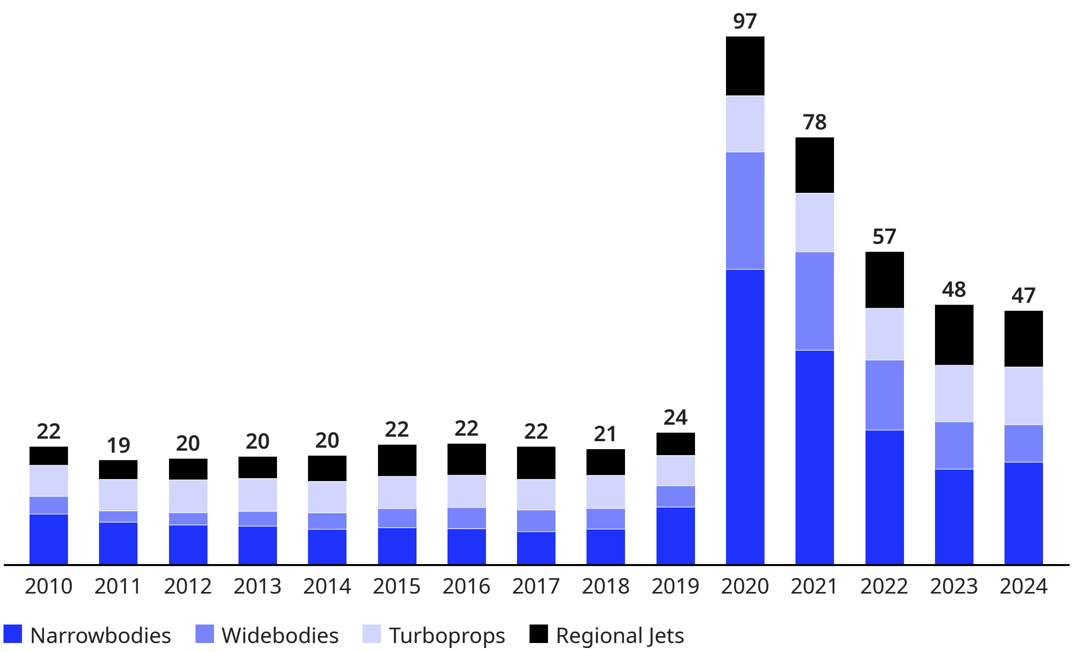
In the case of USM, however, the ability to meet demand is being limited by the reduced availability of older aircraft to be parted out, as many older planes that were expected to be retired are still in active service. Equally, the ability to deploy PMA can be limited by the availability of PMA options or the willingness of some airlines and lessors to consider PMAs for aircraft transitions.

Longer TATs lead to more inventory in the repair cycle versus on the shelf and available for use by airlines. This means airlines either need to hold more inventory to have the same amount on hand as they had previously, or they need to accept worse performance. And with less inventory on the shelf, parts shortages become an issue, increasing the duration of aircraft on the ground situations, which require parts to resolve, and increasing costs if alternative parts must be sourced at the last minute.

Increased TATs and insufficient spares are ultimately reducing operational capacity, resulting in an increase in the number of aircraft in storage (defined by aircraft that are out of service for at least seven consecutive days). While the pandemic led to a spike in stored aircraft in 2021 and 2022, the overall figure remains significantly higher than historical norms, even as air travel demand has returned (Exhibit 26).

**Exhibit 26: Aircraft in storage by type, 2010-2024**

In thousands




Source: Aviation Week, Oliver Wyman analysis

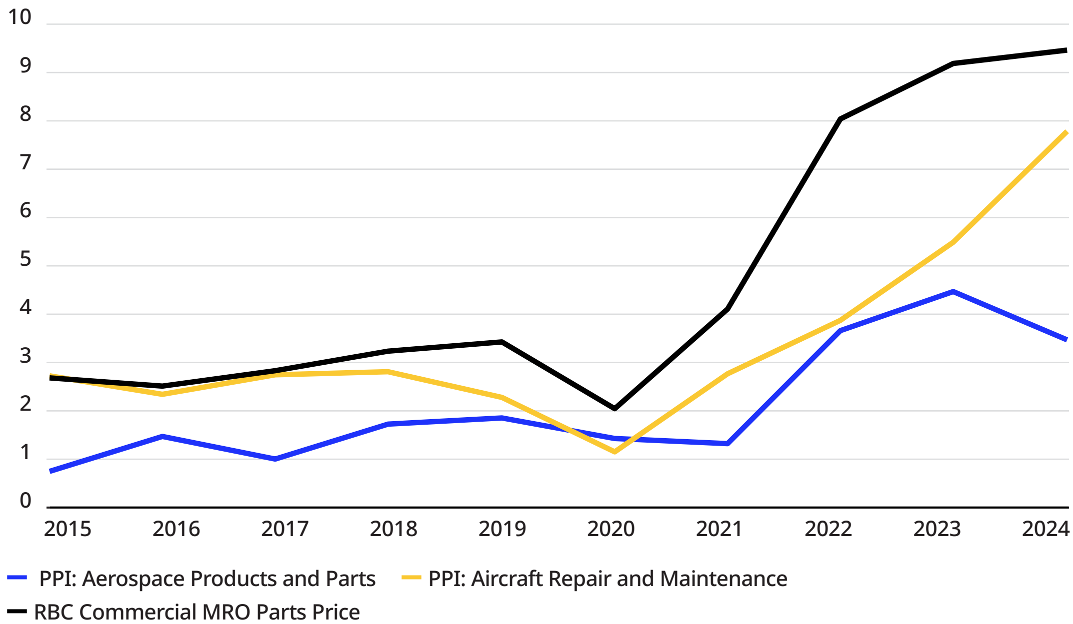
# Price Increases

Supply chain challenges have caused a steep increase in prices, especially for spare parts and maintenance services. By way of example, the US Federal Reserve's Producer Price Index (PPI) increased by nearly 5% at its 2023 peak for aerospace products and parts — well over the historical average of around 1.5%. The sharpest rise in the PPI has been for aircraft repair and maintenance — with annual increases exceeding 8% in 2024. RBC Capital Markets' annual MRO survey confirms this trend, showing MRO materials price changes of around 10% in both 2023 and 2024.[10]

10 RBC figures are higher as it surveys the actual prices consumers pay, while the PPI reflects the cost base.

**Exhibit 27: Aerospace parts inflation over time, 2015-2024**

Annual percentage change




Source: St. Louis Federal Reserve, RBC Capital Markets MRO Survey

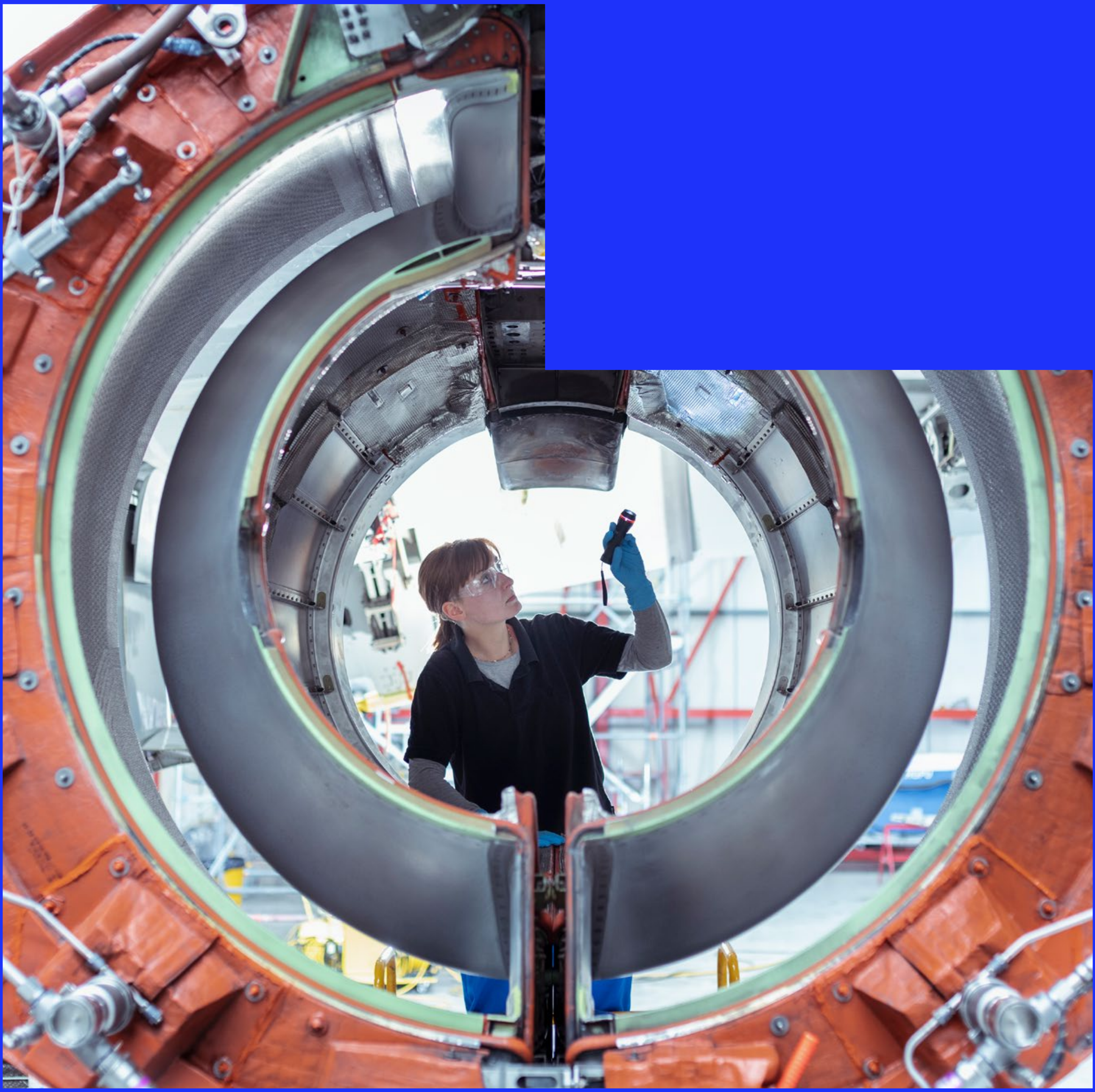
Oliver Wyman's most recent MRO industry survey further supports this trend, with participants indicating materials cost increases of more than 7% in the past year. OEM and MRO providers report experiencing slightly greater cost pressures than airlines (Exhibit 28). For airlines, this means rising expenses not only in acquiring new aircraft but also in sustaining older fleets longer than planned.

**Exhibit 28: Growth of material costs in the past year, 2024 vs. 2025**

Percent of MRO Survey respondents by firm type, weighted average rate of change


Note: "Other" includes broker, disassembly provider & MRO, USM trader, repair shop, service provider, consultancy, OEM distributor, GSE supplier, PE sponsor/owner, and engineering services

Source: Oliver Wyman 2025 MRO Survey



SECTION IV.

# Root Causes of Supply Chain Challenges

The supply chain challenges currently affecting airlines are interconnected, with multiple root causes. These challenges primarily stem from three core themes, as presented below: the current aerospace economic model, supply chain disruptions, and labor shortages.

# Theme 1: Aerospace Economic Model

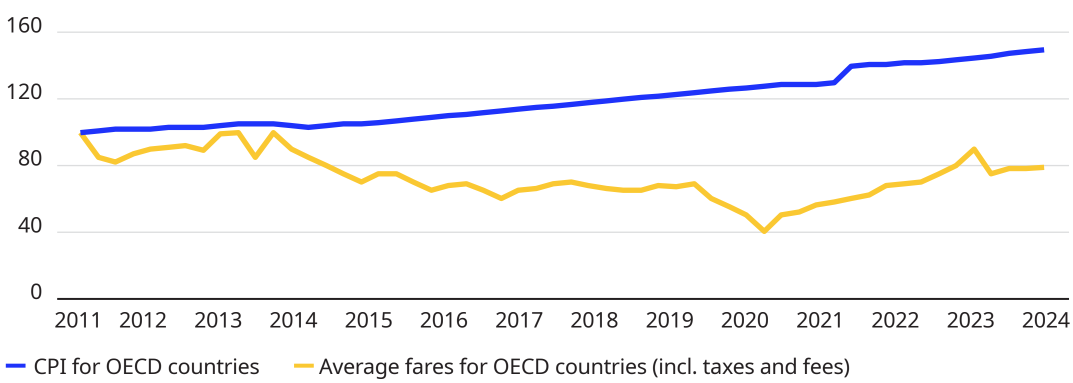
## Airline Pressures

Since 2011, airline ticket prices have lagged inflation and average fares for OECD countries are lower today than they were in 2011. This has effectively compressed airlines' revenue per passenger and intensified pressure on profitability (Exhibit 29).

Airline industry EBIT, which has been increasing since 2010, has been in the mid to high single digits (excluding 2020-2022). Individual airline profitability, however, historically has been volatile and often negative. One major factor influencing profitability is fuel cost. Fuel is often the largest or second largest expense for airlines (competing with labor), accounting for approximately 20-30% of total operating costs. To manage this cost, airlines rely heavily on the fuel efficiency improvements delivered by succeeding generations of aircraft. For example, the Boeing 737 Next Generation (NG) offered fuel efficiency gains of around 10-15% compared to the earlier 737 Classic series. And the 737 MAX has improved fuel efficiency by an additional 14-20% over the 737 NG. These gains have helped the aviation industry reduce its fuel use per available tonne-kilometer (ATK) steadily over time: From 1990 to 2019, industry fuel efficiency measured in liters per ATK improved by 1.5-2.0% annually.

**Exhibit 29: Indexed average airfares versus Consumer Price Index (CPI), 2011-2024**

2011 = 100




Source: IATA Sustainability and Economics, Direct Data Solutions (DDS), and OECD Statistics

In addition to fuel cost challenges, airlines have faced ownership cost pressures and changed how they purchase aircraft, creating downstream implications for the materials and repairs available to them. From 2005 to 2019, aircraft list prices increased annually on average by 3% per year (ranging from 0% to 6%). As lessors entered the global market to provide financing for fleet renewal, the percentage of aircraft leased grew from 10% of the fleet in the 1970s to 58% at the end of 2023. In Europe, Latin America, and Asia, 70% of the fleet is leased, while in North America 40% of the fleet is leased.

One side effect of a larger leased fleet has been a preference for OEM materials and repairs. Many lessors have traditionally preferred the use of OEM parts and repairs during maintenance events to maintain asset values, enable worldwide marketability, and ensure future leasing opportunities. In addition, some airlines historically have been unwilling to accept non-OEM materials and repairs due to internal airline policies, lack of awareness, contractual pressures, and the inability to justify business cases. A variety of industry initiatives, including those encouraged by IATA, are underway to increase awareness, acceptance, and adoption of alternative parts and approved repair instructions. Progress against these goals will require collaboration from all stakeholders, including airlines, lessors, OEMs, and MROs.

## Technological Advancements

The pursuit of improved fuel efficiency drives OEMs to invest in researching and developing new aircraft models incorporating advanced technologies. Historically, engines typically deliver the greatest efficiency gains on a new aircraft platform. The latest generation of narrowbody engines that entered service in the mid-2010s, for example, offer a number of new features. These engines have higher bypass ratios with larger diameter fans and increased internal temperatures, necessitating new materials and specialized coatings. In turn, larger fans require wider nacelles, driving the use of lighter composite materials to manage weight. Additionally, certain landing gear, pylons, and flight control systems had to be redesigned to support the increased size, weight, and placement of new narrowbody engines.

Certain technological advancements have created advantages for OEM parts and aftermarket services and limited the development of non-OEM options. Technologies like advanced coatings and composites that are manufactured and repaired using process technology are more difficult to reverse engineer and substantiate equivalency, providing original design holders with an IP advantage.

From 2005 to 2019, aircraft list prices increased annually on average by 3% per year (ranging from 0% to 6%).

The introduction of cutting-edge technologies, however, has increased maintenance complexity. New materials, propulsion systems, and avionics require novel maintenance approaches and specialized expertise. During the design phase, OEMs must balance tradeoffs between weight/fuel optimization and maintenance costs due to the use of more advanced materials. As with many new technologies, the latest aircraft innovations have experienced reliability and durability challenges that are still being worked through.

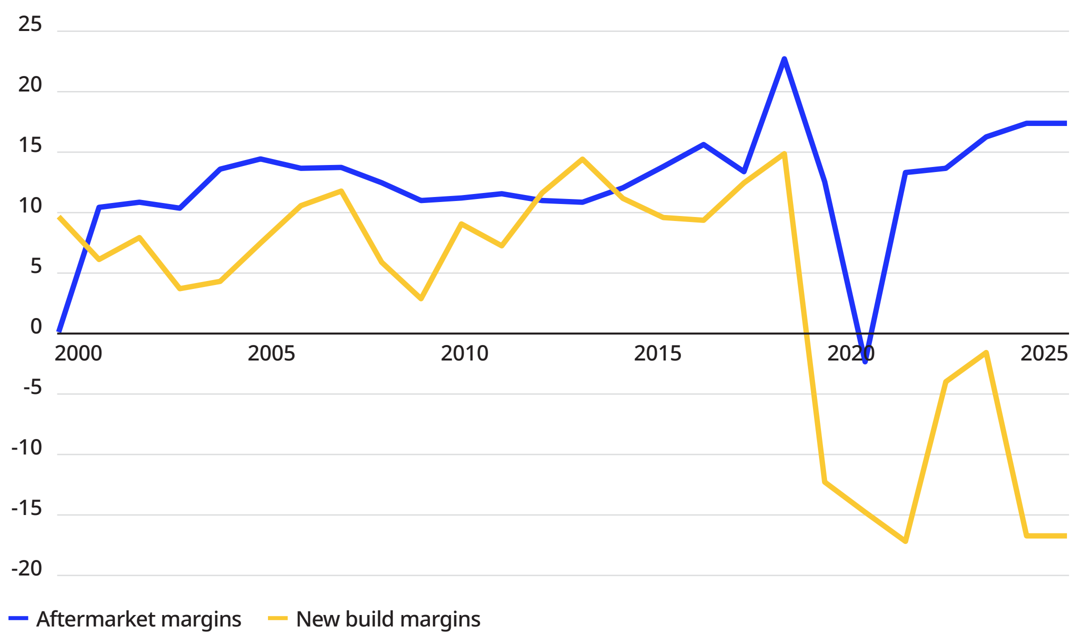
New technologies and entry into service challenges have strained OEM and MRO supply chains. OEMs, struggling to meet ramp-up targets, have been beset with additional demand for maintenance and spare parts on in-service aircraft. Without readily available alternatives, lead times for parts on the production line and in service centers have increased, extending wait times for new aircraft and turnaround times for maintenance, thereby impacting fleet availability.

## OEM Aftermarket Participation

The high non-recurring engineering (NRE) costs associated with aircraft technology development, together with the competitive pricing for new aircraft required to secure airline orders, have prompted OEMs to increase their participation in the aftermarket to recoup their investments through higher-margin services. Services have historically offered a higher and more stable margin profile than new build (Exhibit 30). Services range in importance to airframers and engine OEMs from as little as 10-20% of revenues to over 70%.

**Exhibit 30: Indicative airframer operating margins, 2000-2024**

In percent




Note: Based on publicly available segment breakdowns for major airframers

Source: S&P Capital IQ, Oliver Wyman analysis

To reduce their own development costs and risks, airframers have capitalized on risk-sharing models for new aircraft programs. Tier 1 OEMs invest in these programs and in exchange expect access to the MRO market and aftermarket revenues for their systems. Over time, however, suppliers have consolidated to capture economies of scale and improve their negotiating leverage with airframers. This has resulted in fewer suppliers in the value chain overall and greater supplier control of the aftermarket.

This model has increased challenges for independent service providers to develop competing aftermarket solutions and consequently led to a reduction of MRO market alternatives (beyond those licensed MROs that are generally closely aligned with OEMs), which in turn is often associated with higher maintenance costs for airlines.

# Theme 2: Supply Chain Disruptions

In recent years, Airbus and Boeing have launched re-engined versions of narrowbody designs: the A320neo and 737 MAX. These aircraft offer significant fuel efficiency improvements from new engines and aerodynamic improvements, reducing fuel burn, $CO_2$ emissions, and improving range. Given that the A320 and 737 families of aircraft are the only two aircraft offering capacity and performance in this segment of the market, demand for these aircraft has been unprecedented, and both airframers have been trying to ramp up production to new heights.

This ramp-up, however, has coincided with external disruptions such as geopolitical instability, raw material shortages, transportation logistics issues, and heightened military/business jet demand, all of which have contributed to the industry's current supply chain challenges. This situation is being exacerbated by the stronger grip of OEMs, resulting in fewer aftermarket alternatives. In addition, Boeing has faced significant production challenges in the aftermath of several occurrences that have plagued the airframer.

## Geopolitical Instability

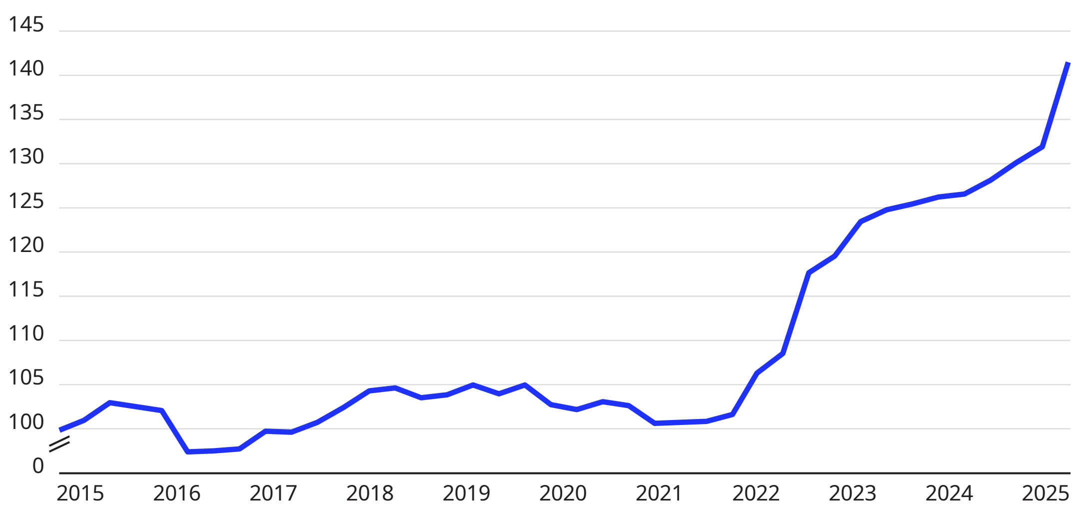
Geopolitical instability is significantly disrupting global supply chains, with the Russia-Ukraine war serving as a prominent example. Early on in this conflict (February 2022), Collins Aerospace, which produced heat exchangers for Boeing's 787 Dreamliner in a joint venture with Russia's Hamilton Standard-Nauka, ceased Russian operations and shifted production to facilities in the US and UK. At that time, Boeing's production rate for the Dreamliner was low enough for Collins to meet demand despite the transition. But as Boeing aims to ramp up output, the relocated production lines have struggled to keep pace.

Simultaneously, Boeing ended its joint venture with a major Russian titanium supplier. Raw materials like titanium are essential for manufacturing aircraft components that are both lightweight and durable. Before the conflict, Russia was a key global supplier of titanium to both Boeing and Airbus, as well as engine OEMs. The conflict triggered a roughly 90% surge in titanium prices, and prices remain elevated, reflecting ongoing market uncertainties (Exhibit 31). Impacts to Tier 4 (that is, raw materials) companies can cripple large, complex supply chains, impacting material availability, production capacity, and ultimately, aerospace manufacturing timelines and costs.

In addition, geopolitical issues have created challenges in the tax-free movement of aerospace products throughout the world. Historically, commercial aviation has been tax and customs exempt to allow for the free movement of aircraft, engines, and related parts and components. Article 24 ("Customs duty") of the Chicago Convention (ICAO Doc 7300) and Doc 8632 — ICAO's Policies on Taxation in the Field of International Air Transport, have been adopted by governments worldwide to facilitate such movements across national borders. The 1979 Agreement on Trade in Civil Aircraft, to which 33 countries are signatories, also provided for duty-free trade of civil aircraft, engines, flight simulators, and related parts and components. However, trade tensions have put pressure on these agreements and the free movement of goods. Engines, components, and various aircraft parts travel across multiple borders, making them vulnerable to customs delays, complex export/import controls, and inconsistent government regulations.

**Exhibit 31: Producer Price Index for titanium, 2015-2025**

2015=100




Source: Federal Reserve economic data

## Materials Shortages

Raw material shortages are creating significant bottlenecks across the commercial aviation supply chain, affecting key aerospace suppliers globally. Various Tier 1s and other suppliers have grappled with shortages of aluminum and steel, in addition to titanium, which have disrupted foundry operations and hindered their ability to supply parts on time. These shortages also include specialized materials like Inconel, a family of high-temperature alloys critical for engine components and other high-stress applications.

The scarcity of materials stems from increased global demand on the one hand, especially from countries expanding their defense capabilities, and constrained processing capacity for special coatings and fabrication on the other. The pandemic further exacerbated these issues, as many metal mills either shut down or redirected production lines to less-affected industrial sectors, making it slow and costly to restart aerospace-specific manufacturing.

Supply challenges are compounded by shifts in demand and recycling dynamics. During the pandemic-driven downturn in aerospace manufacturing, scrap metal generation dropped sharply, reducing the availability of recycled titanium, nickel, chromium, and rhenium that typically supplement raw material supplies. Unexpected surges in demand for superalloys also occurred, as major aircraft manufacturers announced ambitious production targets in 2022-23, putting additional strain on already tight material supplies.

Collectively, raw material constraints are slowing production ramp-ups, increasing costs, and adding complexity to the aerospace supply chain.

## Military and B&GA Spending Influence

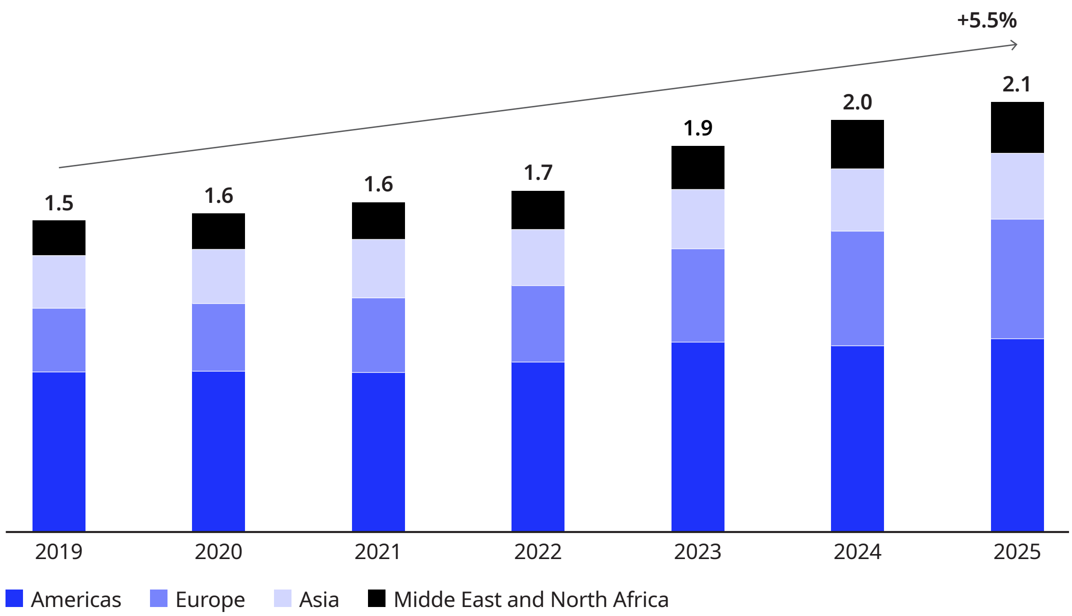
Rising geopolitical tensions are increasing military spending, while changing market dynamics are driving growth in business and general aviation (B&GA). Together, these trends are intensifying competition with commercial aviation for critical resources. Heightened global conflicts — including the war in Ukraine, Middle East instability, and Indo-Pacific deterrence efforts — have boosted military aircraft procurement budgets, which increased by 5% a year on average from 2019 to 2025 (Exhibit 32). Major programs, including the F-35 and large unmanned aerial vehicles, are accelerating production and maintenance activities.

Simultaneously, the pandemic boosted global demand for business and private jets, and utilization rates for business jets remain more than 15% above pre-pandemic levels, with strong order backlogs at leading manufacturers, including Gulfstream, Bombardier, and Embraer.

These demand surges are supported by customers' willingness to accept higher prices and shorter contract terms, enabling suppliers to better manage inflationary pressures compared to the long-term, fixed-price contracts typical in commercial aviation. But where these programs compete with commercial aviation for the same materials and manufacturing supply, they put more strain on shared supply chain choke points.

**Exhibit 32: Global defense spending by region, 2019-2025**

$ trillions




Source: Janes GPS, International Toplines

For example, critical components such as castings and forgings — including high-pressure turbine (HPT) disks and landing-gear beams — are in limited supply. Engine maintenance and overhaul slots for military engines like the F-135, GE T408, and CFM56 overlap with commercial engine programs such as the PW1100G and LEAP, creating bottlenecks in depot capacity.

Equally, military programs compete aggressively with commercial aviation for an acutely limited skilled labor pool (see Theme 3).

Collectively, these pressures from military and business aviation amplify supply chain constraints, delaying commercial aircraft production, increasing costs, and complicating efforts to meet growing airline demand.

# Theme 3: Labor Challenges

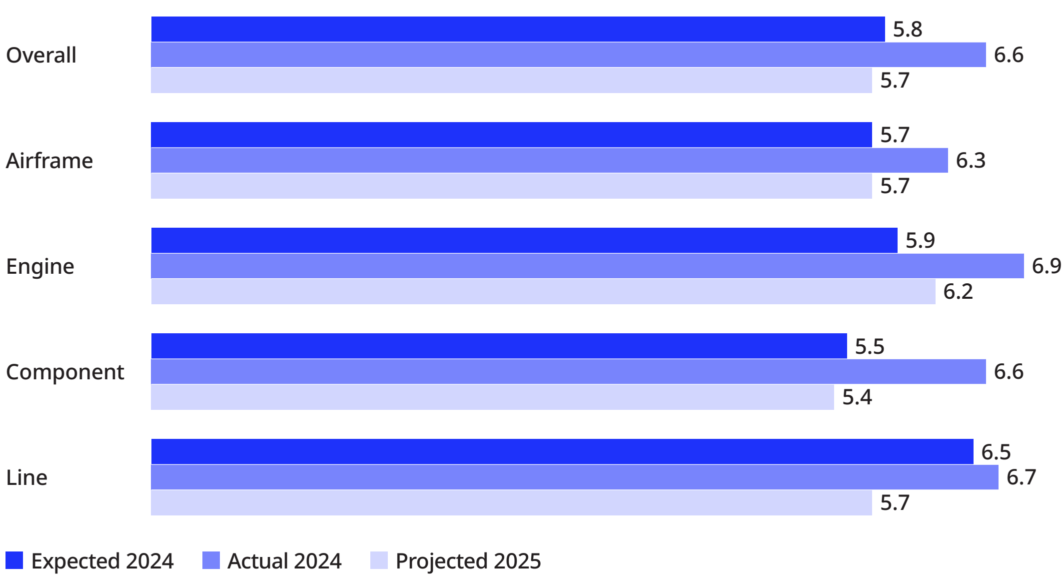
The global aerospace industry is experiencing a pronounced labor shortage, driven by the large-scale retirement of older workers (which has pushed up industry wages across the board for suppliers). This labor shortage is particularly noticeable among mechanics and aircraft maintenance technicians (AMTs) as the industry struggles to recruit Gen Z and millennial workers but can be seen across regulatory personnel as well. Challenges exist to recruiting younger generations, due to their focus on more technology-driven solutions and innovative approaches to problem-solving in a highly regulated environment.

Oliver Wyman's latest MRO survey of industry executives showed that in 2024, respondents expected year-over-year wages to grow by 5.8%, but instead saw 6.6% growth, indicating that wage inflation remains persistent in the industry (Exhibit 33).

More than one-third of aircraft mechanics in North America are at or near retirement age (Exhibit 34). This group of skilled technicians with a high degree of in-house knowledge is exiting the workforce along with their undocumented techniques. As more junior staff fill the gaps, airlines and independent MROs are reporting that it is taking 2-3 years for new AMTs to become fully productive. This implies that more staff are needed to complete tasks or that turnaround times could be longer, directly impacting airlines.

**Exhibit 33: Anticipated/actual 2024 and projected 2025 maintenance labor rate increases**

In percent, average of MRO Survey responses by segment



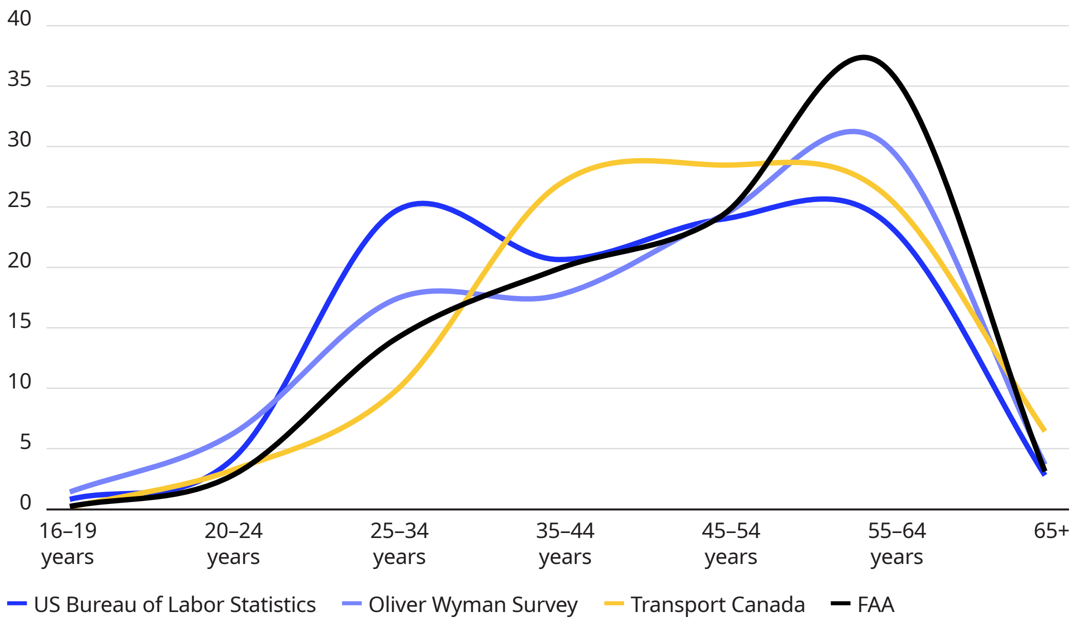

Source: Oliver Wyman 2025 MRO Survey

In North America alone, Oliver Wyman expects a shortfall of 17,800 commercial aviation maintenance workers in 2025, with these numbers rising to 22,000 by 2027.

While these shortages are acute in advanced economies, they also have been reported in China and emerging markets.

**Exhibit 34: Maintenance technician age profiles**

Data by source




Note: Oliver Wyman survey includes certified and non-certified personnel working at independent MROs and regional, mainline, and cargo airlines

Source: US Bureau of Labor Statistics, Transport Canada, Federal Aviation Administration, Oliver Wyman survey and analysis

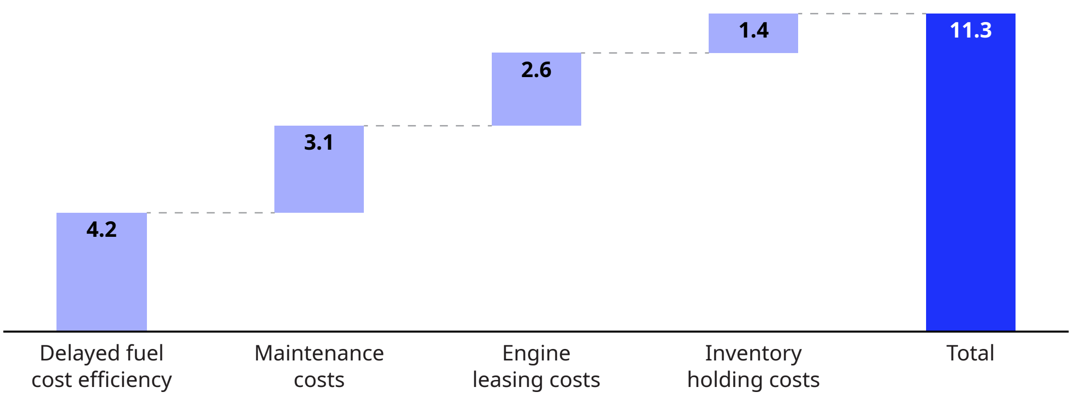
SECTION V.

# Impact on Airlines

Supply chain challenges affect airlines across the spectrum — from lost revenue and decreased customer satisfaction to increased operating costs and greenhouse gas emissions.

Out of many impacts, Oliver Wyman quantified four primary impacts: delayed fuel cost improvements from flying less efficient aircraft; higher maintenance costs due to flying older aircraft and OEMs' limiting other MRO competition on newer aircraft models; higher engine leasing costs due to increased TATs; and higher increased inventory holding costs. Together, these impacts could cost the industry an estimated $11.3 billion in 2025 (Exhibit 35) (see Appendix A for cost methodology). And beyond this, additional cost impacts will likely result from increased complexity, risks, penalties, and inefficiencies.

**Exhibit 35: Potential estimated cost impact for airlines of supply chain challenges, 2025**
$ billions




Source: Oliver Wyman analysis

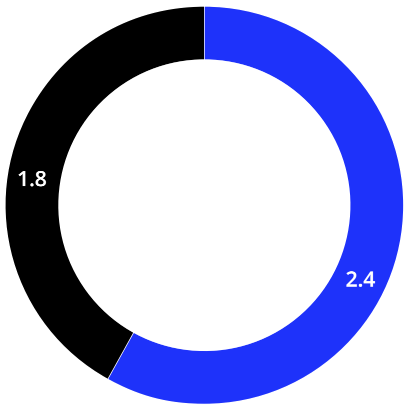
# Delayed Fuel Cost Efficiency

As a result of aircraft delivery delays, airlines are having to operate older, less fuel-efficient aircraft that also emit higher greenhouse gases. The added fuel costs from operating these older models instead of newer models (for example, A320neo vs. A320ceo, 737 MAX vs. 737 NG) could amount to $4.2 billion in 2025 alone (based on a 2024 average jet fuel price of $2.34 per gallon).[11]

Added fuel costs represent around 1.6% of the $260 billion in global annual jet fuel expenditure by the commercial airline industry. Narrowbodies account for 40% of the total impact, while widebodies account for 60%, given their higher fuel burn rates (Exhibit 36).

11 Given jet fuel price volatility, the total impact could vary from as low as $1.7B (based on 2020 fuel prices of around $1 per gallon) to as high as $6B (based on 2022 fuel prices of over $3 per gallon).

**Exhibit 36: Fuel efficiency cost impact on airlines by aircraft type, 2025**
$ billions




Source: Oliver Wyman analysis

When viewed from a cost per available seat-mile (CASM) and profitability perspective, the impacts are even more notable (Exhibit 37). Based on IATA statistics, global industry expenses are around $904B, with fuel costs accounting for 29% of all operating costs. A $4.2B change in fuel costs represents a 0.46% change in operating costs for airlines, and an equivalent 0.46% change in CASM, assuming constant available seat-miles. This also represents a 13% change in profits, based on global airline net profits of $32B in 2024.

Beyond the direct financial impact, the environmental consequences are equally significant. Continued operation of legacy aircraft models has resulted in approximately 17 million metric tons of avoidable $CO_2$ emissions — representing 1.8% of the aviation industry's annual total emissions (approximately 950 million metric tons). At an individual airline level, fleet renewal is a significant lever for achieving 2050 net zero targets, typically accounting for around 15-20% of total emissions reductions.

**Exhibit 37: Potential cost and profitability impact on airlines of delayed fuel efficiency**
Based on jet fuel price/gallon scenarios

| | | | | Using 2024 jet fuel prices | | |
|---|---|---|---|---|---|---|
| **Jet fuel price/gallon** | $1.0 | $1.5 | $2.0 | $2.3 | $3.0 | $3.5 |
| **Cost impact** | $1.8B | $2.7B | $3.6B | $4.2B | $5.4B | $6.2B |
| **CASM impact** (Assuming industry expenses = $904B) | 0.2% | 0.3% | 0.4% | 0.5% | 0.6% | 0.7% |
| **Profitability impact** (Assuming industry profits = $32B) | -6% | -8% | -11% | -13% | -17% | -19% |

Source: Oliver Wyman analysis

# Increased Aircraft Maintenance Costs

The global fleet is nearly two years older on average than it was in 2019 (Exhibit 38). Had all expected aircraft deliveries been made, the global fleet would be only one year older today than in 2019. These older aircraft, having been through a greater number of hours and cycles, are more costly to maintain than new aircraft. At the aggregate level, assuming that older aircraft are flown instead of newer ones, the global additional maintenance cost to airlines could amount to $3.1 billion in 2025.

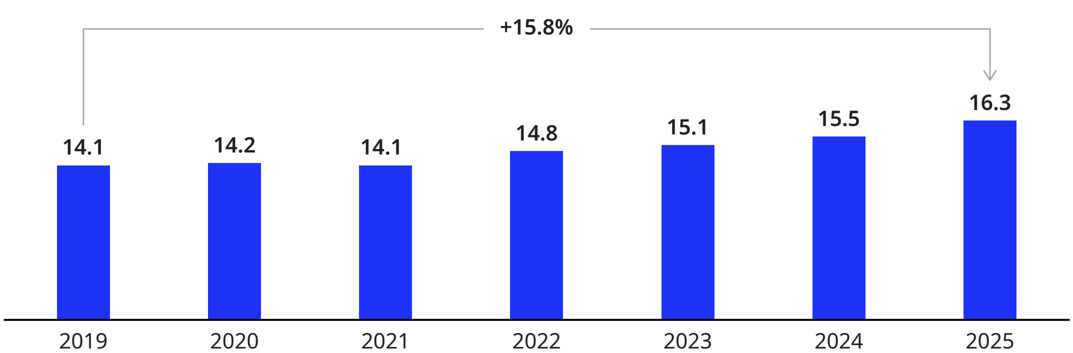
Maintenance costs for aging aircraft rise for several reasons: Routine maintenance increases in frequency and complexity, as scheduled inspections reveal more issues, and major components like engines and landing gear require costly overhauls at key lifecycle stages. Regulatory inspection requirements to prevent widespread fatigue damage also add significant expense, including structural modifications needed to extend airworthiness.

Non-routine maintenance also grows as material degradation from stress, environment, and use causes cracks, corrosion, and other damage that requires repair or replacement. This is often detected during inspections or failures and becomes more frequent later in an aircraft's design life. Mandatory Airworthiness Directives (ADs) and Service Bulletins (SBs) impose additional costs through required modifications and ongoing inspections for safety issues. Aging-related structural, wiring, and fuel tank repairs, along with mid-life regulatory retrofits, further increase maintenance complexity before costs eventually stabilize near the end of service.

All aircraft models (not just aging ones) also are being impacted by a general increase in component maintenance costs, due to longer spares delivery lead times and longer equipment shop repair turnaround times. For example, airlines are having to spend more for additional components exchange and for substitution loan services. Longer lead/turnaround times are the result of parts shortages, which are being exacerbated by other factors, such as restrictive access to repair manuals beyond OEM networks and limited use of DER/Part 21 repairs and PMA parts.

**Exhibit 38: Average global fleet age, 2019-2025**

In years




Source: Oliver Wyman analysis

# Engine Leasing Costs

Increased TATs for engine maintenance, due to parts and labor shortages (among other reasons) result in grounded aircraft awaiting engines, a greater need to maintain spare engines, and the need to lease engines. Together, these impose a financial burden on the industry that could range from $2.6 billion to $5.0 billion (based on an increase in TATs from a baseline of 60 days up to 90-120 days for an engine overhaul). This figure could vary depending on the severity of TAT increases (Exhibit 39).

**Exhibit 39: Engine visit turnaround time increases: cost impact on industry**

| **Turnaround time in days** (Assuming baseline = 60) | 70 | 80 | 90 | 100 | 110 | 120 |
|---|---|---|---|---|---|---|
| **Cost impact** | $0.9B | $1.7B | $2.6B | $3.4B | $4.2B | $5.0B |

Source: Oliver Wyman analysis

# Inventory Holding Costs

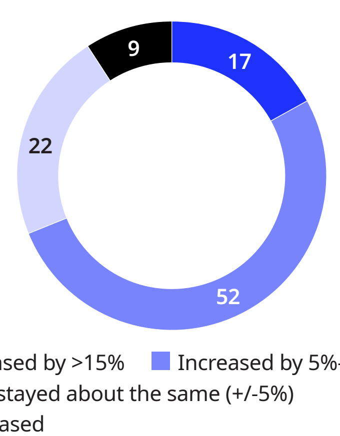
As a direct result of increased maintenance turnaround times and longer supply chain lead times, airlines have increased their spares inventory where they can. According to Oliver Wyman's survey of MRO industry executives, current inventory levels are likely up 8% on average above the historical norm, with some respondents indicating inventory levels up more than 15% (Exhibit 40).

This buffer strategy aims to mitigate the risks associated with unpredictable parts supply. But inventory buildup comes at a cost: an increase in capital for parts, plus the increased holding costs of storing and managing inventory. And it creates additional problems for airlines without the means to increase their own inventory, since parts may not be available to them due to additional inventory being held at other airlines. Inventory pooling is a potential solution, but adoption has not significantly increased. Perennial concerns over pool administration, ownership, and inventory quality still hinder widespread adoption.

Holding excess inventory could increase overall costs by $1.3 billion across the global fleet. For airlines, this equates to an additional $44,000 per narrowbody and $69,000 per widebody in holding costs annually.

**Exhibit 40: Inventory level increases to compensate for longer lead times/supply chain uncertainty**

Percent of MRO Survey respondents selecting each option




Source: Oliver Wyman 2025 MRO Survey

# Other Costs

The quantified impacts above by no means fully comprise the potential cost impact on airlines. Beyond what is quantified above, further impacts on airlines could include (but are not limited to):

- Lost revenue due to delayed aircraft deliveries, preventing service expansion
- Not meeting customer expectations, due to continuing use of older aircraft with fewer passenger amenities
- Additional spare aircraft required to support prolonged maintenance events, due to the use of older, less reliable aircraft; increased repair turn times; and a lack of spare parts
- Increased Aircraft on Ground (AOG) frequency and duration, due to a lack of available inventory to proactively address issues that lead to AOGs (such as Minimum Equipment Lists dispatch restrictions) and/or to respond to AOG events, leading to passenger re-accommodation costs, passenger rights penalties, crew displacement, etc.
- Increased costs for last-minute parts sourcing (such as via the AOG desk) due to parts shortages
- Aircraft configuration degradation, from last-minute parts sourcing, where alternative part numbers might need to be accepted to fulfill demand
- Additional carbon trading and offset costs, due to increased emissions from older, less efficient aircraft

SECTION VI.

# Conclusion: Actions for Industry

Supply chain challenges are impacting nearly every organization in the commercial aerospace landscape, from airlines and lessors to OEMs, suppliers, and MROs. Every organization is looking to better meet its own customers' demands, control costs, improve margin, and hire sufficient talent.

There are no easy solutions to fixing this multi-headed problem. But while some levers are outside of the industry's control, we describe five actions below that we think could help the industry accelerate recovery.

# Action 1: Ramp Up Collaboration

A critical first step is that commercial aerospace industry participants need to develop a collaborative approach among all stakeholders in the supply chain that is more fundamental and strategic, with the goal of finding collective solutions to the problems that now weigh on the industry. Clearly, individual firms have not been able to move the needle through their own efforts in terms of better meeting aircraft production and maintenance demand.

## Increase schedule stability

Airframers and OEMs could do a better job collaborating with the supply chain to rebuild confidence in forecasts, thereby creating more schedule stability and a unified view of achievable production run-rates. This might require running at lower rates longer and ramping up incrementally. Run-rate targets should be aspirational but achievable, based on all elements of the supply chain. Airframers and OEMs also could consider employing other methods that help bring more stability to the supply chain, such as "take or pay" contracts.

## Enhance early warnings and contingency planning

OEMs, which in some sense are the "first stop" on the aircraft supply chain, could play a vital role in providing early warnings about potential supply chain problems to airlines and suppliers. Early signals into trouble coming down the pipeline — such as part shortages, logistics delays, or capacity constraints — could enable supply chain participants to trigger both common and individual strategies to keep such issues from escalating. Transparency around inventory management policies; preferred suppliers; purchasing policies; and sales, inventory, and operations planning (SIOP) could further improve visibility.

OEMs could take a leadership role as well in developing joint contingency plans tailored to specific risk areas, by prioritizing critical components (such as those with long lead times or that are single source or complex). Equally, airframers could facilitate more frequent coordination meetings and working groups to review the status of emerging issues and raise the alarm for key suppliers across the supply chain.

### Share best practices

On the customer side, airlines could collaborate within the framework of industry working groups and open forums to increase their understanding of supply chain issues. This might involve developing formal mechanisms to ensure ongoing sharing of lessons learned, to highlight inefficiencies and best practices.

More transparent and collective communication also could help airlines identify and reduce wasteful processes and risks. For example, sharing more data on the technical root causes of maintenance delays or parts shortages could help pinpoint systemic issues that could be followed up with collaborative problem solving.

### Improve documentation consistency

Airlines also could work toward more consistent approaches to the depth and type of documentation required to transact for spare parts and engines. More consistent approaches to the amount of maintenance history required (that is, back-to-birth documentation) or consistent standards (such as resetting documentation required after a major overhaul) could increase the liquidity of markets and speed transactions, increasing part availability.

## Action 2: Improve Supply Chain insight

Supply chain visibility across tiers has long been an industry goal. While some visibility currently exists for the higher tiers of the supply chain, the industry generally lacks the full end-to-end transparency that exists in other sectors, such as automotive.

Airframers and Tier 1 OEMs sign support agreements (such as the Airbus SSC and the Boeing PSAA) that entail certain obligations for performance, reliability, cost escalation, etc. for the parts and systems they provide. A good understanding and possible automated monitoring of these agreements is a first step toward greater supply chain visibility.

In addition, developing a detailed understanding of the entire global supply chain, including all tiers, logistics partners, and customers, could help more proactively manage supply chain issues and improve efficiency.

### Reveal critical risks

Mapping could reveal hidden dependencies and potential bottlenecks, such as sole-source suppliers or critical logistics nodes that could disrupt production. Early warning and assessment of risks would be enhanced, enabling the supply chain to be managed more proactively, versus only reacting when problems arise. This in turn would support more effective inventory management throughout the supply chain.

Identifying vulnerabilities also would enable OEMs to develop targeted mitigation strategies, such as dual sourcing or alternative routings, thereby strengthening risk management and increasing resilience.

### Expose inefficiencies

Enhanced visibility also would expose inefficiencies and enable leaner, more coordinated production processes. It could foster stronger collaboration and innovation, by clarifying supplier relationships and enabling integration of digital tools, such as Internet of Things (IoT) and blockchain, for real-time track and trace. Finally, such insights could support more strategic decision-making around sourcing, capacity planning, and adapting to market or geopolitical shifts.

The availability of tools and advanced analytics to both map and monitor the supply chain are improving, but achieving better supply chain insights also requires industry-wide commitment and a secure and trusted process for data sharing.

## Action 3: Better Leverage Inventory and Maintenance Data

Airlines have a wealth of information available to them on the performance of their fleet and individual components. Modern aircraft are producing more data than ever, with GE estimating that the global fleet generates 10 exabytes (or 10 million terabytes) of flight, maintenance, and operational data annually. This data can be better leveraged to improve access to spare parts and forecasts, reducing the amount of inventory required to maintain a high level of performance.

### Use traditional and virtual parts pooling

One method for reducing inventory requirements is by sharing inventory across airlines. There are several options for achieving this. Traditional for-profit parts pools offered by third parties have been around for many years, but usage is mixed, due to issues around ownership, access priority, configuration standards, costs, and governance. Better data on part history could help increase usage of such pools.

Other pools, like the International Airlines Technical Pool (IATP), enable airlines to offer and seek parts on a neutral platform that facilitates transactions. Airlines also could consider “virtual pools” that offer more real-time visibility into parts availability across groups of airlines. This would help facilitate traditional loan, borrow, or purchase transactions.

## Develop advanced supporting processes for predictive tools

Predictive maintenance can help airlines avoid unscheduled maintenance, reducing the need for last-minute sourcing of parts (which strains the supply chain and can increase costs). Predictive maintenance has the potential to turn unscheduled events into a predictable demand signal that can be planned for, potentially reducing inventory safety stocks.

Achieving this, however, will require cooperation across airlines, lessors, MROs, and OEMs to evolve processes and commercial agreements. Airlines must learn how to leverage the output from predictive maintenance systems alongside other information (such as stock levels, go/no-go lists, and minimum equipment list categories). Airlines and maintenance providers need to evolve commercial agreements to accommodate and review potential increases in "no-fault-found" and determine who holds responsibility for executing a "Predict" service order.

## Centralize maintenance data

With the support of aircraft manufacturers through open data access (that is, by following open standards such as ARINC norms), all airlines could benefit from a central repository of aircraft maintenance data. This would serve as a shared knowledge base available to all, without discrimination. Such a centralized data hub could facilitate effective use of digital and AI tools to better analyze and disseminate maintenance information.

By leveraging AI-driven insights and exploiting data generated by their own fleets, airlines might improve maintenance capabilities, potentially reducing unplanned maintenance events and avoiding unnecessary routine maintenance activities. Recent industry initiatives, such as the Principle on Aircraft Operational Data facilitated by IATA and agreed between several OEMs in October 2024, have sought to enable such open data access but investment and determined collaboration will be needed to fuel these initiatives.

Predictive maintenance can help airlines avoid unscheduled maintenance, reducing the need for last-minute sourcing of parts.

# Action 4: Expand Maintenance and Parts Supply

With parts in short supply and long lead times for repairs, the supply chain needs to consider alternatives to create additional capacity.

## Increase materials repair

Every part that can be repaired displaces the need for a spare part, alleviating pressure on the supply chain and making more parts available for production lines and instances where repairs are not feasible. Repairing parts generally also has a lower environmental impact than producing a new part. This would require more active coordination between airlines, OEMs, lessors, MROs, approved Design Organizations (DOAs), and regulators.

OEMs could support more rapid development of repairs, especially on newer platforms, and evaluate making repairs available to more MROs. This would increase both repair ability and capacity. Airlines in turn could become more comfortable accepting alternatives to OEM repairs and more actively use FAA DER and EASA Part 21. This might require collaborating with lessors on updates to terms, wherever alternative repairs are currently commercially discouraged or restricted. Lessors have historically accepted Supplemental Type Certificates (STCs) and acceptance of Part 21 "minor changes" for the development of other approved repair instructions is a natural evolution of current practices. MROs without a DOA can partner with independent DOAs to design and substantiate repairs and so offer new options to their customers. This could be especially helpful for unlicensed MROs.

In addition, regulators could evaluate ways to reduce regulatory cycle times and backlogs for applicable approval of new repair instructions submitted by DOAs that are not categorized as minor changes, as well as review and clarify expectations for information provided in Instructions for Continued Airworthiness (ICAs).

## Increase alternative parts and USM usage

Increasing the use of materials from alternative suppliers through FAA's owner-airline-produced-parts and/or under EASA's Part 145 parts local fabrication privilege and PMA could alleviate supply chain pressure on traditional suppliers. This could be an especially productive strategy for parts on older platforms, which often are disruptive for OEMs. There are many suppliers willing and better equipped to take on such lower volume, high-mix work, and there may be non-traditional suppliers outside the aerospace ecosystem that could be brought into the fold.

Advances in additive manufacturing could streamline design and development of parts from alternative materials, enabling a shorter time to market. These technologies can more rapidly prototype and create first-article samples, and are well suited for the quick response, low-volume production runs required in this space, where more traditional techniques might prove prohibitive on a time and cost basis.

OEM involvement and commitment could help expand the use of alternative materials. OEMs can directly license parts to other manufacturers, support quality control, and accommodate alternative parts, freeing up OEM capacity to focus on critical parts choking the supply chain. Independent PMA manufacturers could bring additional value by further developing their own catalogs.

Opportunities also exist to take better advantage of significant volumes of USM, whether complete line replaceable units (LRUs) and/or subcomponent assemblies at repair workshops. Industry platforms such as Aeroxchange and the IATA MRO Smarthub are examples of tools available to identify, value, and trade USM.

### Leverage existing contractual enablers

Airlines could better leverage the warranty terms and performance guarantees in existing agreements to open up additional solutions, capacity, and potentially reduce costs. Many airlines are reasonably well versed in the management of warranties and guarantees for BFE and maintenance services, as they directly negotiate such agreements with their suppliers. However, airlines could increase their awareness and leverage of agreements covering SFE. The Boeing PSAA and Airbus SSC are available to airlines and describe the support to be provided by airframe SFE equipment OEMs. Other agreements, like the IATA-CFM Agreement on Engine Maintenance and IATA and Rolls Royce Statement on Best Practices for Maintaining Competition in Aerospace Markets, also can be leveraged by airlines in negotiations with OEMs.

These agreements will need to continue to be evaluated and updated as the aftermarket landscape changes — especially as lessons are learned from narrowbody engines going through their first shop visits in the second half of this decade. Finally, other OEMs could consider additional frameworks similar to the Rolls Royce and CFMI agreements, to open up additional supply chain solutions.

## Action 5: Support the Current and Future Workforce

Across the industry, all parties are working to attract, retain, and effectively train the current and future workforce, particularly to handle the growing complexity of modern aircraft. Given the intricacies of workforce development, this action includes near-term (such as training and incentive programs) as well as longer term (such as expanding the talent pipeline, industry-wide coordination) initiatives.

### Innovate training and incentive programs

Training programs must embrace innovative methods (such as virtual reality and AI) for younger generations now entering the workforce, who are more tech-savvy but also have different learning styles than older generations. On the other end of the spectrum, as older, highly expert workers retire, creating digital repositories to capture and share their institutional knowledge could help preserve that expertise, standardize guidance, and accelerate onboarding.

Incentive programs need to be tailored to reduce turnover in today's highly competitive market, as well to appeal to what each generation values. A diverse menu of options can ensure broad appeal, including performance bonuses, mentoring/coaching, flexible work options and career development paths, and certification partnerships. With five generations currently in the workforce, a "one size fits all" approach simply will not work.

## Expand the talent pipeline

Expanding the talent pipeline will require that airlines and OEMs continue efforts to reach out to educational institutions at all levels — from STEM outreach in middle and high schools to joint certification programs with colleges and trade schools. And recruitment strategies must cast a wide net, considering related industries with transferable skills, like automotive and utilities; experienced former military personnel; and people from more diverse backgrounds.

## Invest in an industry-wide approach

Finally, aviation needs to implement a coordinated, industry-wide approach to attract talent. As an example, in response to similar challenges in the US shipbuilding industry, the Navy and key members of the industrial base launched the Blue Forge Alliance, which, among other roles, coordinated industry outreach with consistent, catchy marketing; national ad placement; and the "buildsubmarines.com" recruiting site. All organizations in the commercial aerospace value chain could benefit from a similarly coordinated approach.

In conclusion, today's aircraft fleet is larger, more technologically advanced, and fuel efficient than ever before. The production and aftermarket supply chains and economic models that have developed to deliver this fleet, however, are exacerbating supply chain challenges. The costs of these challenges to airlines are real and are a headwind for the health and sustainability of the industry.

Re-evaluating how the current industry economic structure could impact future platforms might pave the way toward rebalancing the equation between new OEM programs and the aftermarket costs borne by airlines. This crisis could be an opportunity for the industry to openly revisit foundational aspects of current OEM business models.

Finally, a broader and united industry response that is more proactive, flexible, and strategic could help all stakeholders resolve current supply chain issues and better prepare for future challenges.

APPENDIX A

# Cost Impact Methodology

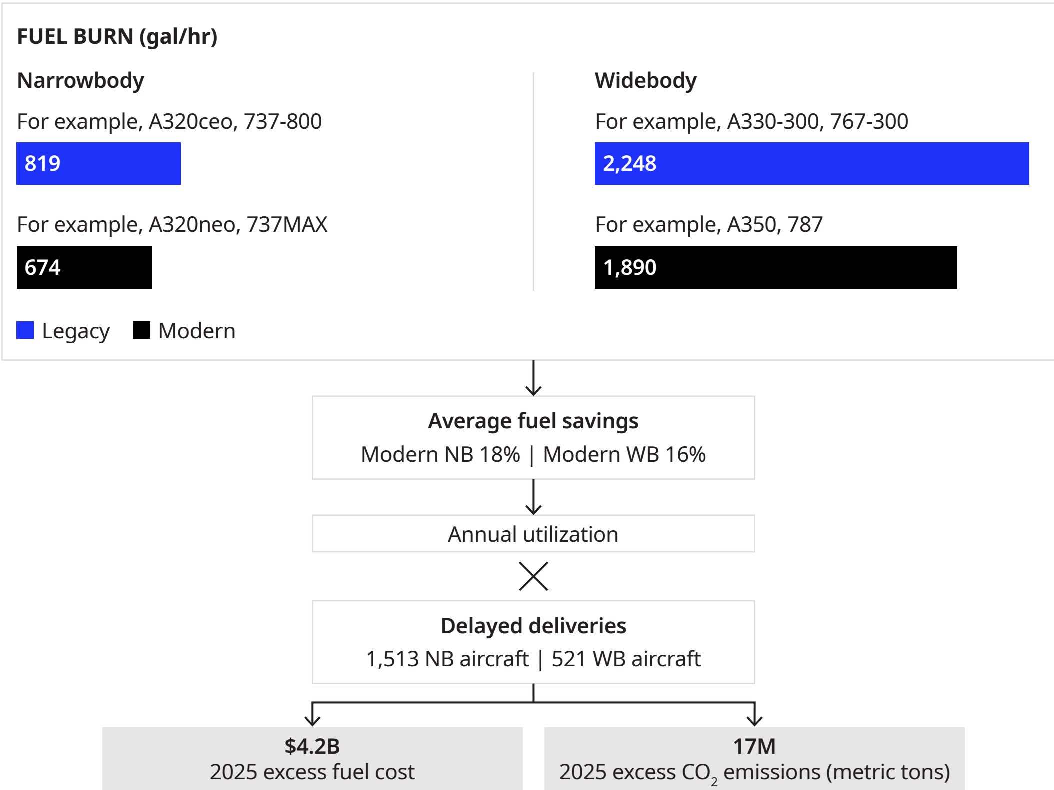
The cost impact figures below are based on major aircraft models (such as the 737 MAX, A320neo, 787, 777, etc.). Deliveries expected in 2020 and 2021 are removed to cancel out the effects of the COVID-19 pandemic. The gap in deliveries is based on Oliver Wyman's 2019 and 2025 fleet forecasts, with approximately 2,000 deliveries that were expected from 2019 to 2025 and did not occur.

## Delayed Fuel Cost Efficiency

To quantify the fuel cost impact for airlines, a four-step process was applied: first, the fuel cost and CO2 emissions savings per hour were calculated for a range of aircraft options. These savings per hour figures were based on legacy model emissions (for example, A320ceo, 767) relative to newer model emissions (for example, A320neo, 787). Next, the "gap" between 2025 actual aircraft in service relative to 2019 forecasts was determined, with pandemic year deliveries (2020 and 2021) zeroed out. This "gap" or aircraft not delivered figure was then multiplied by the average annual flying hours for each aircraft and the fuel/CO2 cost difference per hour. This resulted in the final $4.2 billion figure representing the fuel costs that would have been averted had all aircraft been delivered (Exhibit 41).

We estimate that $4.2 billion in fuel costs would have been averted had all expected aircraft been delivered.

**Exhibit 41: Fuel cost efficiency calculations**



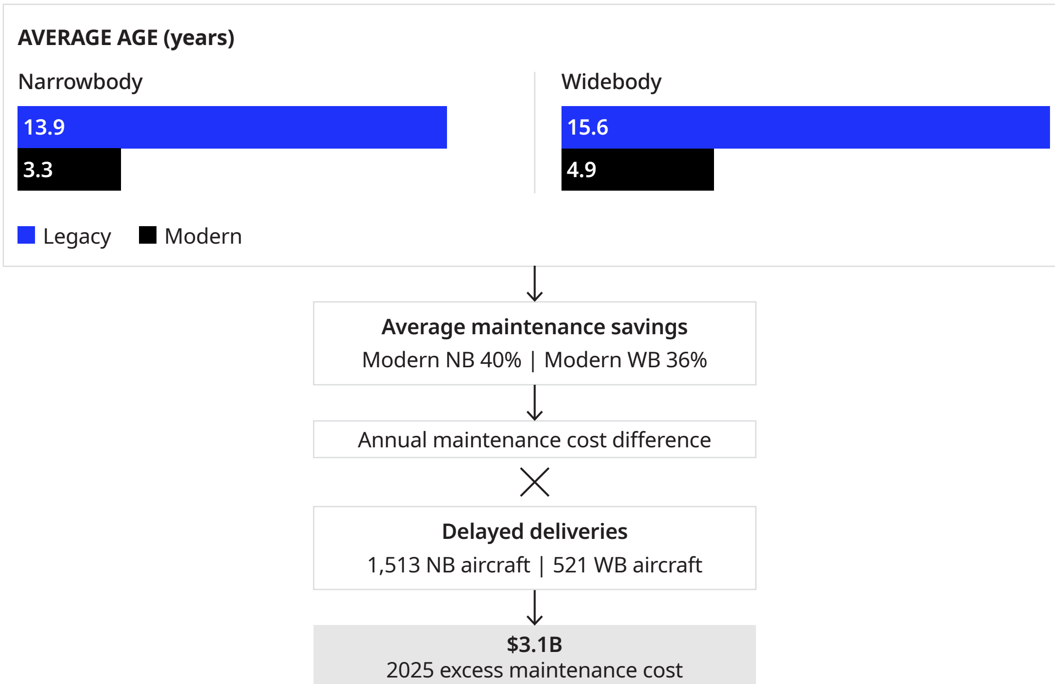

Note: NB = narrowbody, WB = widebody
Source: Oliver Wyman analysis

## Maintenance Costs

To derive the maintenance impact for airlines, "typical" maintenance costs by year for aircraft were used. For example, the average new narrowbody (based on a set of major aircraft like the 737 and A320) today is around 3 years old, while an older narrowbody is nearly 14 years old. Aggregated data across a set of aircraft models (A320, A330, 737 MAX, A220, A350, 195-E, and 787) show that an older narrowbody is 40% more expensive to maintain relative to a newer one.

Similarly, the average new widebody is 5 years old and an older widebody is nearly 16 years old and costs 36% more to maintain. This cost difference was then multiplied by the "gap" between 2025 actual aircraft in service relative to 2019 forecasts to get to the full cost impact. The final $3.1 billion figure represents the maintenance costs that could have been averted had all aircraft been delivered (Exhibit 42).

**Exhibit 42: Maintenance cost impact calculations**




Note: Note: NB = narrowbody, WB = widebody. Maintenance cost numbers are example figures based on a set of aircraft models (incl. A320, A330, 737 MAX, A220, A350, 195-E2, and 787)

Source: Oliver Wyman analysis

## Engine Leasing Costs

A baseline TAT of 60 days was established for engine overhauls. Oliver Wyman's proprietary OEM Value Map was used to obtain global engine counts for selected models experiencing increased TATs (such as CFM56, V2500, GE90, and CF6). Applying assumptions of 10-15% annual overhaul rates to these engine populations (based on our industry knowledge and experience), the number of engines undergoing overhaul each year was estimated. From this, the total annual "days of engines under visit" was calculated for both the baseline and extended TAT scenarios. This figure was then converted into the required number of annual engines spares, which, when multiplied by current engine prices, provided an estimate of the total cost impact to the industry.

## Inventory Holding Costs

To quantify the cost impact of increased inventory on airlines, typical inventory holding costs per aircraft were estimated. These costs could reach up to $2.8 million for widebody aircraft and approximately $750,000 for turboprops. A holding cost rate of 30% of the inventory value was assumed. The inventory increase was derived from Oliver Wyman's 2025 MRO Survey, which indicated an average rise of 8%. This percentage was applied to average inventory levels to calculate the additional holding costs.

APPENDIX B

# Glossary

| | | | |
|---|---|---|---|
| **AD** | Airworthiness Directive | **LLP** | Life-limited part |
| **AMT** | Aviation maintenance technician | **LRU** | Line replaceable unit |
| **AOG** | Aircraft on ground | **MRO** | Maintenance, repair, and overhaul |
| **APU** | Auxiliary power unit | **NRE** | Non-recurring engineering |
| **ATA** | Air Transport Association | **OEM** | Original equipment manufacturer |
| **ATK** | Available tonne-kilometer | **PBH** | Power-by-the-hour |
| **B&GA** | Business and general aviation | **PMA** | Parts Manufacturer Approval |
| **BFE** | Buyer-furnished equipment | **PPI** | Producer Price Index |
| **CASM** | Cost per available seat-mile | **PSAA** | Boeing Product Support and Assurance Agreement |
| **DER** | Designated Engineering Representative | **SATCOM** | Satellite communications |
| **DOA** | Design Organization Approval | **SB** | Service Bulletins |
| **EASA** | European Aviation Safety Agency | **SFE** | Seller-furnished equipment |
| **EIS** | Entry into service | **SSC** | Airbus Supplier Support Conditions |
| **FAA** | US Federal Aviation Administration | **STC** | Supplemental Type Certificate |
| **FMS** | Flight management system | **STEM** | Science, technology, engineering, mathematics |
| **HPT** | High-pressure turbine | **T&M** | Time and materials |
| **IATA** | International Air Transport Association | **TAT** | Turnaround time |
| **ICA** | Instructions for Continued Airworthiness | **TCAS** | Traffic collision avoidance system |
| **IP** | Intellectual property | **USM** | Used Serviceable Materials |

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## ABOUT THE INTERNATIONAL AIR TRANSPORT ASSOCIATION

The International Air Transport Association (IATA) is the trade association for the world's airlines, representing some 350 carriers and more than 80% of global air traffic. IATA represents airlines worldwide by engaging with governments and regulators to shape policies that support aviation's role in connecting people, goods, and economies. It leads the industry through global standards that make flying safe, secure, and efficient, while improving the passenger experience and reducing costs. It also serves the industry with products, services, and expertise that help airlines operate effectively and sustainably. For more information, visit iata.org or follow on LinkedIn and X.

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Oliver Wyman, a business of Marsh McLennan (NYSE: MMC), is a management consulting firm combining deep industry knowledge with specialized expertise to help clients optimize their business, improve operations and accelerate performance. Marsh McLennan is a global leader in risk, strategy and people, advising clients in 130 countries across four businesses: Marsh, Guy Carpenter, Mercer and Oliver Wyman. With annual revenue of $23 billion and more than 85,000 colleagues, Marsh McLennan helps build the confidence to thrive through the power of perspective.

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