AVIATION WEEK
Fleet&MRO
FORECASTS

2024 MARKET SUMMARY REPORT

COMMERCIAL

AVIATION WEEK
NETWORK

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Foreword: Shortages – The Watch Word for Commercial Aviation

Brian Kough, Senior Director, Forecasts & Aerospace Insights, Intelligence & Data Services

Commercial aviation activity has taken the entire world by storm since the previous commercial forecast was released. As anticipated last year, business is taking off. With the Asia Pacific region at 89% of pre-pandemic utilization levels and China's recent jump to 139%, these two areas bookend the uneven recovery around the world. Asia Pacific operators and MROs are busy trying to meet passenger demands and adjust to the new normal as Europe and the Americas have done, and China is leading all other areas in utilization metrics after fully opening for international travel. India, Latin America, and the Middle East are all above 2019's northern hemisphere summer travel season levels. The market can neatly be described as "busy".

Regional Utilization Change – hour % of Jul 2019 Index	
China	135%
India	109%
Europe	97%
Latin America	104%
Middle East	102%
North America	98%
Asia Pacific	89%

As this forecast is released, the other prevalent theme in the market is "shortages". Supply chains are being stretched for both manufacturers and MROs supporting the air transport activities increasing costs, labor shortages are creating productivity and cost pressures, raw material shortages along with castings and forgings are hampering engine manufacturer's ability to supply new aircraft and support the aftermarket, while petroleum supply tensions are increasing jet fuel prices impacting profitability for operators.

Airbus A321
Expected to become one of the most popular aircraft with +6,500 deliveries

Credit: Nigel Howarth, Aviation Week Network

Gross domestic product (GDP) projections appear largely positive around the major world regions underpinning continued growth in commercial passenger activities. However, the ability to produce new aircraft with engines to meet demand is strained. Airbus is having growing pains producing the newly popular A321 and Boeing suffers from production quality issues on both of their most popular programs, the 737 and 787. These production issues are creating abnormalities in the normal aircraft retirement process – older aircraft are being kept in service as a means to meet passenger demand but also as a hedge against OEMs production capabilities. USM, PMA, DER, and green time swaps, methods to bypass OEM supply chains, will become even more popular.

Foreword: Shortages – The Watch Word for Commercial Aviation

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Despite these issues and the previously mentioned shortages, the expectations are that they will eventually be overcome in the short-term leading to a fleet growth rate of 3.3% CAGR, a passenger seat increase of at least 4.7% CAGR, and a non-inflation adjusted MRO CAGR of 2.4% over 10-years. New deliveries in this scenario top out at $3.3 trillion (retail). The aftermarket is worth $1.2 trillion, split largely between Boeing ($573 billion) and Airbus ($533 billion) for both legacy and new generation aircraft. CFM's dominant engine fleets will capture most of the engine aftermarket ($177.5 billion/33%).

Concerning factors this year are the market shortages mentioned as well as inflation. Inflation is magnified across the aerospace market typically, and with shortages, the issue is exacerbated. We have noted roughly a 9.5% increase in aftermarket increases year on year and it is even more pronounced with the engine repair market. Engine shop visit schedules are at a premium with historically high turnaround times. Pratt & Whitney, dealing with critical engine reliability issues which will affect dispatching operations over the next two years, is anticipating up to 300-day turnaround times and announced the opening of seven new repair facilities before 2025 to compensate. Higher interest rates mean the chance for less investments in the market and fuel prices are eating into operator market profits that are just now emerging from an enormous business catastrophe. As we anticipate the future market, geopolitical tensions are always lurking, and we have no shortages in this realm.

Scheduled ASKs

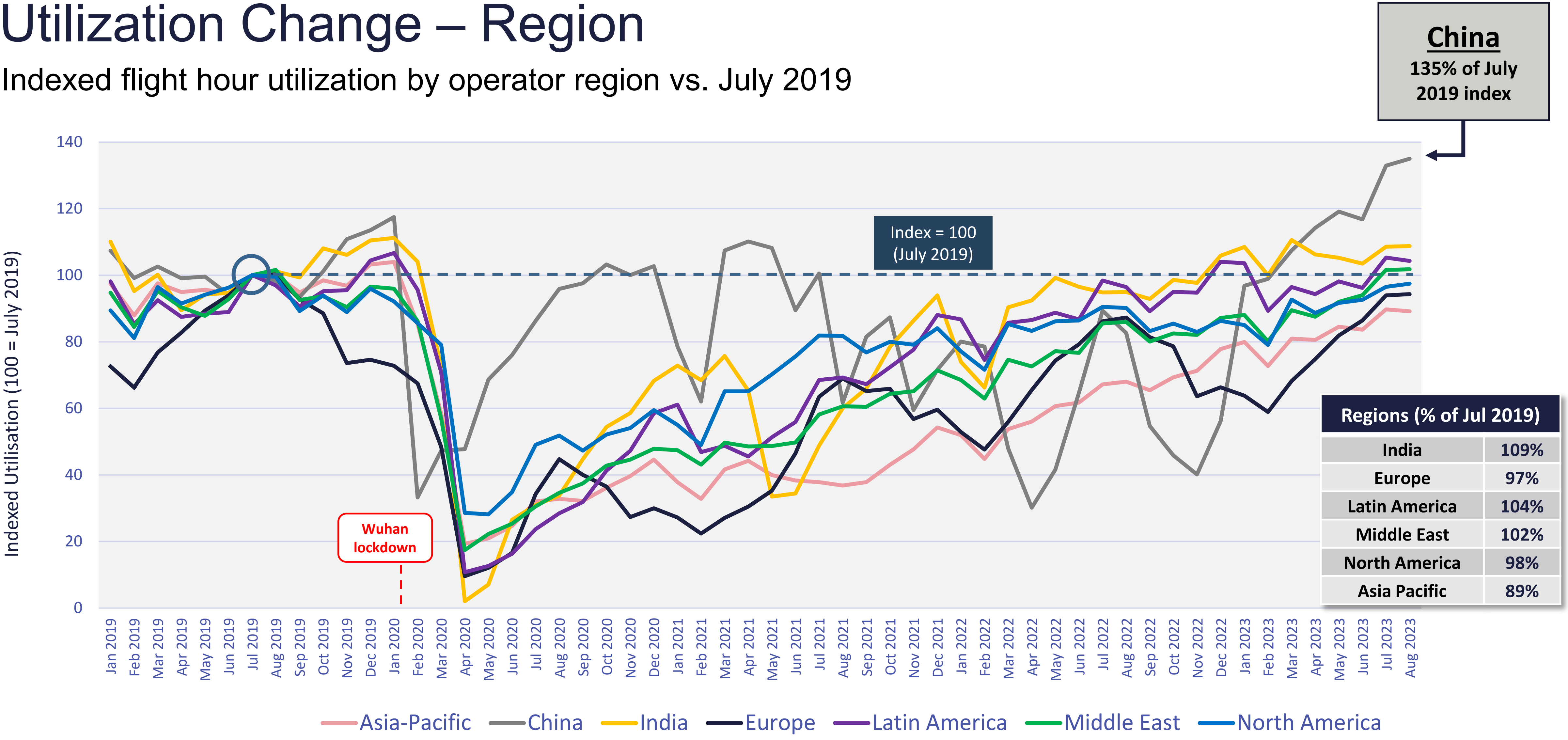
Region	Q4 2023 vs. 2022 % Change	2023 vs. 2022 % Change
U.S. & Canada	+14%	+16%
Europe	+17%	+19%
Asia-Pacific	+34%	+50%
China	+104%	+66%
LATAM & Caribbean	+12%	+13%
Middle East	+21%	+27%
Africa	+21%	+25%

Deliveries Year to Date Through Sept

	Jan-Sep 2023	vs. 22	vs. 21	vs. 20	vs. 19
AIRBUS	483	-10%	-12%	-30%	18%
BOEING	366	-15%	-40%	-78%	-27%
EMBRAER	39	-31%	-18%	-56%	46%
ATR	22	-41%	-27%	-77%	41%
Others	30	10%	37%	7%	53%
TOTALS	940	-13%	-22%	-50%	3%

Utilization Change – Region

Indexed flight hour utilization by operator region vs. July 2019

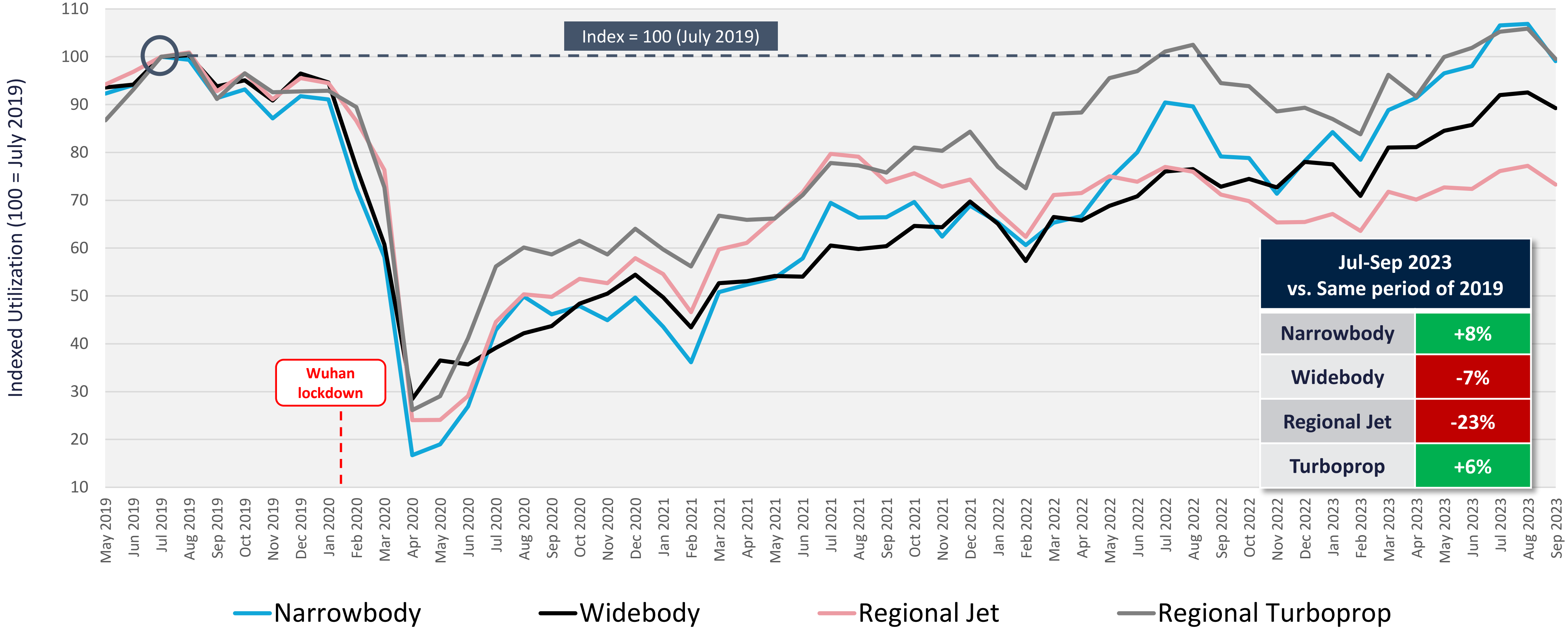


Regions (% of Jul 2019)	
India	109%
Europe	97%
Latin America	104%
Middle East	102%
North America	98%
Asia Pacific	89%

Source: Aviation Week Intelligence Network, Flight Tracking Data, Copyright 2023.

Utilization Change – Aircraft Category

Indexed flight hour utilization vs. July 2019 and Jul-Sept comparison

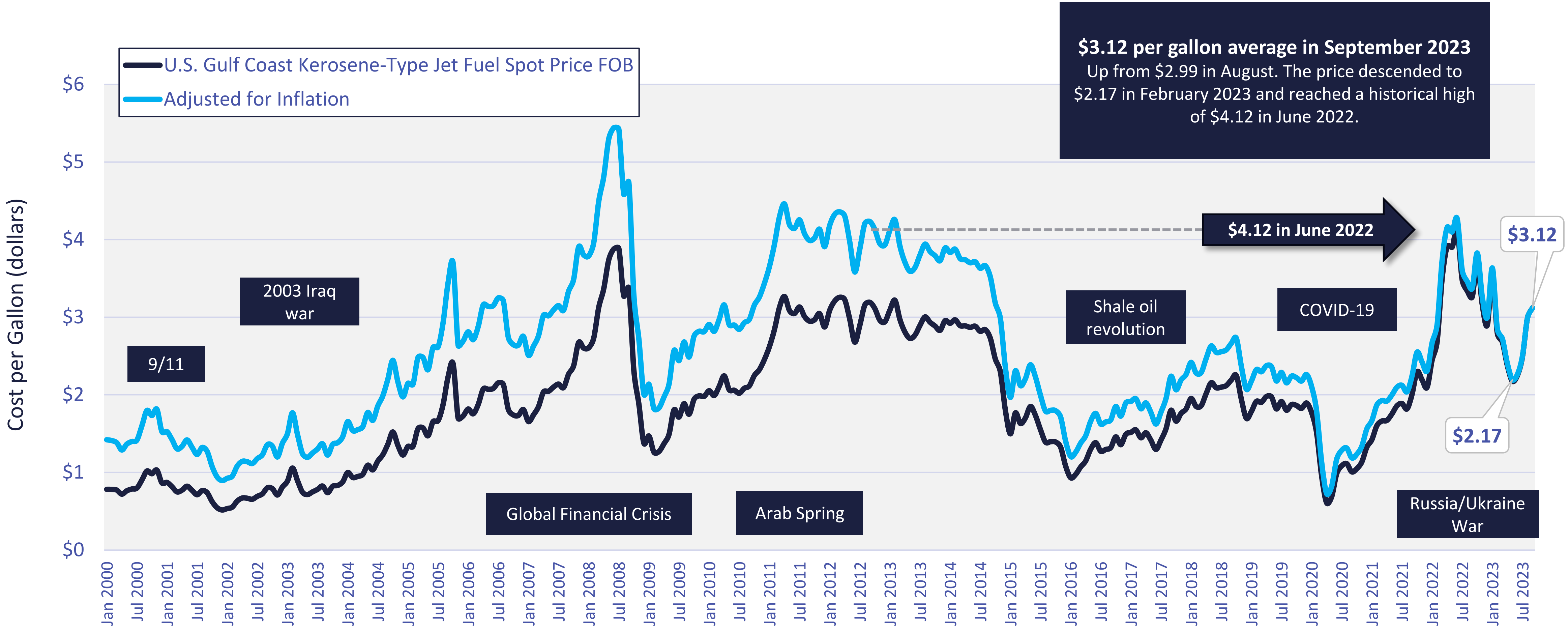


Jul-Sep 2023 vs. Same period of 2019	
Narrowbody	+8%
Widebody	-7%
Regional Jet	-23%
Turboprop	+6%

Source: Aviation Week Intelligence Network, Flight Tracking Data, Copyright 2023

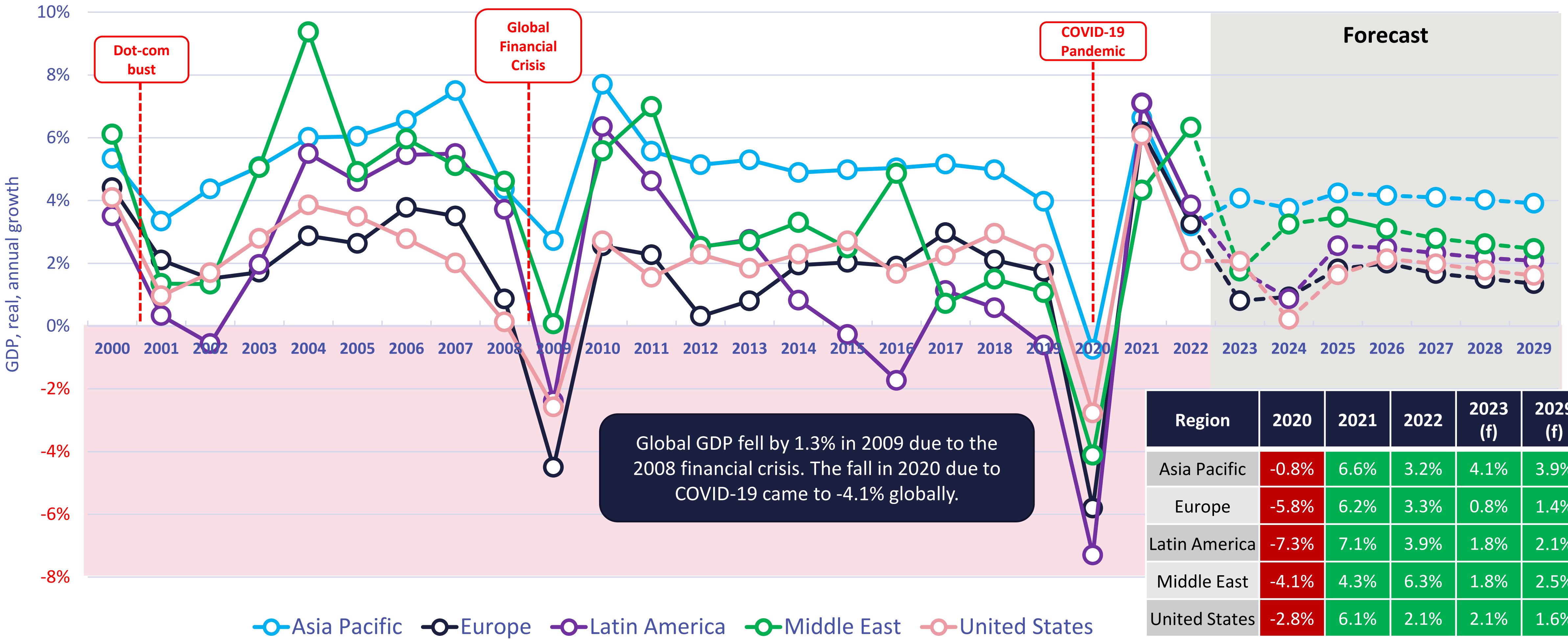
Jet Fuel Price and Inflation Adjusted

U.S. CPI-adjusted in latest month's price



Source: US EIA, U.S. Gulf Coast Kerosene-Type Jet Fuel Spot Price FOB and U.S. Bureau of Labor Statistics CPI Index.
Note: Prices adjusted for inflation. Today's dollar value – all monthly prices are monthly averages adjusted for inflation using U.S. CPI data.

Foreword: GDP, Recent Economic Shocks & Forecast



Region	2020	2021	2022	2023 (f)	2029 (f)
Asia Pacific	-0.8%	6.6%	3.2%	4.1%	3.9%
Europe	-5.8%	6.2%	3.3%	0.8%	1.4%
Latin America	-7.3%	7.1%	3.9%	1.8%	2.1%
Middle East	-4.1%	4.3%	6.3%	1.8%	2.5%
United States	-2.8%	6.1%	2.1%	2.1%	1.6%

Source: Oxford Economics Ltd
(20 September 2023 update)

What's New This Year?
Product Changes

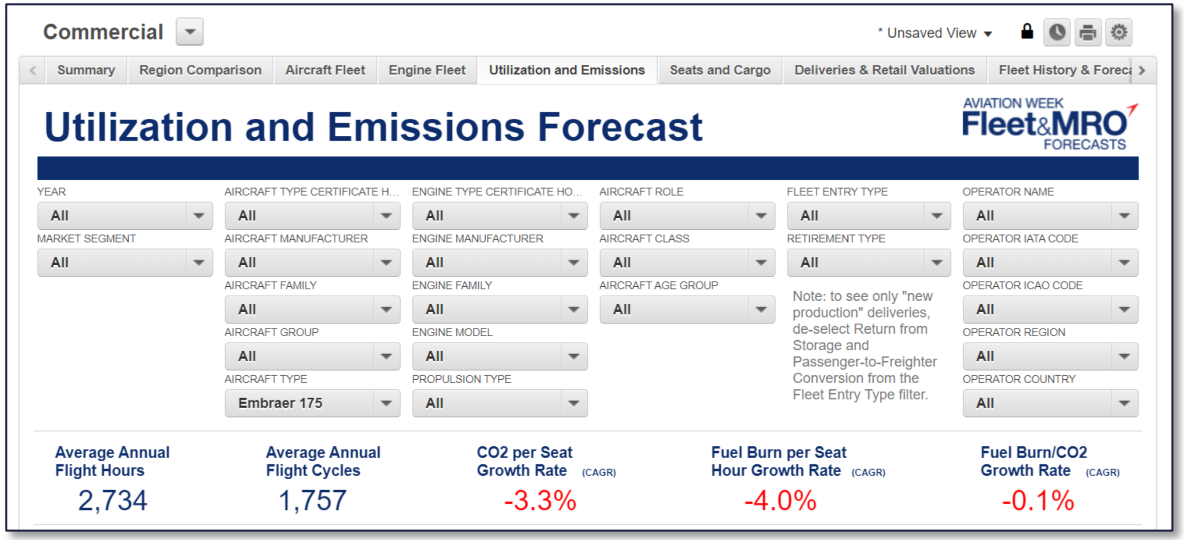
What’s New This Year?

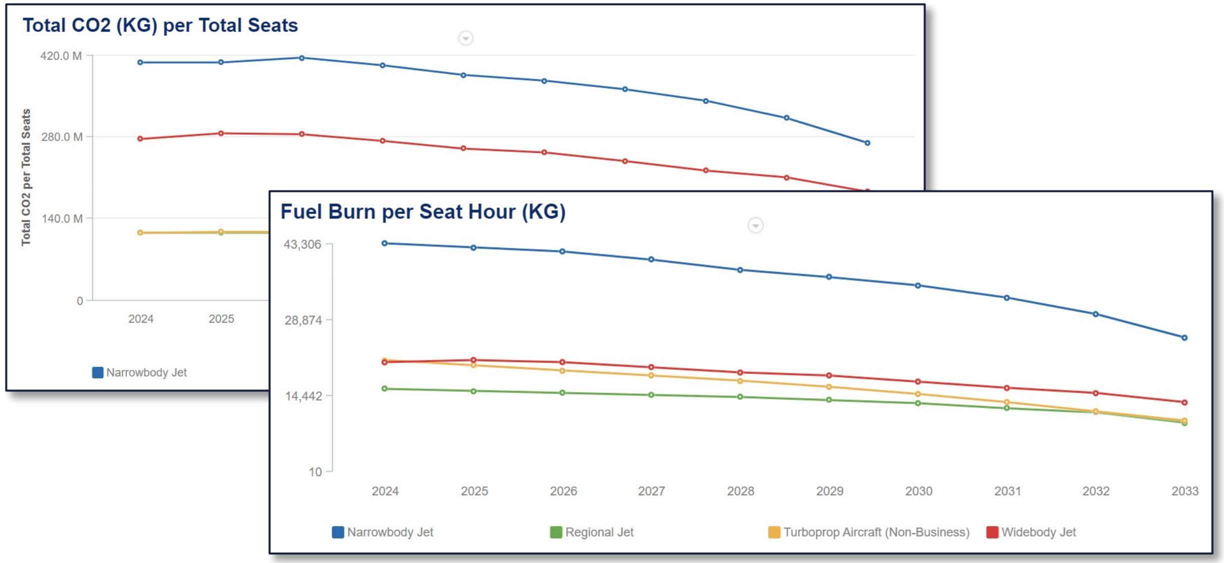
Emissions and Fuel Consumption Projections

New this year, projected emissions and fuel consumption are highlighted in the forecast dashboard on a new tab along with various utilization metrics (utilization metrics are otherwise unchanged from last year).

- Emissions are filterable by all the accompanying filter fields at the top of the tab.
- Fuel consumption (fuel burn) are filterable by all the accompanying filter fields at the top of the tab.
- Various headline reports and charts are provided to assist the user in visualizing the information on the tab.

Note: Emission and fuel consumption projections are based on Eurocontrol standard baselines. These baselines are combined with Aviation Week Network proprietary assumptions, calculations, and forecasts to provide an estimate of future values. In all cases, nominal values are used for number of seats per aircraft, fuel burn, hourly utilization, and CO_2 emissions. For example, all 737 Max or A320 aircraft receive a nominal seating configuration, nominal fuel burn, and nominal CO_2 emissions figure regardless of the actual operator’s seating configuration or flight operational parameters.





What's New This Year?

Engine "Hospital Visits" Filter

Location: **MRO Demand Module**
Expense category: **Engine Maintenance**
Added filter: **ATA 72 Engine OEM Tech Upgrade**

ATA 72 Engine OEM Tech Upgrade projects events and MRO demand for retroactive corrective actions forecasted to take place in future years 2024/25 for the CFM LEAP and PW1000G (GTF) engines. This expense type reflects unscheduled warranty repair maintenance.

The results are a count estimate of issues, per engine, accounted for separately. Actual, physical engine "shop visits" will likely combine multiple issues/*events* at a single shop visit. For instance, a hypothetical PW1000 engine may receive maintenance for: HPT blades, combustion chamber, LLPs, and a performance restoration, all at one visit. The forecast output does not project which will be combined.

To remove hospital visits from results, de-select the Expense Type at:
MRO Demand tab> MRO Expense Type = "ATA 72 OEM Tech Upgrade"

Engine Expense Types

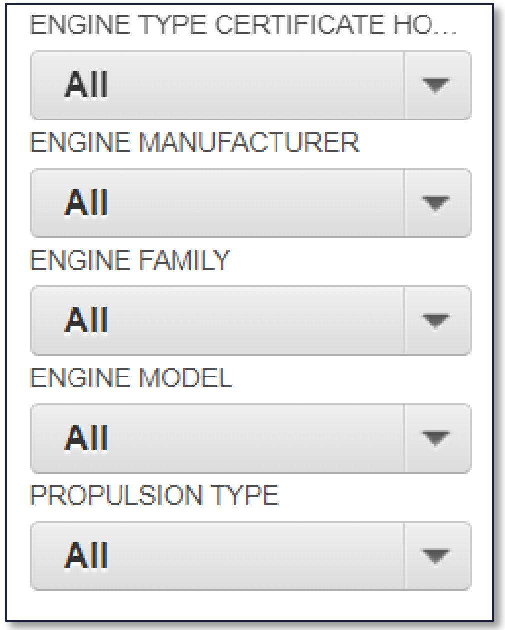
- [x] ATA 72 Engine LLP
- [x] ATA 72 Engine OEM Tech Upgrade
- [x] ATA 72 Engine Overhaul Event
- [x] ATA 72T Engine LLP
- [x] ATA 72T Engine Overhaul Event

Hospital visits forecasted:
- GTF - HPT #1 and #2
- GTF - combustion/heat exchanger
- LEAP - fuel nozzle upgrade

What’s New This Year?

Added Engine Type Certificate Holder (TCH)

- The engine (TCH) is the current owner of the relevant certification authority’s Type Certificate or loosely speaking the brand. Similar to an aircraft Type Certificate, the owner holds the legal rights to the design and is held responsible for its upkeep.
- A type certificate is issued by the authorities of a nation state mandating the airworthiness standard for the aircraft type, model, engine or propeller. Thus, the technology, engineering designs, intellectual property is held by this entity.
- The impact is that the TCH may license the technical manuals, technical software, as well as procedures to establish airworthiness standards for maintenance, i.e. maintenance intervals, tooling, technics, etc.



Aircraft scope changes from last year – Aircraft removed from the delivery forecast

- Boeing 777-8
- Embraer 175-E2
- Sukhoi Superjet
- Irkut MC21

Market Outlook

Market Outlook

Jens Flottau, Executive Editor, Commercial Aviation, Aviation Week Network

When airlines were looking ahead to what 2023 could be like, the big theme was that it would be the first normal year, not affected by Covid lockdowns are fleet groundings. While there were no lockdowns keeping people from traveling, 2023 again turned out far from being routine and the fall-out of events is going to affect airlines and OEMs for at least some years: Supply chain constraints continue to hold back production ramp-up and necessary engine repairs traced back to production flaws will have a serious impact on at least the Airbus A320neo family through 2026. Managing the unexpected therefore continues to be a key skill needed for senior executives in the industry.

Nonetheless, the latest edition of the Aviation Week Network forecast for commercial aviation sees the industry continuing on its growth path. Over the next ten years, the commercial aircraft fleet is going to see a compound annual growth rate (CAGR) of 3.3%. 22,120 new aircraft are going to be delivered in the 2024-2033 period and as 11,600 are going to be retired (with some of them going into passenger to freighter conversion and therefore staying), the fleet will grow by 12,500 units. For perspective: Aviation Week Network projects an active commercial aircraft fleet of more than 32,000 by the end of this year. Interestingly, this is up from 25,000 at the lowest point of the Covid pandemic in 2020.

For the first time, Aviation Week Network is also publishing its own forecast on emissions. According to the projections and based on current policy frameworks and technology evolution, emissions from aviation will continue to grow through the early 2030s. While there are efficiency improvements mainly through the use of new engines and more efficient (widebody) aircraft, these are overcompensated by the fast growth of the sector, exposing it to increased criticism and potentially more political action around its environmental performance.

Jens Flottau

The forecast predicts a 4.5% annual increase in total CO2 emissions, higher than the predicted fleet growth. While that may seem counterintuitive given that older aircraft are replaced by new ones, there are concrete reasons for it: airlines continue to upgauge their average aircraft size and these larger aircraft burn more fuel per trip. Also, utilization is expected to go up. In spite of the issues affecting mainly the Pratt & Whitney powered part of the narrowbody fleet, over time the aircraft delivered now are going to be used more than those they are replacing, partly as narrowbodies such as the A321XLR will be flying new long-haul routes too thin for widebodies.

The upgauging does have a positive effect on per seat CO2 emissions, which will decline by 6.3% annually. It is also shown in the predictions for seat availability: airlines will grow capacity as measured in seats by 4.7% annually, almost 1.5 times as fast as their fleet growth in aircraft units.

The numbers also reflect Airbus' success in the narrowbody market, which Aviation Week Network expects to continue in the next ten years. The Airbus A320 fleet will outnumber the Boeing 737 by more than 1,500 aircraft by 2023. And there are still substantial risks on the Boeing side, particularly for the certification timeline of the 737-7 and -10.

Already for many years a marked shift favoring narrowbodies could be observed: low-cost carriers have been growing faster than their legacy peers – their fleets are typically made up of single-aisle aircraft and slowly but surely more narrowbodies are being deployed into markets previously exclusive to widebodies as a function of their range capabilities. That trend is to continue and accelerate. Airbus plans to deliver the first A321XLR by the middle of next year – it has more than 550 orders for the type alone.

Given the current fleet age and issues such as the PW1100G production quality and durability shortfalls, retirements will stay low for a number of years. But they will pick up in 2027 and 2028. Then more than 3% of the in-service fleet will be retired every year, a historical high.

While the overall story of commercial aviation is about growth, there are sub-sectors that are actually no longer growing. The regional jet fleet is expected to contract by 1.2% annually over the next ten years. Most OEMs have left the market and fleets are beginning to age. Not all of the aircraft are replaced by regional jets, upgauging to narrowbodies is also continuing as low-cost carriers are entering even more markets that would have been the domain of regional airlines in the past and hub feeding is also transitioning to larger aircraft. For the time being, Embraer remains the only regional jet manufacturer.

The trend is even more distinct in the turboprop field where the in-service fleet will shrink by 3.3% annually. ATR will dominate the market. There are a number of new entrants lined up using hybrid-electric or hydrogen propulsion but their market shares will still be small during the forecast period.

Airbus

A220

Supply chain constraints continue to slow down production growth of the A220 but Airbus sticks to its target of reaching a rate of 14 aircraft per month by the middle of the decade, a forecast that leaves it with some flexibility on timing. The aircraft's future will largely be determined by if and when Airbus decides to stretch it further and develops the A220-500 (or A221 or A220 Stretch). That version would get into the 170-180 seat category and compete with the 737-8 and, in-house, with the A320neo. Some design requirements such as range are still being discussed with operators. Most observers expect Airbus to launch the variant by the time of the 2025 Paris Air Show with service entry by the end of the decade.

A320neo family

Airbus' main challenge is to build as many aircraft as customers want on time – a target it currently misses on essentially every single delivery. The supply chain is responsible for part of the problem, but Airbus also has internal issues to fix. Also, it has to produce more of the complex A321neos than of the relatively simple A320neos increasing the workload per aircraft significantly. The A321XLR will start to be delivered by the middle of 2024 helping the family to grow into thing long-haul markets where it could replace the Boeing 757 and enter new routes. Airbus is still working on limiting the range impact of new European Union Aviation Safety Agency (EASA) requirements for rear center fuel tank fire insulation that are adding weight.

A330neo

The A330neo is still at relatively low levels of production with three aircraft built per month. Airbus plans to raise output to four aircraft per month by 2024, but that is still far away from the historic highs of the A330 in the mid-2010s when Airbus built around ten per month. Those times are unlikely to return, even though significant orders from Condor, ITA Airways and Avolon have improved the outlook. There are now 210 A330-900s yet to be delivered, but just five of the smaller -800.

A350

Airbus continues to work on a fast return to higher production numbers on the A350 program. The OEM plans to deliver nine aircraft per month at some point in 2025, a 50% increase of the current rate. Airbus will deliver the first of 50 -900s to Emirates in 2024, there has also been a large order from Air India for the -1000, of which 148 have yet to be delivered. Airbus is also continuing development of the A350 freighter for which it has 39 firm orders.

A350-1000

Credit: Nigel Howarth, Aviation Week Network

Boeing

737 MAX

Boeing has won some significant orders for the 737 MAX at Air India, Vietnam Airlines and Ryanair lately. The first two are relevant because Airbus' market position in Asia is particularly dominant. Deliveries of remaining MAX orders to China appear to be resuming soon. Nonetheless, the market share loss vis-à-vis the A320neo is set to continue. Even in a growth market that is an issue because suppliers and customers will want greater discounts at the same time squeezing margins. Bank of America recently published a study urging Boeing to launch a new aircraft for the middle of the market sooner rather than later to contain and ultimately reverse market share trends. Two of the MAX variants, the -7 and the -10, remain uncertified.

777X

Boeing continues to work hard toward certifying the 777X. Airlines are beginning to question whether the timeline, now set for the middle of 2025, will hold. The aircraft is to replace the ageing 747-400 fleet, older 777-200/300ERs and fill the void left by the A380. While the 777-9 appears to be variant of choice for airlines, there are serious questions about the smaller -8. Boeing has confirmed it will prioritize the freighter after the -9 has been put into service.

787

787 deliveries have resumed but the program still incurs serious delays as fuselage rework is being performed on a second final assembly line in Charleston temporarily. Production ramp-up can only follow once the rework, also partly performed in Everett, is completed.

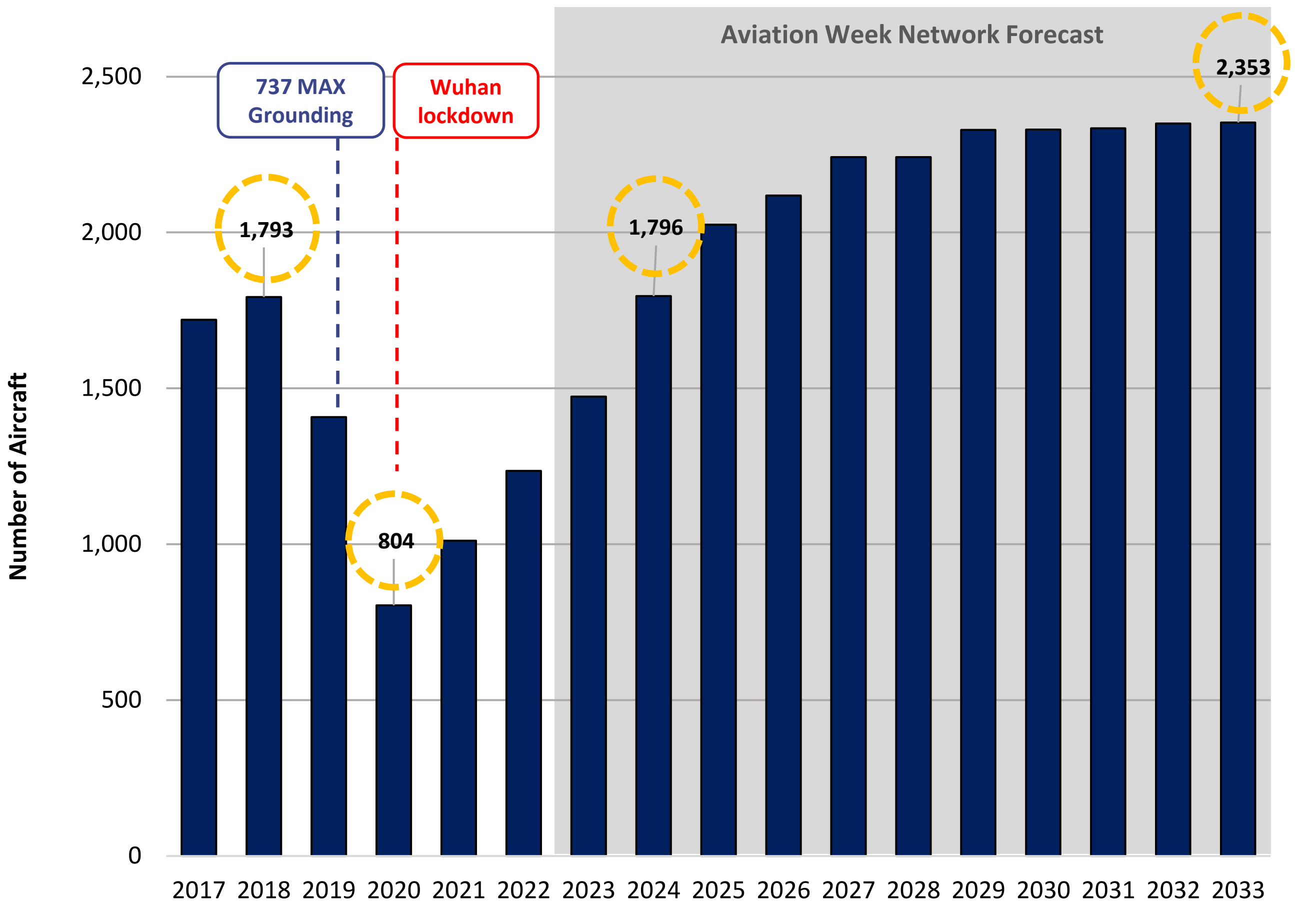
Credit: Nigel Howarth, Aviation Week Network

Credit: Nigel Howarth, Aviation Week Network

Fleet Forecast & Trends

Historical & Forecast Commercial Deliveries

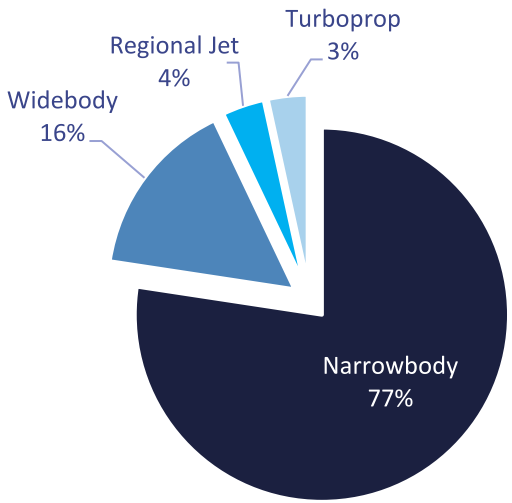
Annual new deliveries, historical & forecasted



Highlights

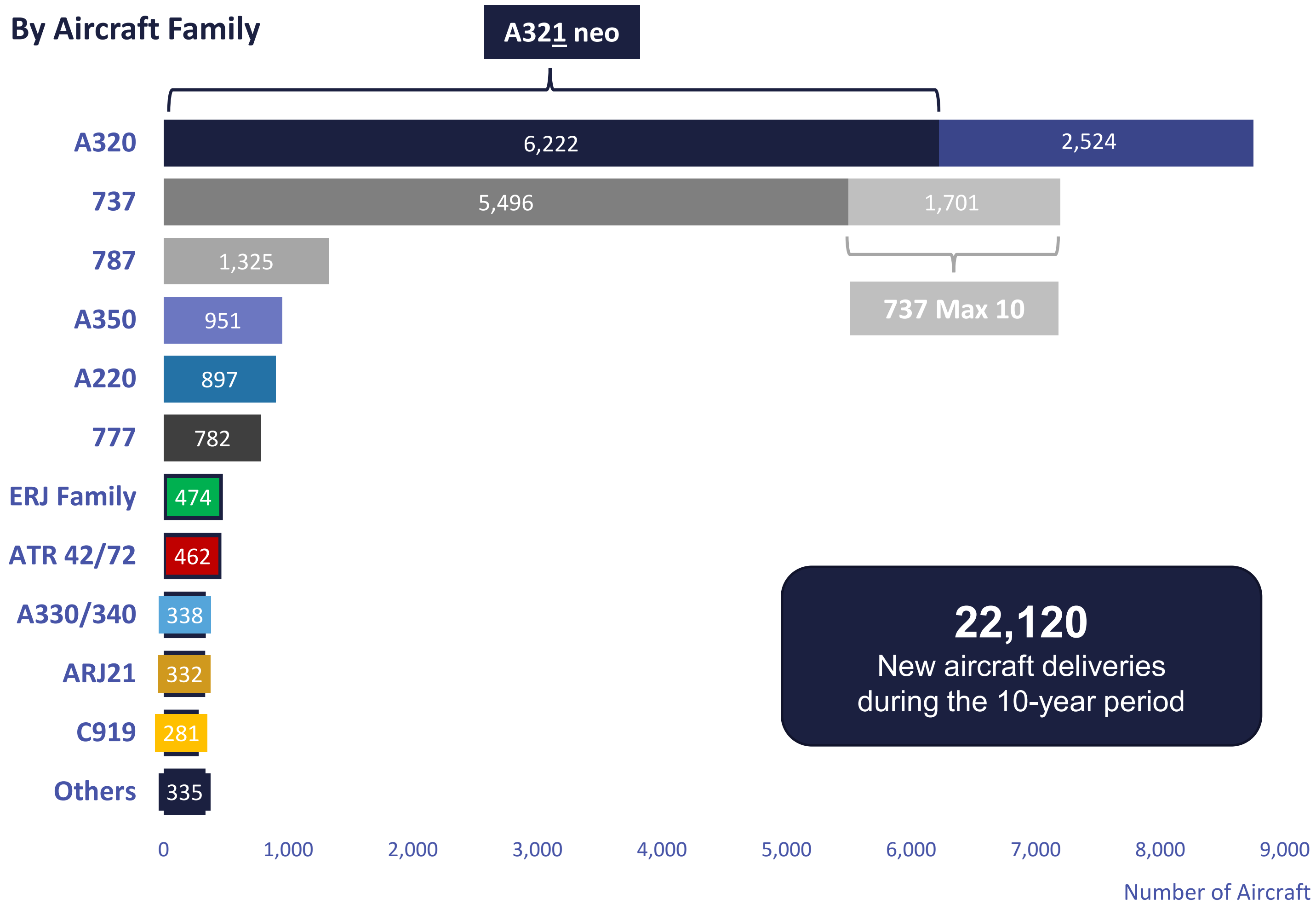
- 22,120 new deliveries over 10-year 2024-33 forecast period.
- Over 2,000 annual deliveries from 2025 onwards.
- Narrowbodies lead all size categories - Airbus A320 outpaces Boeing 737.
- Narrowbody share is 78% vs. 16% share for widebodies.
- Russian origin types removed from forecast – see scope.
- New model freighters added to forecast: A350F, 777-8F, ARJ21F.

2024-33 Share of Deliveries



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

New Build Aircraft Deliveries by Family 2024-33



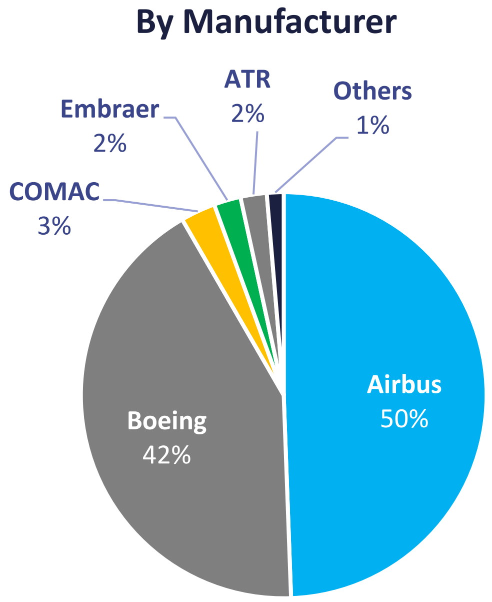
22,120
New aircraft deliveries during the 10-year period

The A320 and 737 will accelerate their domination of the delivery market. Of the 22,120 aircraft that are expected to be delivered between 2024 and 2033, 72% (15,943 units) will be these two aircraft families. Deliveries of the A320 will outpace those of the 737 with the A321 comprising 20% (+6,200) of deliveries alone.

In the twin aisle market segment, the 787 and A350 are the most popular. These two account for 39% and 28% of new build widebody deliveries, respectively. Meanwhile, the 777 represents 23% of new build aircraft deliveries in that segment.

Deliveries of 10,932 new Airbus aircraft are expected over the forecast, accounting for half of the total. Boeing is expected to deliver 9,343 aircraft, representing a 42% share of total deliveries.

The two largest manufacturers therefore account for 92% of aircraft deliveries over the forecast period – two percentage points above last year's forecast.

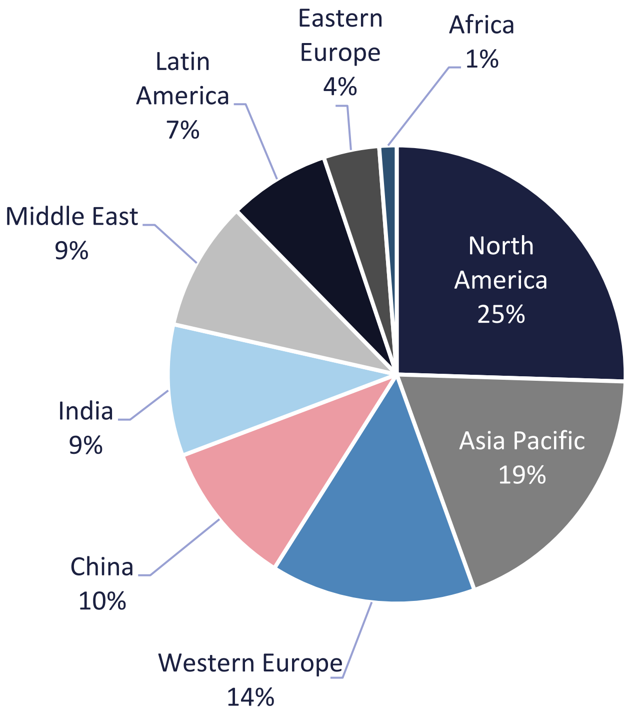


Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

New Aircraft Deliveries by Region 2024-33

Region	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2024-33
North America	473	515	578	515	516	533	656	605	619	628	**5,638**
Asia Pacific	277	345	402	440	446	440	446	475	462	470	**4,203**
Western Europe	242	244	313	373	377	384	304	318	325	324	**3,204**
China	290	264	227	231	227	207	203	205	212	207	**2,273**
India	120	161	174	175	201	185	231	265	274	265	**2,051**
Middle East	137	208	206	193	192	237	234	211	204	201	**2,023**
Latin America	130	191	145	183	148	193	150	153	147	146	**1,586**
Eastern Europe	95	66	42	98	104	123	84	82	86	91	**871**
Africa	32	31	32	34	31	27	22	20	21	21	**271**
TOTAL	**1,796**	**2,025**	**2,119**	**2,242**	**2,242**	**2,329**	**2,330**	**2,334**	**2,350**	**2,353**	**22,120**

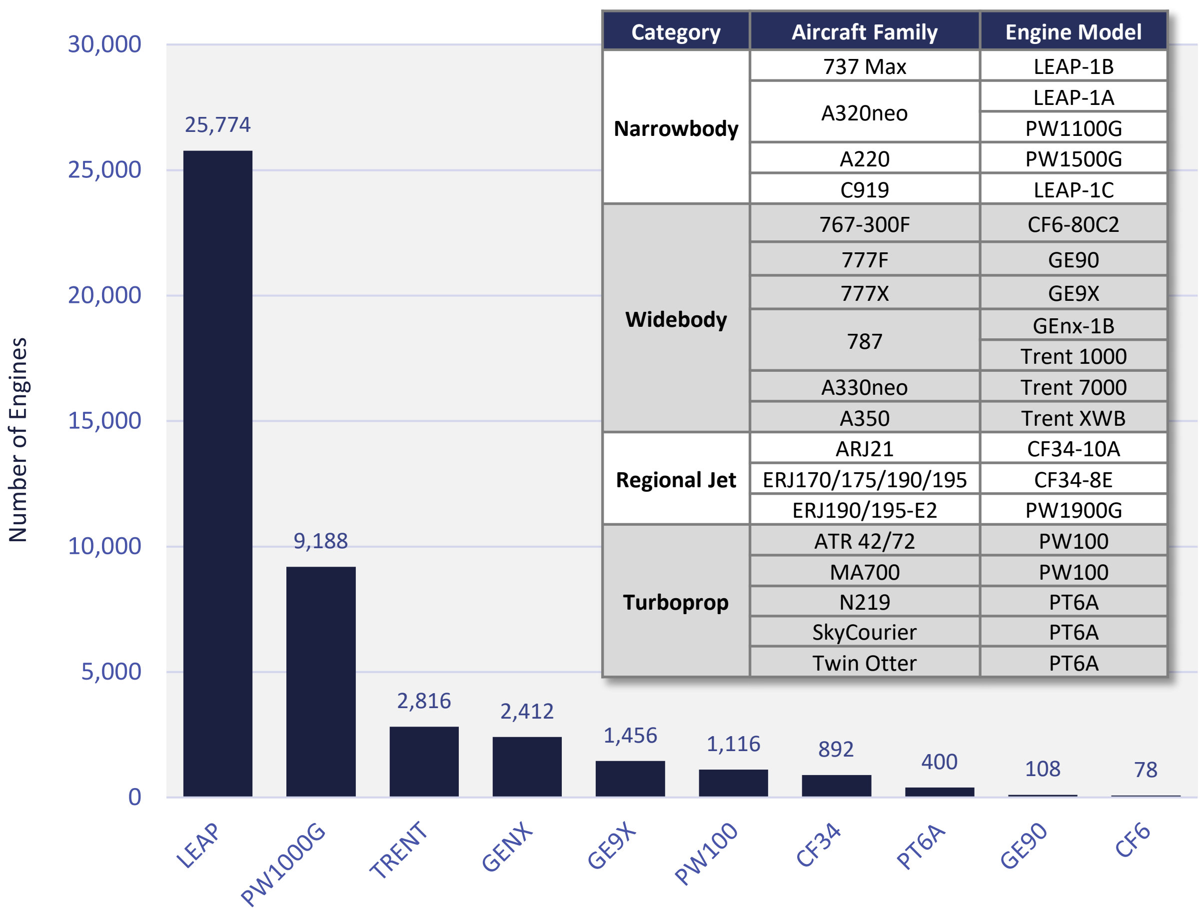
2024-33 Deliveries



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

New Build Engine Deliveries Equipping the Fleet

By Engine Family



Category	Aircraft Family	Engine Model
Narrowbody	737 Max	LEAP-1B
	A320neo	LEAP-1A
		PW1100G
	A220	PW1500G
	C919	LEAP-1C
Widebody	767-300F	CF6-80C2
	777F	GE90
	777X	GE9X
	787	GEnx-1B
		Trent 1000
	A330neo	Trent 7000
	A350	Trent XWB
Regional Jet	ARJ21	CF34-10A
	ERJ170/175/190/195	CF34-8E
	ERJ190/195-E2	PW1900G
Turboprop	ATR 42/72	PW100
	MA700	PW100
	N219	PT6A
	SkyCourier	PT6A
	Twin Otter	PT6A

Driven by the expected growth in the global single aisle fleet, the CFM LEAP and Pratt & Whitney PW1000G will see the highest volume of deliveries. The LEAP alone is projected to account for 25,774 engines between 2024 and 2033, equating to more than half of the 44,240 engines expected to be produced over the decade. Although production of the ubiquitous CFM56 concluded in 2022, its aftermarket impacts will be felt well beyond the scope of this forecast.

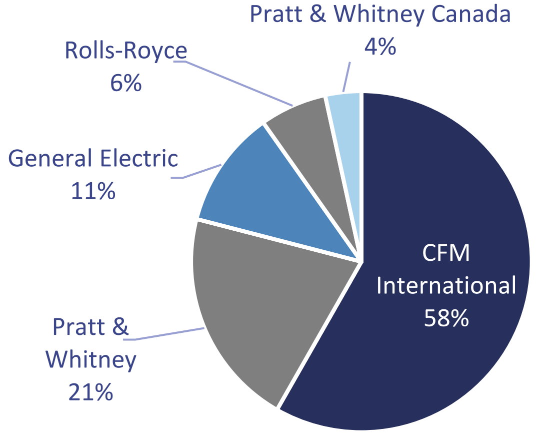
The expansion of the 787 and A350 fleets will drive deliveries of 2,816 TRENT engines and 2,412 GENX engines in the forecast. 68% of all TRENT deliveries will be of the XWB model which powers the A350.

As a result of the success of the LEAP series, CFM international engines will account for 58% of all delivered.

Pratt & Whitney account for a further 21%, General Electric 11%, and Rolls- Royce 6%.

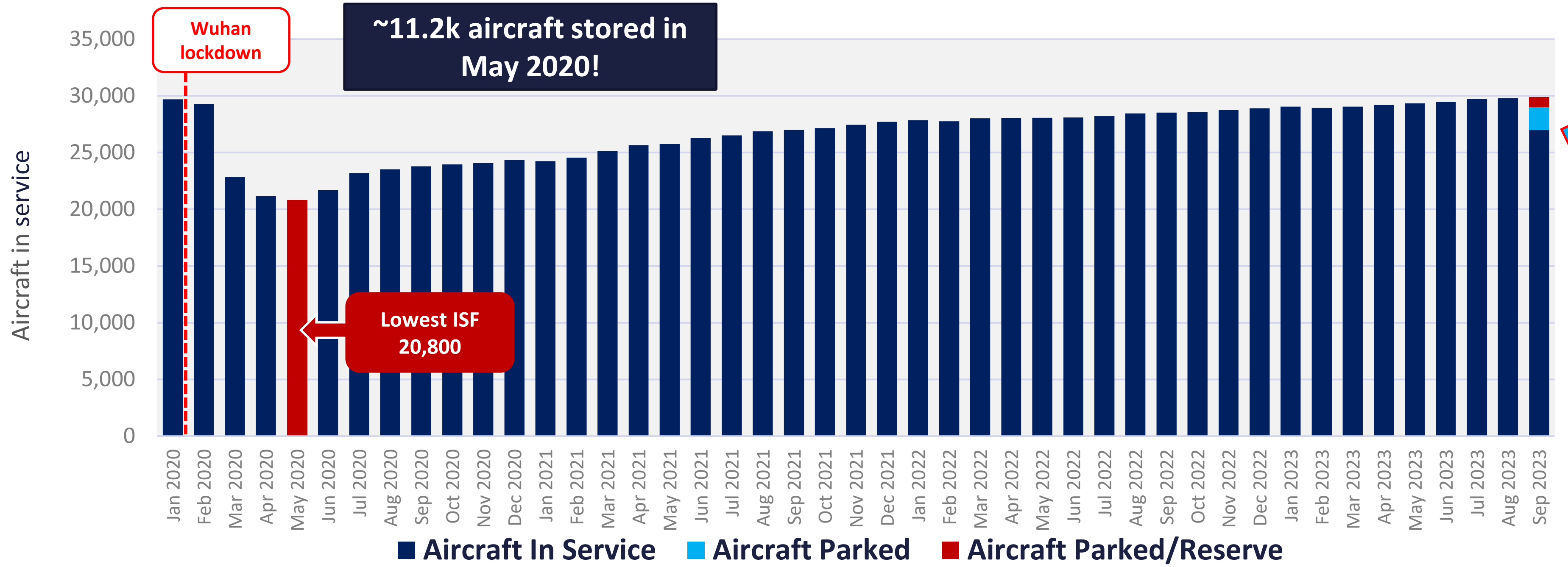
Deliveries of the PW100 and PT6A turboprop engines account for Pratt & Whitney Canada's remaining share.

By Manufacturer



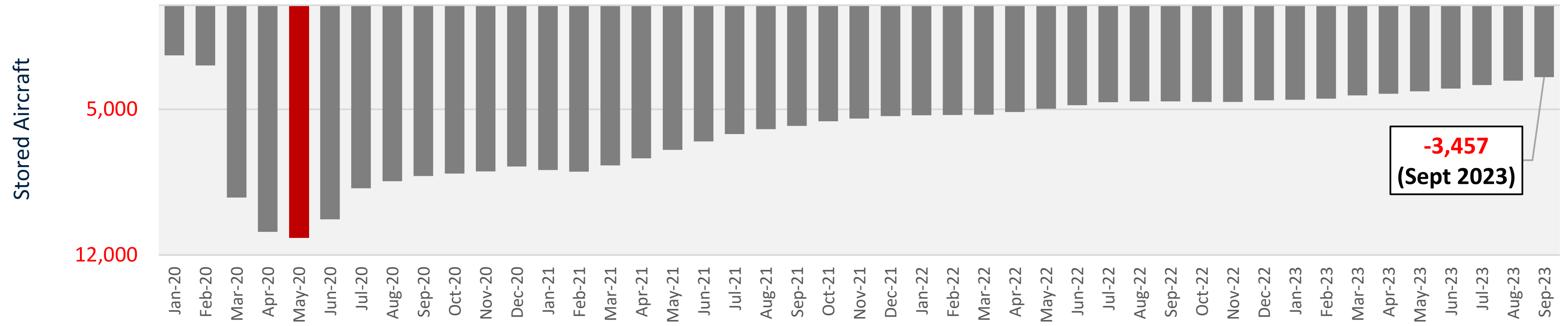
Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Historic Trends in Storage & Global In-Service Fleet



10% of the global fleet temporarily parked or under-utilized, Sep 2023

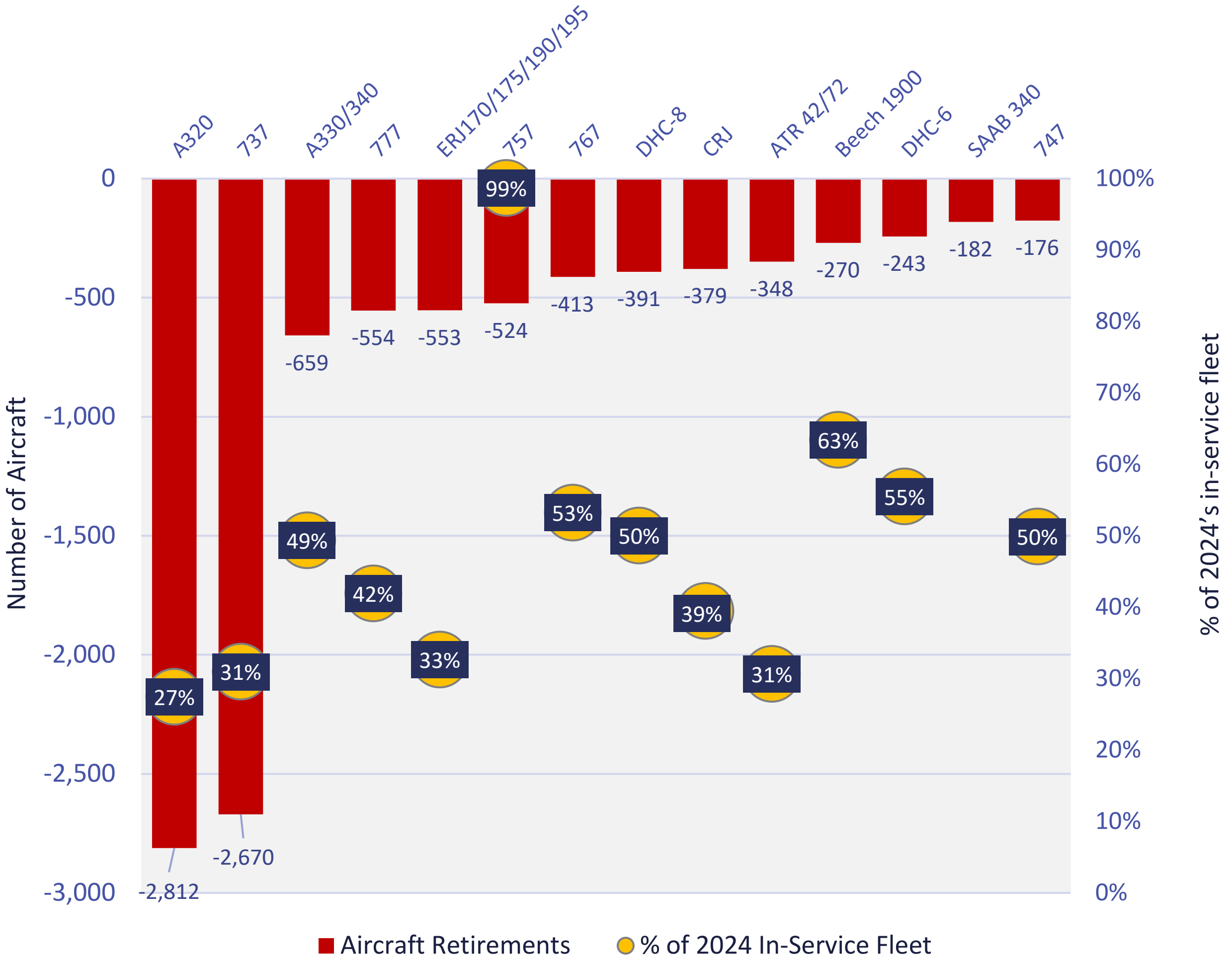
Parked Aircraft During Pandemic



~3.5k stored September 2023

Source: Fleet Discovery, Aviation Week Intelligence Network, Copyright 2023.

Aircraft Retirements 10-Year & Share of Fleet

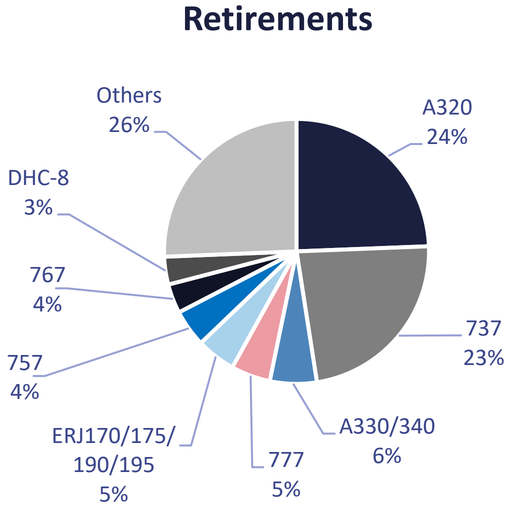


The scale of the in-service fleets of both the A320 and 737 will drive the highest number of retirements over the decade. A useful measure is comparing to the active, remaining fleet. Despite the large number of both of these aircraft families leaving passenger service, the number of retirements in relation to the share of the active fleet as of 2024 is relatively low at 31% for the 737 and 27% for the A320.

By comparison, the number of retirements in relation to the 2024 in-service fleet for the 757 stand at 99%. The Beech 1900 and 767 are at 63% and 53% respectively, as these aircraft are gradually withdrawn over the course of the forecast.

Meanwhile, 176 747s will leave service to be retired out of a fleet of 353 aircraft in 2024.

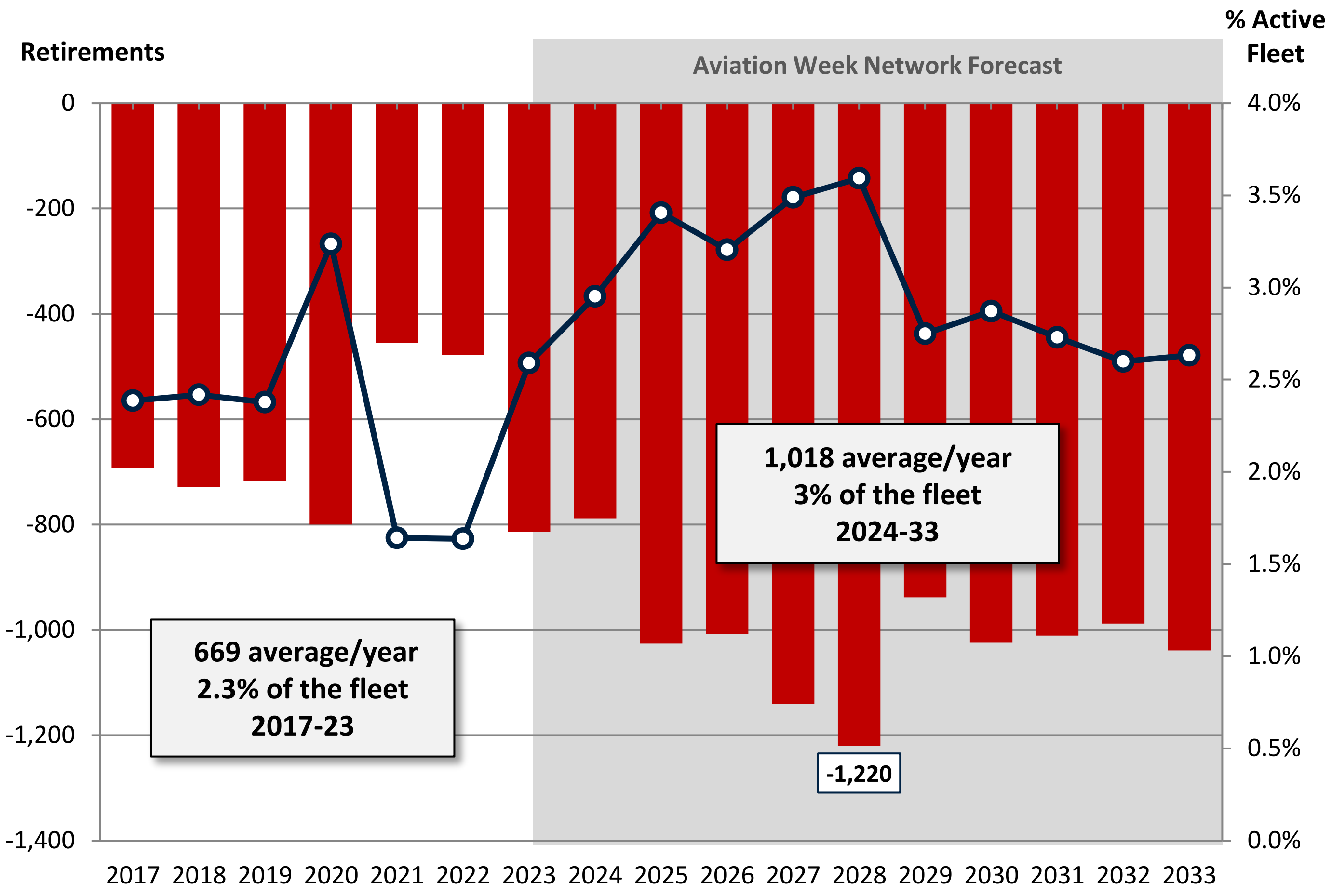
Within the retirement total, over 1,300 commercial aircraft are expected to be converted to freighter configurations over the 10-year forecast period – a steep increase in comparison to recent forecasts. Conversions are primarily for 737s, A320s, 767s and A330s. These are delineated as "fleet exits" and "fleet entries" in the online dashboard tool.



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: "Retired" aircraft removals for passenger-to-freighter (PTF) conversions.

Forecast: Trends in Aircraft Retirements

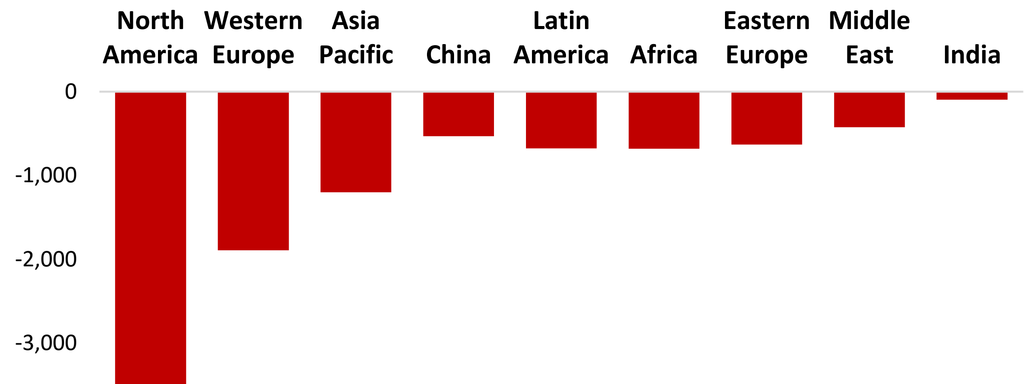
Annual retirements historical & forecasted, % of in-service fleet



Highlights

- ~10,200 retirements over 10-year forecast period.
- ~1,300 PTF conversions extra (not included in adjacent figures).
- Retirement projections peak at 1,220 in year 2028.
- Used spare parts/green time engines may flood markets for popular legacy types depressing pricing.

Regional Retirements 2024-33

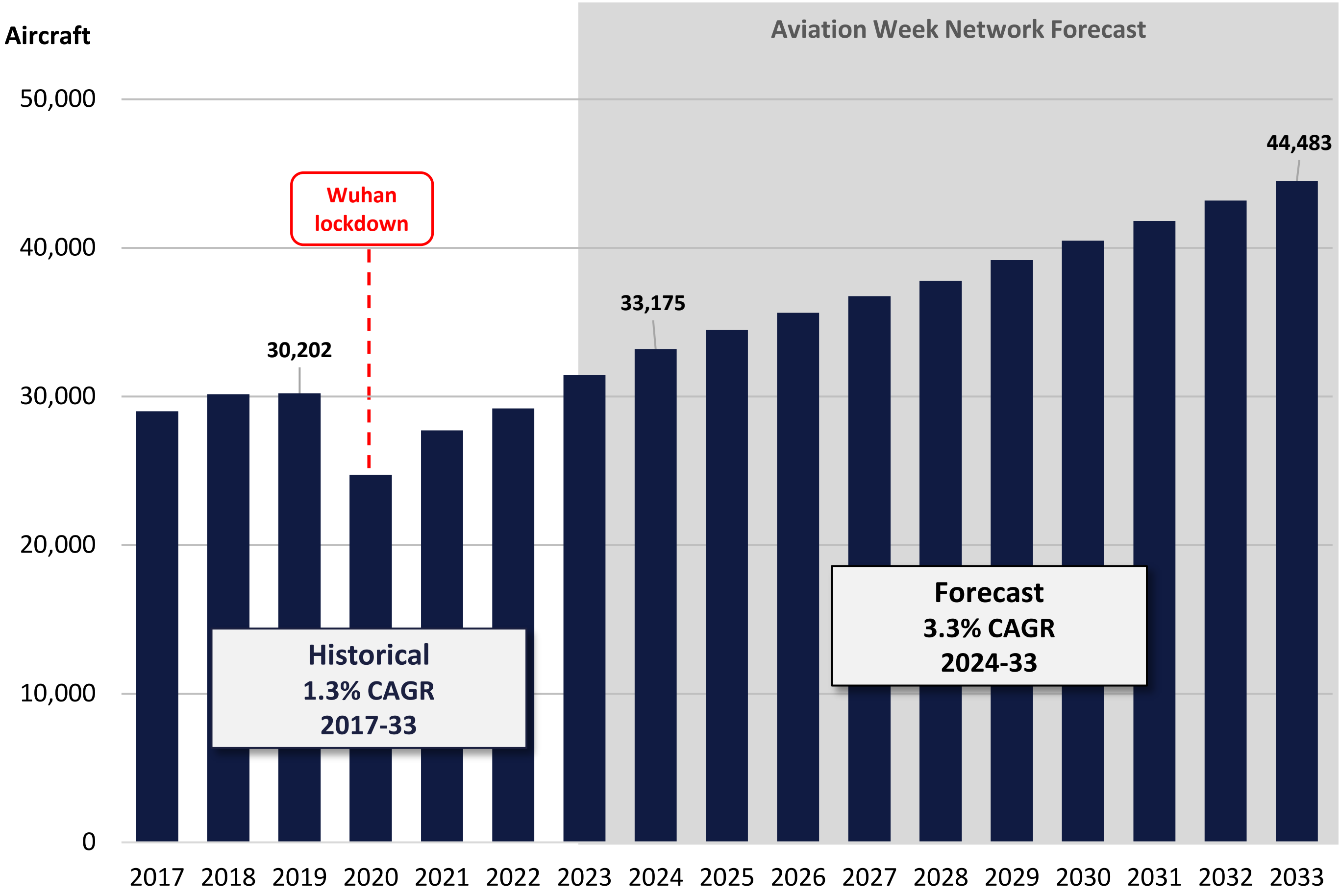


Credit: Nigel Howarth, Aviation Week Network

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Forecast In-Service Commercial Aircraft Fleet

Annual count of active commercial aircraft, historical & forecasted



Highlights

- 3.3% future CAGR expected for the 2024-33 period.
- In-service fleet in 2023 exceeds 2019 levels.
- Narrowbodies are key growth driver over decade.

A321neo

Active fleet increases from 33,175 in 2024 to 44,483 in 2033

34% increase in active fleet strength

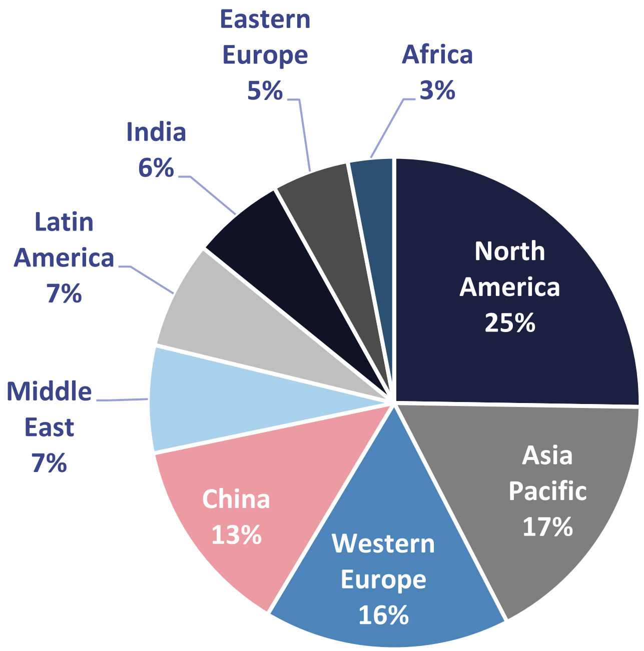
~20% of the fleet is the A321 alone at end of 2033

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Forecast Aircraft In-Service Fleet by Region

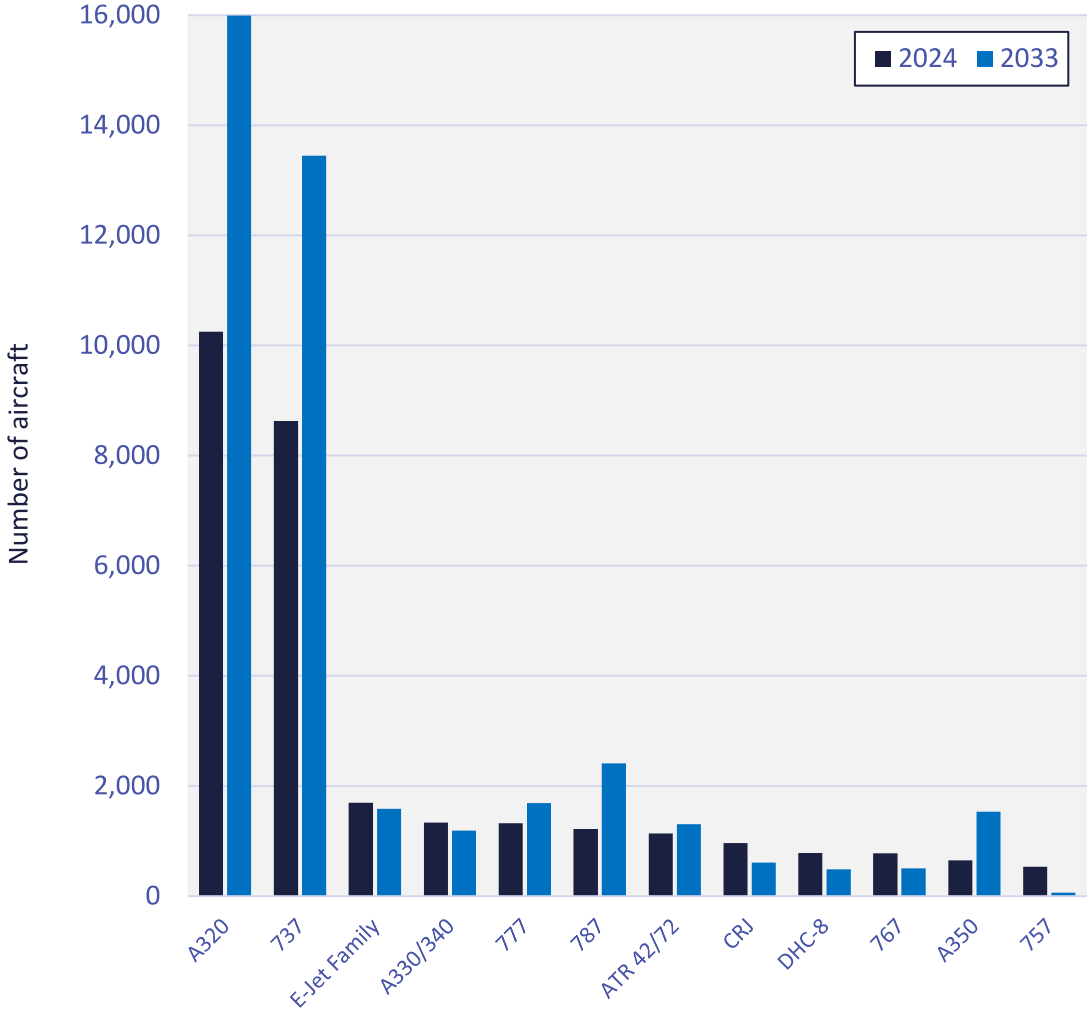
Region	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2024 % Share	2033 % Share	% Change	CAGR
North America	9,483	9,535	9,676	9,670	9,594	9,759	10,085	10,408	10,827	11,237	29%	25%	18%	1.9%
Asia Pacific	4,912	5,211	5,528	5,850	6,164	6,474	6,749	7,042	7,322	7,646	15%	17%	56%	5.0%
Western Europe	6,068	6,179	6,311	6,502	6,697	6,935	7,054	7,178	7,259	7,310	18%	16%	20%	2.1%
China	4,583	4,835	5,021	5,187	5,357	5,493	5,606	5,727	5,853	5,935	14%	13%	30%	2.9%
Middle East	1,765	1,963	2,121	2,275	2,417	2,619	2,822	2,987	3,152	3,296	5%	7%	87%	7.2%
Latin America	2,250	2,408	2,505	2,630	2,719	2,855	2,912	2,980	3,048	3,131	7%	7%	39%	3.7%
India	920	1,080	1,256	1,435	1,636	1,823	2,044	2,299	2,556	2,795	3%	6%	204%	13.1%
Eastern Europe	1,705	1,766	1,764	1,784	1,812	1,867	1,901	1,927	1,962	2,007	5%	5%	18%	1.8%
Africa	1,485	1,475	1,445	1,405	1,372	1,338	1,301	1,256	1,189	1,125	4%	3%	-24%	-3.0%
TOTAL	33,175	34,456	35,631	36,742	37,772	39,167	40,476	41,806	43,169	44,483			34%	3.3%

2033 In-Service Fleet Share



Note: Four aircraft are unassigned.
Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Forecast In-Service Fleet – Aircraft Family

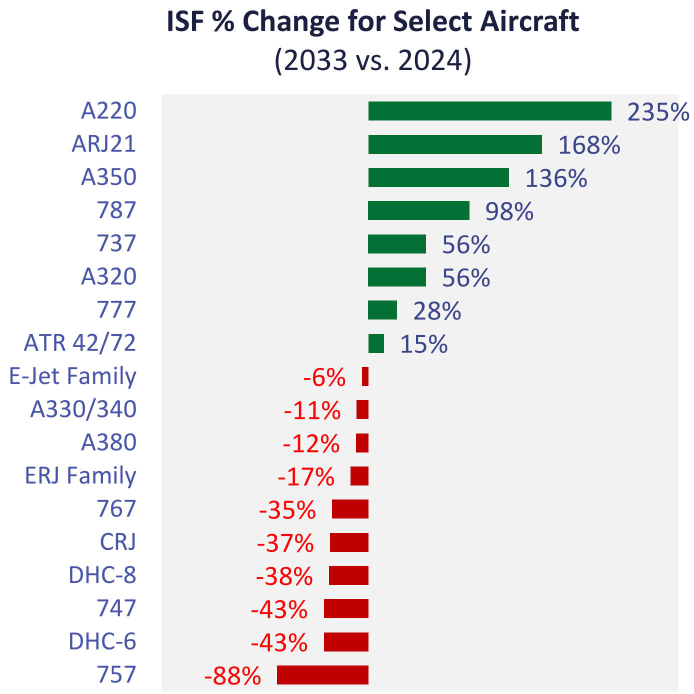


The narrowbody segment is expected to experience the highest growth over the forecast period, expanding by 54%, from 20,081 aircraft in 2024 to 30,991 by 2033. Despite being hit hardest by the pandemic, the widebody fleet is also expected to see growth rising by 28%, from 6,080 aircraft at the beginning of the forecast to 7,764 by the end of the decade. The number of regional turbofan and turboprop aircraft in service is however anticipated to fall by 10% and 26% respectively.

Narrowbodies increase their share of the global in-service fleet from 61% of aircraft in service in 2024 to 70% by 2033. Widebody aircraft see only a marginal shift from 18% to 17%, while regional turbofans decline from 10% to 7% and turboprops from 11% to 6%.

The 2024-33 decade sees in-service numbers of the Airbus A220 and A350, Comac ARJ21 and Boeing 787 expand rapidly. The A220 fleet grows by 235% for the period, from 357 to 1,197 aircraft; The ARJ21 by 168% from 176 to 471; the A350 by 136% from 650 to 1,535; and the 787 by 98% from 1,217 to 2,411 aircraft. Despite their already dominant position within the commercial market, in-service numbers of the A320 and 737 will also increase significantly, both by 56%.

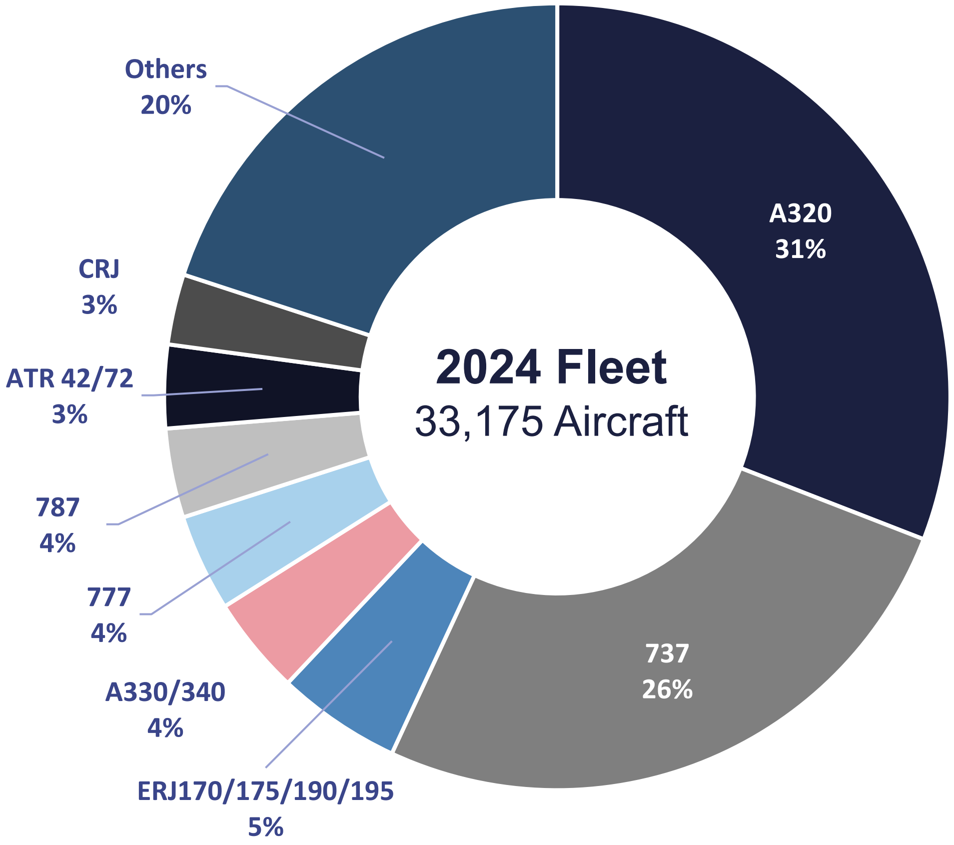
A number of key fleets shrink in size over the decade as new aircraft replace legacy fleets. The 757 declines by 88% to 64 aircraft in service by 2033, the 747 by 43% to 201 aircraft, and the CRJ by 37% to 606 aircraft.

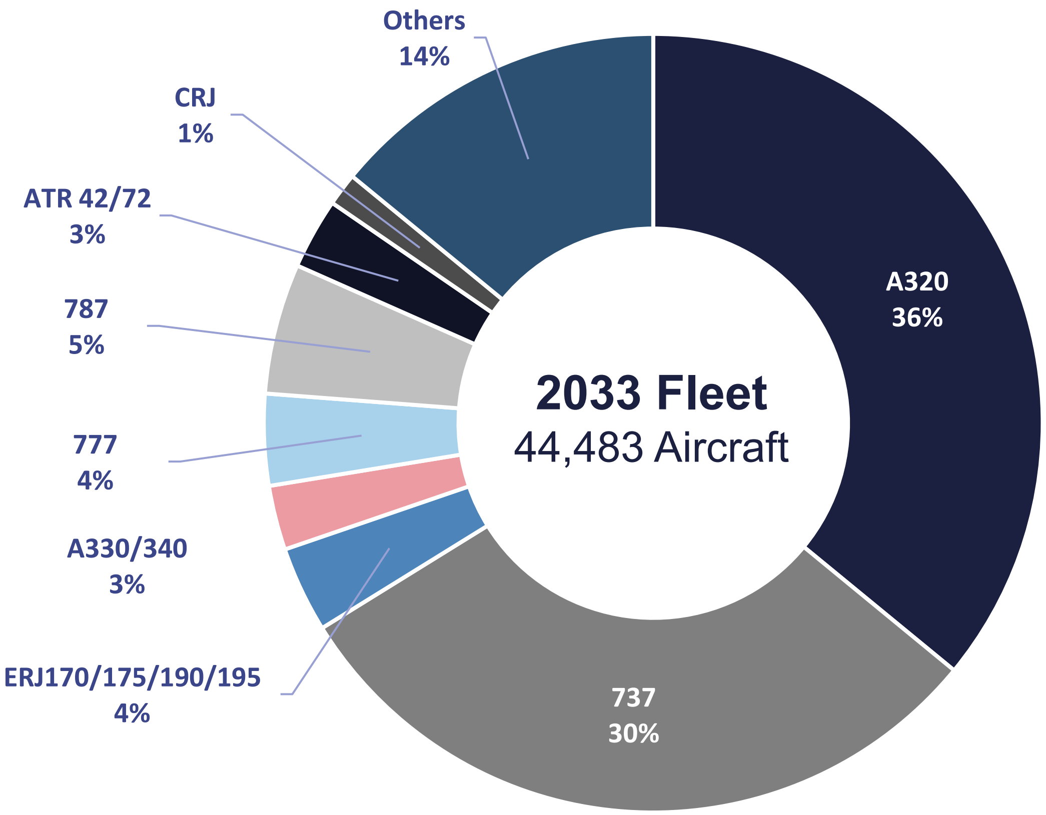


Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

In-Service Fleet Comparison by Aircraft Family

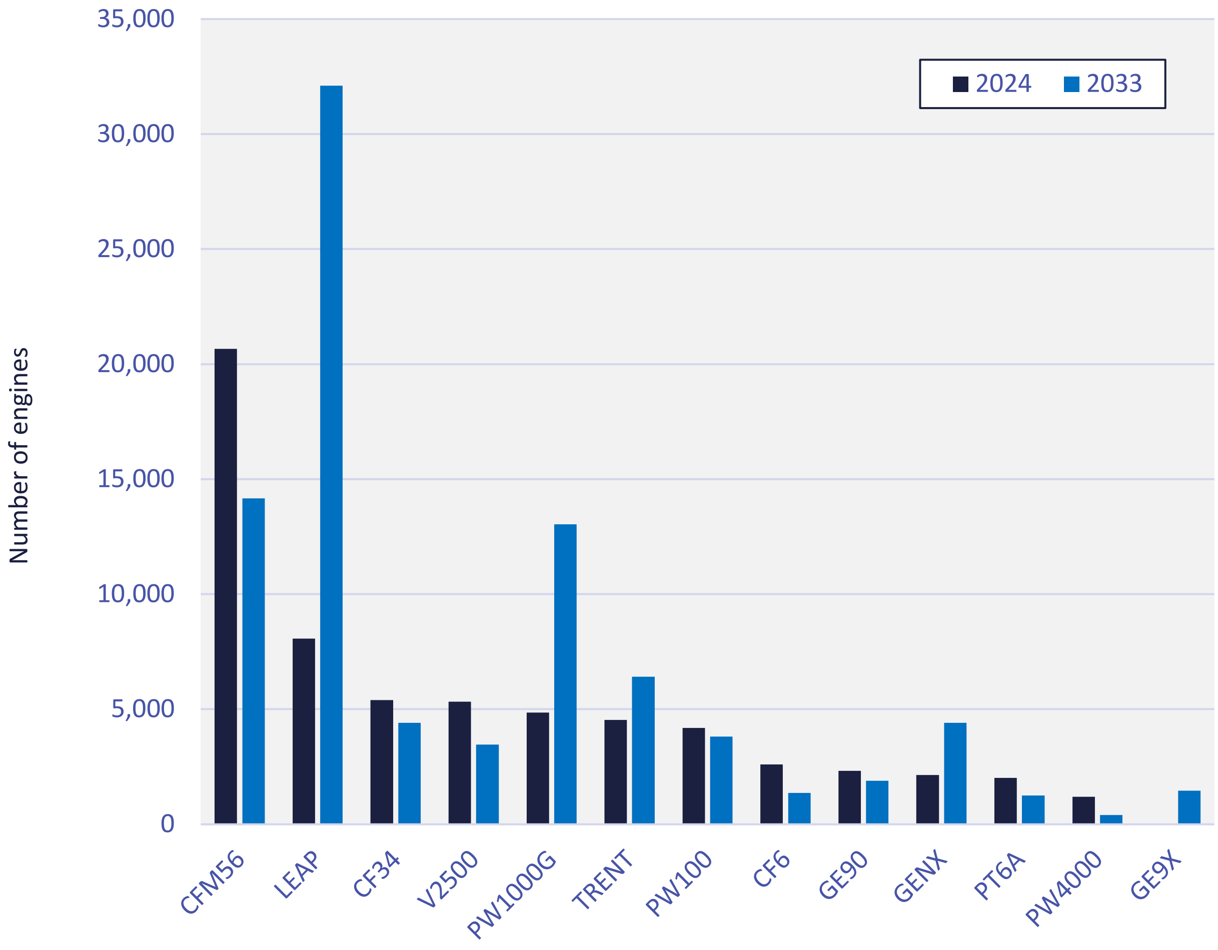
3.3%
CAGR





Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

In-Service Engines - Engine Family



The number of commercial turbofan and turboprop engines in service globally is forecast to increase by 32%, from 67,840 in 2024 to 89,709 by 2033.

At present, the in-service fleet of engines is dominated by the CFM56 family. As of 2024 a total of 20,662 of these engines are in service worldwide, representing almost a third of engines in service on commercial aircraft. While the number of these engines in service will gradually decline through the forecast period as narrowbody fleets transition to aircraft with new generation engines, 14,164 of CFM56s will remain in service in 2033, accounting for 16% of the in-service fleet at that time.

The main beneficiary of the gradual withdrawal of the CFM56 is the LEAP family of engines. The in-service number of the LEAP is projected to increase by nearly 300% over the forecast period, from 8,074 engines in 2024 to 32,104 in 2033. The PW1000G will similarly see numbers of in-service engines increase by 169%, the GENX by 106% and the TRENT family by 41%.

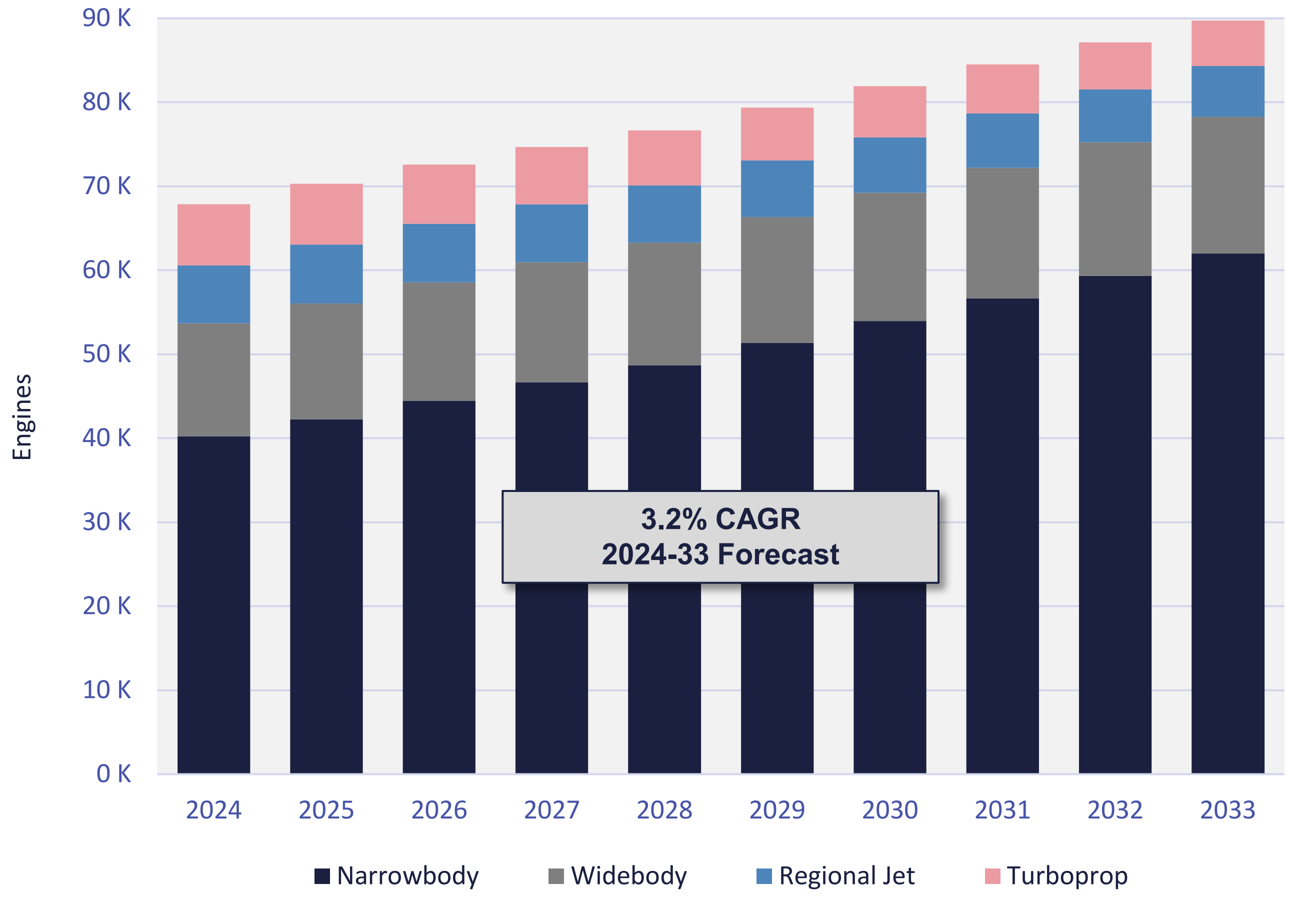
While mature engines such as the CFM56, CF34 and V2500 will continue to account for the majority of the in-service fleet of engines throughout the 2020s, new generation engines will progressively increase their market share over the period. Between 2024 and 2033, new generation engines such as the LEAP and PW1000G combined will increase from 19% of the in-service engine fleet to 50%, as commercial aircraft fleets are gradually recapitalised.

Simultaneously in-service numbers of RB211 engines are expected to fall by 83%, CF6-80s by 48%, V2500s by 35%, CFM56s by 31% and CF34s by 18% over the forecast period.

Note: Selected engine families.
Source: 2024 Commercial Aviation Fleet & MRO Forecast, Aviation Week Network, Copyright 2023.

Trends for Engines

In-service fleet trends by engine category



Highlights

- The engine fleet will rise by 3.2% CAGR over 10 years.
- The predominant driver of growth, narrowbody engines, grow at 4.9% CAGR.
- Narrowbody engines comprise a 69% fleet share by 2033.
- LEAP surpasses CFM56 by 2028.

Engine Fleet increases from 67,840 in 2024 to 89,709 in 2033

Credit: Nigel Howarth, Aviation Week Network

LEAP-1B

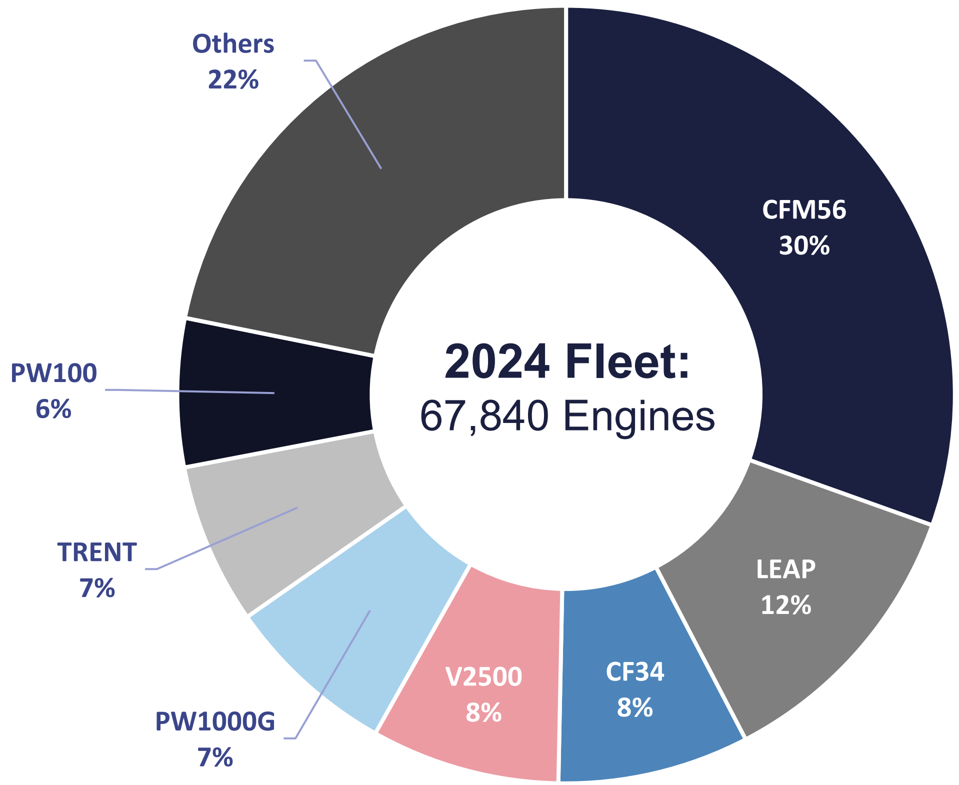
Credit: Brian Bostick, Aviation Week Network

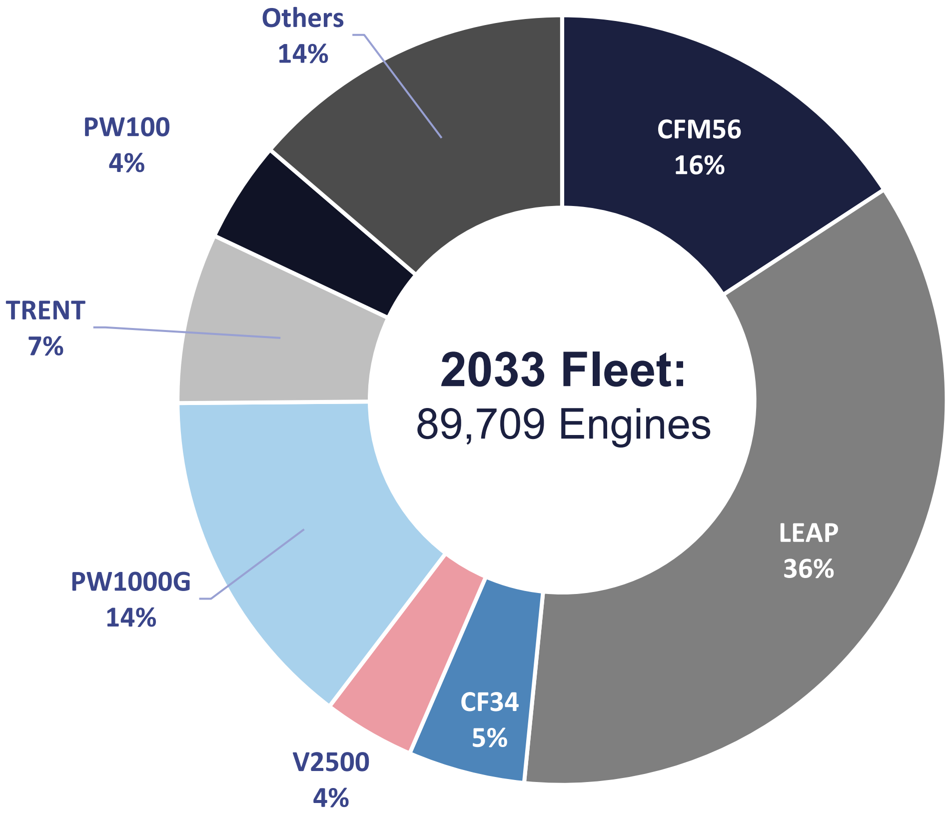
PW1100G

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

In-Service Engine Comparison by Engine Family

3.2%
CAGR

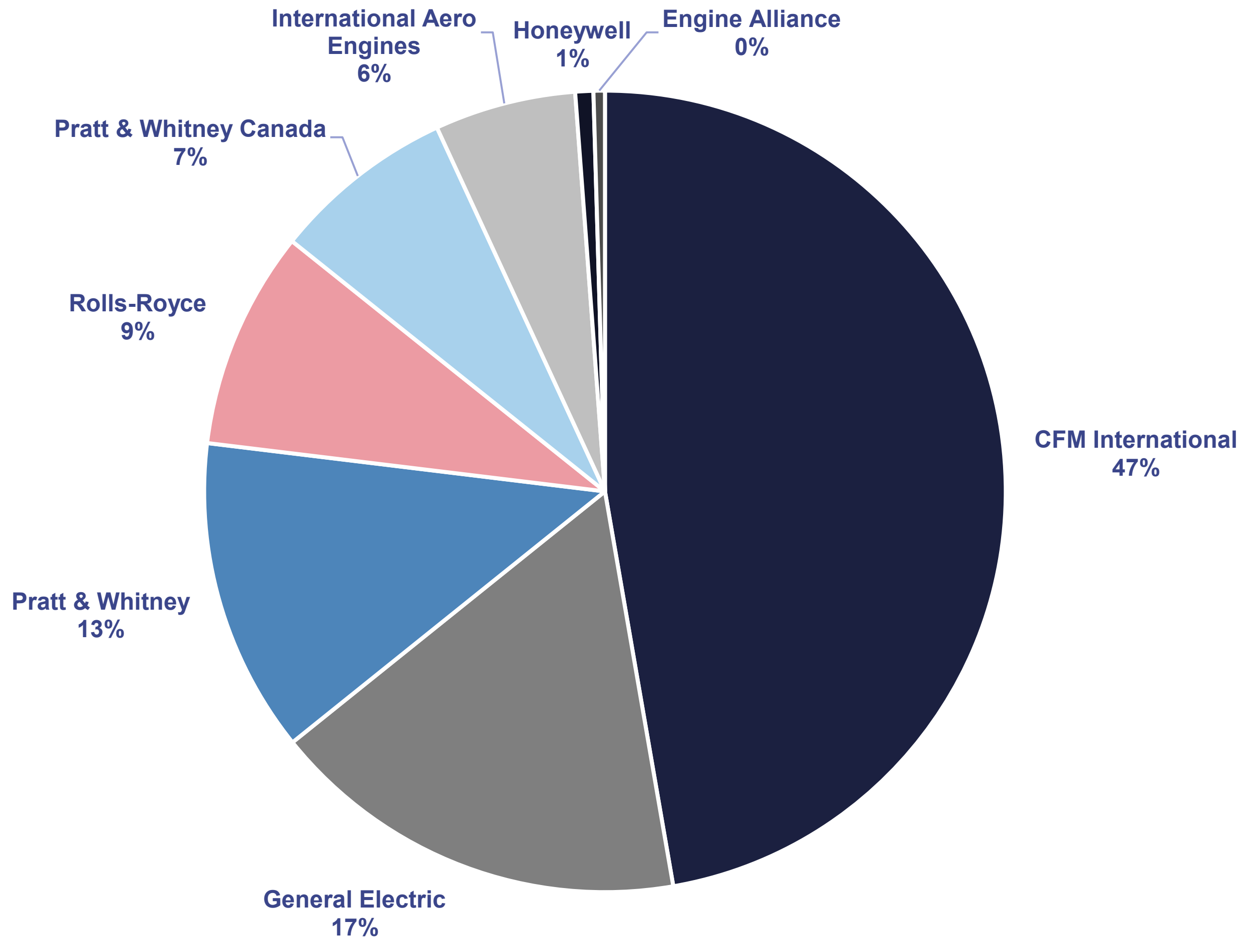




Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

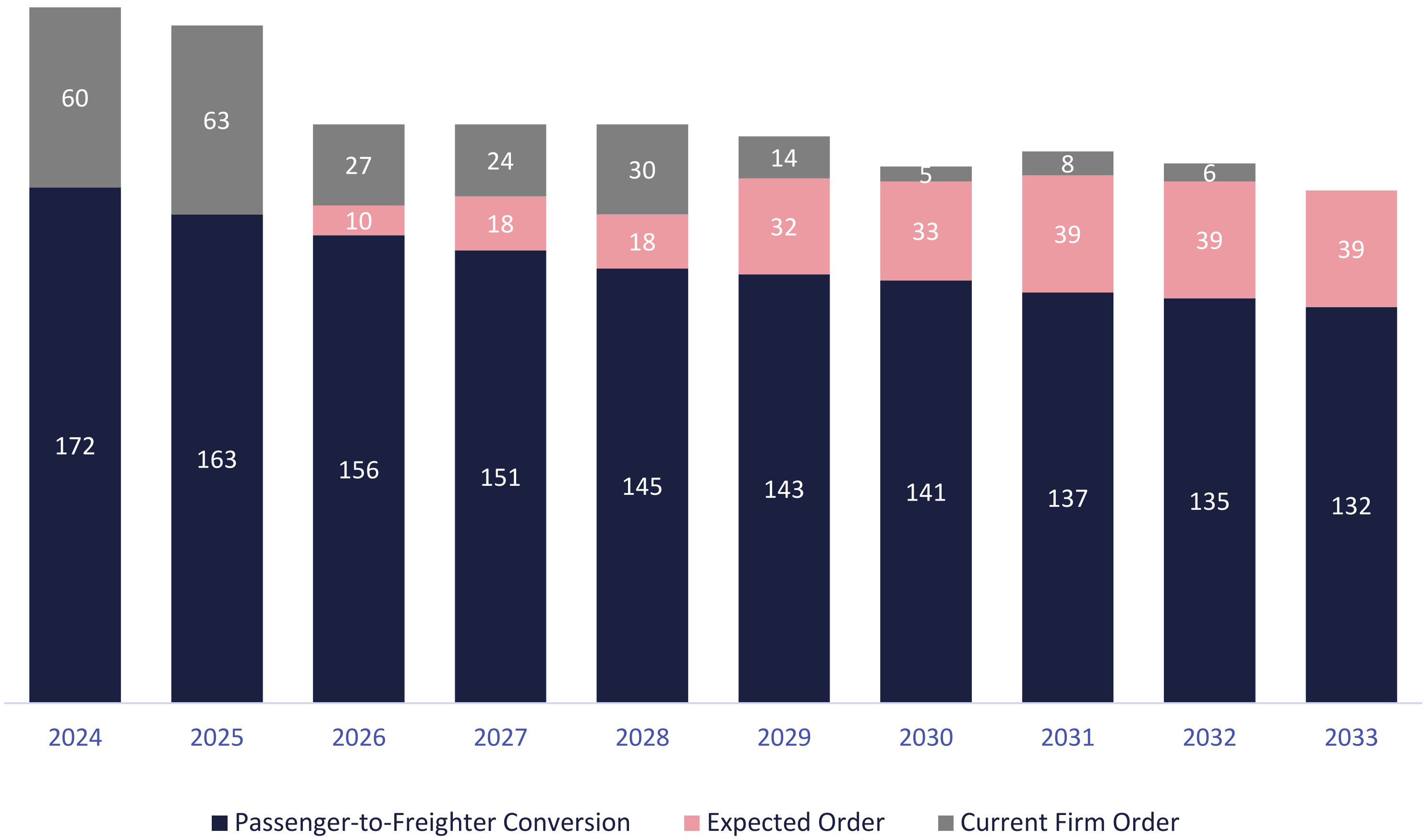
Engine Type Certificate Holder

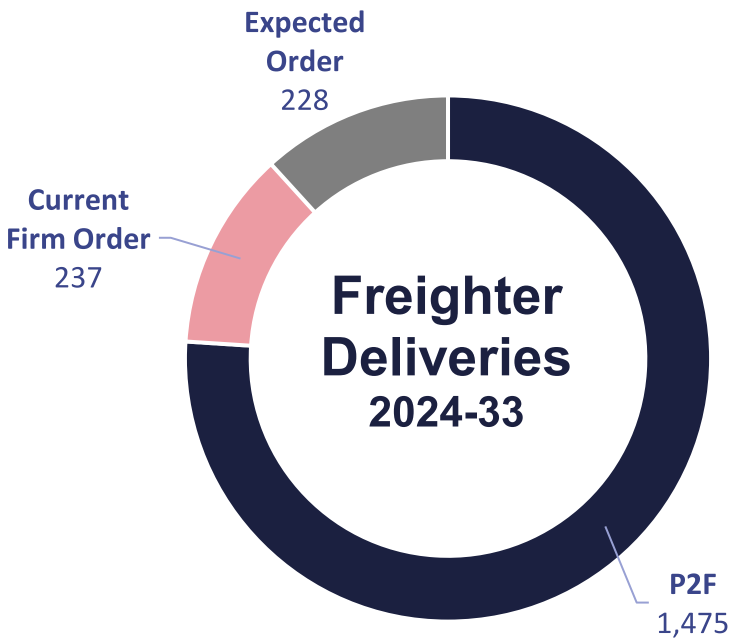
2033 Engines in service by manufacturer



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Freighter Aircraft Delivery Forecast 2024-33



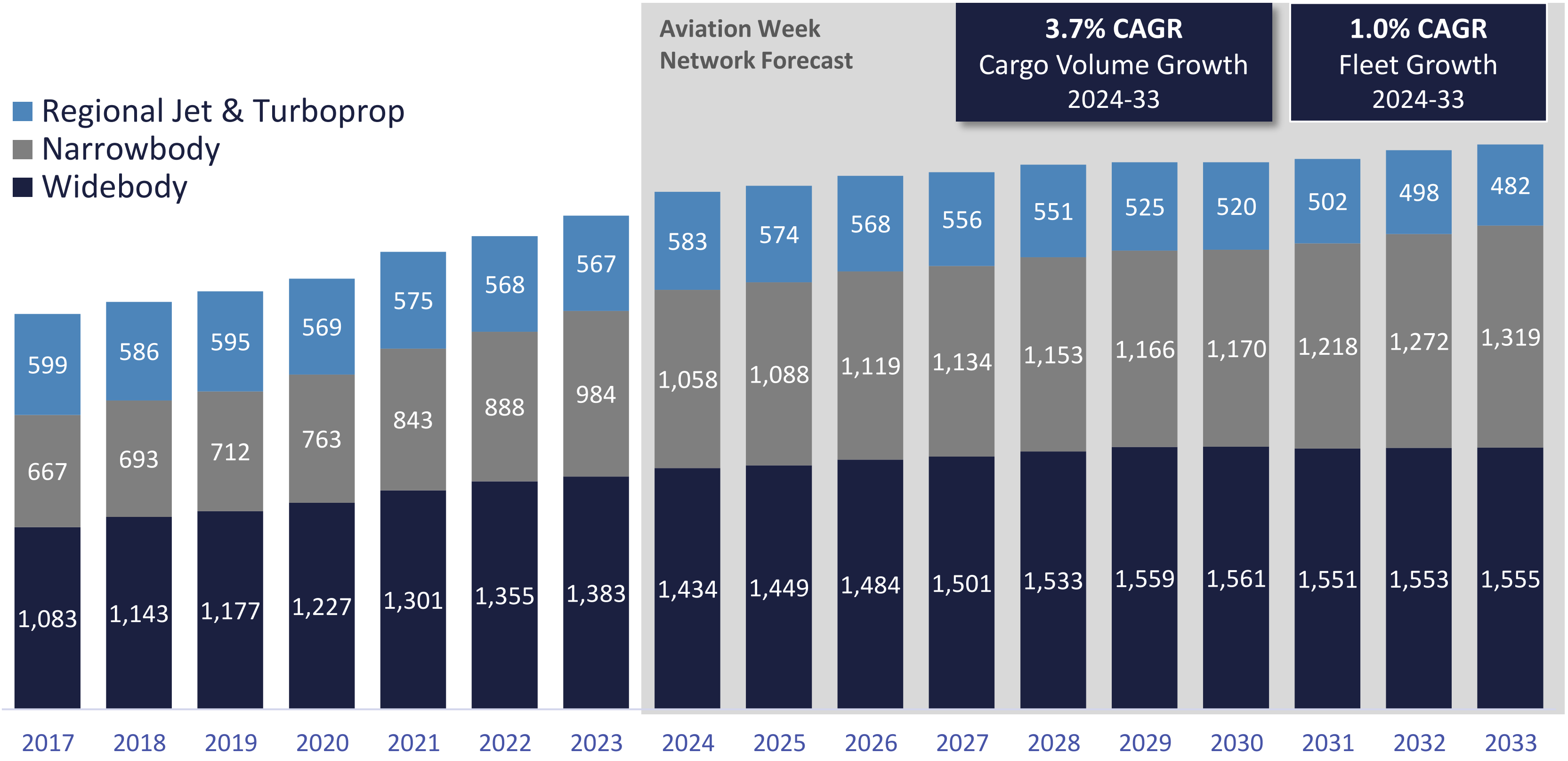


1,940
Dedicated freighter aircraft will be delivered during the 10-year period

48%
Of all conversions for the 2024-33 period will be for the Boeing 737-800

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Forecast: Global Air Cargo In-Service Fleet

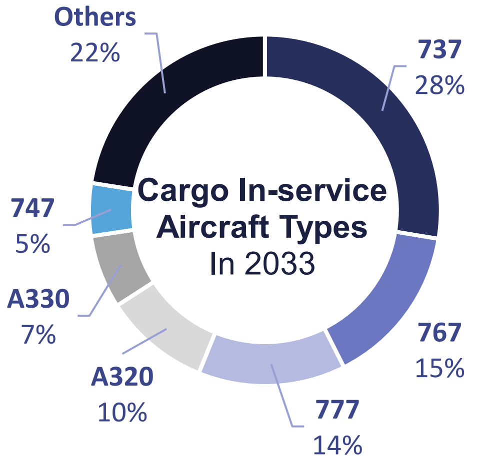


+1,900
Dedicated freighter aircraft delivered over 10-years

48%
Of conversions are for the **Boeing 737-800** over 2024-33 period

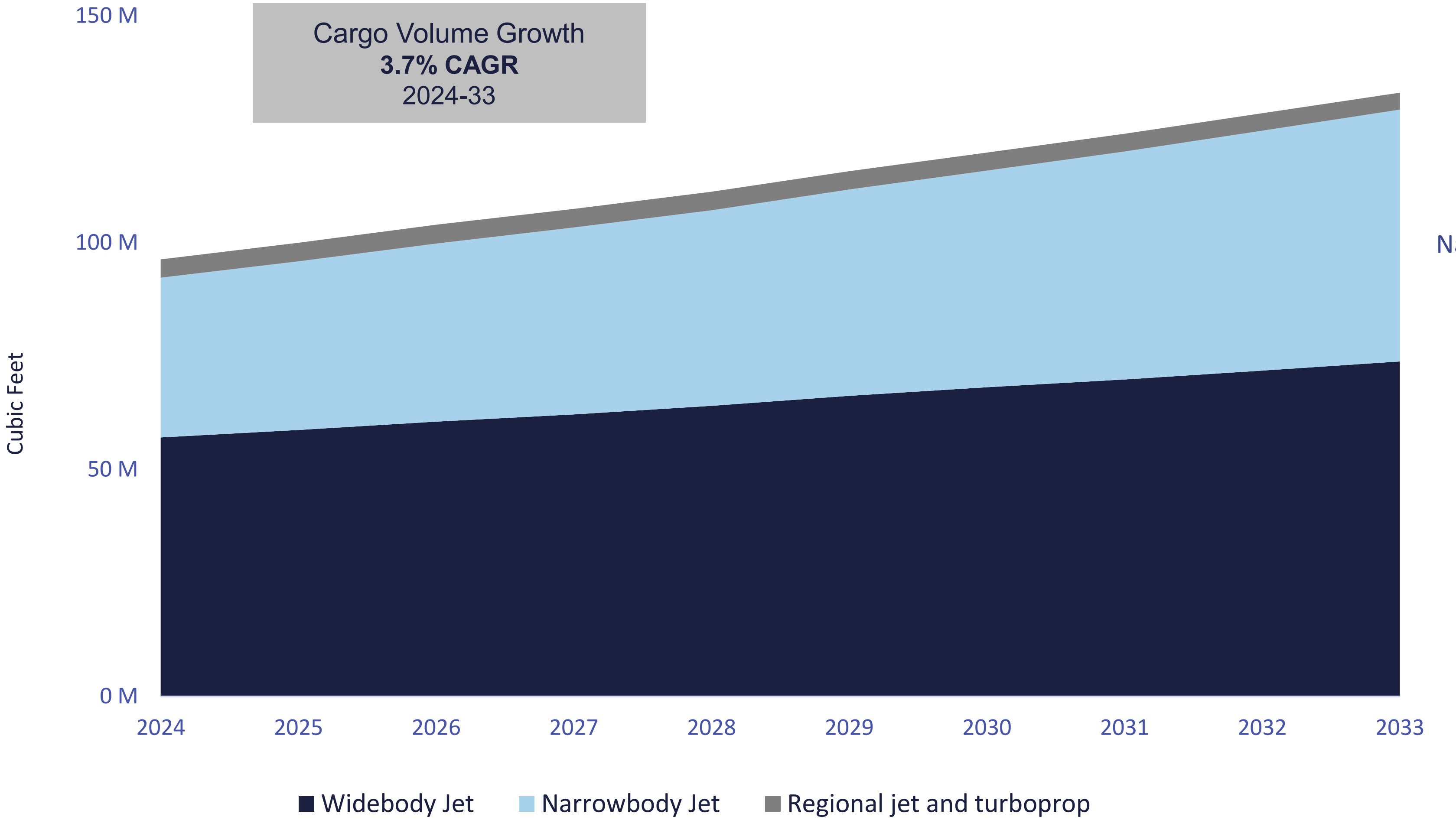
Cargo Fleet Change
(highest increase & decreases)
2033 vs. 2024

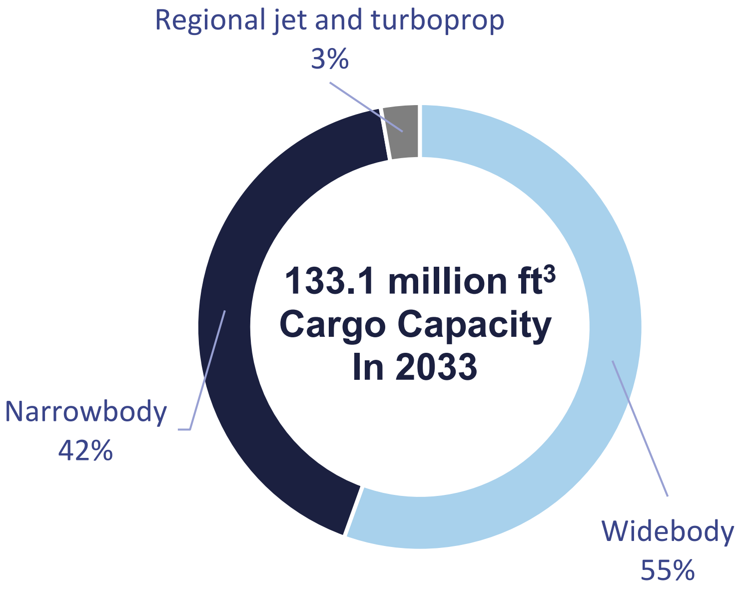
737	+347
A320	+250
777	+165
A350	+143
A330	+131
A300	-99
747	-134
757	-249



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: +19-seat certified capacity size aircraft (when in passenger configuration) and greater.

Cargo Capacity by Aircraft Size Class 2024-33





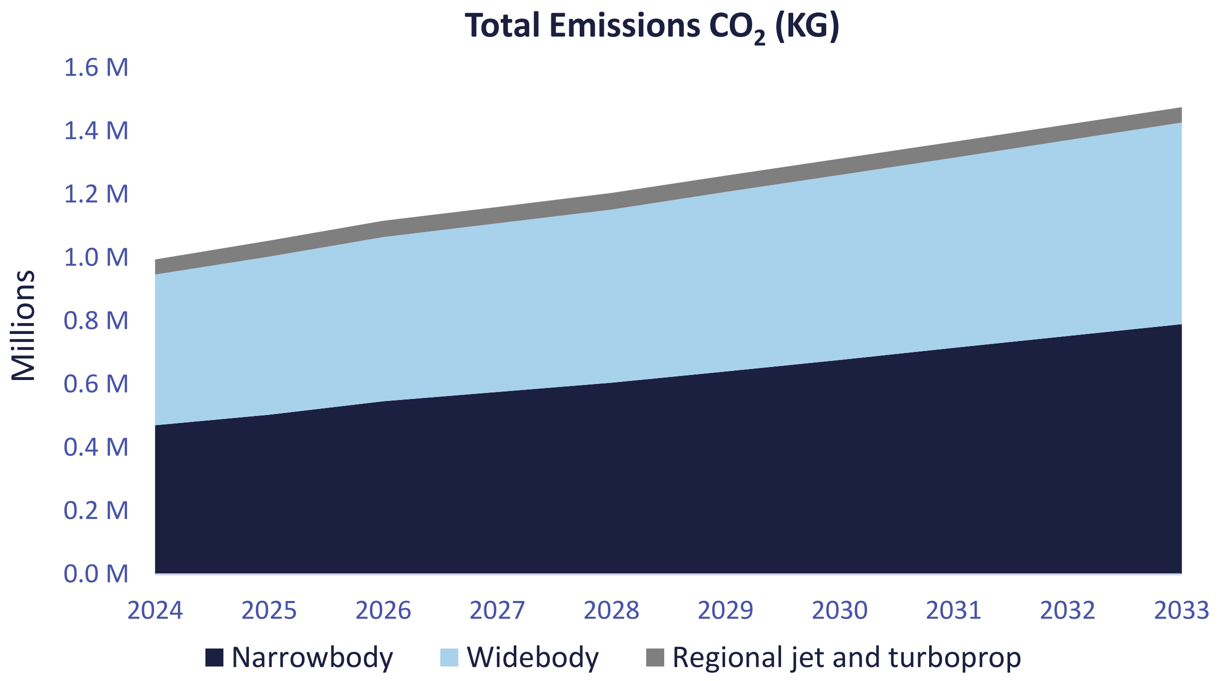
Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Emissions & Fuel Consumption

Jens Flottau, Executive Editor, Commercial Aviation, Aviation Week Network

Total Market Results

Average Annual Flight Hours	Average Annual Flight Cycles	CO2 per Seat Growth Rate (CAGR)	Fuel Burn per Seat Hour Growth Rate (CAGR)	Fuel Burn/CO2 Growth Rate (CAGR)
3,142	1,329	-6.3%	-0.6%	4.5%



For the first time, Aviation Week Network released its own forecast on emissions. According to the projections and based on current policy frameworks and technological evolution, emissions from aviation will continue to grow through the early 2030s. While there are efficiency improvements mainly through the use of new engines and more efficient (widebody) aircraft, these are overcompensated by the fast growth of the sector, exposing the industry to increased criticism and potentially more political action around its environmental performance.

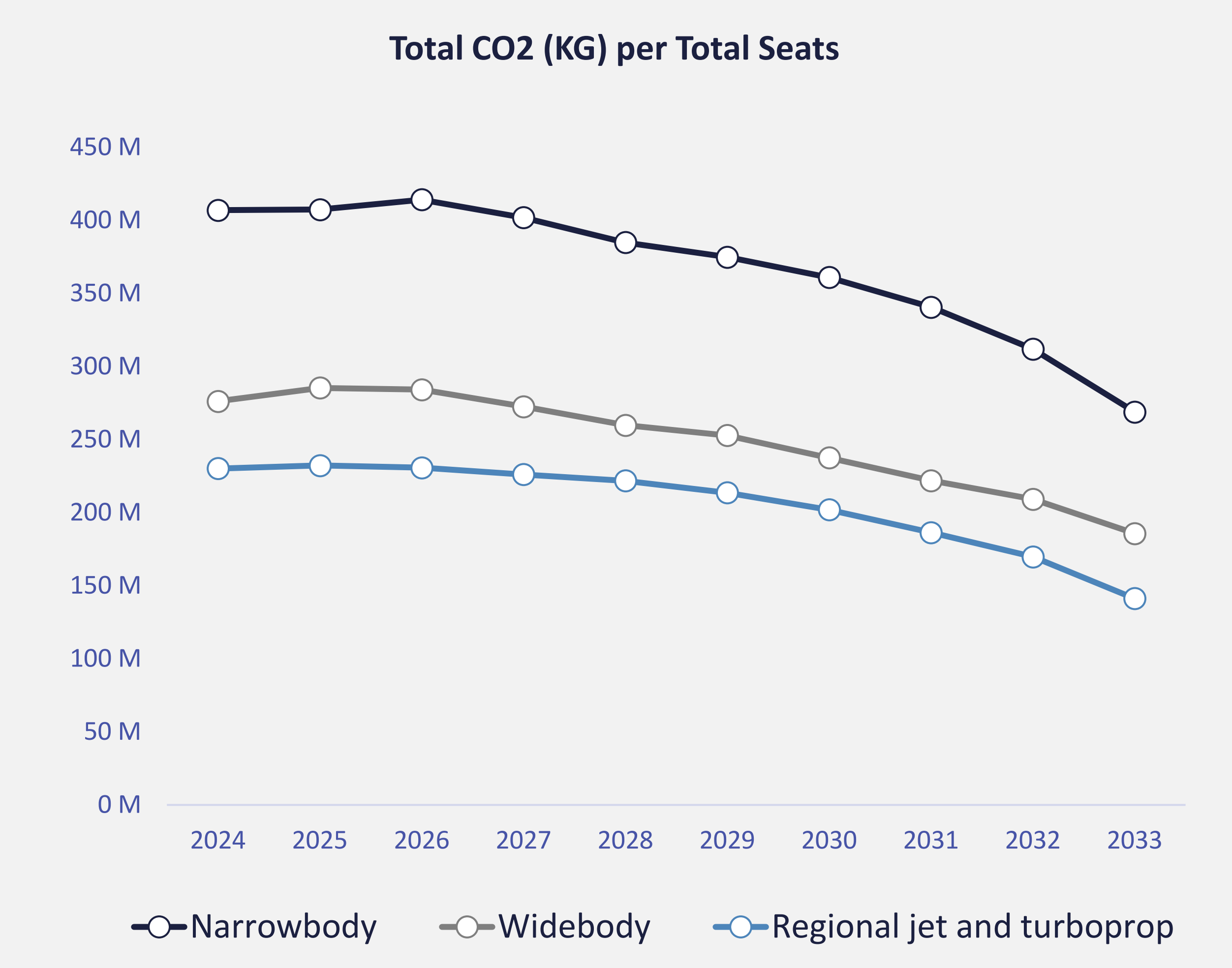
The forecast predicts a 4.5% annual increase in total CO2 emissions, higher than the predicted fleet growth. While that may seem counterintuitive given that older aircraft are replaced by new ones, there are concrete reasons for it: airlines continue to upgauge their average aircraft size, and these larger aircraft burn more fuel per trip. Also, utilization is expected to go up. Despite the issues affecting mainly the Pratt & Whitney powered part of the narrowbody fleet, over time the aircraft delivered now are going to be used more than those they are replacing, partly as narrowbodies such as the A321XLR will be flying new long-haul routes too thin for widebodies.

The upgauging does have a positive effect on per seat CO2 emissions, which will decline by 6.3% annually. It is also shown in the predictions for seat availability: airlines will grow capacity as measured in seats by 4.7% annually, almost 1.5 times as fast as their fleet growth in aircraft units. The numbers also reflect Airbus' success in the narrowbody market, which Aviation Week Network expects to continue in the next 10 years. The Airbus A320 fleet will outnumber the Boeing 737 by more than 1,500 aircraft by 2023. And there are still substantial risks on the Boeing side, particularly for the certification timeline of the 737-7 and -10.

Source: EUROCONTROL; 2024 Commercial Fleet & MRO forecast, Aviation Daily, Aviation Daily, Aviation Week Network, Copyright 2023.

Emissions & Fuel Consumption

Annual analysis for 10-year forecast period



Highlights

- Annual fuel consumption and CO_2 grows 4.5% CAGR over 10-years.
- Seats grow 4.7% CAGR, 7.5 million commercial seats in 2033.
- Upgauging/seat densification driving per seat exposure lower.
- -0.6% CAGR fuel consumption per seat hour.
- -6.3% CAGR fuel & CO_2 growth.
- Cargo aircraft, while seeing a 1.9% CO_2 CAGR rate, only experience a 1.6% CAGR increase in cubic volume.

Credit: Nigel Howarth, Aviation Week Network

Source: EUROCONTROL; 2024 Commercial Aviation Fleet & MRO Forecast, Aviation Week Network, Copyright 2023.

MRO Market Outlook

State of MRO

Sean Broderick, Senior Air Transport Editor, Commercial Aviation, Aviation Week Network

Sean Broderick

MRO demand is largely a function of new aircraft delivery and fleet utilization patterns. In normal times, a regularly flown narrowbody will need an engine overhaul 7-10 years after delivery and a major airframe check in a set number of months. While new-aircraft deliveries are still helping dictate MRO activity, these are not normal times. Delivery delays on major programs mean older models tapped for retirement are sticking around--and demanding more aftermarket support.

Production-quality problems means shops are seeing engines sooner than expected for both hospital visits and, in the Pratt & Whitney PW1100G's case, full engine overhauls. The immediate ramifications for affected shops and suppliers will be far more demand than they can handle. This translates into higher turn times for operators and headaches for all involved. While several platforms are affected, the P1100G--one of two engine options for the Airbus A320neo family--is seeing the most disruption. Manufacturing issues in certain high pressure turbine and high pressure compressor disks are causing cracks. Pratt originally believed the issue could be managed with inspections during scheduled shop visits, but revised its thinking in early 2023. Now, checks are needed as often as every year for high-utilization engines.

The initial round of inspections will require 700 unscheduled shop visits by mid-2024. Supply chain and shop capacity pressures could see turn times rise to 300 days--double the already high 150 days that PW1100G hospital visits require.

For airlines with options, older aircraft--A320ceos or Boeing 737 variants--will be kept around to fill the capacity gap. Many affected operators will have no choice but to cut capacity and wait. The issue will be prevalent for years. Pratt's fleet management plan tackling the problem envisions an average of 300 aircraft on the ground at any given time through 2026. During the 10-year forecast period, retirement activity is projected to peak in 2028.

The scenario is one of several issues keeping downward pressure on retirement rates. Aviation Week's forecast expects retirements to begin climbing in the next few years, however, as Airbus and Boeing reach higher monthly production targets on key programs--notably their A320 and 737 narrowbody cash cows.

Credit: Nigel Howarth, Aviation Week Network

State of MRO

Sean Broderick, Senior Air Transport Editor, Commercial Aviation, Aviation Week Network

Meanwhile, surging passenger demand and steady cargo activity are keeping the active fleet busy--and feeding MRO shops.

Major third-party airframe providers such as AAR Corp are reporting earlier customer bookings for slots. Supply chain issues are leading some MRO providers to pull work in house, such as parts manufacturing or reconditioning, rather than rely on smaller suppliers that may not have enough skilled labor.

Labor continues to be a concern across the marketplace and is expected to be for the duration of the forecast. Large shops need skilled technicians to meet customer demand; small shops must have it to keep material flowing up the supply chain.

The alternative-parts market, led by parts manufacturer approval (PMA) suppliers, continues to grow as operators seek safe, reliable, low-cost options for keeping their fleets active.

Add it up, and this forecast projects MRO aftermarket demand at $1.196 trillion over 10 years, growing at a 2.4% CAGR. Engine maintenance will account for 46%, followed by components at 23% and line maintenance at 19%. MRO expenditures by aircraft type certificate holder (TCH) indicates that Boeing aircraft will demand 48% of the MRO spend, followed by Airbus (44.6%). Commercial engine MRO spend by TCH signifies that CFM International will capture 36% of total expenditures followed by General Electric (27%) and Rolls Royce (17%) engines.

Boeing 737-800

Credit: Nigel Howarth, Aviation Week Network

Base Maintenance Underway Tampa, USA

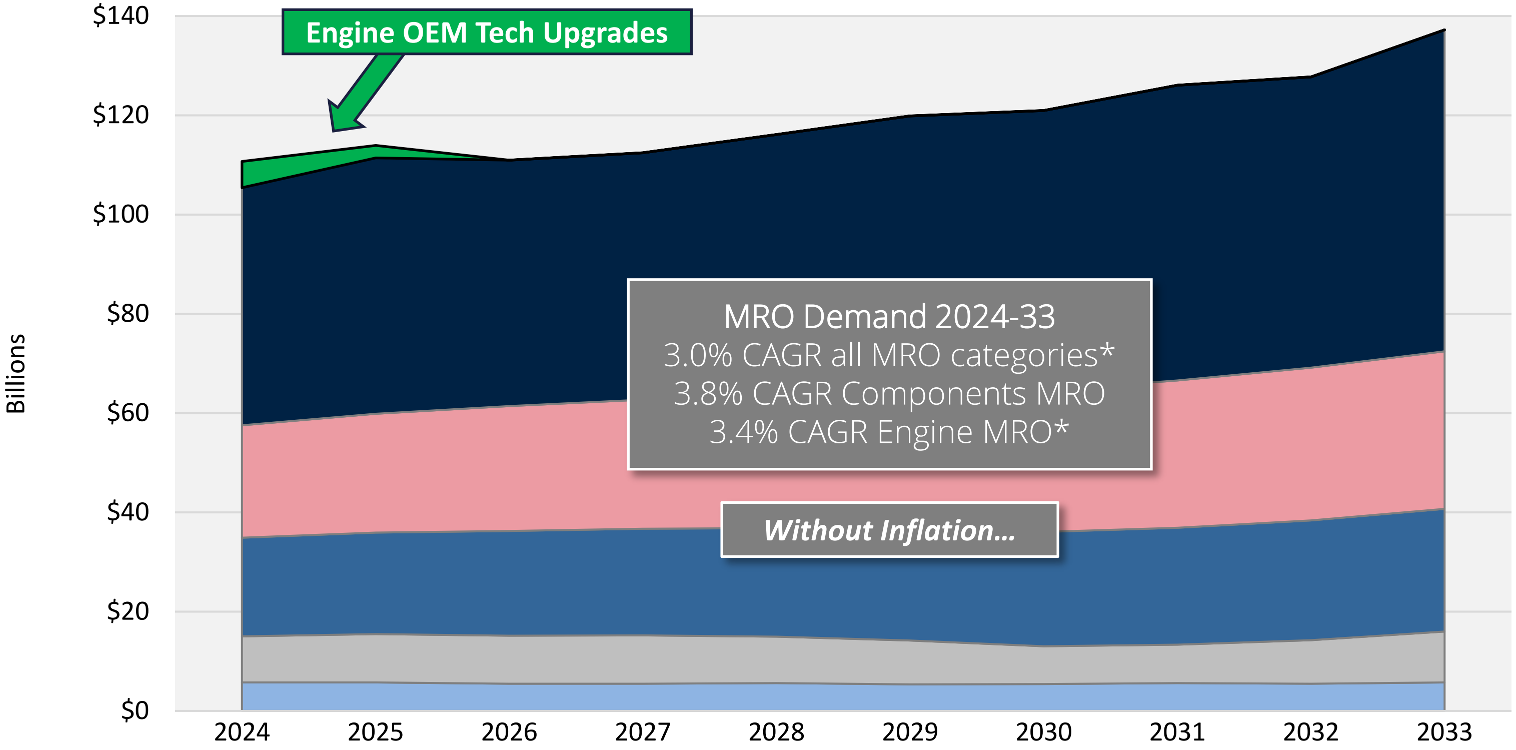
Credit: Brian Kough, Aviation Week Network

Airbus A321

Credit: Brian Kough, Aviation Week Network

MRO Demand Forecast & Trends

Forecast MRO Demand Trends

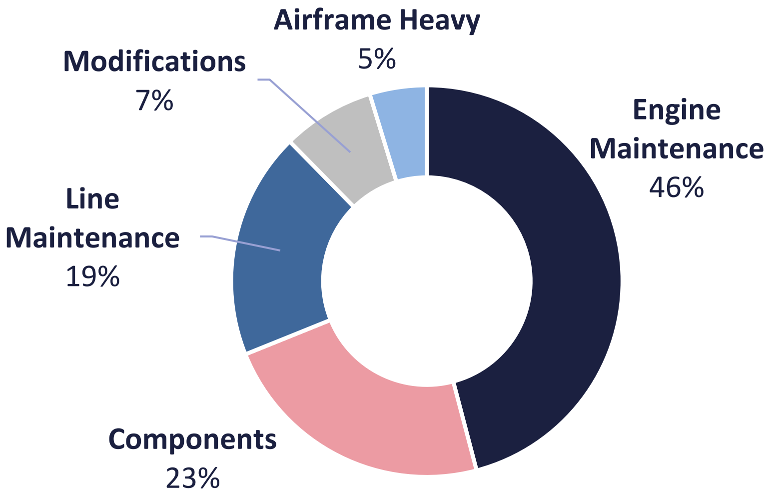


	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
OEM Tech Upgrade	$5.3	$2.5								
Engine Maintenance	$47.9	$51.6	$49.5	$49.7	$52.3	$55.4	$56.4	$59.5	$58.6	$64.7
Components	$22.6	$23.9	$25.2	$26.0	$27.0	$27.8	$28.5	$29.7	$30.8	$31.8
Line Maintenance	$19.9	$20.5	$21.1	$21.5	$21.8	$22.5	$23.0	$23.6	$24.1	$24.7
Modifications	$9.3	$9.7	$9.7	$9.7	$9.4	$8.8	$7.6	$7.7	$8.7	$10.2
Airframe Heavy	$5.8	$5.8	$5.5	$5.5	$5.6	$5.4	$5.5	$5.7	$5.5	$5.8

Highlights

- $1,188 billion* over the 10-year forecast period.
- Over 123,000 engine shop visits worth $545.5 billion.
- $273.2 billion in components demand.
- $222.6 billion in line maintenance.
- $90.8 billion in modifications demand.
- Over 119,000 heavy airframe checks (C and D checks).

MRO Demand 2024-33
$1.2 Trillion



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: *2024/2025 engine technical upgrades/warranty repairs shown on chart only, not included in analysis nor CAGR figures.

Unscheduled Engine Repairs

Engine OEM Tech Upgrades
See slide #68 Methodology For details

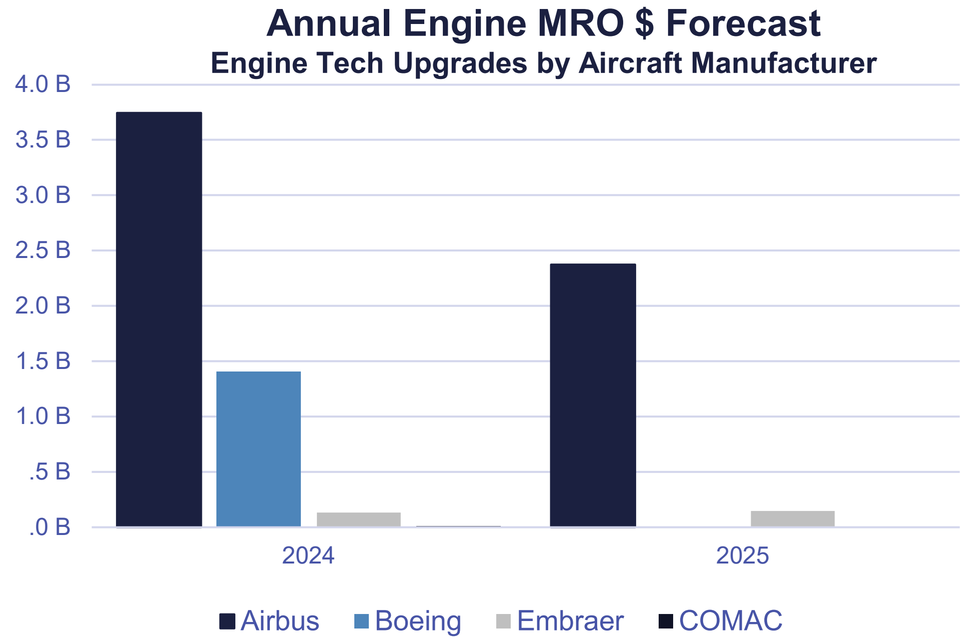
$7.8 billion MRO aftermarket impacts for Pratt & Whitney GTF & CFM LEAP

Issues

- GTF - combustion/heat exchanger
- GTF - HPT #1 and #2, HPC (2015-21 year of manufacture)
- LEAP - fuel nozzle

$7.8 Billion

Aftermarket impacts for Pratt & Whitney and CFM hospital visit warranty work



Aircraft/engine retrofits/fixes 2024/25

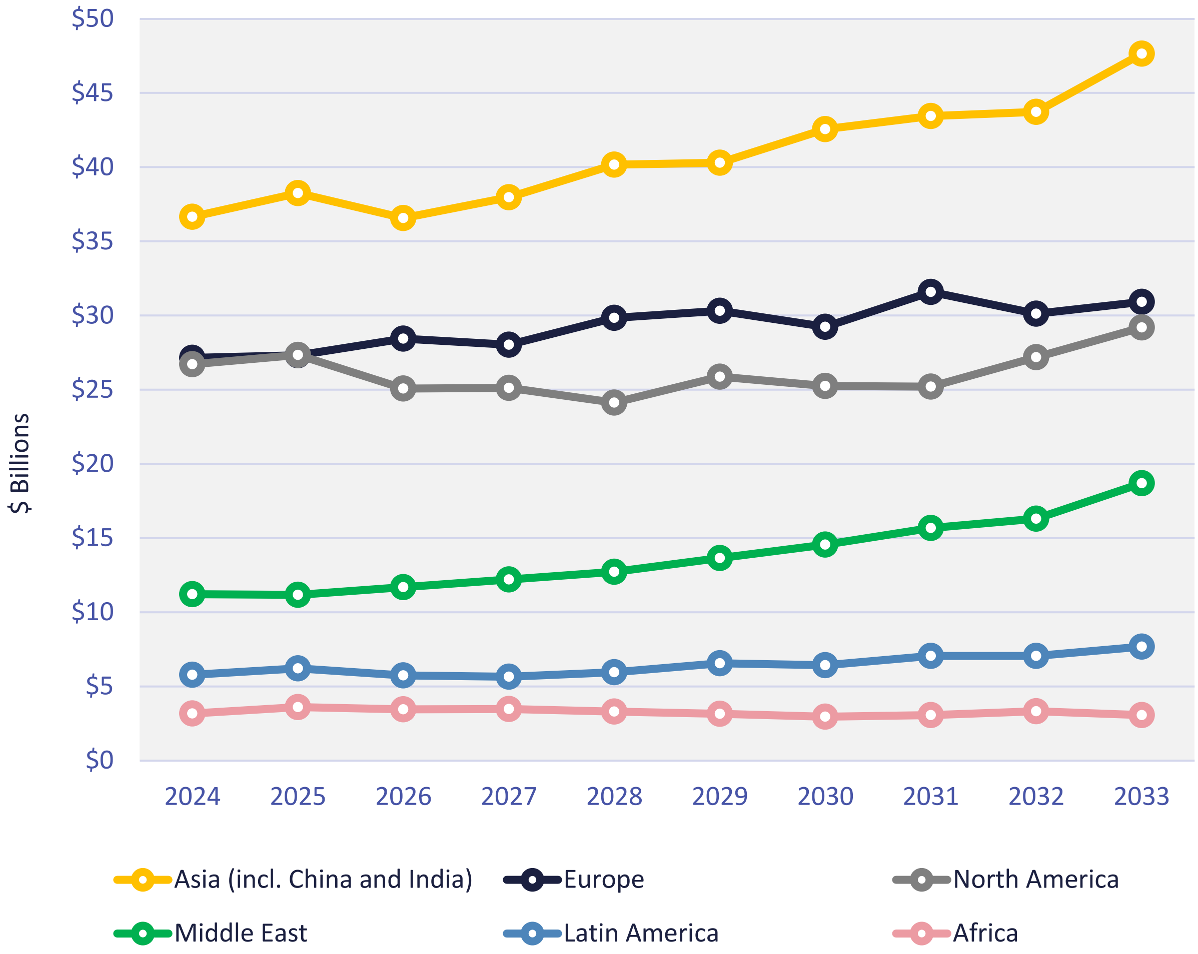
Commercial Aircraft	Engine Family	Engine Model
737 Max 7/8/9/10	LEAP	LEAP-1B
A220-100/300	PW1000G	PW1500G
A319/320/321neo	LEAP	LEAP-1A
	PW1000G	PW1100G-JM
C919	LEAP	LEAP-1C
E190/E195-E2	PW1000G	PW1900G

Credit: Brian Bostick, Aviation Week Network

Credit: Nigel Howarth, Aviation Week Network

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

MRO Demand – Region

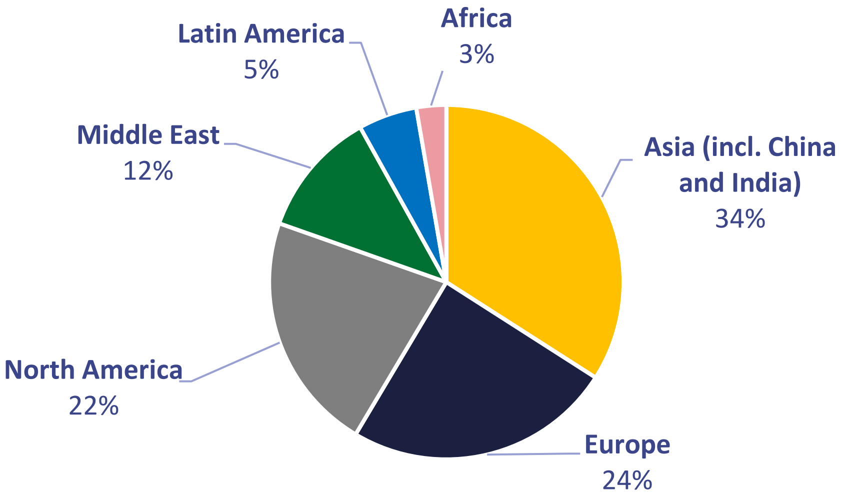


The majority of the world's regions will see MRO demand growth throughout the decade. The growth is primarily driven by higher utilization projections, increasing fleet strengths, and fleet compositions.

In some geographies, this trend is driven by aircraft composition and routes. As aircraft utilization picks up due to more international flying and use of widebodies, it's a double impact more usage with more expensive aircraft – particularly in Asia and the Middle East.

The expansion of commercial aircraft fleets in each of the regions forms the foundation of the growth trend. The fastest rate of growth in MRO demand is expected in the Middle East, with a 5.8% CAGR over the decade, much of which is driven by new aircraft entering the market.

The overall Asian region is expected to generate the most MRO demand over the forecast period, at a total of $407 billion. Demand in Asia is expected to increase from $36.6 billion in 2024 to $47.6 billion by 2033, an increase of 39% over the forecast period. Europe alone is expected to generate $292 billion between 2024 and 2033 – its growth is influenced by fleet growth and also the composition of a bit older aircraft. The North America market, still bound for a massive fleet recapitalization, will see demand shrink in the early years with newer aircraft being operated, but will then increase to near European levels at the end of the decade.



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

Forecast Regional MRO Demand, +$1 Trillion

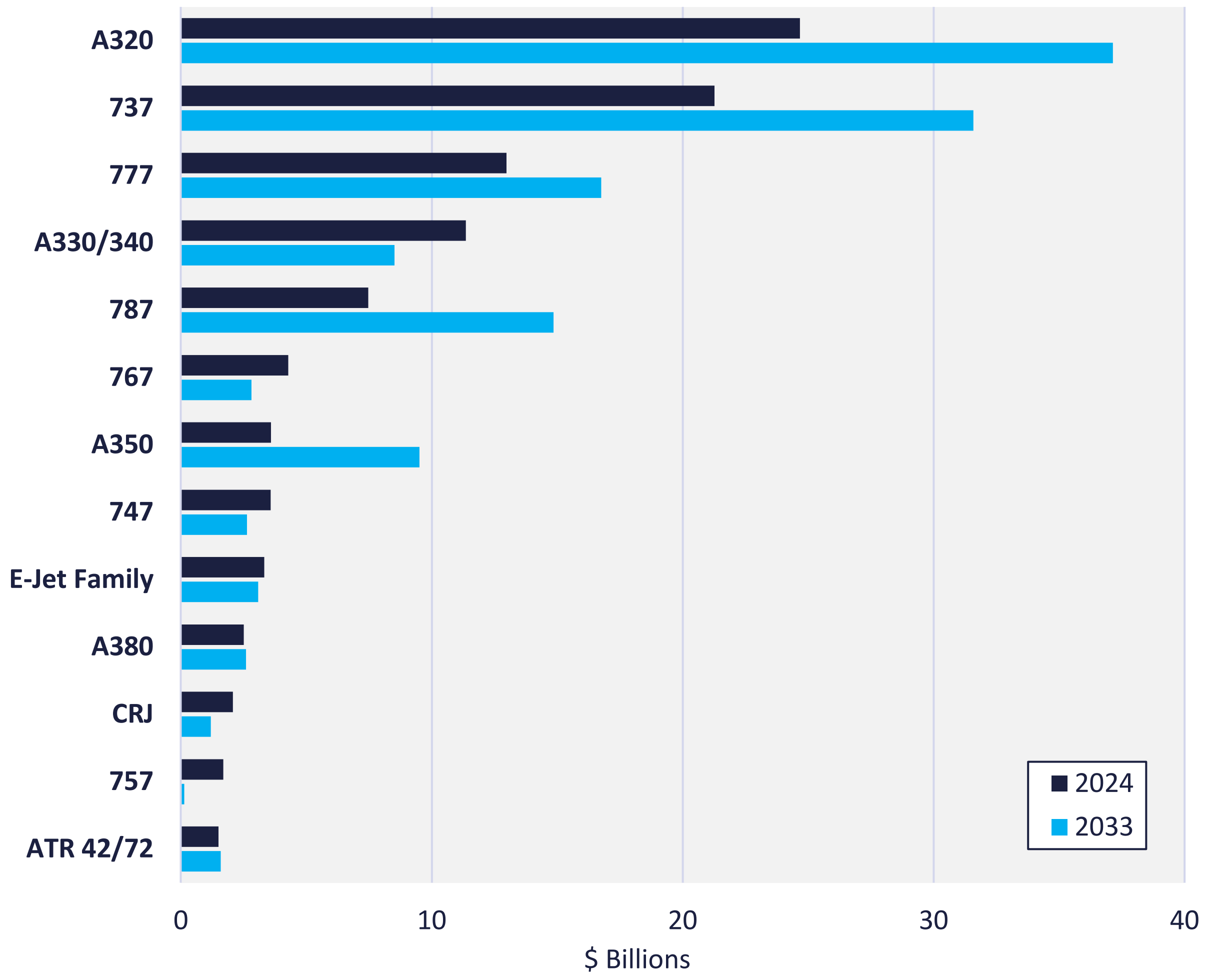
Region	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2024 % Share	2033 % Share	% Change	CAGR
North America	$25.5	$26.8	$25.1	$25.1	$24.1	$25.9	$25.2	$25.2	$27.2	$29.2	24%	21%	14%	1.5%
Western Europe	$21.8	$22.2	$23.4	$22.8	$24.4	$25.3	$24.5	$26.1	$24.8	$26.0	21%	19%	19%	2.0%
Asia Pacific	$18.7	$20.6	$19.4	$20.1	$20.7	$20.8	$22.0	$22.3	$21.2	$24.1	18%	18%	29%	2.8%
China	$13.2	$13.5	$14.0	$14.3	$14.5	$13.8	$14.3	$14.3	$14.6	$15.4	13%	11%	17%	1.7%
Middle East	$11.0	$11.1	$11.7	$12.2	$12.7	$13.7	$14.5	$15.7	$16.3	$18.7	10%	14%	70%	6.1%
Latin America	$5.2	$5.8	$5.7	$5.7	$5.9	$6.6	$6.4	$7.0	$7.0	$7.7	5%	6%	47%	4.4%
India	$2.9	$3.4	$3.2	$3.6	$5.0	$5.7	$6.3	$6.9	$7.9	$8.1	3%	6%	181%	12.2%
Eastern Europe	$3.9	$4.3	$5.0	$5.2	$5.4	$5.0	$4.7	$5.5	$5.3	$5.0	4%	4%	27%	2.7%
Africa	$3.1	$3.6	$3.5	$3.5	$3.3	$3.2	$3.0	$3.1	$3.3	$3.1	3%	2%	-1%	-0.2%
TOTAL	**$105.4**	**$111.4**	**$111.0**	**$112.5**	**$116.1**	**$119.8**	**$121.0**	**$126.1**	**$127.7**	**$137.2**	**100%**	**100%**	**30%**	**3.0%**

Credit: Nigel Howarth, Aviation Week Network

Credit: Nigel Howarth, Aviation Week Network

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

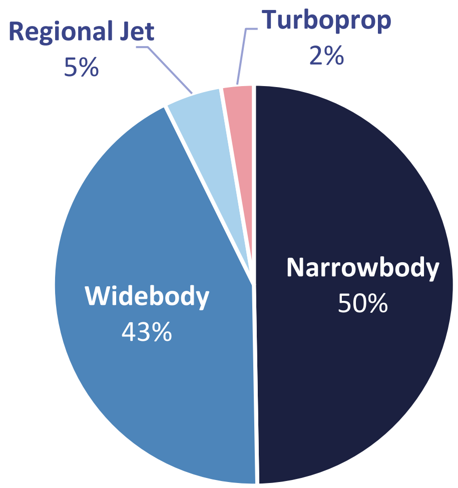
Forecast MRO Demand – Aircraft Family



While narrowbody aircraft dominate the global fleet in the future, the higher costs associated with larger widebody aircraft will ensure that MRO demand is split almost equally between the two. Between 2024 and 2033, narrowbodies account for 50% of demand, widebodies 43%, regional jets 5% and turboprops 2%.

The two biggest programs by some distance will be the Airbus A320 and the Boeing 737. The A320 family alone is expected to generate $320 billion in demand, equivalent to 27% of all MRO activity over the decade. Boeing's 737 family is expected to generate $249 billion, representing a further 21% of the total.

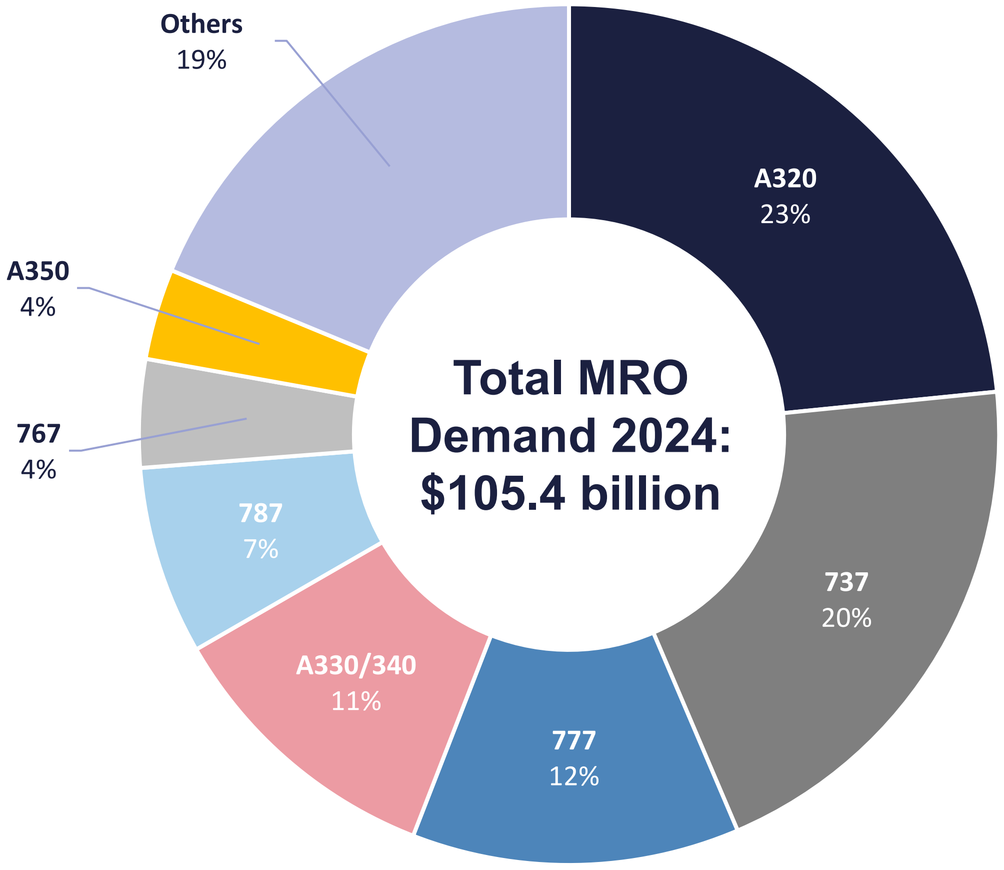
The fastest growing widebody aircraft families are the Airbus A350 and the Boeing 787, which are expected to see combined demand growth from $11.0 billion in 2024 to $24.3 billion by 2033. Increased demand from these families will offset the decline of other widebody types, such as the Boeing 747 and 767.

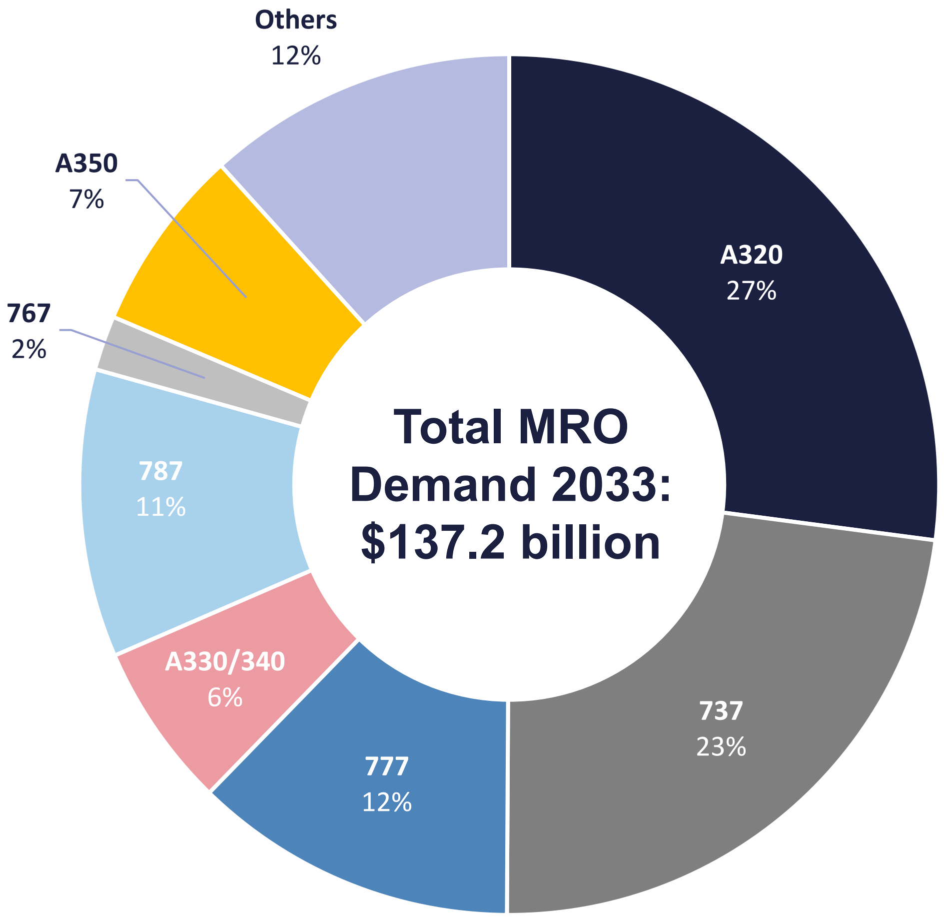


Credit: Nigel Howarth, Aviation Week Network

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

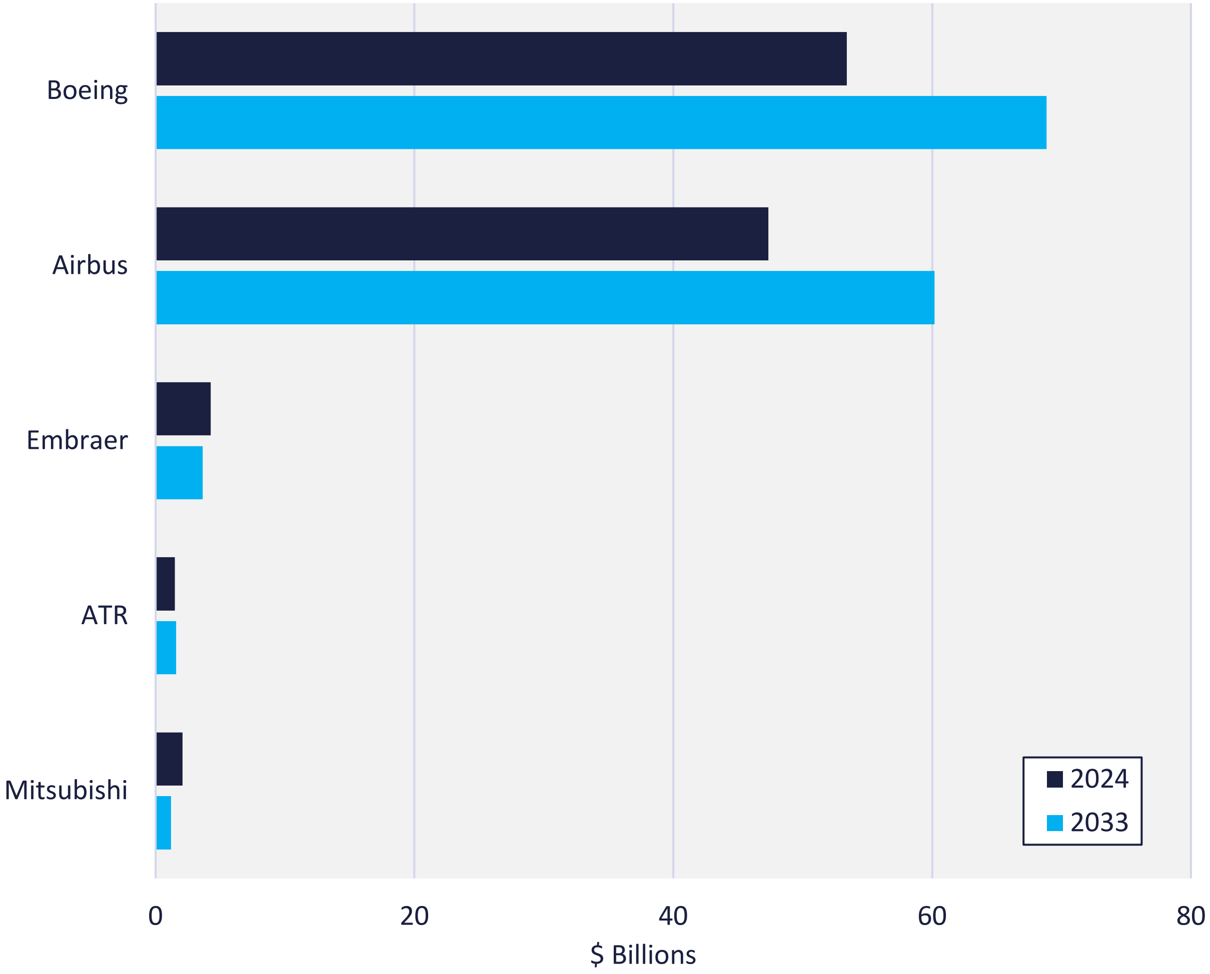
MRO Demand – Aircraft Family Shifts





Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

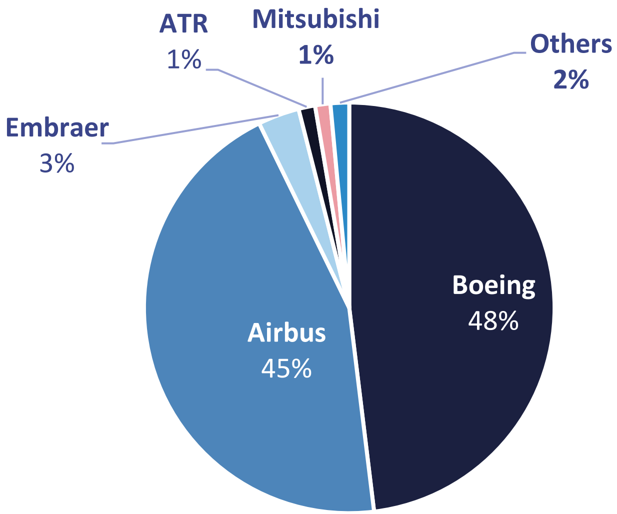
MRO $ Demand Change – Aircraft Type Certificate Holder



The Airbus A320 family will account for the largest percentage of MRO capture by unique airframe family, accounting for over 27% of the total MRO demand. The popular A321 amongst that family in particular will experience 17% MRO demand CAGR.

Boeing's 737 (20.9%) and 777 (11.5%) families rank 2nd and 3rd overall. The 737 will drive $250 billion growing at 3.7% CAGR.

By total TCH, Boeing aircraft account for the largest share of MRO demand during the forecast period at 48% or a value exceeding $573 billion. Airbus follows with a share of 45% and a value of $533 billion. In 2033 alone, MRO demand for Boeing aircraft will surpass $68.8 billion, with Airbus accounting for $60.1 billion that year without inflation.

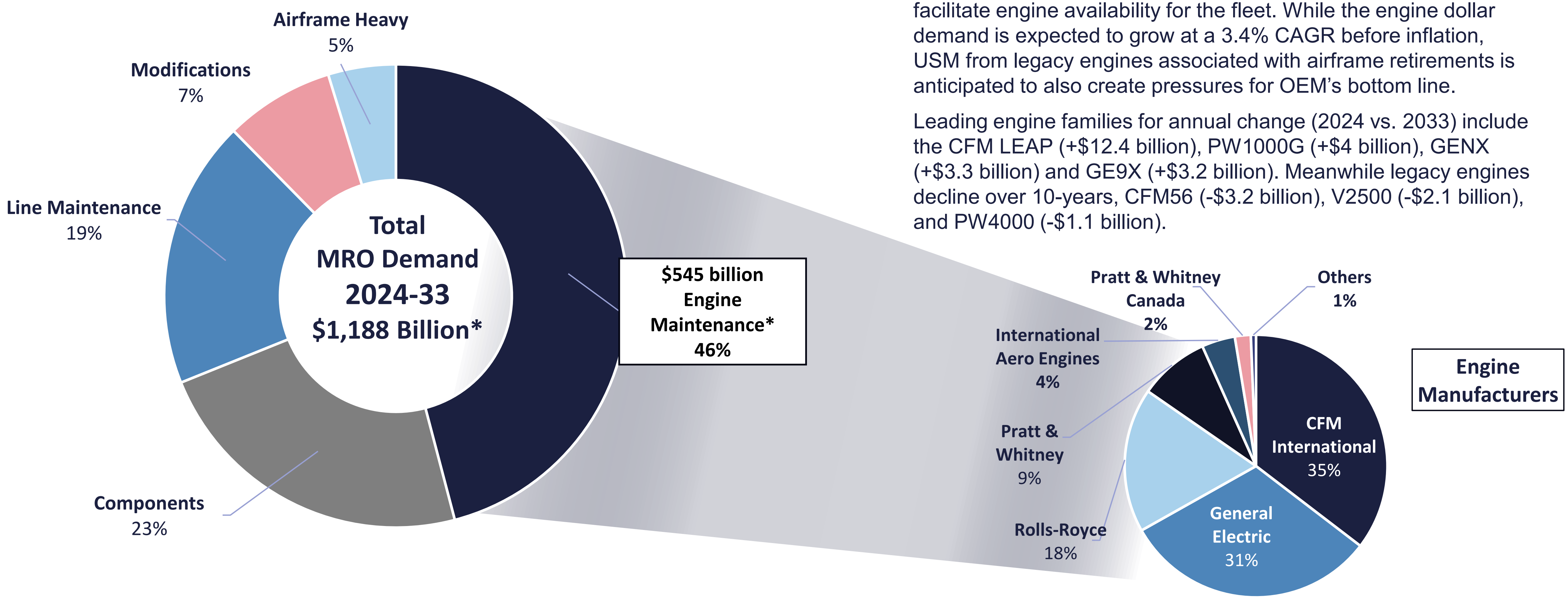


Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

MRO $ Demand Share – Engines

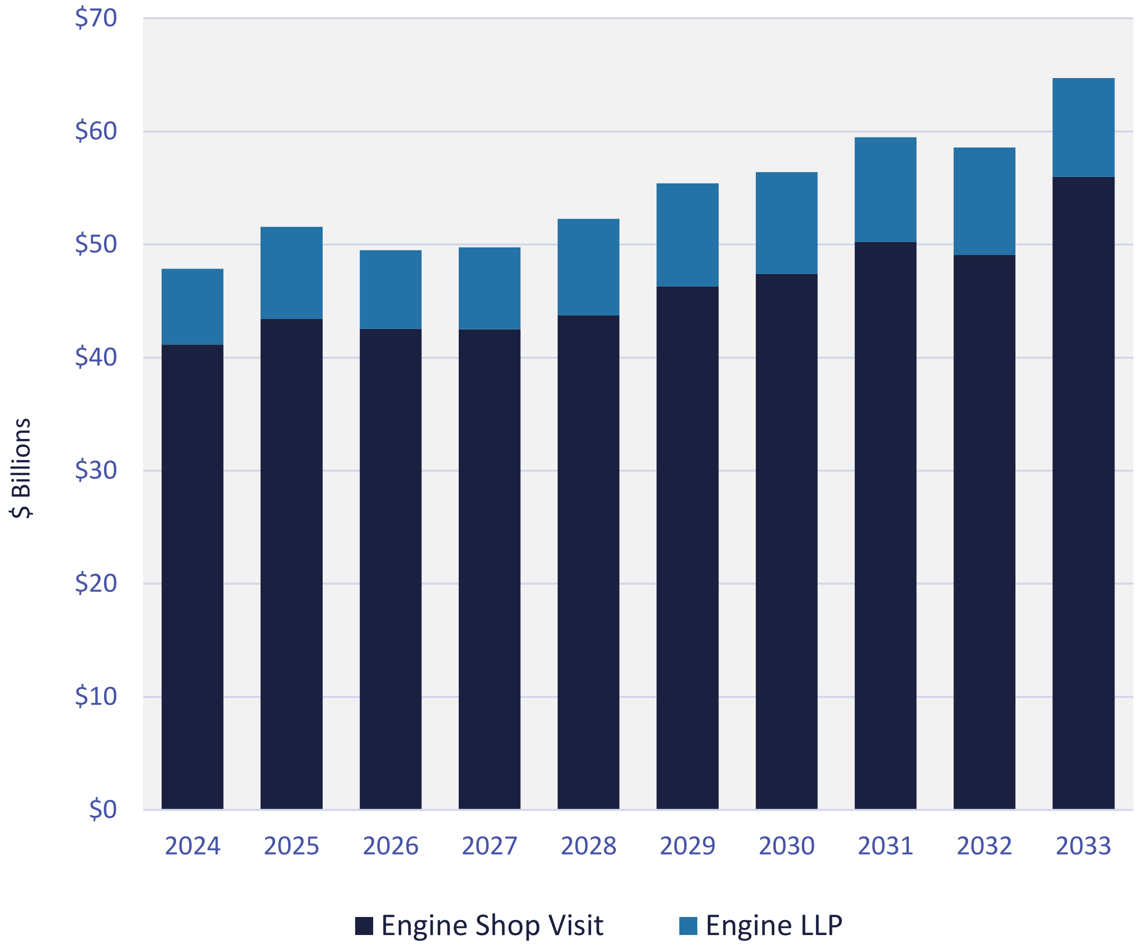
Top shares of the projected 10-year aftermarket revenue go to CFM, GE Aviation, and Rolls Royce. With increasing supply chain and shop visit pressures, OEM replacement parts are under increasing pressure from PMA parts and local DER approvals to facilitate engine availability for the fleet. While the engine dollar demand is expected to grow at a 3.4% CAGR before inflation, USM from legacy engines associated with airframe retirements is anticipated to also create pressures for OEM's bottom line.

Leading engine families for annual change (2024 vs. 2033) include the CFM LEAP (+$12.4 billion), PW1000G (+$4 billion), GENX (+$3.3 billion) and GE9X (+$3.2 billion). Meanwhile legacy engines decline over 10-years, CFM56 (-$3.2 billion), V2500 (-$2.1 billion), and PW4000 (-$1.1 billion).



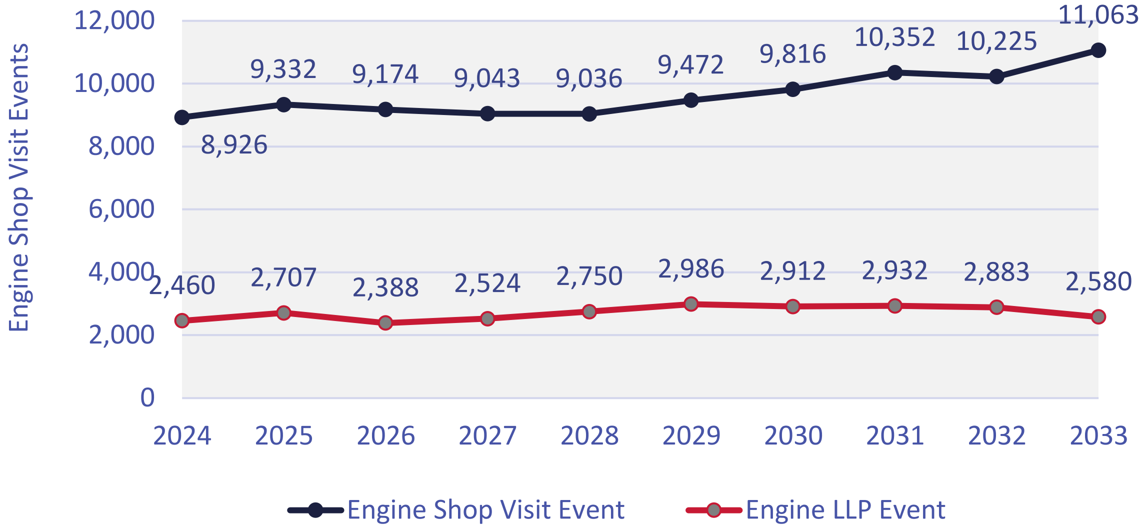
Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: *2024/2025 engine technical upgrade events not included.

MRO Demand – Engine Maintenance



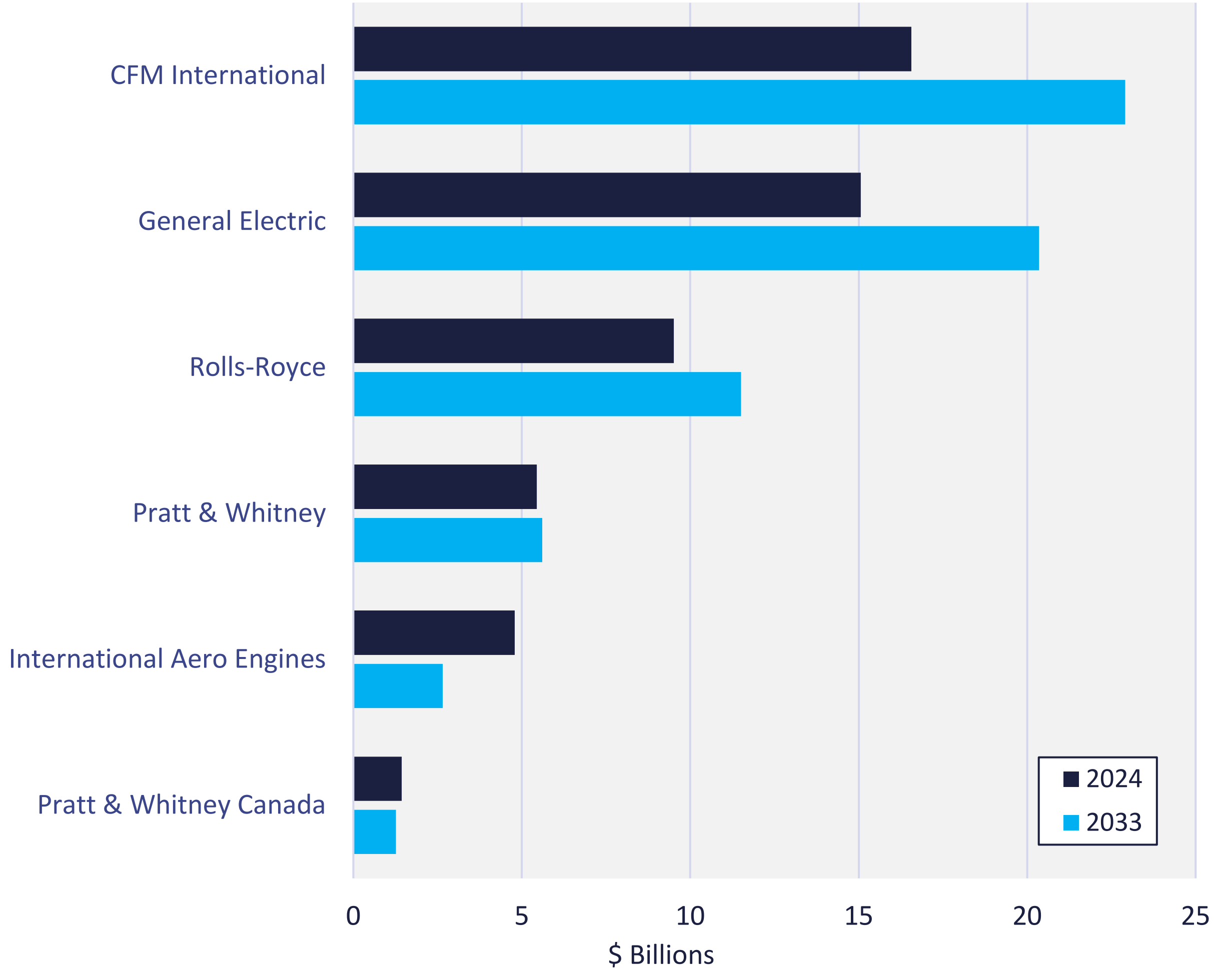
Engine maintenance makes up the largest share of MRO demand over the decade at 46% and is projected to total $545B over the forecast period. It grows at a 3.4% CAGR, the second highest rate by expense category after Components (3.8%). A share of 97% of the $1,188B of MRO demand over the decade will be generated by aircraft powered by turbofan engines, with turboprop MRO valued at $31B.

A share of 85%, or $462B of expenditures, relate to engine performance restoration shop visits (SVs) with the remaining 15% associated with the cost of replacing life limited parts (LLPs). SVs are accounted for distinctly aside from LLP replacements, both by events and by dollar demand. Over 96,000 engine restorations are expected over the period, while more than 27,000 LLP replacement events are also projected to be needed.



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

MRO Demand Change – Engine Type Certificate Holder



CFM engines account for the largest share of MRO demand, at 35% during the 2024-33 period. GE Aviation and Rolls-Royce follow with shares of 31% and 18% respectively.

By 2033, the leading three type certificate holders generating the most demand annually will remain CFM International ($22.9bn, up 38%), GE Aviation ($20.3bn, up 35%), and Rolls-Royce ($11.5bn, up 21%) on a 2023 constant dollar basis. Increasing pressures from material costs, labor, supply chain and PMs will act to reduce profitability, however.

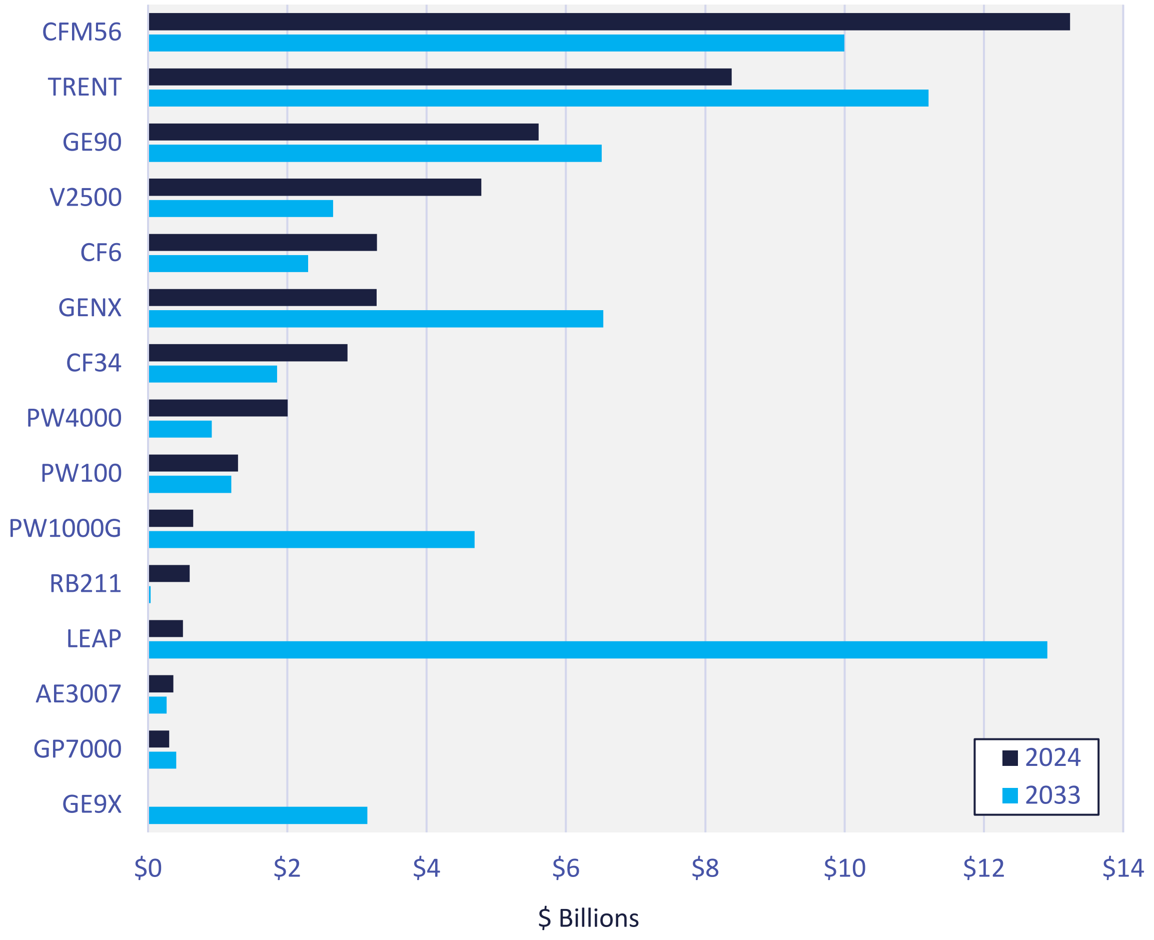
Engine TCH	Engine OEM
CFM International	CFM International
Engine Alliance	Engine Alliance
General Electric	General Electric
Honeywell	Garrett-AiResearch
	Honeywell
	Textron-Lycoming (AVCO)
International Aero Engines	International Aero Engines
Pratt & Whitney	Pratt & Whitney
Pratt & Whitney Canada	Pratt & Whitney Canada
Rolls-Royce	BMW + Rolls-Royce
	Rolls-Royce

Delta TechOps - Engine Test Stand
Credit: Brian Kough, Aviation Week Network

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Aviation Week Network, Copyright 2023.
Note: 2024/2025 engine technical upgrade warranty events not included in demand figures here.

MRO Demand Change – Engine Family

Effects of new generation engines on MRO demand will be felt by the end of the decade



While declining, the CFM56 family alone will still account for almost a quarter of all demand at $120B. Maintenance spending is expected to peak during the 2020s as classic 737 and A320ceo models are gradually replaced. Demand for V2500 MRO will similarly start to decline before the end of the decade.

PW1000G and LEAP shop visits ramp up in the latter half of the forecast period generating $5B and $12B in annual demand respectively by 2033. GENX demand doubles over the decade rising from $3.9B in 2024 to just over $6.5B by 2033. Shop visits relating to these three families of engines are expected to rise from 2,330 to 10,685 over the course of the decade.

Linked closely to the shifts in the composition of widebody fleets around the world the TRENT family will see rapid growth over the decade. Driven by increased demand from Boeing's 787's, the TRENT1000 and the Airbus A350's TRENTXWB, spending on maintenance for the Rolls Royce family of engines is expected to rise from $8.4B to $11.2B over the decade.

Decline in demand for CF6-80 and RB211 maintenance over the forecast is closely linked to the weakening around the ultra large widebody market segment. The PW4000 and AE3007 will also see demand fall over the decade.

PW1500G

Trent XWB

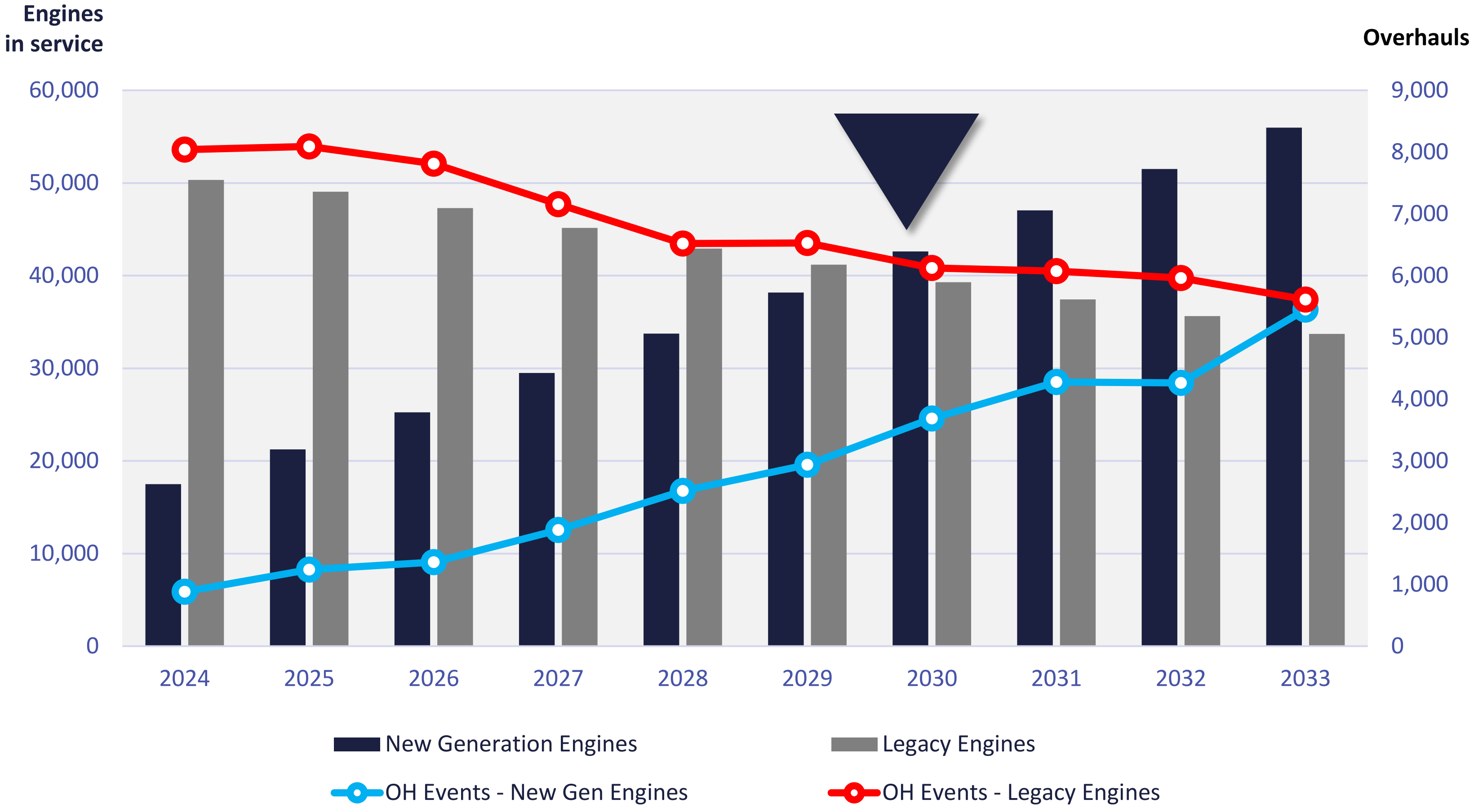
CFM LEAP-1B

Credit: Nigel Howarth, Aviation Week Network

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

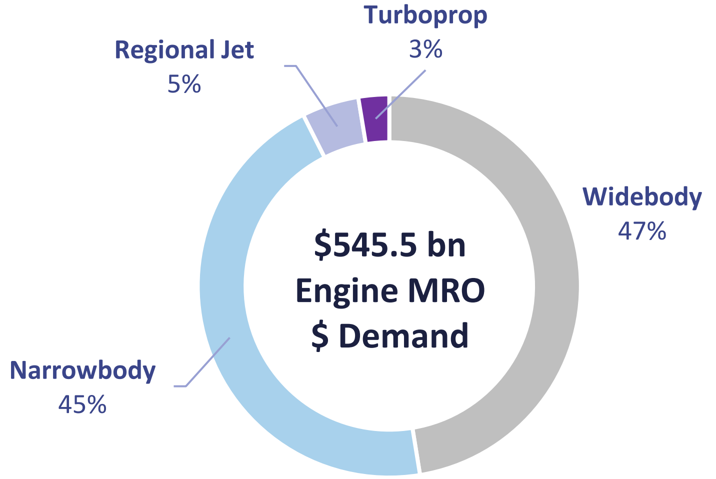
Forecast Engine Fleet & Overhaul Events

New generation vs. legacy fleet share & overhaul event forecast



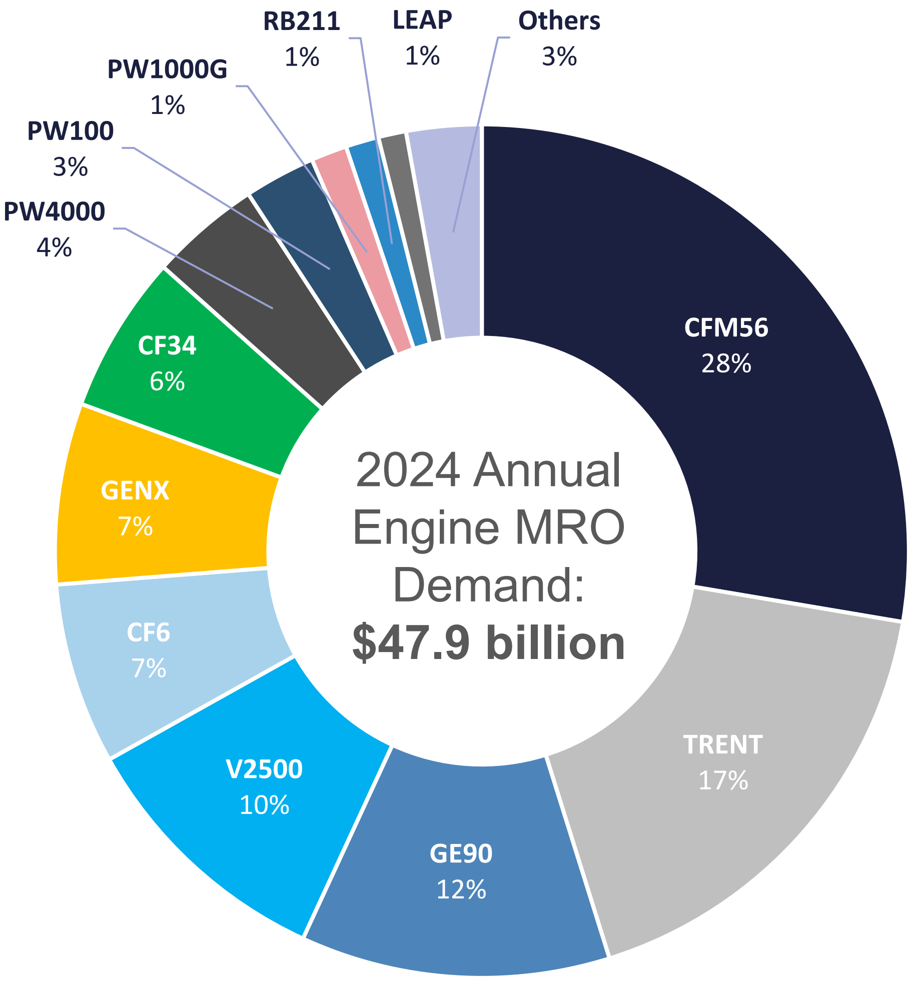
2030
Inflection Year for
New Generation Engine Fleet Strength.

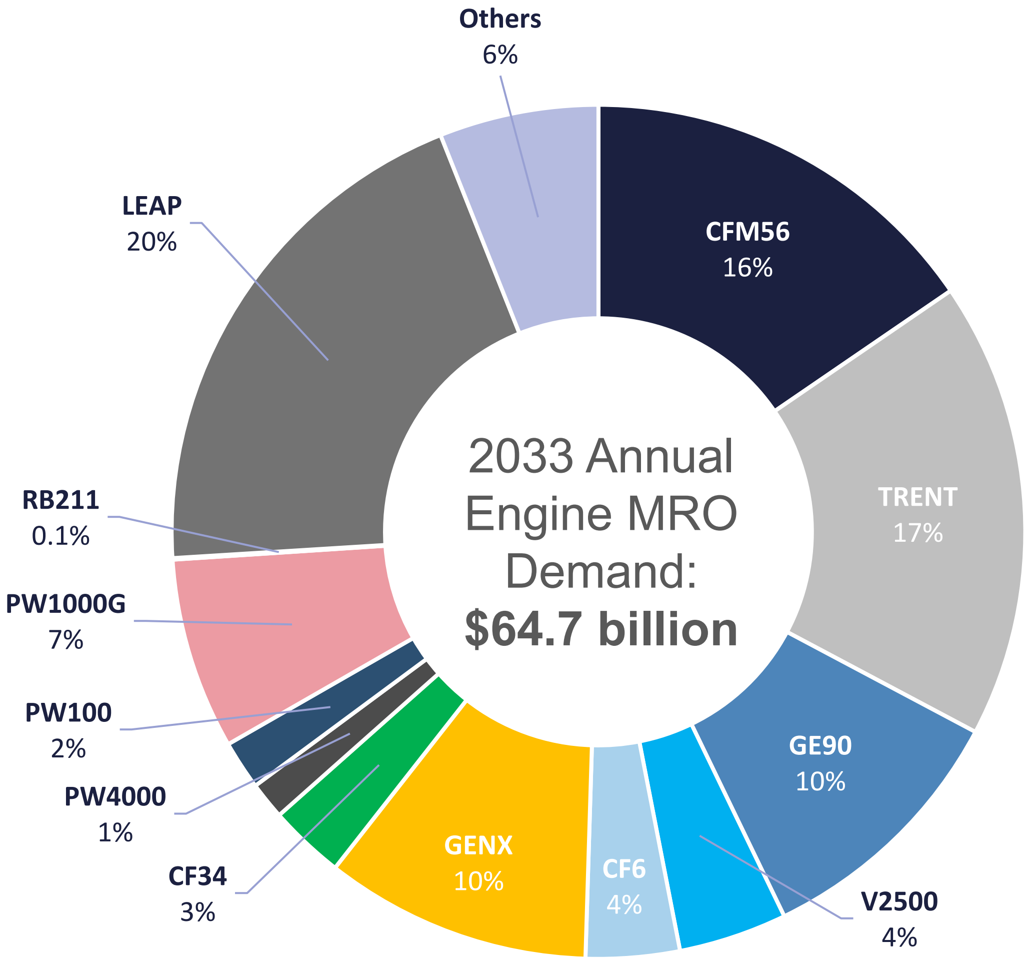
96,400+
Overhaul Events during period.
Inflection beyond 2033.



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Notes: LLPs and 2024/2025 engine technical upgrade *events* not included. New generation engines include Leap, PW1000G, GENX, GE9X and Trent 1000/7000/XWB.

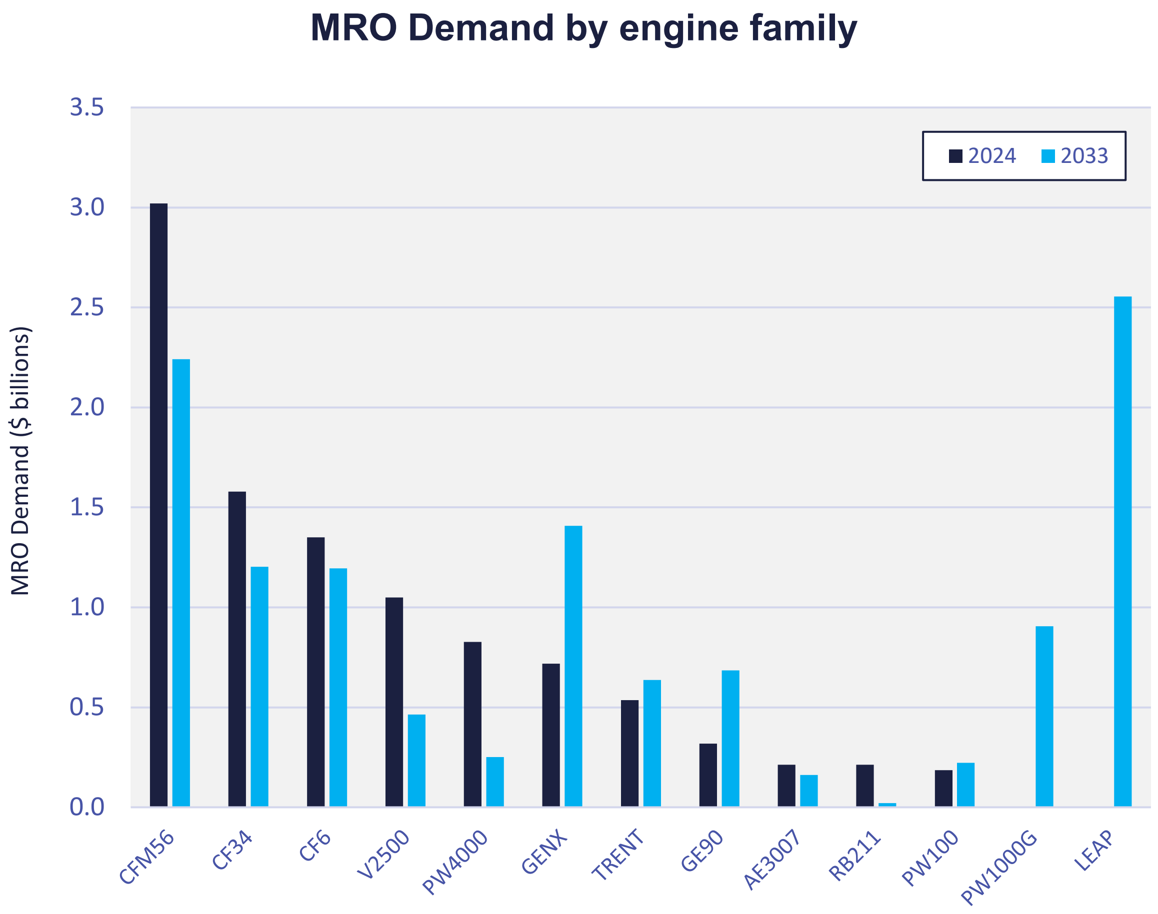
MRO Demand – Engine Family

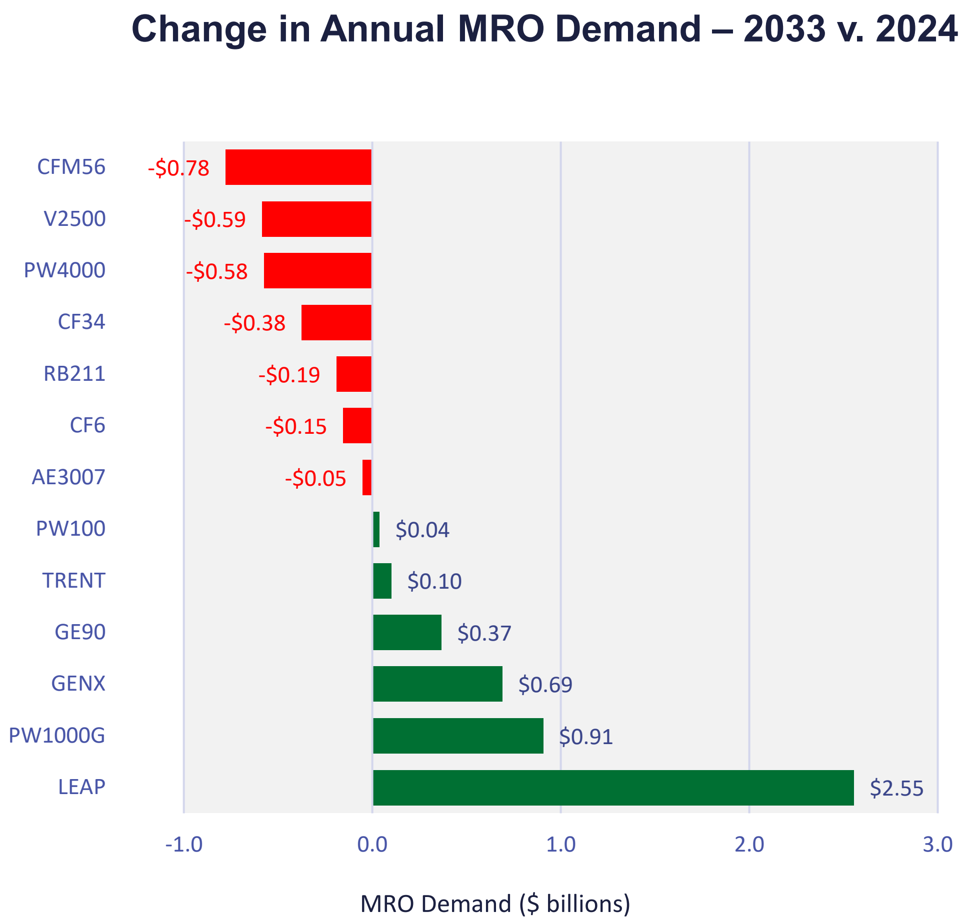




Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

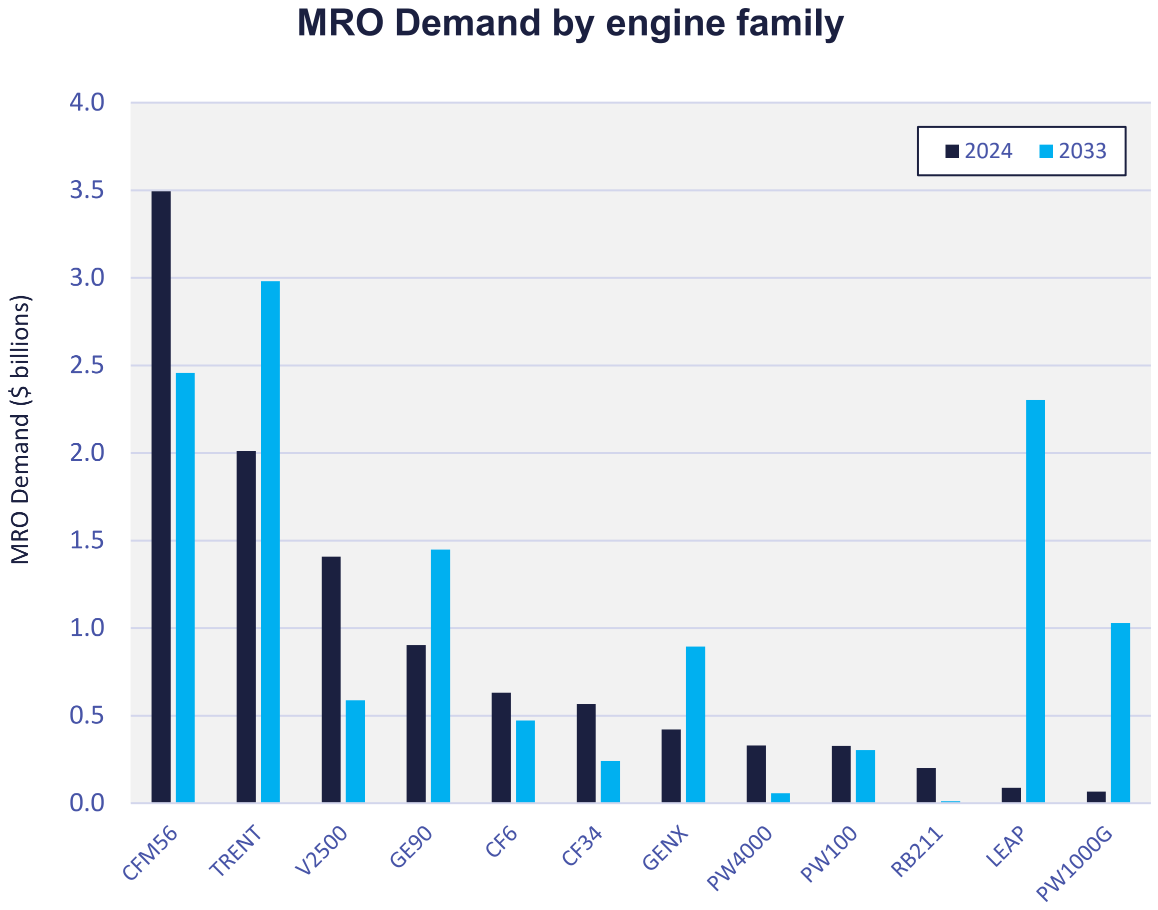
Engine MRO Demand – North America

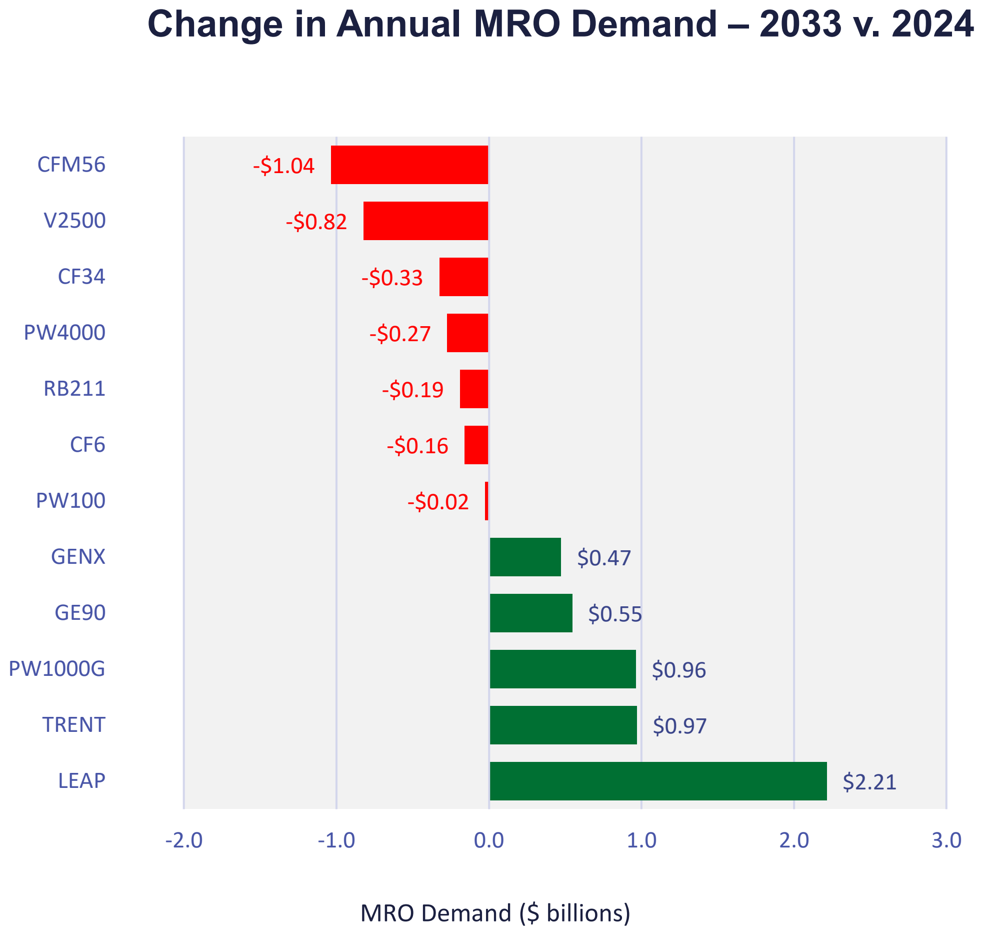




Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

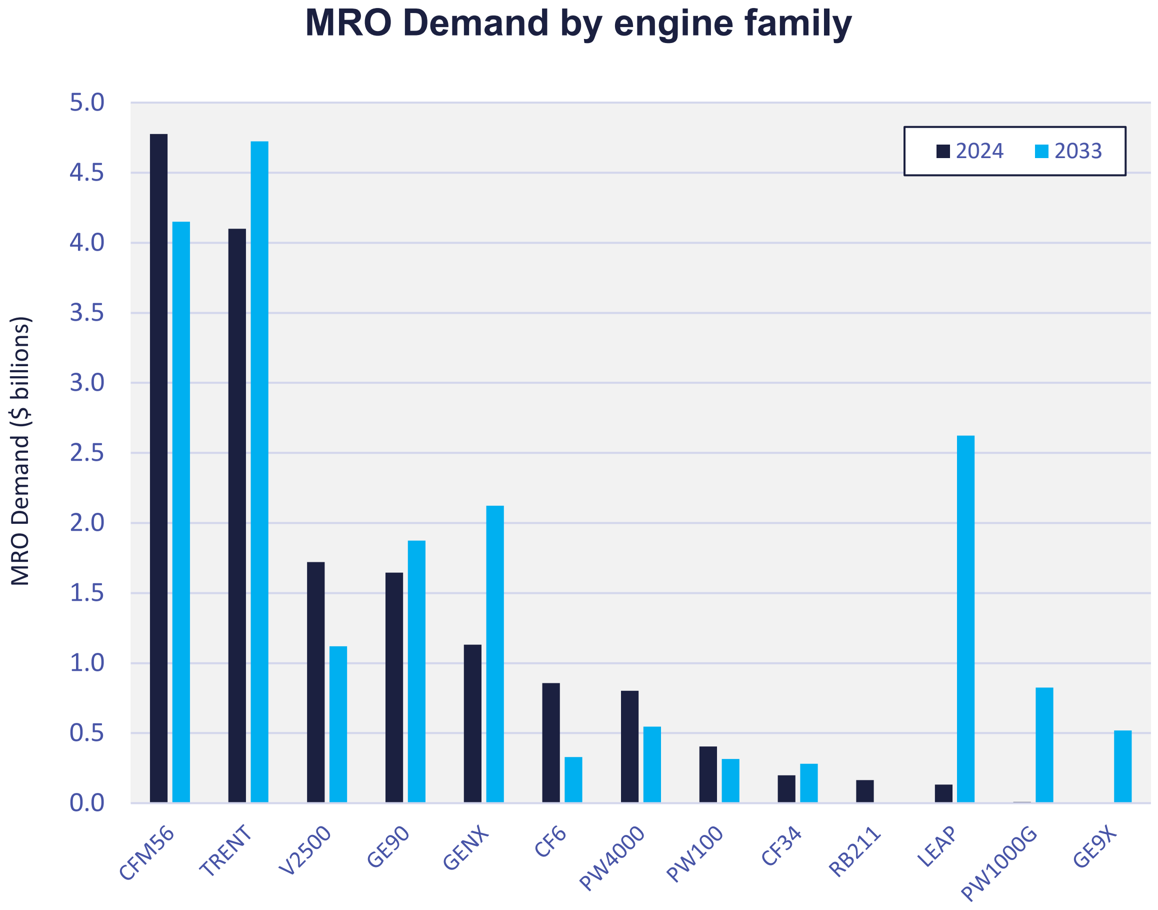
Engine MRO Demand – Europe

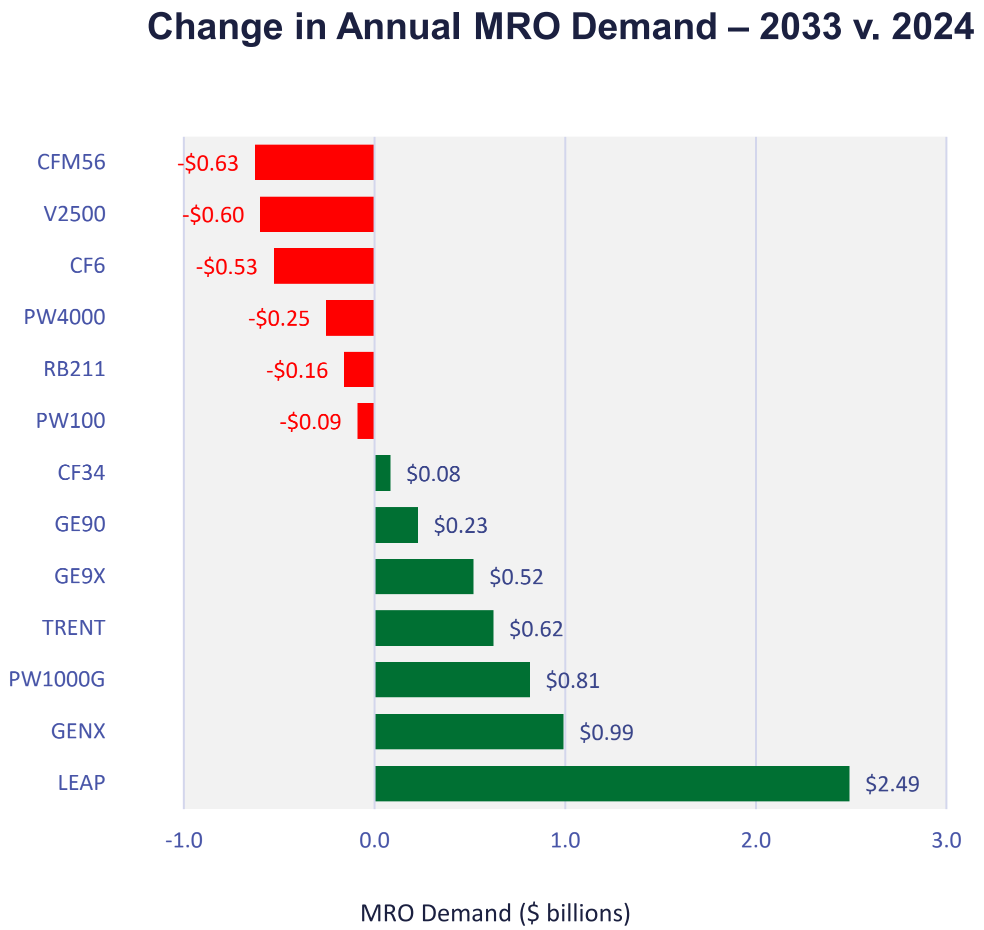




Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

Engine MRO Demand – Asia Pacific and China

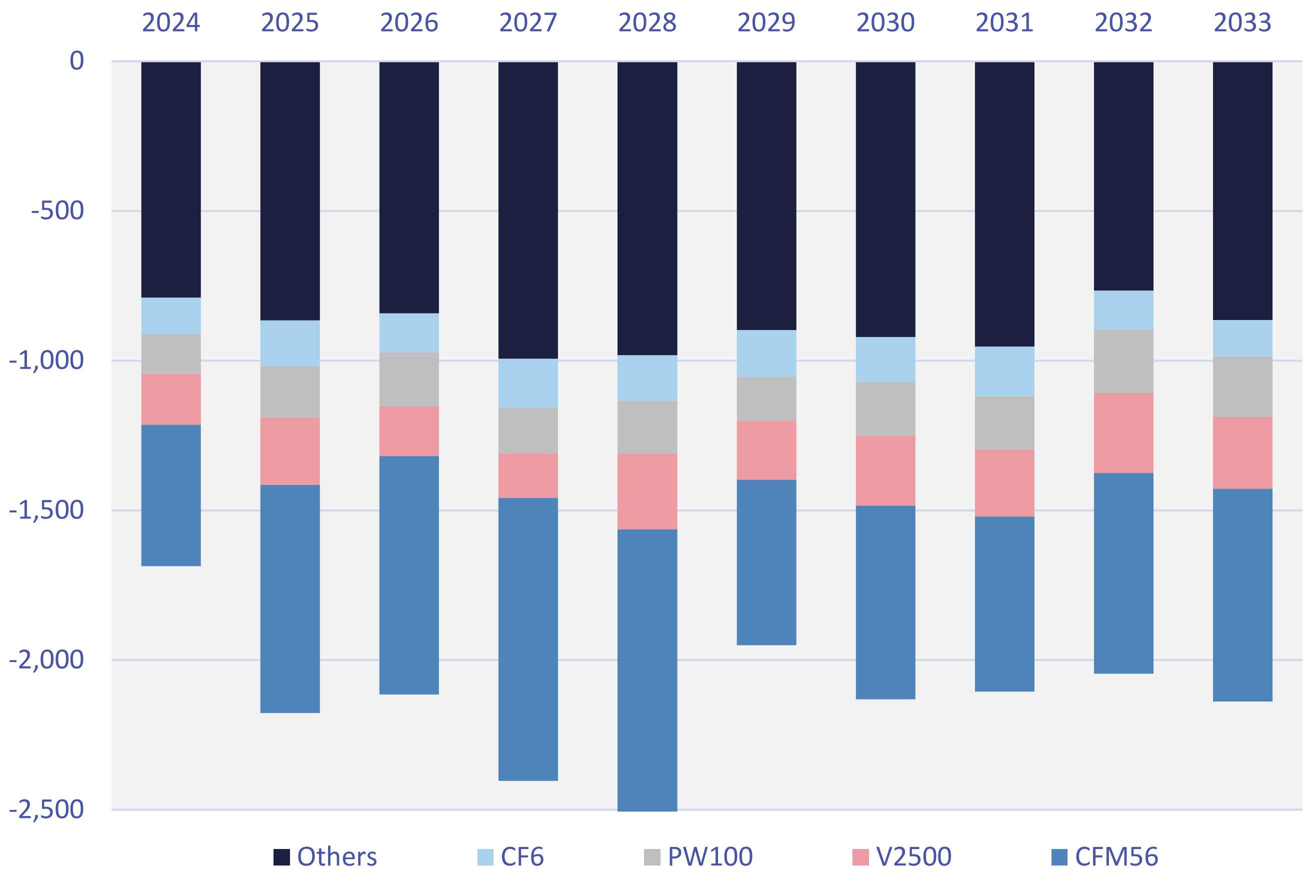




Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 new generation engine technical upgrade events not included.

Commercial Engines – USM and Green Time

Engines associated with retiring aircraft, potentially available as used serviceable material (USM) or green time spares



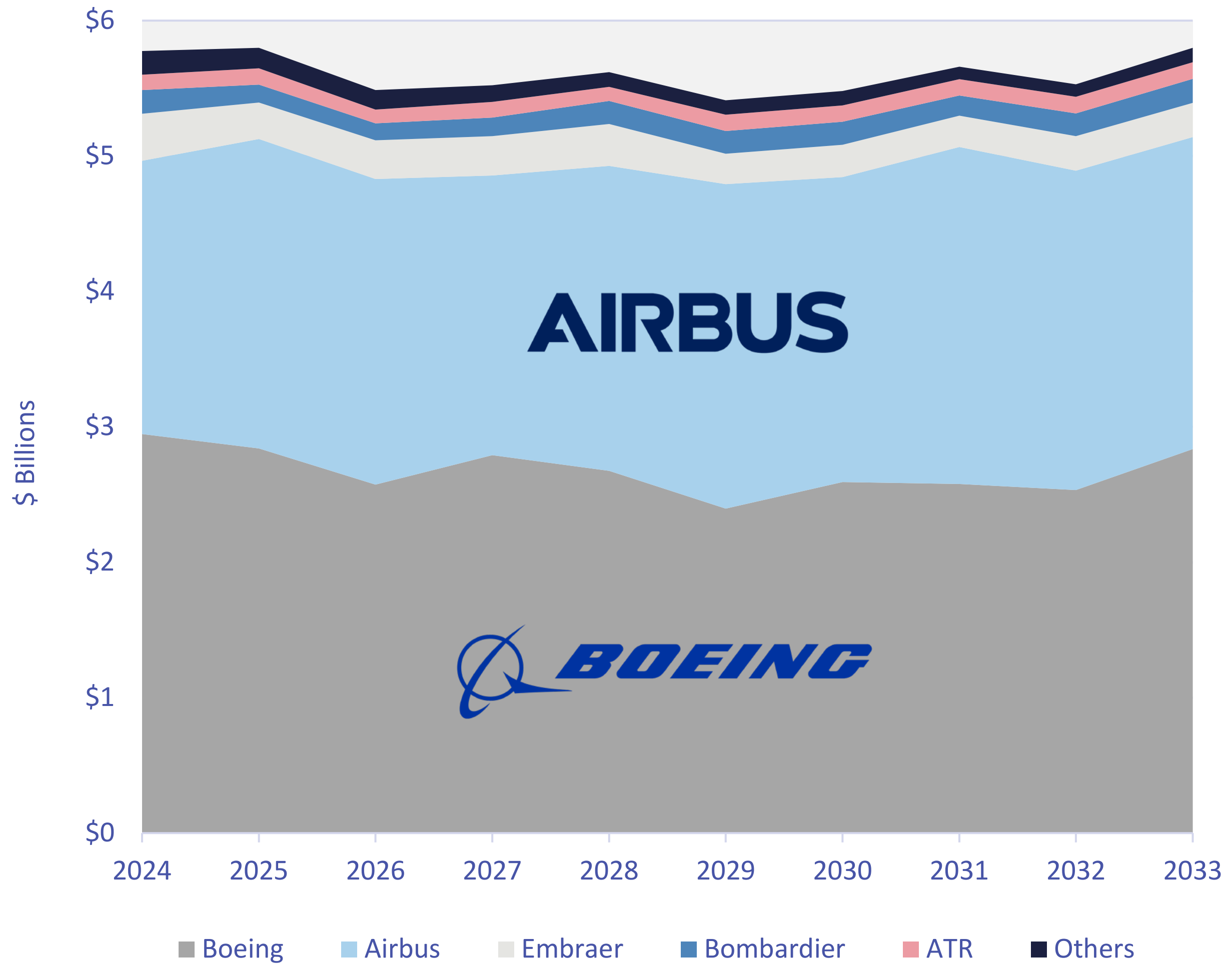
Over the course of the forecast, the retirement of large numbers of legacy aircraft is expected to have significant impact on engine MRO market demand. Topping the list, 7,000 CFM56s, 2,100 V2500s and 1,700 PW100s powerplants are associated with retiring airframes, providing many engines – potentially with green time – to become available for legacy aircraft that remain in service. These engines will be available either as complete powerplants (spares) or as components after part out (USM).

While retirements of aircraft have not been meeting expectations in the last few years, withdrawals are expected to gather pace as the decade progresses. Operators now generally chose to store or park aircraft rather than retire them permanently. This has the potential to apply downward pressure on the material cost of shop visits as engines reaching limits are exchanged for ones with green time. Similarly, the use of USM from legacy engines has the potential to reduce costs through the abundance of USM relating to these popular engine families.

Trends prior to 2023 suggest that both airframe and engine maintenance events were avoided by switching aircraft and engines between parked and active fleets to delay maintenance costs. However, the wave of shop visits/overhauls is now evident. Additionally, new generation engine hospital visits are creating additional demand to keep legacy aircraft flying. Once this constraints and others, such as materials and supply chain issues are resolved, look forward to increasing airframe retirements.

Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

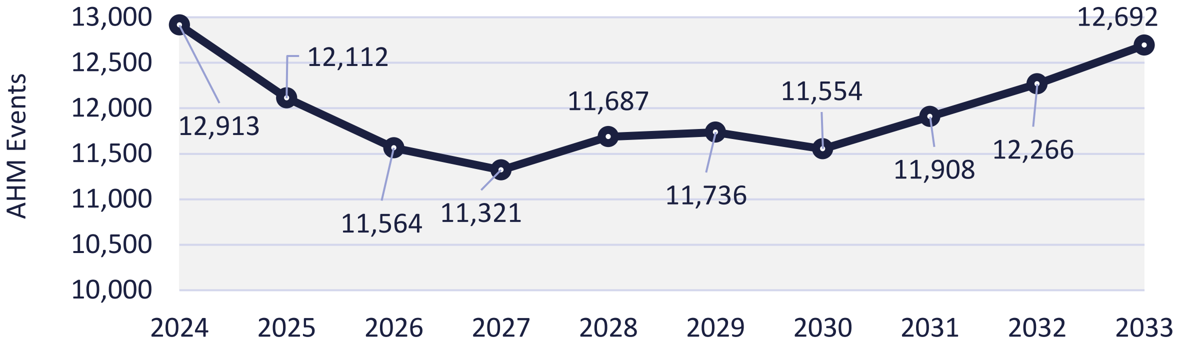
MRO Demand – Airframe Heavy Maintenance



$56.1 billion is expected to be spent on airframe heavy maintenance (C & D checks) over the next decade; however, CAGR remains unchanged –the lowest rate of any MRO category. Annual demand is expected start at a peak of $5.8 billion in 2024, decline over the following years, and return to that level in 2033 2033.

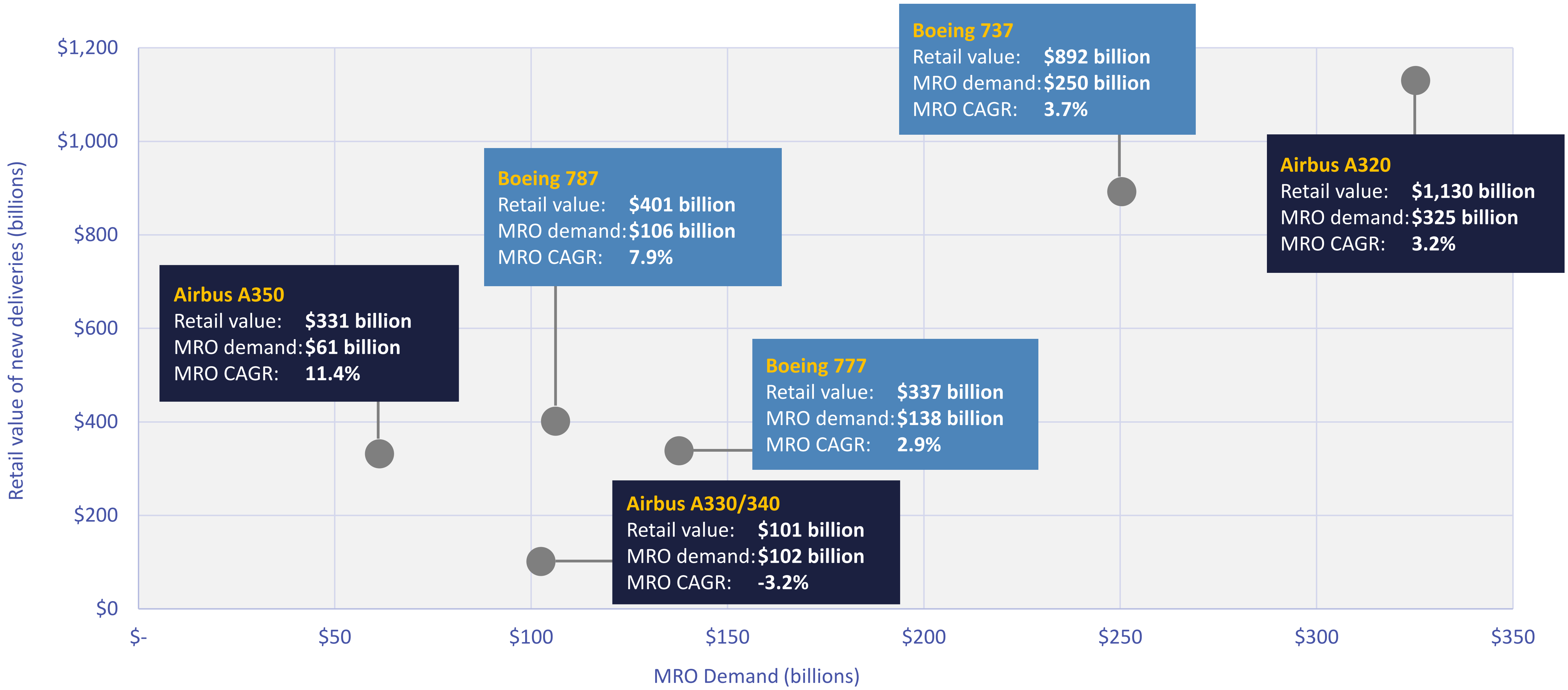
The biggest driver is Boeing who's AHM demand will shrink because of intervals between check events is increasing for newer generation aircraft. Legacy aircraft such as the 737 Classic, 767 and 747 which have 18–24-month C Check and 72-96-month D Check intervals are being replaced by new generation aircraft with 36-month C Check and 108-month D Check intervals. In contrast, Airbus, who generally has had longer intervals, will see demand increase 14% over 10-years.

Another factor is stored aircraft. Over 1,200 aircraft stored long-term are expected to return to service between 2024/25 which creates an expectation that most will require a C Check before returning to revenue service. This creates an initial bow wave of C Checks in 2024. Other timing and fleet factors take over in the intervening years, while eventually ending up near the same level due to organic growth.



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.

Most Valuable Aircraft Programs – Aircraft Family (2024-33)



Source: 2024 Commercial Aviation Fleet & MRO Forecast, Fleet Discovery, Aviation Week Network, Copyright 2023.
Note: 2024/2025 engine technical upgrade events not included in MRO demand.

Methodology

Methodology

Overview

Market Summary Reports are a synopsis of the forecast and represents a highlight of the extensive dataset of fleet and MRO information complied in-house by the Aviation Week Network Intelligence & Data Services' research. The comprehensive forecast dataset is available via an online business-information (BI) tool. Users may customize analysis by filtering through various categories—such as: aircraft family/group/type/categories, geographic regions, OEMs, engines and operators as well as MRO categories or expense types—to yield customized data, graphs and table displays for any segment of the fleet and MRO projections. Dedicated summary, regional, fleet, engine, MRO and MRO event tabs provide users with access to the most sought-after information for strategic planning. Projections by the Aviation Week Fleet & MRO Forecast commercial aviation segment are predicated on data for estimated aircraft production, deliveries, retirements and resultant in-service fleets, as well as projections for maintenance requirements based on historical and future trends, aircraft operating economics, regional variations, variable labor rates and ownership types. This independent industry resource combines Aviation Week's aircraft fleet database information, Fleet Discovery, with past/projected utilization, OEM hour/cycle/calendar MRO service intervals along with service cost assumptions to develop an MRO forecast for strategic decision-makers and analysts. Its dedicated research team, with more than 150 years of industry experience, acquires first-hand information and developments from industry surveys, OEM data feeds, and guidance from external advisory board contributors representing top-tier OEMs, MRO providers, consultants and independent analysts.

Scope

The forecast examines the 10-year (**2024-33**) market for commercial turbine-powered aircraft with seating capacities greater than 19 seats and most freighters in commercial service. It projects fleet and MRO demand across nine world regions (see map and appendices). The aircraft scope encompasses the entirety of the world's Western-built commercial fleets as defined by type and/or operator.

Forecast World Regions – See also Appendices

Included

The forecast includes commercial aircraft operated in scheduled airline service, nonscheduled airline service, cargo/freight operations, and commercial types in *civil* government service. Additionally, these popular aircraft are included by virtue of being *powered* by Western engines:, Comac C919, and Comac ARJ21.

Excluded

The Sukhoi Superjet 100 and Irkut MC-21 are excluded this year due to engine manufacturer change.

Types operated by or operated for a military service are excluded. Military *operators* of commercial or crossover types such as the Dornier Do228, Boeing 737 (P-8), Boeing 707 (E-3), Boeing 767 (KC- 46), de Havilland DHC-6, Embraer 110 and McDonnell Douglas DC-10 are also excluded.

Likewise, business types: Airbus ACJs, Boeing BBJs, Embraer Lineage (ERJ190)/Legacy (EMB135), and Challenger 800/850/870/890 (CRJ-200/700/900) are excluded.

The number of in-service (not stored) aircraft and utilization projections are combined in each of ten forecast years to create a model of fleet strength and potential utilization and MRO demand at multiple levels such as aircraft family/group, ATA chapter code, engine, OEM, operator, region and country.

Methodology

The summation of an extensive dataset of fleet and MRO information is complied in-house by the Aviation Week Network, Intelligence & Data Services. Assumptions within the model reflect estimates for dollar demand, hourly costs and/or shop-visit events at the airframe, engine and/or the Air Transport Association (ATA) Chapter Code levels, which are derived from primary research, manufacturers, survey data, and/or industry standards.

Aviation Week does not model characteristics of individual operators; data or outputs in the model do not reflect any single operator's specific airframe or engine maintenance programs, specific operating environment or aircraft retirement policies. MRO yields represent *average* costs for a given utilization, which is customized by aircraft type and operating region dynamics. For a complete listing of aircraft in scope or country/region assignments, please see the appendices.

Fleet Modeling, Fleet Forecast, Models & Assumptions

The forecast modeling begins with the present active fleet initially tracked at the tail/serial number and operator levels and extracted from Fleet Discovery. The total in-service fleet for each subsequent year is calculated by factoring in projected annual deliveries and decrementing retirements. The effects on fleet totals of parked/stored or destroyed aircraft also are calculated to determine annual in-service fleet values. Stored aircraft are *not* counted as active and do not add any MRO requirements but are not retired either; however, predictions on their return from storage are estimated and shown in the online tool.

Deliveries

New aircraft forecast deliveries are based on an analysis combining general macro-economic factors, known *firm* orders and production capacity - especially in the case of narrowbodies. Order and delivery estimates are created for the period beginning with confirmed firm orders announced by OEMs for specific operators by year and type. *Firm orders* are assigned to operators and individual countries. *Expected* delivery estimates fill any gaps between firm orders and what the market is anticipated to receive based on production capacity and economic conditions. The balances of expected orders are then allocated by region based on projected economics-driven demand, but *not* assigned to individual operators or countries. "Fleet entries" is the term used for aircraft that are returning to active service from storage/parked status or after undergoing passenger-to-freighter conversions.

New-production deliveries are expected to be significantly dependent on the certification and the delivery velocity capability of manufacturers, especially for the Boeing 737 MAX and Airbus A320 aircraft. The final certification outcome of the Max 7 and 10 as well as the production velocity capabilities for the Airbus A321 XLR remain speculative.

Retirements & Parked/ Stored Aircraft

Projections for turbofan aircraft are assigned among candidates with specified age/airframe criteria and then evaluated by group/type, both regionally and overall, by industry experts for consensus and final adjustments. Turbofan retirement assumptions follow a specific unique formula.

Hierarchy - Typology

Aircraft Hierarchy (Arranged from highest to lowest level)	MRO Major Categories & Expense Types
Family	Airframe Heavy Maintenance
Group	Components
Type	Engine
Model (unused)	Line Maintenance
	Modifications

Methodology – In-Service Fleet Calculation

2023 Year-End Projected In-Service Fleet + **2024 Fleet Entry Projections** − **2024 Fleet Removal Projections** = **2024 In-Service Fleet**

Aircraft in-scope fleet data extract at the end of 2023 becomes the starting point for year one (2024) of the 2024-2033 forecast

+ New-build deliveries in 2024 are added to the in-service fleet.
+ Returns from long-term storage.
+ Converted passenger-to-freighter aircraft (PTF).

- Retirements in 2024 are subtracted.
- Aircraft selected for conversions to freighters are removed.

In-service fleet net result is the active fleet for one year. Each individual aircraft in-service drives future MRO demand.

This algorithm provides year one (2024) of the active, in-service fleet for the 2024-2033 forecast. The process repeats for the subsequent years in the forecast.

Methodology

Retirements & Parked/Stored Aircraft (cont.)

After a minimum *trigger* retirement age is reached—which varies by aircraft model and role—aircraft are retired with their next heavy-maintenance event, D Check, in mind.

Turboprop projections are based solely on airframe age and initially are randomly distributed among candidates with specified age/airframe criteria and then evaluated by group/type, both regionally and overall, by industry experts for consensus and final adjustments. Retirement curves are recalibrated with fleet data during the analysis, leading up to the forecast release to incorporate the latest data by type for both utilization and actual retirements.

In the online interface, care should be taken to select appropriate filtering between traditional retirements as mentioned above and fleet departures for passenger-to-freighter conversions.

Stored (sometimes called parked) aircraft analysis is based on several factors, including assessment of future demand, age and relative attractiveness of a particular type. Parked aircraft returned to active service are specifically noted in the forecast model and allocated to roles, regions and the year of their projected return. Should an aircraft be stored for a prolonged period, it is evaluated and retired from the active fleet if assessed as unlikely to return - these retirements are not counted in the modeling, only retirements from active service are enumerated.

In May 2020 over 12,000 aircraft entered long term storage! In September of 2022, nearly 5,000 aircraft remained in storage not including less formal, locally “parked” aircraft. Stored aircraft do not generate MRO demand, but temporarily parked aircraft do. The return from storage estimation is critical again this year. Nearly 1,850 are expected to come out of storage by 2024. More details are found in the online tool.

Retail Price-Based Valuations

Aviation Week examines the value of new deliveries and MRO over the 10-year period in *constant 2023 U.S. dollars*. The study uses advertised retail prices and does not adjust for discounts. To draw conclusions about the future market, the examination looks at regional distribution by year of aircraft-size classes, aircraft families, manufacturers and roles.

MRO Modeling

A life-cycle algorithm loop models each aircraft type, from service-entry date through retirement. The utilization database is fed by historical OEM utilization data and augmented significantly with in-house flight tracking data. Utilization is projected by region, aircraft size category, and type – mapping projected pandemic recovery aspects - and is used to drive most MRO demand projections. Calendar-based event triggers are also used which has become very important due to the large number of aircraft with deferred maintenance in long-term storage.

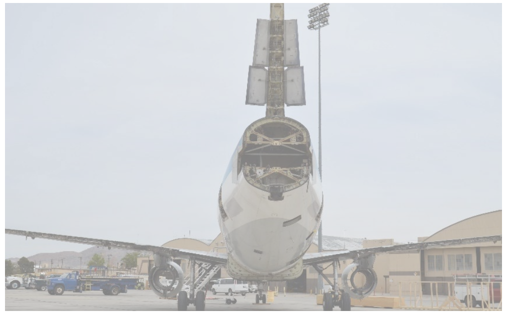
Data output includes maintenance demand such as engine service and airframe events based on projected utilization, component costs per flight hour and modification demand. In all, 42 distinct expense types are projected. Utilization changes based on actuals to date, the aircraft’s age, and its role and operating region also are considered with unique factors. Key parameters of the life-cycle loop then are fed back into the main algorithm.

Engine Methodology

Engine Service Event Scope:

Major maintenance service events are usually performed off the aircraft at an engine repair facility. Turbofan engines are assumed to be overhauled to manufacturer’s type-certificate specifications. On-condition and life limited component parts are inspected and/or replaced as necessary. The model assumes turbofans have each of four different events with unique costs and cycle intervals. Tech inserts, unscheduled engine removals, airworthiness-directive/service-bulletin compliance and dilution rates for spare engines are not assumed as unique events, but compliance costs during overhauls are built into the event. Cycle event-trigger algorithms are used to note when an event should occur, and the corresponding expense/demand is recorded. In general, events are based on historical engine fleet-wide averages applied to unique predicted events. No factors are applied for a specific operators for proprietary engine maintenance practices/schedules assumed under their certification authority; however, harsh environmental condition factors are applied by country location. Turboprop engines follow the same modeling as turbofan engines.

Retirement Processing/Algorithm – MRO Informed Retirement Projections



Drivers/Considerations

- Aircraft economics
- Engine economics
- Stored fleet types, storage history
- Lease rates
- Future viability as a passenger-to-Freighter (PTF) conversions
- Value as scrapped USM
- Heavy Maintenance Visit (HMV) costs/economics

Passenger-to-Freighter (PTF) conversions, add to in-service fleet

Credit: Brian Kough, Aviation Week Network

INPUTS - AIRCRAFT FLEET DATA

- Assign or calculate age of each aircraft using the starting, baseline in-service fleet.
- Assign or calculate current utilization hours and cycles per aircraft of the in-service fleet.

ASSUMPTIONS – UTILIZATION, MRO & HMV TRIGGERS

- Project hour & cycle utilization
  - For each of 10 forecast years
  - For each aircraft category (NB, WB, freighter, etc.) and world region.
- Determine months, hours, and or cycles between maintenance events for AHM D Check (MRO assumptions) .

RETIREMENT TRIGGER AGES

- Evaluate historical fleet retirements by type to estimate average future retirement ages, determine: Initial retirement trigger, years past trigger, old age trigger, maximum retirement age.
- Evaluate current aircraft economics/popularity by type (subjective SME).
  - Fleet counts
  - Historical retirement ages
  - Storage activity
  - Intelligence on subject aircraft

RETIREMENT SELECTION – ALGORITHM & SME INTERVENTION

SME QUALITY ASSURANCE REVIEW

- Assign old age trigger to each aircraft.
- Determine retirement ages - calculate by adding trigger + year to retire (for those not already too old).
- Any aircraft past trigger age is assigned the maximum retirement age as the age to retire, then further D Check logic is used.
- Identify the projected HMV D Check event timing for aircraft within the window.
- D-check logic. When an aircraft is in-service and has not been retired by one of the above algorithms, then it is evaluated for the next D-check past the old age trigger and retired at estimated D Check timing.
- If intelligence exists to support retiring aircraft earlier, an additional step to remove aircraft manually from the fleet is included; likewise, to retain aircraft, manual intervention is required.

SME QUALITY ASSURANCE REVIEW

Methodology

Engine Service Event Modeling

Engine events are forecast based upon the following parameters:

- Aircraft projected flight cycles per year
- Engine projected flight cycles per year
- Average fleet engine service intervals (average engine cycles between shop visits derived from OEMs and surveys of MROs) triggered uniquely by projected utilization.

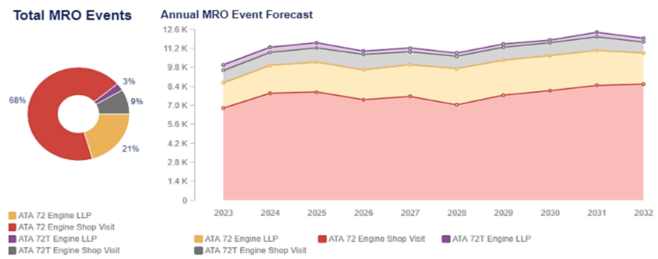
The model links the engines continuously to the aircraft. Roughly speaking, the algorithms make the following calculations: engine utilization history + projected utilization in Year 1 + projected utilization in Year 2, and so on. Once the aircraft/engine combination arrives at a cycle trigger limit, a service event is counted, and its corresponding costs are recorded against that airframe/engine combination.

See also the new unscheduled engine event modeling, aka hospital visits.

Engine Count Modeling

Aircraft deliveries, retirements and in-service fleet counts are proxies for engine counts in the forecasts. For example, when the forecast shows a Boeing 737 MAX delivered, the model adds two Leap-1Bs to the engine in-service fleet. At that point, utilization starts accruing for the aircraft/engine combinations and MRO demand accrues for event triggers. As an aircraft is retired, the corresponding engines are retired in the model. The forecast does not account for spare engines at operators or MROs.

Engine Event Reporting



E195-E2

Credit: Brian Kough, Aviation Week Network

Airframe Methodology

Airframe Service Event Scope:

Airframe events include multiple different maintenance events per aircraft based on manufacturers' designated service intervals.

Events are categorized and forecast under both line maintenance and airframe heavy maintenance. (See the appendices for a breakout of these categories into expense types and definitions).

Generally, these categories include:

- **Line maintenance**: aircraft A checks, daily and weekly checks, transit check/turnaround checks/preflight checks and other scheduled line maintenance, if appropriate.
- **Airframe Heavy C check**: aircraft C checks (extensive system/component checks) excluding line/light maintenance and major modification programs.
- **Airframe Heavy D check**: aircraft D checks or four C checks (extensive structural and system component checks) excluding line/light maintenance and major modification programs.

Methodology

AKA Engine Hospital Visits

A new feature this year is accounting for major, unscheduled but known maintenance events. These are limited in the forecast to two narrowbody engine families but have such a wide-ranging impact that it is important to note in the analysis. Nearly all current engines have had limited work scope, warranty-type procedures during their lifetime to correct deficiencies that arise after entry into service. These are manifested as Service Bulletins from the manufacturer recommending maintenance or worse case, Airworthiness Directives from the certification authority mandating maintenance.

Colloquially, these are known as “hospital visits” as they typically involve a limited work scope engine inspection and or component(s) replacement. In the case of the three issues projected, each are off-wing events. It is anticipated that most engine issues will be rectified in one ”service visit”, but the forecast accounts for each issue individually as an event, much like LLP accounting.

Aircraft engine hospital visits (ATA 72 Engine OEM Tech Upgrade - in the online tool) are calculated based on two known issues for the Pratt & Whitney GTF family and one for the CFM LEAP engine family.

Hospital Visits Forecasted

1. GTF - HPT #1 and #2 (4Q 2015 to 3Q 2021, date of MFG)
2. GTF - combustion/heat exchanger
3. LEAP - fuel nozzle/module upgrade

Per engine accounting for these issues is based on industry reporting for the scope, magnitude, and costs associated for the individualized repairs.

Potential Engine Fleet Strengths for Calculations			
Commercial Aircraft	**Engine Family (Models)**	**2024 Forecast** Engine **In-Service Fleet**	**2025 Forecast Engine In-Service Fleet**
737 Max 7/8/9/10 A319/320/321neo C919	**LEAP** (LEAP-1A, LEAP-1B, LEAP-1C)	8,074	NA
A220-100/300 A319/320/321neo A319/320/321neo E190/E195-E2	**PW1000G (GTF)** (PW1500G, PW1100G-JM, PW1900G)	4,850	5,804

The modeling assumption is that each engine will require one repair for each issue. The exception is the PW1000G (Issue #1) - for the powder metal issue affecting the HPT blades – it is limited to engines built between 4Q 2015 to 3Q 2021 inclusive. For this single issue, 2,288 engines are believed to be affected.

The other engines are assigned one issue each for rectification.

Methodology

AKA Engine Hospital Visits

The modeling algorithm builds a projection of *potential* dollar demand and events as each individualized operator case is impossible to account for using available information and tools. What is known is that actual, physical off-wing *service visits* will be far fewer than the *events* depicted, i.e., they will have combined work scopes when inducted into an engine shop.

For instance, as a GTF engine is inducted into maintenance, it may potentially undergo as many as four procedures in one physical service visit: issue 1, issue 2, an LLP replacement, and a performance restoration (overhaul). It will depend on the age, cycles/hours, physical condition, warranty status, and decisions of each individual engine's owner/operator as to the work scope involved. Similarly, a LEAP engine could undergo three issue repairs: issue 3, LLP replacement, and a performance restoration. What is known is that many issues will be combined into a single service visit due to economics, but it is very difficult to account for which ones and when.

Another permutation is that aircraft engines operated in harsh environments/high particulate air are more susceptible to needed upgrades sooner than those in more benign environments. Similarly, engines used on heavier aircraft variants (higher thrust limits) are more susceptible to earlier repairs too.

The dollar demand annual totals are given high confidence as each issue is likely to occur as forecasted, i.e., we have high confidence in their costs per engine and therefore annually. However, predicting the *timing* of the completion of events/issues is left to the judgement of the user. We felt compelled to separate out these issues into events so that users may make their own assessments as to timing and combinations as many have detailed, on the ground experience in these markets.

Users of the online forecast tool may "toggle" between seeing the hospital visit's dollar demand and events and not seeing them by using the MRO filters. Also, extensive use of the other available forecast filters provides more granular insights into our projections, for example, years, regions, aircraft types, engine types, other projected engine events, etc.

Credit: Nigel Howarth, Aviation Week Network

Methodology

Airframe Service Event Modeling

Airframe demand is modeled by applying triggering assumptions for average time (hours or cycles), or date (calendar) intervals for each active aircraft in-service during each forecast year. Once an aircraft reaches an event trigger, costs for that service are recorded in the model for that aircraft.

Costs are applied for both labor and material for A, C and D checks. Labor costs vary by operator region based on prevailing rates. Material costs are established on prevailing fleetwide averages and applied uniquely to each active aircraft per event sequence, i.e. C1, C2, C3, or D2, etc. Each event sequence has both unique material costs and unique labor hours. Demand is calculated for each forecast year when the events trigger, on a constant dollar basis.

Example: **AHM event C3 = C3 material costs + (C3 labor hours x regional labor rate)**

Components Methodology

Most component costs are based on cost-per-flight-hour factors, e.g., $10.35 per each flight hour of utilization. As an individual airframe accrues hourly utilization in the model, these factors are applied per the projected utilization for each airframe/operator region combination for each forecast year. Demand accrues and is aggregated on an annual basis at multiple levels: airframe, operator, region, OEM, TCH and other categories. Several components are tracked/forecasted on an event basis, such as landing gear and thrust reversers, where either hours, cycles, or calendar intervals are used to trigger unique maintenance spending events.

Credit: Brian Kough, Aviation Week Network

Assumptions

Fleet

Aviation Week's fleet database, Fleet Discovery, tracks individual aircraft by tail number/owner/operator and other attributes and combines operator-provided or derived utilization data to offer initial assumptions about the fleet's aircraft. These preliminary assumptions become the baseline for projections of utilization, MRO service events, and ultimately, MRO demand.

Delivery counts are projected to be influenced heavily by the expected continued entry into service of the un-grounded Boeing 737 MAX. This caused a spike in deliveries in 2021/2 and will again in 2023 from handovers of previously built, parked aircraft to their customers. Thus, careful examination will show depressed new aircraft *production* rates for Boeing while *deliveries* for Boeing will be artificially enhanced by the MAX deployment. Airbus A320 delivery rates are also being hampered by supply chain issues along with the 737. Used, stored aircraft will also display above normal fleet entries, especially in year 2023.

This models' growth prospects are predicated on a return to "normal" by the end of 2023 through 2024. A detailed utilization projection scheme models a return to the new normal by aircraft class, region and operator type. For example, widebodies in Western Europe operated by a passenger carrier in year 2023 might be projected at 89% of their 2019 rates. On the delivery side, accounting for depressed production rates is filled with uncertainty as supply chain issues play out and global economic forces provide headwinds. Our assessment has grown out of gaming likely scenarios and choosing the most likely outcome.

MRO

MRO dollar-demand—based on unique per-aircraft utilization projection assumptions and fleet turnover—shows demand for services and material increasing at a 2.8% CAGR. This is *abnormal* territory, slightly lower than last year's 3.2%, and lower than the fleet CAGR of 3.5%. It is based on a statistical condition (a higher start point - the fleet experienced a decline throughout 2020-21 and has now returned to a new normal), and MRO demand's constant-dollar velocity vector is slower than in 2022.

The total demand for MRO will surpass $1,027 billion and is up from $1,013 billion total in the 2022-31 forecast. Also contributing is the penchant for operators to favor newer generation aircraft when they return to service, making an overall lesser maintenance footprint. Comparing last year's 10-year forecast with this forecast period shows heavy airframe, modifications, line maintenance and components all increased on an absolute basis by $20.3 billion. Engine MRO demand decreased $5.9 billion on an absolute, constant dollar-basis.

Methodology

Fuel Consumption & Emissions Projections

Fuel Consumption

Consumption or fuel burn is calculated based on nominal values as recognized by Eurocontrol standards. These baselines are combined with Aviation Week Network proprietary assumptions, calculations, and forecasts to provide an estimate of future values for each forecast year. In all cases, nominal values are used for number of seats per aircraft (Aviation Week) and fuel burn (Eurocontrol) while hourly utilization is an Aviation Week forecast projection.

Engine Emissions

Engine CO_2 emissions are calculated based on nominal values as recognized by Eurocontrol standards. These baselines are combined with Aviation Week Network proprietary assumptions, calculations, and forecasts to provide an estimate of future values for each forecast year. In all cases, nominal values are used for number of seats per aircraft (Aviation Week) and emissions (Eurocontrol) while hourly utilization is an Aviation Week forecast projection.

Analysis

Projected emissions and fuel consumption are highlighted in the online forecast dashboard along with various utilization metrics. Fuel consumption (fuel burn) and emissions are filterable by all the accompanying filter fields at the top of the tab. Supporting analysis, various headline reports and charts are provided to assist the user in visualizing the information for any given filterable scenario over the next 10-years.

Market Situation

Wild swings can occur rapidly in this market as we've seen, but pent-up passenger demand is returning, unevenly regionally. The major concerns now are global economic conditions and manufacturing capability.

The pandemic is the overarching shock still influencing this market. Its ramifications were severe and the new normal is uncertain as regulations, travel importance, and passenger behaviors are still being solidified. However, dramatic tail winds occurred for utilization in North America, Europe and is rising in Asia shadowed by newfound demands being placed on business aviation to fulfil high-end commercial passenger's demands. International traffic is still heavily impacted, but optimism in the commercial market is now high.

Economic, manufacturing and financial factors influenced this forecast. Debt levels and inflation is high in the Americas and Europe. Fuel costs are relatively high impacting margins. Capital costs are increasing rapidly, while the US dollar is at all time highs. Manufacturing issues include supply chain issues and labor shortages. The potential for continued economic softening in many regions, including inflation and recessions, could all potentially conspire to impact the commercial market before airlines are able to become profitable despite the nascent recovery.

General Assumptions

Delivery predictions are derived from OEM production estimates, corporate announcements, one-on-one discussions, internal staff research, and are evaluated against external and internal sources before forecast release. GDP predictions from major sources are used to estimate overall economic conditions over the forecast period and shape the end results.

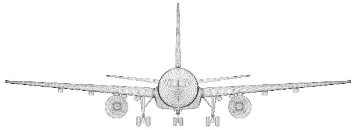
Model assumptions reflect estimates for aircraft utilization that influence service intervals as well as average costs at the airframe, engine, modification, component and line-maintenance levels. The forecast does not model characteristics of individual operators nor their unique maintenance programs; however, it does provide valuable market trend information for strategic investment and decisions.

Constant U.S. 2023 dollars, without adjustment for inflation or escalation, are used in all cost figures. Additionally, material costs and regional labor rates are not escalated in MRO assumptions, but costs are adjusted for inflation in each annual release of the forecast.

Future global and regional recessions and/or major geopolitical shocks cannot be predicted and are not accounted for in the forecast; however, current global risks and trends are accounted for to shape the forecast results.

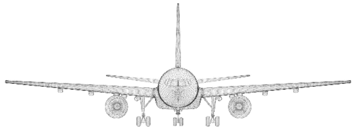
Appendices

Appendix – Aircraft In-Scope



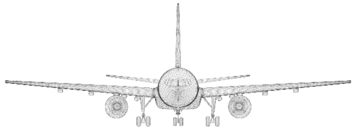
Type Certificate Holder	Original Aircraft Manufacturer	Aircraft Group	Aircraft Category
328 Support Services	Avcraft Aviation	328JET	Regional Jet
328 Support Services	Dornier	328JET	Regional Jet
328 Support Services	Fairchild-Dornier	328JET	Regional Jet
328 Support Services	RUAG	328JET	Regional Jet
Airbus	Airbus	A220-100	Narrowbody Jet
Airbus	Airbus	A220-300	Narrowbody Jet
Airbus	Airbus	A300	Widebody Jet
Airbus	Airbus	A300-600	Widebody Jet
Airbus	Airbus	A310	Widebody Jet
Airbus	Airbus	A318	Narrowbody Jet
Airbus	Airbus	A319	Narrowbody Jet
Airbus	Airbus	A319NEO	Narrowbody Jet
Airbus	Airbus	A320	Narrowbody Jet
Airbus	Airbus	A320NEO	Narrowbody Jet
Airbus	Airbus	A321	Narrowbody Jet
Airbus	Airbus	A321NEO	Narrowbody Jet
Airbus	Airbus	A330-200	Widebody Jet
Airbus	Airbus	A330-200F	Widebody Jet
Airbus	Airbus	A330-300	Widebody Jet
Airbus	Airbus	A330-300F	Widebody Jet
Airbus	Airbus	A330-700L	Widebody Jet
Airbus	Airbus	A330-800	Widebody Jet
Airbus	Airbus	A330-900	Widebody Jet
Airbus	Airbus	A340-200/300	Widebody Jet
Airbus	Airbus	A340-500/600	Widebody Jet
Airbus	Airbus	A350-1000	Widebody Jet
Airbus	Airbus	A350-900	Widebody Jet
Airbus	Airbus	A350-950F	Widebody Jet
Airbus	Airbus	A380	Widebody Jet
Airbus	Airbus	BELUGA	Widebody Jet
Airbus	Bombardier	A220-100	Narrowbody Jet
Airbus	Bombardier	A220-300	Narrowbody Jet
ATR	ATR	ATR42	Turboprop
ATR	ATR	ATR72	Turboprop
ATR	ATR	ATR72F	Turboprop
BAE Systems	British Aerospace	ATP	Turboprop
BAE Systems	British Aerospace	BAE 146	Regional Jet
BAE Systems	British Aerospace	HS748	Turboprop
BAE Systems	British Aerospace	JETSTREAM31	Turboprop
BAE Systems	British Aerospace	JETSTREAM41	Turboprop

Appendix – Aircraft In-Scope, cont.



Type Certificate Holder	Original Aircraft Manufacturer	Aircraft Group	Aircraft Category
BAE Systems	Hawker-Siddeley Aviation	HS748	Turboprop
Boeing	Boeing	707	Narrowbody Jet
Boeing	Boeing	717	Narrowbody Jet
Boeing	Boeing	727	Narrowbody Jet
Boeing	Boeing	737-200	Narrowbody Jet
Boeing	Boeing	737-300	Narrowbody Jet
Boeing	Boeing	737-400	Narrowbody Jet
Boeing	Boeing	737-500	Narrowbody Jet
Boeing	Boeing	737-600	Narrowbody Jet
Boeing	Boeing	737-700	Narrowbody Jet
Boeing	Boeing	737-800	Narrowbody Jet
Boeing	Boeing	737-900	Narrowbody Jet
Boeing	Boeing	737-MAX10	Narrowbody Jet
Boeing	Boeing	737-MAX7	Narrowbody Jet
Boeing	Boeing	737-MAX8	Narrowbody Jet
Boeing	Boeing	737-MAX9	Narrowbody Jet
Boeing	Boeing	747-200/300	Widebody Jet
Boeing	Boeing	747-400	Widebody Jet
Boeing	Boeing	747-8	Widebody Jet
Boeing	Boeing	747-8F	Widebody Jet
Boeing	Boeing	747SP	Widebody Jet
Boeing	Boeing	757	Narrowbody Jet
Boeing	Boeing	767	Widebody Jet
Boeing	Boeing	767-200F	Widebody Jet
Boeing	Boeing	767-300F	Widebody Jet
Boeing	Boeing	777-200/300	Widebody Jet
Boeing	Boeing	777-200ER/LR	Widebody Jet
Boeing	Boeing	777-200F	Widebody Jet
Boeing	Boeing	777-300ER	Widebody Jet
Boeing	Boeing	777-300F	Widebody Jet
Boeing	Boeing	777-8F	Widebody Jet
Boeing	Boeing	777-9	Widebody Jet
Boeing	Boeing	787-10	Widebody Jet
Boeing	Boeing	787-8	Widebody Jet
Boeing	Boeing	787-9	Widebody Jet
Boeing	Douglas Aircraft	DC-9	Narrowbody Jet
Boeing	McDonnell Douglas	DC-10	Widebody Jet
Boeing	McDonnell Douglas	DC-8-60/70	Narrowbody Jet
Boeing	McDonnell Douglas	DC-9	Narrowbody Jet
Boeing	McDonnell Douglas	MD-10	Widebody Jet

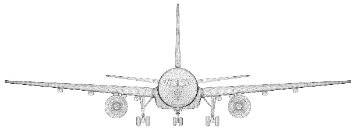
Appendix – Aircraft In-Scope, cont.



Type Certificate Holder	Original Aircraft Manufacturer	Aircraft Group	Aircraft Category
Boeing	McDonnell Douglas	MD-11	Widebody Jet
Boeing	McDonnell Douglas	MD-80	Narrowbody Jet
COMAC	COMAC	ARJ21	Regional Jet
COMAC	COMAC	C919	Narrowbody Jet
De Havilland Aircraft of Canada	Bombardier	DHC-8-100/200	Turboprop
De Havilland Aircraft of Canada	Bombardier	DHC-8-300	Turboprop
De Havilland Aircraft of Canada	Bombardier	DHC-8-400	Turboprop
De Havilland Aircraft of Canada	De Havilland Aircraft of Canada	DHC-8-400	Turboprop
De Havilland Aircraft of Canada	de Havilland Canada	DHC-8-100/200	Turboprop
De Havilland Aircraft of Canada	de Havilland Canada	DHC-8-300	Turboprop
Deutsche Aircraft	Dornier	DO328	Turboprop
Embraer	Embraer	E190-E2	Regional Jet
Embraer	Embraer	E195-E2	Regional Jet
Embraer	Embraer	EMB110	Turboprop
Embraer	Embraer	EMB120	Turboprop
Embraer	Embraer	EMB135/140/145	Regional Jet
Embraer	Embraer	EMB170/175	Regional Jet
Embraer	Embraer	EMB190/195	Regional Jet
Embraer	Yabora Industria Aeronautica	E190-E2	Regional Jet
Embraer	Yabora Industria Aeronautica	E195-E2	Regional Jet

Type Certificate Holder	Original Aircraft Manufacturer	Aircraft Group	Aircraft Category
Embraer	Yabora Industria Aeronautica	EMB170/175	Regional Jet
Embraer	Yabora Industria Aeronautica	EMB190/195	Regional Jet
Fokker	Fokker	F-27	Turboprop
Fokker	Fokker	F-28	Regional Jet
Fokker	Fokker	Fk100	Narrowbody Jet
Fokker	Fokker	Fk50	Turboprop
Fokker	Fokker	Fk70	Regional Jet
General Atomics AeroTech Systems	Dornier	DO228	Turboprop
General Atomics AeroTech Systems	Dornier	DO228NG	Turboprop
General Atomics AeroTech Systems	Hindustan Aeronautics Ltd.	DO228	Turboprop
General Atomics AeroTech Systems	Hindustan Aeronautics Ltd.	DO228NG	Turboprop
General Atomics AeroTech Systems	RUAG	DO228NG	Turboprop
Hawker Beechcraft	Beech Aircraft Corporation	BEECH1900	Turboprop
Hawker Beechcraft	Raytheon Aircraft	BEECH1900	Turboprop
Indonesian Aerospace (PTDI)	Indonesian Aerospace (PTDI)	N219	Turboprop
Lockheed Martin	Lockheed	L-1011	Widebody Jet
M7 Aerospace	Fairchild Aircraft	METRO	Turboprop
M7 Aerospace	Swearingen	METRO	Turboprop
Mitsubishi	Bombardier	CRJ-100/200	Regional Jet
Mitsubishi	Bombardier	CRJ-700/900/1000	Regional Jet

Appendix – Aircraft In-Scope, *cont.*



Type Certificate Holder	Original Aircraft Manufacturer	Aircraft Group	Aircraft Category
Mitsubishi	Canadair	CRJ-100/200	Regional Jet
SAAB	SAAB	SAAB2000	Turboprop
SAAB	SAAB	SAAB340	Turboprop
Textron Aviation (Cessna)	Textron Aviation (Cessna)	CE408	Turboprop
Textron Aviation (Cessna)	Textron Aviation (Cessna)	CE408F	Turboprop
Viking Air	de Havilland Canada	DHC-6	Turboprop
Viking Air	de Havilland Canada	DHC-7	Turboprop
Viking Air	Short Brothers	SHORT330	Turboprop
Viking Air	Short Brothers	SHORT360	Turboprop
Viking Air	Viking Air	DHC-6-300G	Turboprop
Viking Air	Viking Air	DHC-6-400	Turboprop
Xi'an Aircraft Industrial Corporation	Xi'an Aircraft Industrial Corporation	MA700	Turboprop

Appendix – Engines In-Scope

Engine Manufacturer	Engine Family	Engine Model
Allison	AE2100	AE2100
BMW + Rolls-Royce	BR700	BR700
CFM International	CFM56	CFM56-2
CFM International	CFM56	CFM56-3
CFM International	CFM56	CFM56-5A
CFM International	CFM56	CFM56-5B
CFM International	CFM56	CFM56-5C
CFM International	CFM56	CFM56-7B
CFM International	LEAP	LEAP-1A
CFM International	LEAP	LEAP-1B
CFM International	LEAP	LEAP-1C
Engine Alliance	GP7000	GP7000
Garrett-AiResearch	TPE331	TPE331-1 to 8
Garrett-AiResearch	TPE331	TPE331-10/11
Garrett-AiResearch	TPE331	TPE331-12
Garrett-AiResearch	TPE331	TPE331-14
General Electric	CF34	CF34-10A
General Electric	CF34	CF34-10E
General Electric	CF34	CF34-3A
Allison	AE2100	AE2100

Engine Manufacturer	Engine Family	Engine Model
General Electric	CF34	CF34-3B
General Electric	CF34	CF34-8C
General Electric	CF34	CF34-8E
General Electric	CF6	CF6-50
General Electric	CF6	CF6-80A
General Electric	CF6	CF6-80C2
General Electric	CF6	CF6-80E
General Electric	CT7	CT7
General Electric	GE90	GE90
General Electric	GE90	GE90-110B
General Electric	GE90	GE90-115B
General Electric	GE90	GE90-94B
General Electric	GE9X	GE9X
General Electric	GENX	GENX-1
General Electric	GENX	GENX-2
Honeywell	TPE331	TPE331-1 to 8
Honeywell	TPE331	TPE331-10/11
International Aero Engines	V2500	V2500-A1
International Aero Engines	V2500	V2500-A5
General Electric	CF34	CF34-3B

Appendix – Engines In-Scope, *cont.*

Engine Manufacturer	Engine Family	Engine Model
Pratt & Whitney	JT3	JT3D
Pratt & Whitney	JT8D	JT8D
Pratt & Whitney	JT8D	JT8D-200
Pratt & Whitney	JT9D	JT9D-7A
Pratt & Whitney	JT9D	JT9D-7R4
Pratt & Whitney	PW1000G	PW1100G-JM
Pratt & Whitney	PW1000G	PW1500G
Pratt & Whitney	PW1000G	PW1900G
Pratt & Whitney	PW2000	PW2000
Pratt & Whitney	PW4000	PW4000-100
Pratt & Whitney	PW4000	PW4000-112
Pratt & Whitney	PW4000	PW4000-94
Pratt & Whitney Canada	PT6A	PT6A LARGE
Pratt & Whitney Canada	PT6A	PT6A MEDIUM
Pratt & Whitney Canada	PT6A	PT6A SMALL
Pratt & Whitney Canada	PW100	PW100 LARGE
Pratt & Whitney Canada	PW100	PW100 MEDIUM
Pratt & Whitney Canada	PW100	PW100 SMALL
Pratt & Whitney Canada	PW300	PW300
Pratt & Whitney	JT3	JT3D

Engine Manufacturer	Engine Family	Engine Model
Rolls-Royce	AE2100	AE2100
Rolls-Royce	AE3007	AE3007
Rolls-Royce	BR700	BR700
Rolls-Royce	DART	DART
Rolls-Royce	RB211	RB211-524BC
Rolls-Royce	RB211	RB211-524GH
Rolls-Royce	RB211	RB211-535
Rolls-Royce	SPEY	SPEY
Rolls-Royce	TAY	TAY600
Rolls-Royce	TRENT	TRENT1000
Rolls-Royce	TRENT	TRENT500
Rolls-Royce	TRENT	TRENT700
Rolls-Royce	TRENT	TRENT7000
Rolls-Royce	TRENT	TRENT800
Rolls-Royce	TRENT	TRENT900
Rolls-Royce	TRENT	TRENTXWB
Textron-Lycoming (AVCO)	LF507	LF507
Rolls-Royce	AE2100	AE2100
Textron-Lycoming (AVCO)	LF507	LF507

Appendix – Region-Country Alignments

Region	Country
Africa	Algeria
Africa	Angola
Africa	Botswana
Africa	Burkina Faso
Africa	Cameroon
Africa	Cape Verde
Africa	Central African Republic
Africa	Chad
Africa	Comoros
Africa	Congo
Africa	Côte d'Ivoire
Africa	Democratic Republic of the Congo
Africa	Djibouti
Africa	Egypt
Africa	Equatorial Guinea
Africa	Eritrea
Africa	Eswatini (Swaziland)

Region	Country
Africa	Ethiopia
Africa	Gabon
Africa	Gambia
Africa	Ghana
Africa	Guinea
Africa	Kenya
Africa	Lesotho
Africa	Libya
Africa	Madagascar
Africa	Malawi
Africa	Mali
Africa	Mauritania
Africa	Mauritius
Africa	Mayotte
Africa	Morocco
Africa	Mozambique
Africa	Namibia

Region	Country
Africa	Niger
Africa	Nigeria
Africa	Reunion
Africa	Rwanda
Africa	Sao Tome and Principe
Africa	Senegal
Africa	Seychelles
Africa	Somalia
Africa	South Africa
Africa	South Sudan
Africa	Sudan
Africa	Tanzania
Africa	Togo
Africa	Tunisia
Africa	Uganda
Africa	Zambia
Africa	Zimbabwe

Region	Country
Asia Pacific	Afghanistan
Asia Pacific	Australia
Asia Pacific	Bangladesh
Asia Pacific	Bhutan
Asia Pacific	Brunei
Asia Pacific	Cambodia
Asia Pacific	Cook Islands
Asia Pacific	East Timor
Asia Pacific	Fiji
Asia Pacific	French Polynesia
Asia Pacific	Hong Kong
Asia Pacific	Indonesia
Asia Pacific	Japan
Asia Pacific	Kiribati
Asia Pacific	Korea, Republic of
Asia Pacific	Lao People's Democratic Republic
Asia Pacific	Macau

Appendix – Region-Country Alignments, *cont.*

Region	Country
Asia Pacific	Malaysia
Asia Pacific	Maldives
Asia Pacific	Marshall Islands
Asia Pacific	Mongolia
Asia Pacific	Myanmar
Asia Pacific	Nauru
Asia Pacific	Nepal
Asia Pacific	New Caledonia
Asia Pacific	New Zealand
Asia Pacific	Pakistan
Asia Pacific	Papua New Guinea
Asia Pacific	Philippines
Asia Pacific	Singapore
Asia Pacific	Solomon Islands
Asia Pacific	Sri Lanka
Asia Pacific	Taiwan
Asia Pacific	Thailand

Region	Country
Asia Pacific	Tuvalu
Asia Pacific	Vanuatu
Asia Pacific	Vietnam
China	China
Eastern Europe	Albania
Eastern Europe	Armenia
Eastern Europe	Azerbaijan
Eastern Europe	Belarus
Eastern Europe	Bulgaria
Eastern Europe	Croatia
Eastern Europe	Czech Republic
Eastern Europe	Estonia
Eastern Europe	Georgia
Eastern Europe	Hungary
Eastern Europe	Kazakhstan
Eastern Europe	Kyrgyzstan
Eastern Europe	Latvia

Region	Country
Eastern Europe	Lithuania
Eastern Europe	Moldova
Eastern Europe	Montenegro
Eastern Europe	Poland
Eastern Europe	Romania
Eastern Europe	Russia
Eastern Europe	Serbia
Eastern Europe	Slovakia
Eastern Europe	Slovenia
Eastern Europe	Tajikistan
Eastern Europe	Turkmenistan
Eastern Europe	Ukraine
Eastern Europe	Uzbekistan
India	India
Latin America	Antarctica
Latin America	Antigua and Barbuda
Latin America	Argentina

Region	Country
Latin America	Aruba
Latin America	Bahamas
Latin America	Belize
Latin America	Bermuda
Latin America	Bolivia
Latin America	Brazil
Latin America	British Virgin Islands
Latin America	Cayman Islands
Latin America	Chile
Latin America	Colombia
Latin America	Costa Rica
Latin America	Cuba
Latin America	Dominican Republic
Latin America	Ecuador
Latin America	El Salvador
Latin America	Guadeloupe
Latin America	Guatemala

Appendix – Region-Country Alignments, *cont.*

Region	Country
Latin America	Guyana
Latin America	Haiti
Latin America	Honduras
Latin America	Jamaica
Latin America	Mexico
Latin America	Netherlands Antilles
Latin America	Nicaragua
Latin America	Panama
Latin America	Paraguay
Latin America	Peru
Latin America	Saint Martin
Latin America	Saint Vincent and The Grenadines
Latin America	Suriname
Latin America	Trinidad and Tobago
Latin America	Turks and Caicos Islands
Latin America	Uruguay
Latin America	Venezuela

Region	Country
Middle East	Bahrain
Middle East	Iran
Middle East	Iraq
Middle East	Israel
Middle East	Jordan
Middle East	Kuwait
Middle East	Lebanon
Middle East	Oman
Middle East	Qatar
Middle East	Saudi Arabia
Middle East	Syria
Middle East	United Arab Emirates
Middle East	Yemen
North America	American Samoa
North America	Canada
North America	Guam
North America	Saint Pierre and Miquelon

Region	Country
North America	United States
Western Europe	Austria
Western Europe	Belgium
Western Europe	Cyprus
Western Europe	Denmark
Western Europe	Faroe Islands
Western Europe	Finland
Western Europe	France
Western Europe	Germany
Western Europe	Gibraltar
Western Europe	Greece
Western Europe	Greenland
Western Europe	Guernsey
Western Europe	Iceland
Western Europe	Ireland
Western Europe	Isle Of Man
Western Europe	Italy

Region	Country
Western Europe	Jersey
Western Europe	Luxembourg
Western Europe	Malta
Western Europe	Netherlands
Western Europe	Norway
Western Europe	Portugal
Western Europe	San Marino
Western Europe	Spain
Western Europe	Sweden
Western Europe	Switzerland
Western Europe	Turkey
Western Europe	United Kingdom

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Airframe Heavy	Heavy Maintenance D Check	Major Airframe Heavy Maintenance/Base Maintenance	Aircraft "D" Checks (IL, 4C, 8C, etc.) - Extensive structural check. Excludes line / light maintenance and major modification programs.	Service inspections include visual/non destructive structure tests, corrosion, structural, deformation, cracking, other deterioration.
	Heavy Maintenance C Check	Minor Airframe Heavy Maintenance/Base Maintenance	Aircraft "C" Checks (PI, 1C, 2C, 3C, etc.) - Extensive system/component check. Excludes line / light maintenance and major modification programs.	Service inspections include extensive system and component checks, visual, functional, emergency systems, DC bus tie control unit, door seals, flight controls, APU, engine inlet, RAT deployment.
	Turboprop Airframe Heavy Maintenance	Major & Minor Airframe Heavy Maintenance Turboprop	Structural and extensive systems check. Excludes line / light maintenance and major modification programs.	Inspections include visual/non destructive systems and or structure tests, corrosion, structural, deformation, cracking, and deterioration.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Components (1/7)	ATA 21 Air Conditioning & Pressurization	Air Conditioning & Pressurization	Units and components which furnish a means of pressurizing, heating, cooling, moisture controlling, filtering and treating the air used to ventilate the areas of the fuselage within the pressure seals. Includes cabin supercharger, equipment cooling, heater, heater fuel system, expansion turbine, valves, scoops, ducts, etc.	Cabin air distribution system, pressure indicating system, cooling system, pressure sensors, pressure regulators, heating system, temperature control.
	ATA 22 Autoflight	Autoflight	Those units and components which furnish a means of automatically controlling the flight of the aircraft. Includes those units and components which control direction, heading, attitude, altitude and speed.	Autopilot, auto throttle.
	ATA 23 Communications	Communications	Those units and components which furnish a means of communicating from one part of the aircraft to another and between the aircraft or ground stations, includes voice, data, continuous wave communicating components, PA system, intercom and tape reproducers-record player.	Radios, data links, PA system, intercom, ACARS, voice recorders.
	ATA 24 Electrical Power	Electrical Power	Electrical units and components which generate, control and supply AC and/or DC electrical power for systems, including generators and relays, inverters, batteries, etc., through the secondary busses. Also includes common electrical items such as wiring, switches, connectors, etc.	Inverters, regulators, phase adapter IDGs/generators, electrical load distribution, engine starters.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Components (2/7)	ATA 25 Interior Equip & Furnishings	Interior Equip & Furnishings	Those removable items of equipment and furnishings mounted in the aircraft or contained in the flight, passenger, cargo, and accessory compartments. Includes emergency, buffet, and lavatory equipment. Does not include structures of equipment assigned specifically to other chapters.	Seats, carts, galleys, lavatories, storage compartments, emergency equipment: ELTs, life rafts, escape slides.
	ATA 26 Fire Protection	Fire Protection	Fixed and portable units and components which detect and indicate fire or smoke and store and distribute fire extinguishing agent to all protected areas of the aircraft; including bottles, valves, tubing, etc.	Fire/smoke detectors, fire extinguishing equipment, explosion suppression
	ATA 27 Flight Controls	Flight Controls	Components which furnish a means of manually controlling the flight attitude characteristics of the aircraft, including items such as hydraulic boost system, rudder pedals, controls, mounting brackets, etc. Also includes the functioning and maintenance aspects of the flaps, spoilers, and other control surfaces, but does not include the structure which is covered in the Structures Chapters.	Control column, aileron, rudder, elevator actuators, hydraulic boost system, flap drive transmissions, electric motors, servo valves, leading edge slats, trailing edge flaps.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Components (3/7)	ATA 28 Fuel	Fuel Storage & Delivery	Components which store and deliver fuel to the engine. Includes tanks (bladder), valves, boost pumps, etc., and those components which furnish a means of dumping fuel overboard. Includes integral and tip fuel tank leak detection and sealing. Does not include the structure of integral or tip fuel tanks and the fuel cell backing boards which are covered in the Structures Chapters, and does not include fuel flow rate sensing, transmitting and / or indicating, which are covered in Chapter 73.	Engine tanks, distribution systems, valves, boost pumps, sensors, quantity indicating systems, connectors.
	ATA 29 Hydraulic Power	Hydraulics	Components which furnish hydraulic fluid under pressure (includes pumps, regulators, lines, valves, etc.) to a common point (manifold) for redistribution to other defined systems.	Pumps, valves, accumulators, regulators, lines, manifolds, heat exchangers, indicating systems.
	ATA 31 Instruments/Avionics	Instruments/Avionics	Pictorial coverage of all instruments, instrument panels and controls. Procedural coverage of those systems which give visual or aural warning of conditions in unrelated systems. Units which record, store or compute data from unrelated systems. Includes systems/units which integrate indicating instruments into a central display system and instruments not related to any specific system.	Primary and secondary displays, instrument & control panels, flight recorders, enunciators, automatic data reporting systems.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Components (4/7)	ATA 32 Wheels & Brakes	Wheels & Brakes (only)	That portion of the system which provides for rolling and stopping the aircraft while on the ground and stopping wheel rotation after retraction.	Wheels, tires, brakes, brake cylinders.
	ATA 34 Navigation/Avionics	ATA 34 Navigation/Avionics	Components which provide aircraft navigational information. Includes airspeed indicator, air data computer, stall warning, attitude indicator, VOR, pitot, static, ILS, flight director, compasses, GPS, etc.	Flight management systems (FMS), GPS navigation systems, navigation sensors, air data computer/pitot systems, inertial navigation systems, weather radar, ground proximity warning system, TCAS, and ground collision avoidance systems
	ATA 35 Oxygen	Oxygen	Components which store, regulate, and deliver oxygen to the passengers and crew, including bottles, relief valves, shut-off valves, outlets, regulators, masks, walk -around bottles, etc.	Oxygen tanks, bottles, relief valves, shut off valves, regulators, and masks.
	ATA 36 Pneumatics	Pneumatics	Components (ducts and valves) which deliver large volumes of compressed air from a power source to connecting points for such other systems as air conditioning, pressurization, deicing, etc.	Bleed valves, ducts, regulators, heat exchangers.
	ATA 44 IFE(C) Components	IFE(C) Components	Units and components required to deliver video, audio and connectivity services.	Wifi, seat-based video screens and control units, overhead video units, satellite antennas and central control units.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Components (5/7)	ATA 49 APU	APU	Airborne power plants installed on aircraft generating and supplying a single type or combination of auxiliary electric, hydraulic, pneumatic or other power. Includes power and drive section, fuel, ignition and control systems; also wiring, indicators, plumbing, valves, and ducts up to the power unit. Does not include generators, alternators, hydraulic pumps, etc. or their connecting systems which supply and deliver power to their respective aircraft systems.	Auxiliary Power Unit.
	ATA 61 Turboprop Propeller	Turboprop Propeller	Propeller & accessories specifically found in turboprop powered aircraft.	Propeller, propeller systems. Includes propeller spinner synchronizers, pumps, motors, governor, alternators, propulsor duct assemblies, aerodynamic fairing of mechanical components, stators, vectoring systems.
	ATA 73 Engine Fuel & Control	Engine Fuel & Control	Units and components associated with mechanical systems or electrical circuits which furnish or control fuel to the engine beyond the main fuel quick disconnect; and trust augmenter, fuel flow rate sensing, transmitting and/or indicating units whether the units are before or beyond the quick disconnect. Includes coordinator of equivalent, engine driven fuel pump and filter assembly, main and thrust augmenter fuel controls, electronic temperature datum control, temperature datum valve, fuel manifold, fuel nozzles, fuel enrichment system, speed sensitivity switch, relay box assembly, solenoid drip valve, etc.	Fuel controls, main engine pump, and filter assembly valves, fuel flow indicating, fuel nozzles.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Components (6/7)	ATA 75 Bleed Air	Bleed Air	External units and components and integral basic engine parts which go together to conduct air to the extension shaft and torque meter, assembly, if any. Includes compressor bleed systems used to control flow of air through the engine, cooling air systems and heated air systems for engine anti-icing. Does not include aircraft anti-icing, engine starting systems, nor exhaust supplementary air systems.	Compressor bleed systems used to control air through the engine, cooling air systems and heated air systems for engine anti-icing.
	ATA 76 Engine Controls	Engine Controls	Controls which govern operation of the engine. Includes units and components which are interconnected for emergency shutdown. For turboprop engines, includes linkages and controls to the coordinator or equivalent to the propeller governor, fuel control unit or other units being controlled.	Emergency shutdown systems, linkages, and wiring.
	ATA 77 Engine Indicating	Engine Indicating	Units, components and associated systems which indicate engine operation. Includes indicators, transmitters, analyzers, etc. For turbo-prop engines includes phase detectors. Does not include systems or items which are included in other chapters except when indication is accomplished as part of an integrated engine instrument system	Thrust, speed, pressure and temperature indicators, integrated engine instrument systems
	ATA 78 Exhaust Non-Thrust Reverser	Exhaust	Units and components which direct the engine exhaust gases overboard. Excludes exhaust-driven turbines.	Exhaust nozzles, noise suppressors, ducts.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Components (7/7)	ATA 78-30 Thrust Reverser (only)	Thrust Reverser (only)	That portion of the system which is used to change the direction of the exhaust gases for reverse thrust. Includes items such as clamshells, linkages, levers, actuator, plumbing, wiring, indicators, warning systems, etc.	Clamshells, actuators, linkages, indicators, wiring.
	ATA 79 Engine Oil	Engine Oil Storage & Delivery	Units and components external to the engine (airframe furnished) for storing and delivering lubricating oil to and from the engine. Covers all units and components from the lubricating oil engine outlet to the inlet, including the inlet and outlet fittings, tank, radiator, by-pass valve, etc., and auxiliary oil systems.	Oil pumps, tanks, valves, radiators, indicating systems.
	ATA 80 Starting	Engine Starting	Those units, components and associated systems used for starting the engine. Includes electrical, inertial air or other starter systems.	Starters, valves, relays

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Engine Maintenance	ATA 72 Engine Overhaul	Engine – Turbofan Overhaul	Shop visits/major overhauls returning engine to manufacturer's specifications. Aviation Week models this activity as a trigger event based on hours of utilization.	Engine & engine systems.
	ATA 72T Engine Overhaul	Engine – Turboprop Overhaul	Shop visits/major overhauls returning engine to manufacturer's specifications. Aviation Week models this activity as a trigger event based on hours of utilization.	Engine & engine systems.
	ATA 72 Engine LLP	Engine – Turbofan Life Limited Parts (LLPs)	Includes costs of LLPs materials and labor. Aviation Week models this activity based on trigger events based on cycle utilization.	Life limited parts as specified in individual type certificate approvals associated to the engine.
	ATA 72T Engine LLP	Engine – Turboprop Life Limited Parts (LLPs)	Includes costs of LLPs materials and labor. Aviation Week models this activity based on trigger events based on cycle utilization.	Life limited parts as specified in individual type certificate approvals associated to the engine.
	ATA 72 Engine OEM Tech Upgrade	Engine – "Hospital Visits"	Also referred to as "Hospital Visits", the new feature projects both events and MRO demand for retroactive corrective actions forecasted to take place in future years 2024/5 for the LEAP and PW1000G (GTF) engines.	Hospital visits forecasted: GTF HPT #1 and #2, GTF combustion/heat exchanger, LEAP fuel nozzle upgrade.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Line Maintenance	A Check	A Check	Light aircraft check. Includes: Hangar checks at intervals of typically 500 to 1,000 flight hours for narrowbodies and widebodies, respectively. Includes labor costs, materials and overhead. Excludes: Off-wing or off-aircraft activity/materials. Aviation Week models this activity as a flight hour or calendar cost.	Inspections includes oxygen system, emergency lighting, landing gear, brakes, flight controls. Visual inspection for obvious damage, deterioration, or general issues with condition or security.
	Daily & Weekly Checks	Daily & Weekly Checks	Light overall aircraft check. Includes: Daily checks at intervals of 24-36 hours, sometimes described as overnight checks. Weekly checks include 7/8 day checks and 3/4 day checks. Includes labor factors, materials and overhead. Excludes: Off-wing or off-aircraft activity/materials. Aviation Week models this activity as a daily cost.	Inspections include obvious visual damage, deterioration, or general issues with condition or security.
	Transit Check	Transit Check/Turn Around Checks/Pre Flight Checks	Light overall aircraft check. Includes: Turn-around checks sometimes also described as transit check and/or ETOPS checks for long-haul operations. Includes labor factors and overhead Excludes: pilots ‘walkaround’ on an estimated 10% of short-haul operations and technicians doing pushback. Off-wing or off-aircraft activity/materials. Aviation Week models this activity as a cycle based cost.	Inspection includes a walk around inspection looking for obvious visual damage, deterioration, or general issues with condition or security.

Appendix – MRO Categories & Expense Types

Expense Category	Expense Type/ATA Chapter	Overview	Description	Major Components
Modifications	Avionics & Systems Modifications	Avionics & Systems Modifications	Upgrade/modification of the avionics or mission systems	Avionics, FMS, cockpit systems, GPS
	ATA 44 IFE(C) - Modifications	IFE (C) Modifications	Upgrade/modification to the components required to deliver video, audio, and connectivity.	Seat based video screens and control units, overhead video units, satellite antennas and central control units
	ATA 25 Interior Equip & Furnishings - Modifications	Interior Modifications	Upgrade/modification to the interior fixtures/fittings of the aircraft.	Furniture, seats, carpet
	Painting	Painting	Exterior paint	Exterior Paint

AVIATION WEEK Fleet&MRO FORECASTS

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