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FREIGHTER FORECAST 2022-2041

FORECAST THE FUTURE

CFCInsights.com

TWENTY-YEAR

FREIGHTER AIRCRAFT FORECAST

2022-2041

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Executive Summary

Between 2022 and 2041, we predict the addition of approximately 2,650 jet freighters and 390 feeder aircraft to cater for market growth as well as retirements of older aircraft. Between 2022 and 2041, we expect the global jet freighter fleet to grow from about 2000 to 3,400 units, with the world's feeder fleet growing from 260 to 420 units. Table 1 provides an overview of the key numbers in our long-term forecast.

Table 1 - 2022 - 2041 Freighter Forecast Key Numbers

	1Q-22 Fleet	Net Growth	Retired	Total Added	New	P to F	2041 Fleet
Feeders	261	157	233	390	70	320	418
Narrowbody	810	520	677	1197	0	1197	1330
Medium Widebody	640	367	348	715	281	434	1007
Large Widebody	657	417	320	737	574	163	1074
Total	2368	1461	1578	3039	925	2114	3829

Source: Cargo Facts Consulting Freighter Forecast 2022-2041

Our twenty-year forecast is based on an underlying air cargo traffic growth rate of 3.3%. This is marginally lower than our expectations in last year's forecasts, largely because of the long-term impact of a weaker economic outlook over the coming years.

During the forecast period, we expect to see about two thirds of the current jet fleet and almost 90% of the current active feeder fleet retiring. Half of the new and converted aircraft to be added over the next two decades will replace the retired aircraft while the remaining half will cater the growth of the air freight market.

Seventy percent (70%) of the market is expected to consist of converted aircraft, but this varies across segments. While 100% of narrowbody demand will be for converted aircraft, in the medium widebody

market 60% and in the large widebody 22% of demand is expected to be met by conversions. Around 80% of feeder demand is predicted to be met by conversions.

In the third year of the pandemic air cargo market demand and supply remain out of sync. Freighters continue to carry more than their historical share of air cargo traffic due to a slower than originally expected recovery in passenger traffic. At the same time demand for international air cargo remains high due to supply chain disruptions and maritime capacity issues. In domestic and regional markets business to consumer e-commerce demand has led to elevated traffic levels. We do not expect equilibrium to return in the near term.

1. Introduction

This report is presenting our view of the short, medium- and long-term outlook for the air cargo and what it means for freighter demand. As in last year, we commence with an up to date view of the supply and demand dynamics currently affecting the business.

The subsequent chapters cover long term airfreight demand, our analysis and forecast for narrowbody, medium and large widebody and feeder (turboprop and regional jet) freighter fleets. Our freighter usage analysis provides an overview of how and where freighter aircraft are used. With a large part of the world's freighter fleet consisting of aircraft converted from passenger to freighter configuration, we provide an up to date assessment of the current conversion market dynamics and the passenger to freighter feedstock situation and outlook. Appendix 2 provides a reference guide with freighter aircraft characteristics for both in-service and planned cargo aircraft. Appendix 3 contains a summary of each of the most important production and conversion freighter programs.

Our long term forecasts start from the beginning of 2022, and show predicted changes through to the end of 2041, taking into account our assessment of new-build freighter production, passenger-to-freighter (P-to-F) conversion activity, and the retirement of freighters from the existing freighter fleet. The forecasts depict the future fleet evolution in five-year increments through the twenty-year forecast period. Also included is our prediction of the freighter fleet make-up in 2041 by aircraft type, for both the jet freighter and the feeder segments. Both the jet freighter and feeder chapters provide a sensitivity analysis of the impact of changes in traffic growth, freighter productivity, and a shift from freighters to the belly compartments of passenger aircraft.

Subscribers have access to a freighter forecast tool that allows modelling of different growth, belly freighter split and productivity scenarios. This report is also supplemented with a feedstock analysis tool. The Feedstock Analysis tool provides customizable detail on the development of passenger to freighter feedstock for different aircraft types. Both tools are hosted on the Cargo Facts Consulting Insights platform (www.cfcinsights.com),

We trust this report will provide you with valuable independent insights on shaping your freighter aircraft strategy. As always, we welcome your feedback and further questions.

2. The State of The Air Cargo Market in 2022 and Short-Term Outlook

Key Findings:

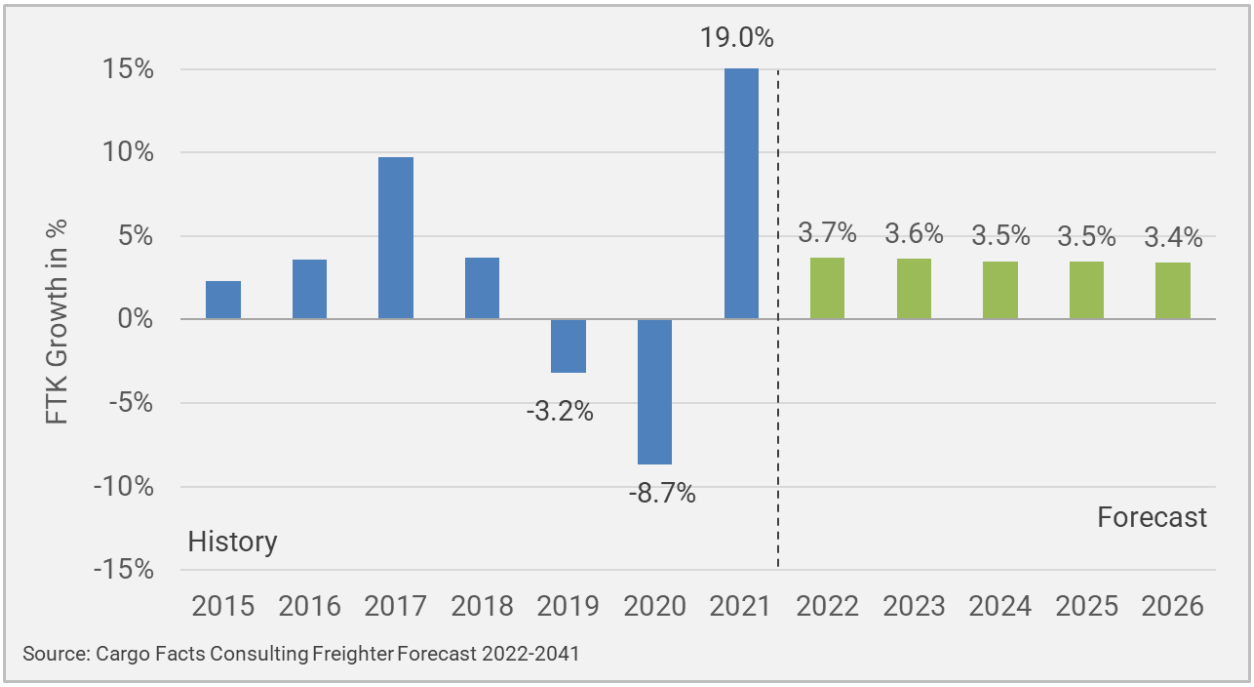
- Supply and demand remain out of sync the in global air cargo business and this is expected to remain over the short to medium term.
- After 19% growth in 2021, air cargo traffic is above pre-pandemic levels.
- Freighters continue to carrier an above average share of traffic, but long-haul passenger capacity is expected to improve leading to a more balanced market.

As we enter the third year of the global pandemic, air cargo demand and supply remain out of sync. There are several themes shaping the current environment including supply chain disruptions and maritime capacity issues affecting intercontinental demand and increased business to consumer traffic moving through domestic express and dedicated e-commerce networks. However, higher inflation, the Ukraine war and a China that remains largely shut off from the rest of the world is creating much uncertainty about the medium term economic and demand outlook. The supply side continues to be constrained, particularly on long haul routes where freighters continue to carry more than their usual share of traffic. This will persist until passenger belly capacity returns. While regional and domestic demand has led to a surge in narrowbody and medium widebody freighter additions and a growing backlog, long haul freighter capacity will remain constrained at least until 2024 due to lack of immediate production freighter and conversion options.

2.1 Demand

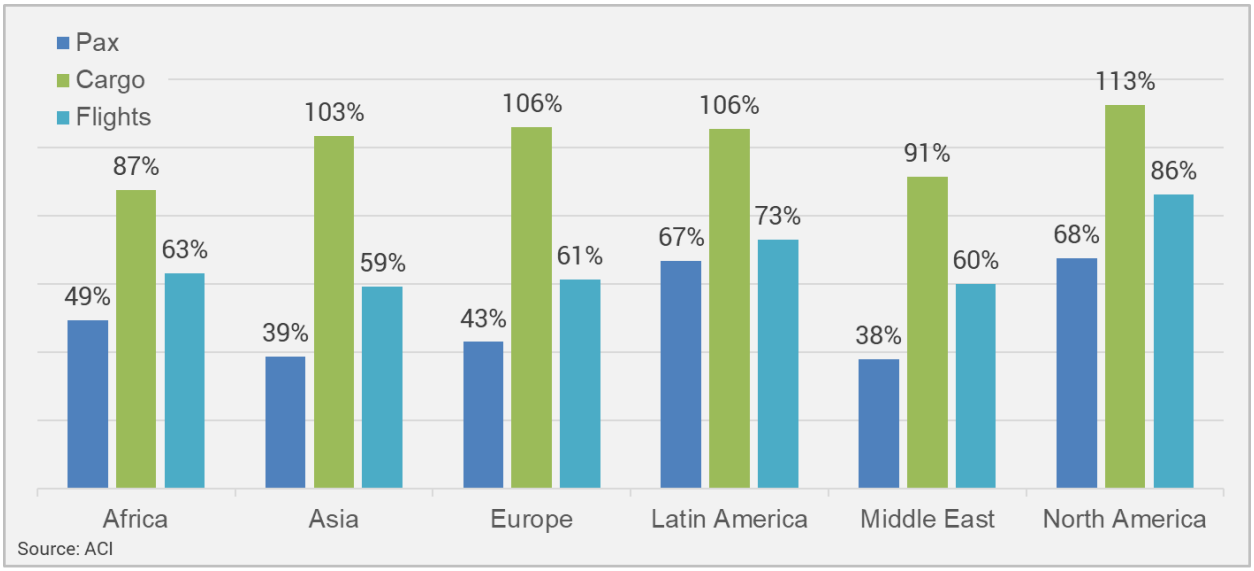
After declining by 3% in 2019 and almost 9% in 2020, global air cargo traffic increased by 19% in 2021. The decline in 2020 was less than we expected at the outset of the pandemic, and the growth in 2022 was higher than we predicted twelve months ago. While in 2020, Covid related shipments and express led to a surge in demand, 2021 saw demand improvement across wide range of segments. At the end of 2021, traffic was even above 2018 levels. Figure 1 provides an overview of global air cargo traffic growth since 2015 and a forecast through to 2026. We expect growth in 2022 and subsequent years to be more subdued – primarily because of a weaker economic outlook.

Figure 1 - Global Air Cargo Traffic History and Forecast 2015 - 2026



In terms of airport tonnage handled, volumes at the end of 2021 were six percent (6%) higher than in 2019, while passenger volumes and movements were at only 50% and 71%, respectively. Aircraft movements have recovered more than passenger volumes in part due to additional cargo only and passenger freighter flights, but also because passenger services continue to operate at reduced load factors.

Figure 2 - Passengers, Cargo Tonnage and Flights by Region, 2021 vs 2019

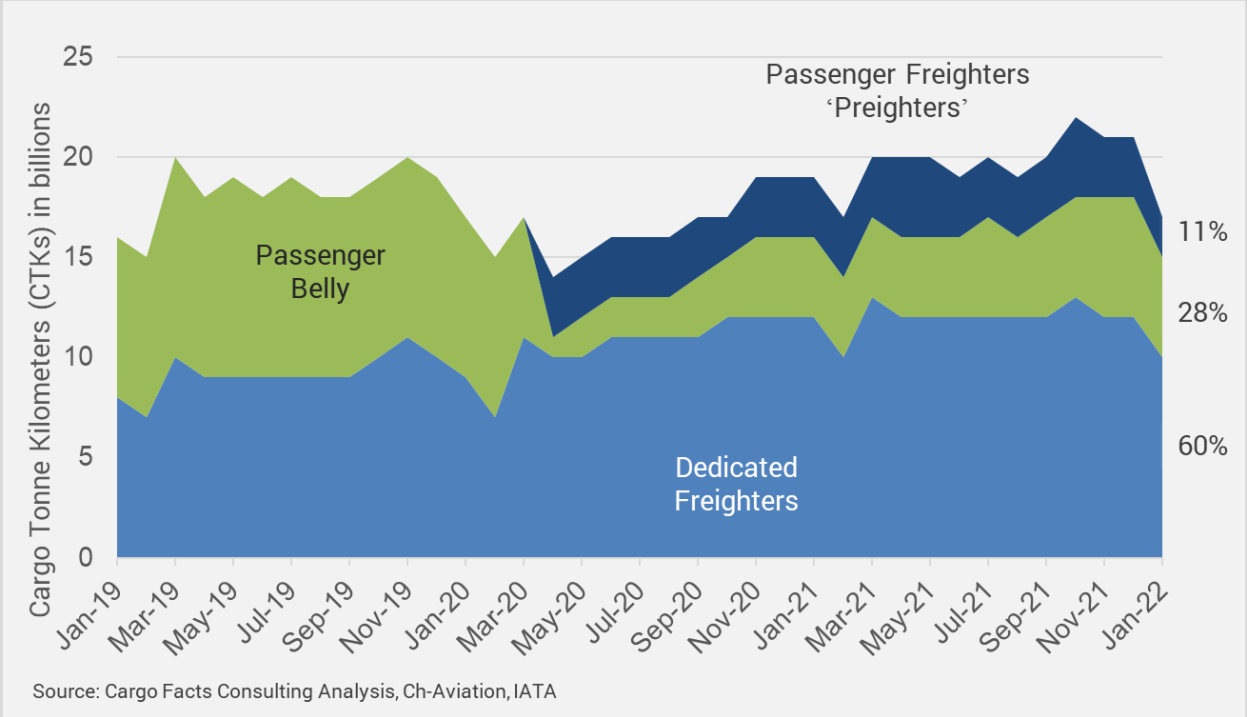


The difference between regions is significant – while North American cargo tonnages are 13% above 2019 levels, Africa, and Asia lag behind (see Figure 2). Africa has suffered from a redeployment of freighter capacity onto more profitable east west lanes. Within Asia there are large differences with South East Asia and Southeast Asia lagging compared to Northeast Asia.

2.2 Supply

Normally just over 50% of global air cargo traffic is carried in the bellies of (mainly widebody) passenger aircraft. However, in both 2020 and 2021, all cargo services accounted for approximately 70% of all traffic. This included both pure freighters and passenger aircraft operating cargo only missions, so called passenger freighters (see Figure 3). At their preak in March to September 2020 and in April and May 2021, passenger freighter services accounted for around 20% of all cargo moved. Since the end of the 2021, these figures have been trending downwards.

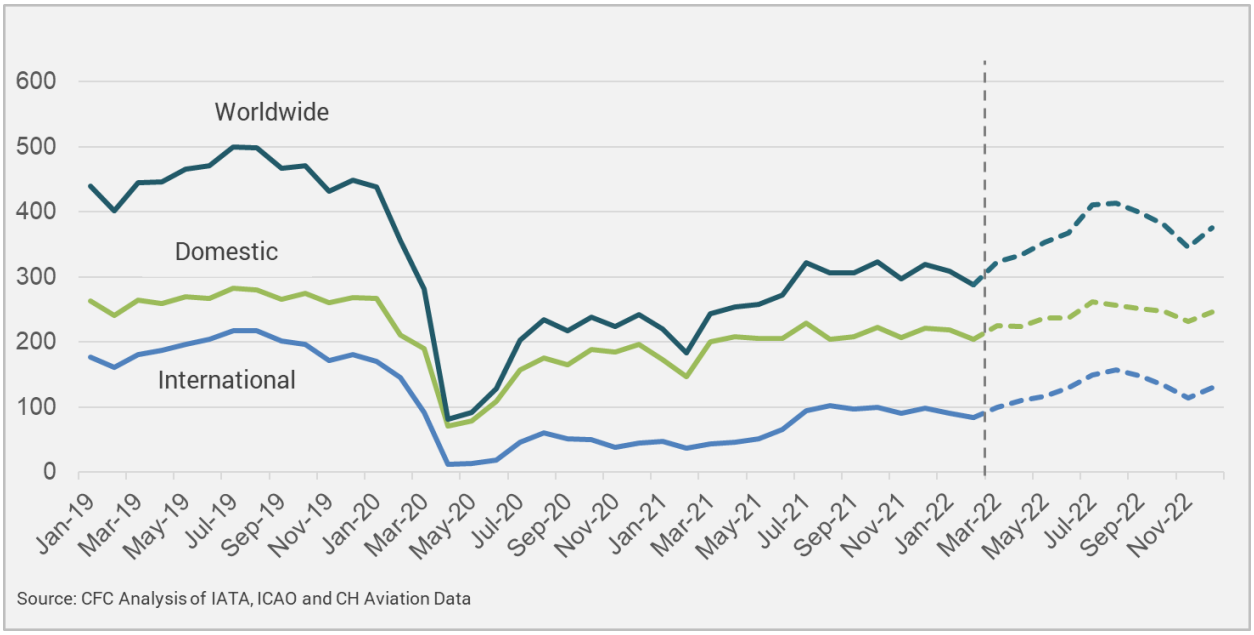
Figure 3 - Cargo Traffic by Type of Service Jan 2019 – Jan 2022



As passenger freighter exemptions expire or are cancelled and normal passenger capacity returns, we expect air cargo supply to converge back to a 50:50 split.

Figure 4 provides an overview of forward scheduled passenger capacity. A recovery in long haul markets commenced in 2021 as large aviation markets in North America and Europe reopened international travel following easing quarantine restrictions.

Figure 4 - Historical Monthly Actual and Scheduled Seat Capacity (in millions)



However, the Asia-Pacific region saw little improvement in restoring international capacity as their governments were more cautious about opening borders – or in the case of China have remained completely closed and subject to continued lockdowns as new cases emerge.

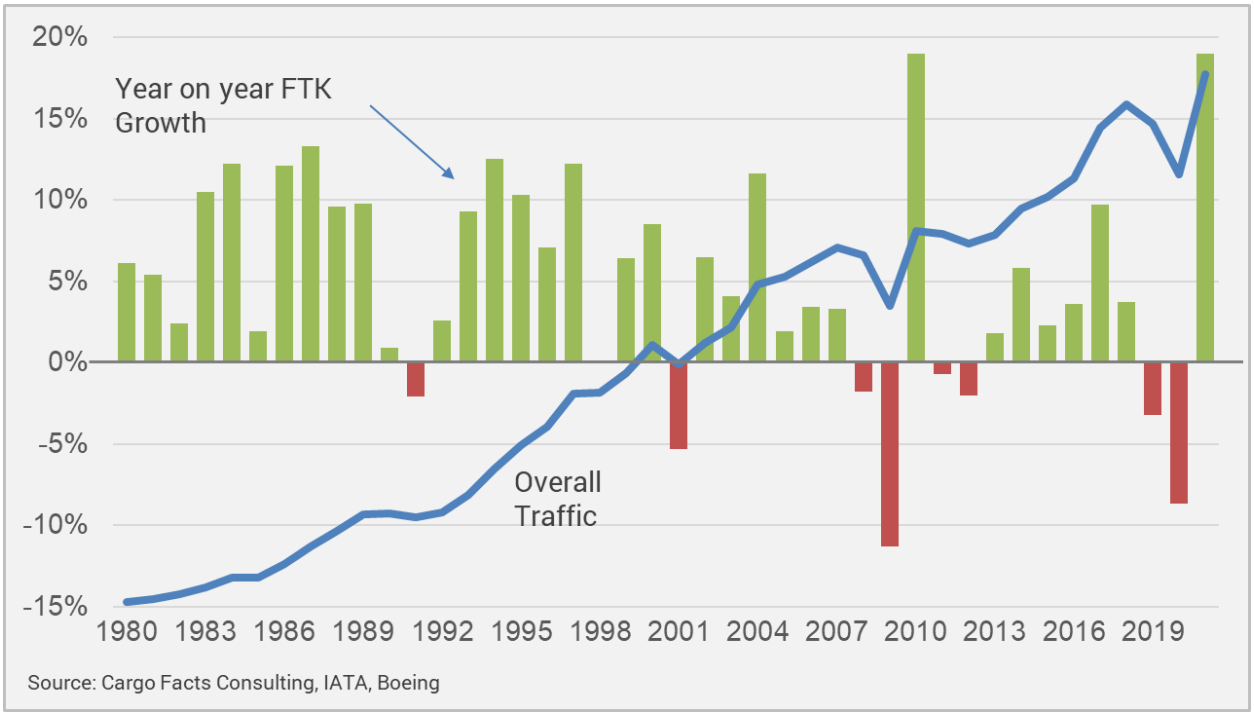
3. Long Term Air Freight Demand and Outlook

Key Findings:

- Historical long-term average growth rates of over 6% have not been experienced since the early 2000s and have been more in the 2-4% range over the past two decades.
- Over the next 20 years we expect to see growth rates averaging 3.3%, with express outperforming general cargo growth at least in the short to medium term.

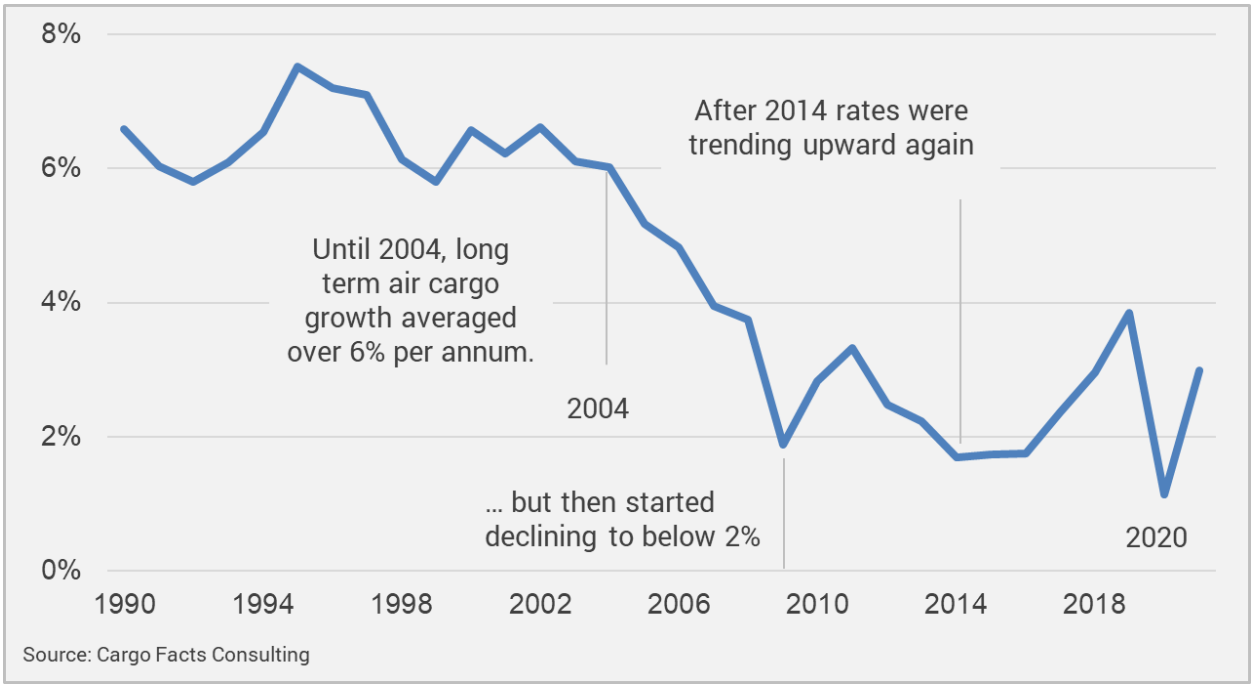
Since 1980, the air freight business has only experienced eight years of declining traffic. Most recently in 2020 (the first year of the pandemic) and 2019 (an economically weak year). The last major decline was during the 2008 financial crisis, whereby the end of 2009 traffic had fallen back to 2004 levels. Year end 2020 traffic levels were comparable to 2016 – a loss of four years of growth (see Figure 5). 2021 traffic grew by 19% and higher than in 2018.

Figure 5 - Air Freight Traffic Growth 1980 – 2021



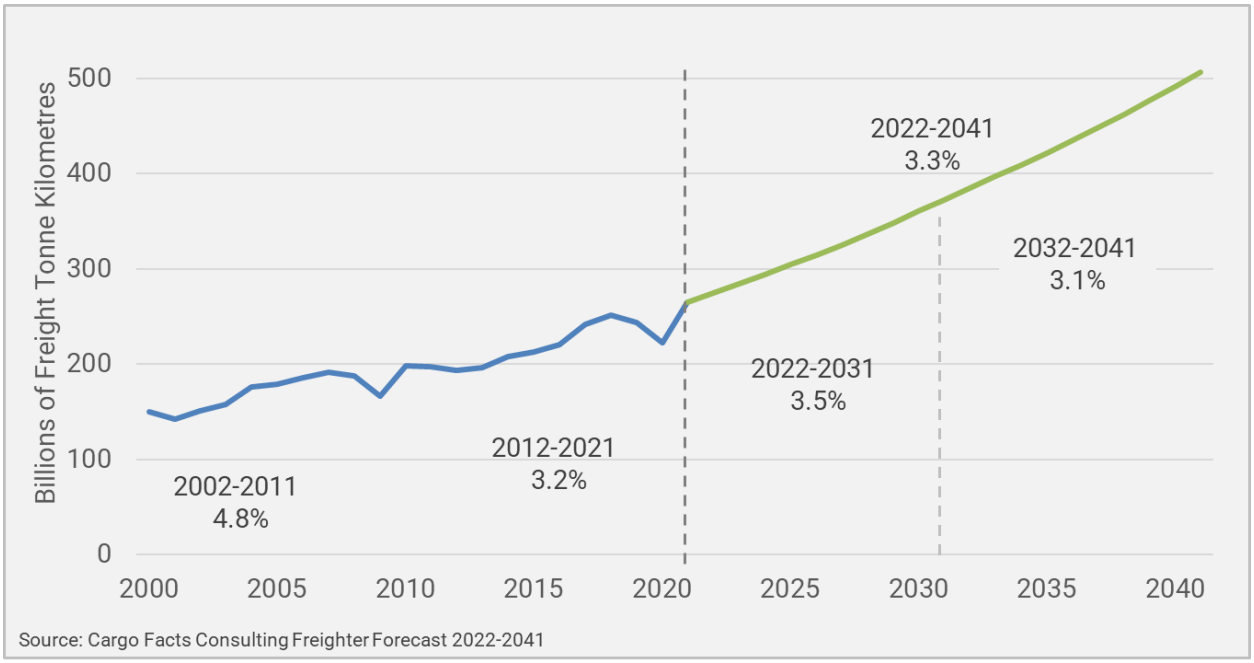
Until about 2004 long term air cargo growth averaged around 6% per annum, but then started declining to below 2% per year because of a weaker growth environment alternating between moderate growth and decline. Post 2014 rates were again rising, but 2019 and 2020 put an end to that.

Figure 6 - Ten Year Moving Average Air Cargo Traffic Growth 1990 – 2021



In the long term, we expect global air cargo traffic to grow by 3.3% per year between for the next 20 years, or about 3.4% of a 2019 basis. base or at 3.5% off a higher 2019 base. In absolute terms this would imply that air cargo traffic doubles over the next 21-22 years compared to 2021 (see Figure 7).

Figure 7 - Air Cargo Traffic History and Forecast 2000 - 2041



Our current long-term forecast is slightly lower than last year's forecast. Part of this is due to the long-term knock-on effects of the current expected inflation driven slowdown in economic activity. Table 2 provides a comparison of our forecast with other commonly referenced forecasts produced over the past 3-4 years.

Table 2 - Cargo Facts Consulting vs Other Traffic Forecasts

Forecast	Baseline	Date Published
Cargo Facts Consulting 2022 – 2041	3.3% (3.4% from 2019-2041)	May 2022
Cargo Facts Consulting 2021 – 2040	4.3% (3.5% from 2019-2040)	April 2021
Cargo Facts Consulting 2020 – 2039	3.8%	April 2020
Cargo Facts Consulting Express 2022-2027	International Express: 5.4% US Domestic: 3.2%-5.5%	May 2022
Airbus 2021-2040 (for 2019-2040 period)	Overall: 3.1% General Cargo: 2.7%, Express: 4.7%	November 2021
Airbus 2019 – 2038	3.8%	September 2019
ICAO Post Covid 2018-28/38/48/50	2.6%/3.3%/3.5%/3.6%	June 2021 update
ICAO Pre Covid 2018-28/38/48/50	4.2%	2019
Boeing 2020 – 2039	4.0%	Nov 2020
IATA 2019 – 2028	4.2%	March 2019

Overall, we expect express growth to outpace general cargo growth at least over the medium term, both in international and in the US domestic market. Our annual Express Market Outlook as well as our E-Commerce Logistics Outlook, both published in the second half of the year provide additional commentary and analysis of expected developments in these important air cargo segments.

4. Jet Freighter Fleet Analysis and Forecast

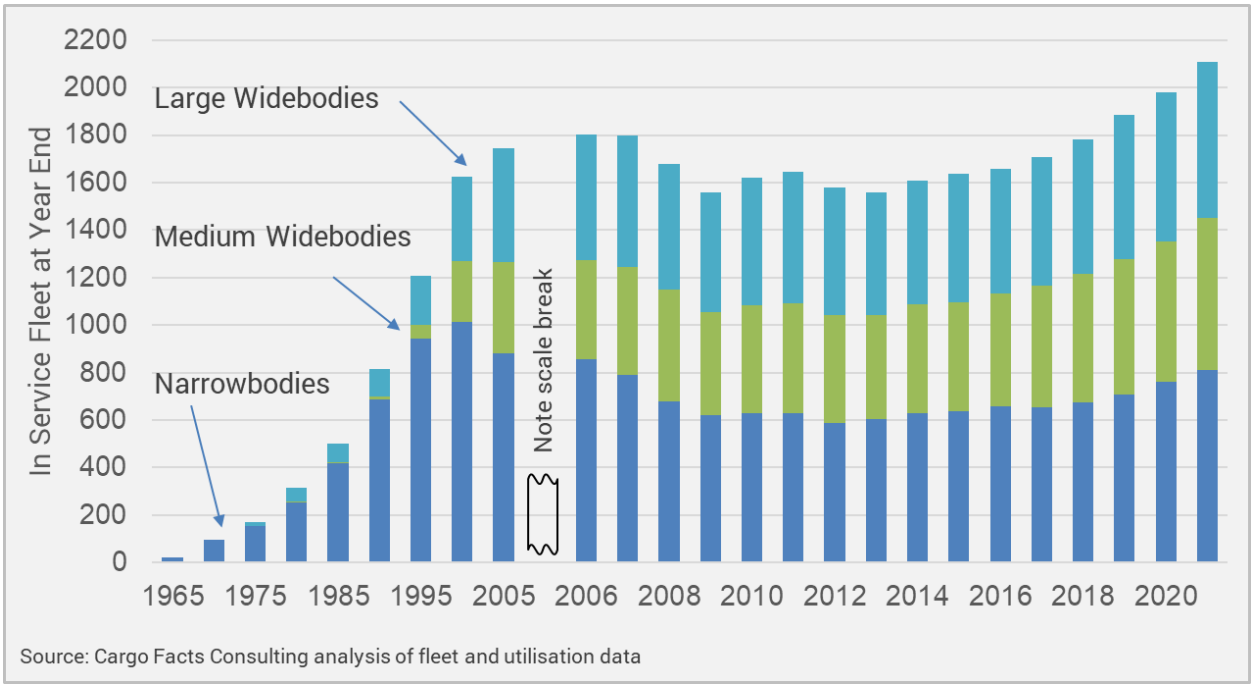
Key Findings:

- The active jet freighter fleet grew by over 6% in 2021, with the largest growth in the medium widebody segment.
- Over the coming 20 years we expect the world's freighter fleet to grow by just over 60% or 2.4% per year.
- Changes to the freighter share of cargo moved, productivity assumptions and traffic growth have large impacts to overall fleet requirements.

4.1 Fleet Evolution and Recent Developments

The jet freighter fleet grew by 6.3% last year as freighter demand stayed high and passenger capacity was recovering slowly. In 2020, the largest increase was in the narrowbody segment while 2021 saw the biggest growth in the medium widebody segment. Figure 8 provides an overview of the evolution of the worlds freighter fleet since 1965 and Table 3 show the current Q1 2022 breakdown of the fleet by type.

Figure 8 - Jet Freighter Fleet Evolution 1965 - 2021



Source: Cargo Facts Consulting analysis of fleet and utilisation data

As of April 2022, there were 2,107 jet freighters in active operation ranging from Bae146s through 747-8Fs. The breakdown includes 657 large widebodies (mostly 777s, 747s and MD-11s), 640 medium widebodies (mostly A300s, 767s and A330s) and 840 jets in the narrowbody segment (comprised of 757s and 737s).

The breakdown and analysis of turboprop and regional jets is included in Chapter 5 of the report. Please note that our fleet tally and forecast do not include special purpose aircraft such as the AN-124 and IL-76, as these generally do not operate in scheduled cargo networks. When determining whether an aircraft is active or not, we analyze CH Aviation, Cargo Facts, and other fleet data, as well as radar data to determine whether an aircraft has flown in the last 365 days. Only aircraft that have flown in the last 365 days it is included in our count. The table below includes the freighters that are currently stored due to the ongoing international restrictions to Russian-based operators.

Table 3 - In Service Jet Freighter Fleet, Q1 2022

Narrow Body 2Q 2022 (2021)	Medium Widebody 2Q 2022 (2021)	Large Widebody 2Q 2022 (2021)
< 85,000 lbs *(< 40 tonnes)*	*85,000 – 180,000 lbs* *(40 - 80 tonnes)*	*> 180,000 lbs* *(> 80 tonnes)*
810 (+5%) Total Units	**640 Total Units (+9%)**	**657 Total Units (+5%)**
11 BAe 146	4 A310-300F	11 MD/DC-10-30/-40
21 DC-9, 24 MD-80	4 A300B4, 163 A300-600	110 MD-11F/CF
9 B737-200	38 A330-200F, 4 -200P2F	219 B777-200F
32 B727-100/-200	9 A330-300P2F	6 747-200/300
117 737-300, 158 737-400	55 B767-200	53 747-400SF/BCF
9 B737-700, 105 737-800	207 767-300F	158 (157) B747-400F/ERF
7 A321-200	156 767-300BCF/BDSF	100 (93) B747-8F
3 TU-204C, 314 757-200	0 MD/DC-10-10	

Source: Cargo Facts Consulting, Cargo Facts, Ch-Aviation. Refers to operating fleet in April 2022.

The lower feedstock value for newer generation aircraft and the several conversion options in this space have accelerated the growth to the newer generation types in the ***narrow body*** segment. The 737-800F has been strong competition for its predecessor, the 737-400F, with an additional container position as

well as an extra 4,800 to 5,900 lbs. (2 -3 tonnes) of payload. The -800 also features technological upgrades as well as improvements in fuel consumption over the -400.

- The less popular 737-700 fleet increased by 1 units and the 737-800 fleet by 54 units to a total of 9 -700s and 105 – 800s, double the total of a year ago. Our estimate shows backlog quantities of over 100 units for the -800 fleet.
- Demand for 737 Classic freighters has slowed down, with more -300s being retired. The active 737-400 grew by 3 units and we still see some operators showing interest for the Classic variants. Currently, there are 275 737-300/400 in operation.
- Airbus conversions are gaining traction, with 7 A321s currently in service with one more unit entering service before the end of May 2022.
- There is limited customer demand in the MD80 space, but we still saw three units delivered in the last twelve months, bringing the fleet to a total of 24 units.
- The number of in-service Bae 146 freighters decreased by 3 units while we saw the DC-9 fleet declining by 2 units.
- The 757-200 remains the most popular aircraft in this segment, with numbers remaining unchanged from 2021.

Feedstock values have also influenced capacity additions in the ***medium widebody*** segment.

- The 767-300 freighter fleet grew from 308 to 363 units. This included an additional 18 production freighters and 37 conversions.
- The A330 family continues to see conversions rising. As of the end of April 2022, there are nine A330-300P2Fs and four A330-200P2Fs in service. DHL has the largest number of A330P2Fs so far, but the diversity of operators will widen in the upcoming years.
- Meanwhile, several older generation types were parked or retired – this includes 1 A300B4 and the remaining MD/DC-10-10Fs that were retired from the FedEx fleet. The number of 767-200 in operation decreased by two units.

Activity in the ***large widebody*** segment is being driven by the 777-200F, but also by the reactivation of several previously parked aircraft and delaying the retirement of older types.

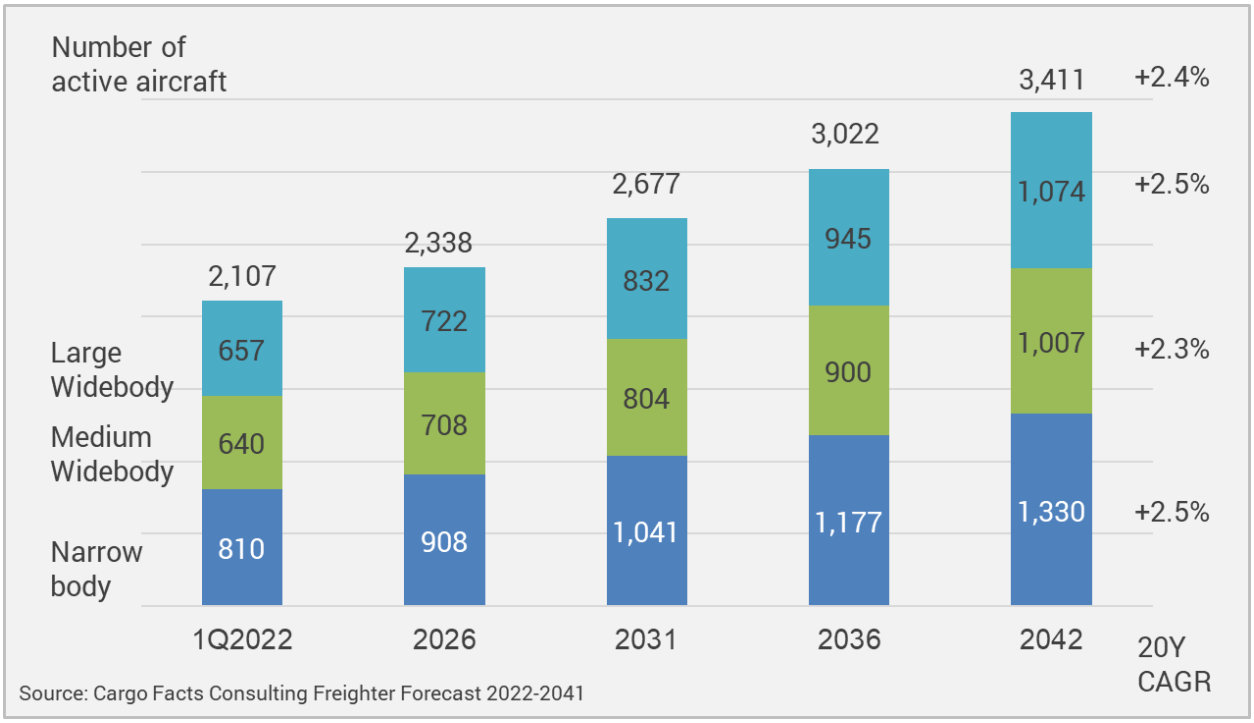
- The number of 777 freighters in operation increased by 19 units to a total of 219 aircraft.

- An additional 7 747-8F were delivered bringing the in-service fleet to 100 units. The remaining backlog for this type is 7 aircraft and Boeing announced the sunset of this program by the end of 2022.
- A few 747-400Fs were reactivated over the last 12 months. This number was lower than in 2020 but the demand for widebody freighter lift was still present. the large widebody freighter segment remains in high demand and the market does not offer too many options.
- The number of MD-11Fs in service remained unchanged. The last Lufthansa MD-11F joined the Western Global fleet, leaving this carrier and FedEx as the only two operators of this type.

4.2 Twenty Year Jet Freighter Forecast

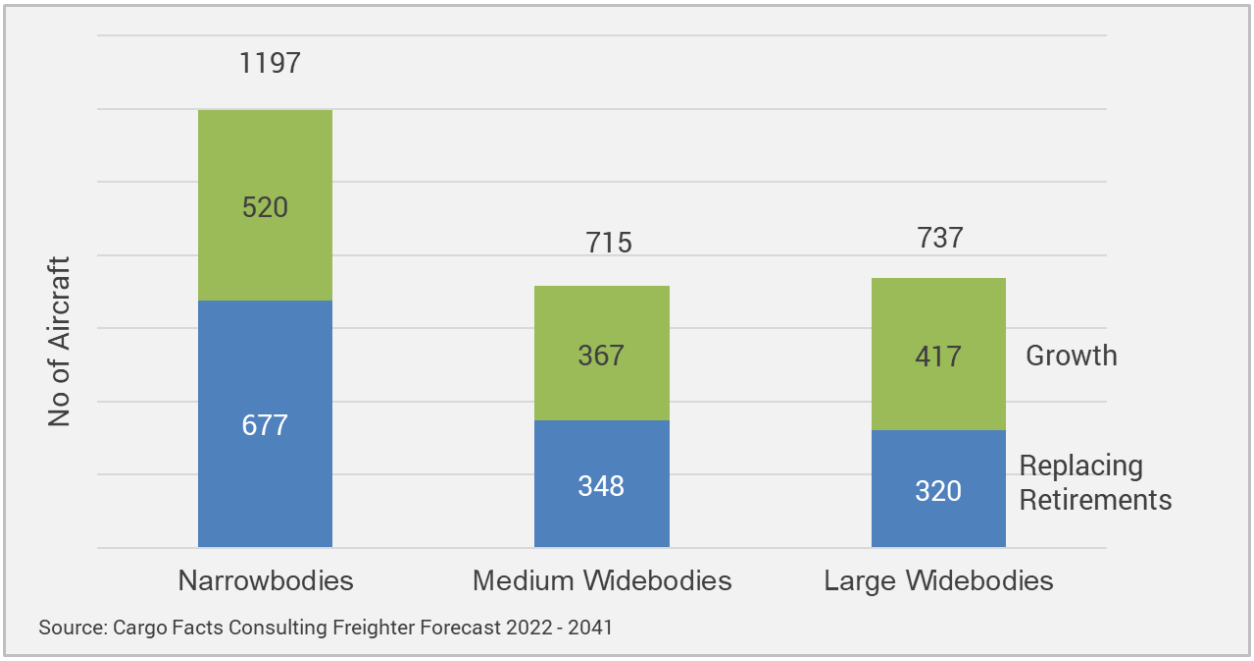
Over the next 20 years we expect the world's jet freighter fleet to grow by about 62%, from 2,107 units today to 3,411 units at the end of 2041 (Figure 9).

Figure 9 - Baseline Jet Freighter Fleet Forecast 2022 - 2041



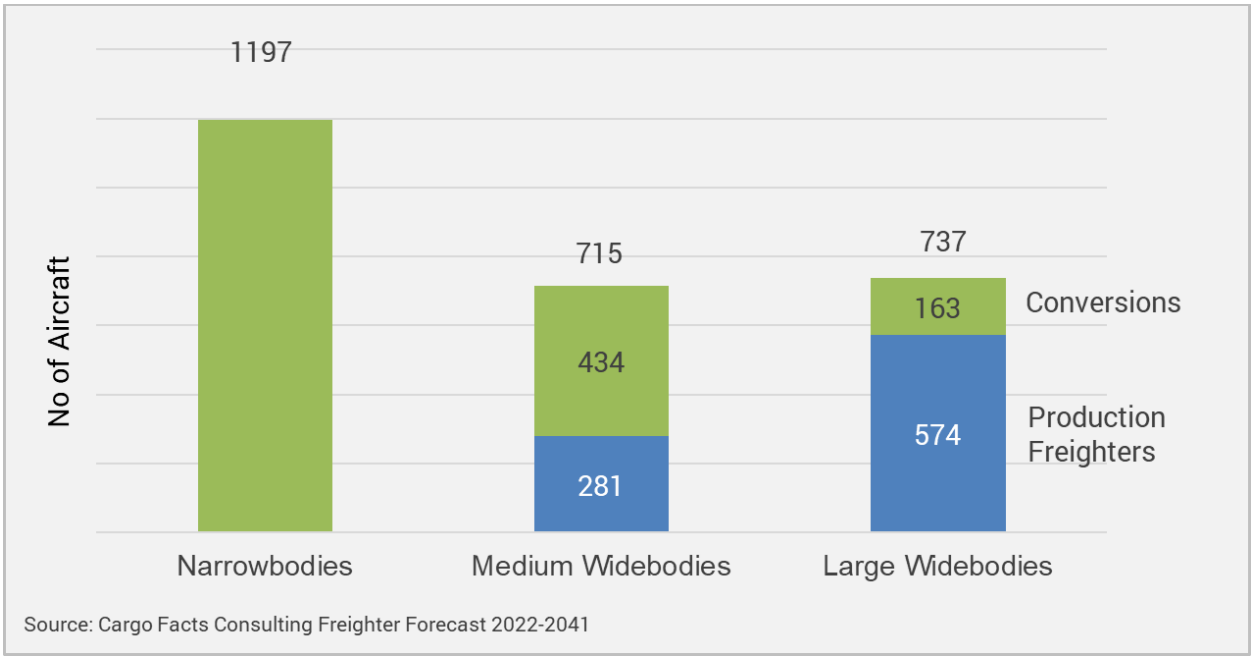
The net growth in fleet size is 1,304 (of all sizes), which when combined with 1,345 retirements, produces the overall need for 2,649 freighters through 2041. This total fleet requirement equates to an average of 132 units per year. Figure 10 shows the details of the new and replacement aircraft added for each size category through 2041.

Figure 10 - New and Replacement Jet Freighters Added 2022 - 2041



The added freighters will consist of 934 production freighters (35% of the total) and 1,685 P-to-F conversions, or 65% of the total fleet (Figure 11).

Figure 11 - New and Converted Jet Freighters Added 2021- 2040



We expect that about 67% of the production freighters will be large widebodies and the share of production freighters in the large widebody space will be 78% compared to the conversions in the same segment. The operator mix, cargo densities, utilization, and unit cost requirements in this segment favor production freighters. Given the lack of active production programs, an abundance of P-to-F feedstock and low aircraft utilization, we do not foresee any production freighter deliveries in the narrowbody segment. Table 4 provides details of our estimated composition of the baseline fleet on a model-by-model basis at the end of the 20-year forecast period.

Table 4 - 2041 Baseline Jet Freighter Fleet

Narrowbody *< 40 tonnes*	Medium Widebody *40 - 80 tonnes*	Large Widebody *> 80 tonnes*
1330 Total Units	**1007 Total Units**	**1074 Total Units**
704 737-700/800 577 320/321 49 757-200	503 A330 404 767-300 100 787/ 767XF	679 777 43 747-400 102 747-8 250 A350

Source: Cargo Facts Consulting Freighter Forecast 2022-2041

Note the dominance of the following types: 737 NGs and A320s/321s in the narrowbody segment; A330s and 767-300s in the medium widebody segment; and 777s plus significant roles for 747-8s and A350s in the large widebody segment. Based on our prediction, there will be less nose door capable aircraft operating in the large widebody fleet in 2041 than today and this will have fundamental implications for the outsized cargo market.

4.3 Jet Freighter Fleet Forecast Assumptions on Aircraft Availability

The forecast reflects our assessment of manufacturers' future product strategies to determine which specific aircraft types will be offered as jet freighters over the next twenty years. Some models shown in our forecast may not become available in freighter configuration, while some that we do not show may be introduced. To the extent that such circumstances develop, it is important for readers of this report to

recognize that the availability or non-availability of any model is unlikely to affect the overall demand for freighter aircraft. Overall demand is a zero-sum game, meaning that other models will fill the gap. Table 5 provides and overview of the current and future freighter aircraft supply situation which drives our future fleet composition estimates.

Table 5 - Aircraft Available to Operators During the Forecast Period

	Narrowbodies	Medium Widebodies	Large Widebodies
Facing near-term extinction	DC-9, 727, Bae 146, 737-200	A300B4, A310	747 Classics, DC/MD-10-30/40
At peak use, or with little future growth potential	MD-80, 737-300/400, 757-200	767-200, A300-600, A330-200F	747-400F/ERF, 747-400SF/BCF, MD-11F/CF, 747-8F
Expanding role going forward	737-700/800, A321/320	767-300F/BDSF/BCF, A330-200/300P2F	777-200F
Planned or Potential Future aircraft	737-900	787XF, 767XF, A330-900F	777-300ERSF, 777-200LRSF, A350 F/P2F, 777-8F

Source: Cargo Facts Consulting Freighter Forecast 2022-2041

In the ***narrowbody segment***, the individual aircraft mix is based on:

- Feedstock availability and higher maintenance and engine costs limiting further conversions of 737 classics and 757s.
- 737 NG and A320/321 conversions available throughout the whole period with enough feedstock to support this.
- A320 family conversions ramping up after 2022 as conversion companies have received their supplemental type certificates.
- No manufacturer developing or offering a production freighter program in this segment.

In the ***medium widebody*** segment the individual aircraft mix is based on:

- An end of the 767-300F production freighter program by 2027 due to ICAO emissions requirements for new aircraft and the 767-300 P2F programs within the next 10 years. No replacement for the 767-300F has been announced at this time.
- Feedstock supporting A330-200 and -300 freighter conversions are available throughout the whole forecast period. As 767 feedstock declines, A330 conversions will become dominant in this segment.
- An A330-900F becoming available within the next 5-10 years. Given that the freighter has similar capabilities to an A330-300 such a program would require a launch of the program would require a substantial order from one of a customer such as Amazon, FedEx, UPS, DHL, or SF Express. Given the lack of success with the A330-200 factory freighter program, we think that Airbus may be reluctant to embark on such a program and that the manufacturers primary focus will be on the A350.
- A 787-XF becoming available between 2027 and 2031. Although we understand there has been some discussion of a stretched and reengined 767 as an alternative to a 787 freighter, we did not consider this aircraft, but note that depending on acquisition cost and specifications, this could affect some demand in the large widebody segment.

By comparison, in the ***large widebody*** segment the individual aircraft mix is based on:

- No further deliveries of the 747-8F beyond the current backlog of 7 aircraft and last production. We expect the program would become inactive after 2022.
- A transition from a 777-200F to a 777XF after 2027. Boeing announced the delivery of its first 777-8F freighter in five years from now. The 777-8F maximum payload of 112 tonnes and a range of 4,410 nautical miles has a total cargo volume of 766 cubic feet. Qatar Airways became the first carrier to commit to the 777-8F with a firm order of 34 units and options for 16 more for delivery starting in 2027. However, there is a risk that certification delays on the 777-9 will have a knock-on effect on the freighter product and there may be a period where Boeing is not producing any freighters.
- In late 2021, Airbus officially launched its A350 freighter product. This aircraft offers 10% more volume than the 777-200F, with a maximum payload of 109 tonnes and a range of 4,700 nautical miles. The A350F is expected to enter service by 2025 and so far, Airbus has recorded 29 orders and commitments from five customers.

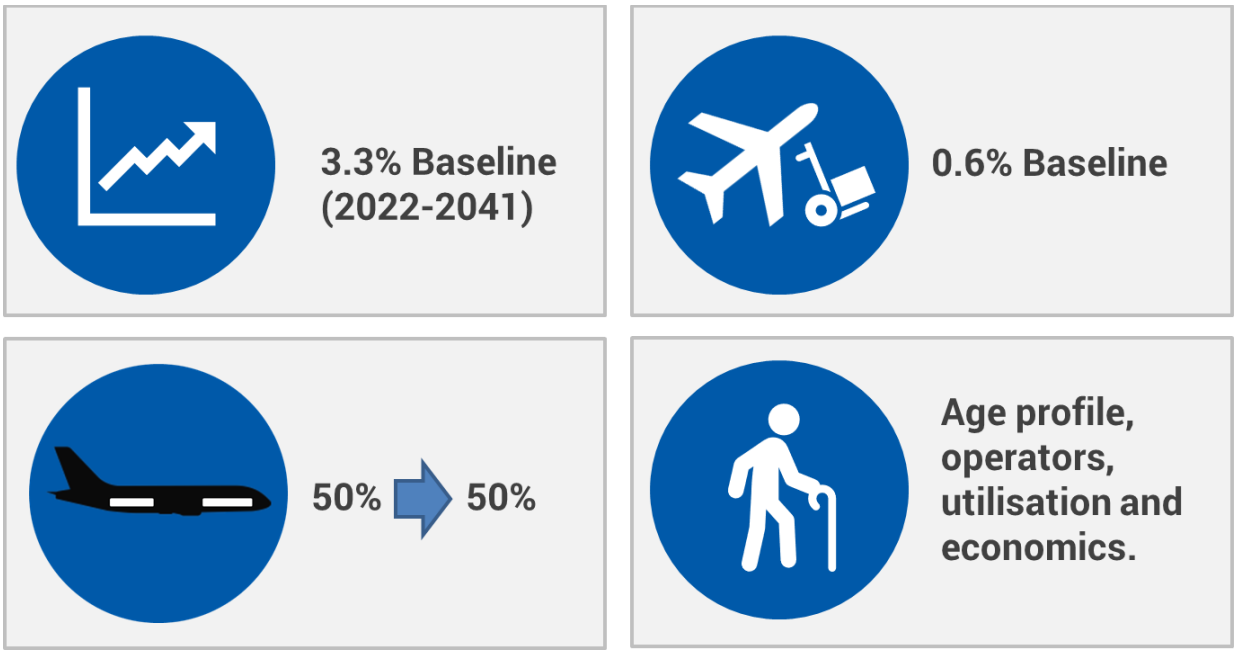
- A 777-300ER conversion available from 2022, following the official launch of the Israel Aerospace (777-300ERSF) Industries (IAI) - GECAS program in late 2019. The two other known 777 conversion programs have already secured their launch customers are Backbone Freighter Leasing for the 777-300ERCF (KMC – NIAR) and Cargojet for Mammoth Freighters' 777-200LRMF and 777-300ERMF.

Regarding retirements, we recognize that freighter aircraft types typically have useful economic lives more than thirty years, with small freighters applied in low-utilization regional express networks often remaining in service over forty years. On average, we predict the retirement of approximately 65 jet freighters per year. Over the next twenty years more than 1,300 freighters from the current fleet (about two thirds of those now in operation) will be retired.

4.4 Jet Freighter Baseline Assumptions and Sensitivity

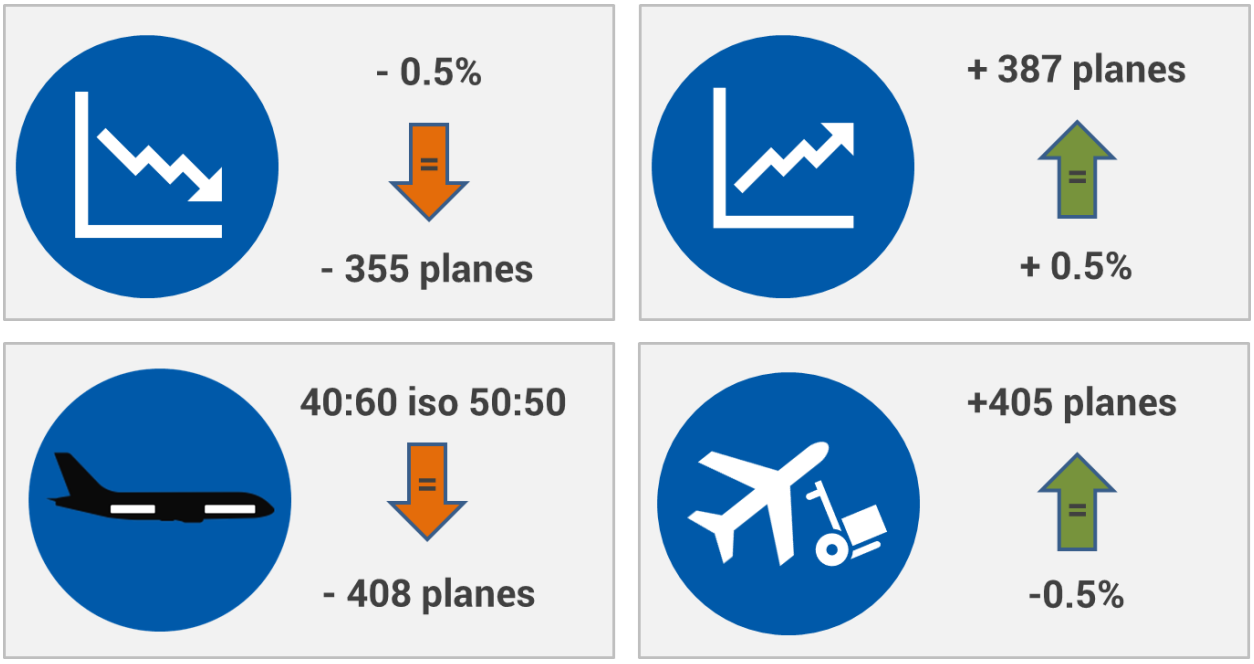
Our analysis technique allows us to determine the impact on freighter requirements given various assumed levels of demand growth, changes in freighter productivity, and shifts in the ratio of freighter-to-belly use. Small changes in assumptions can have large impacts in terms of fleet requirements. Figure 12 provides an overview of the baseline assumption of the forecast and Figure 13 illustrates the impact of changes in key assumptions.

Figure 12 - Baseline Assumptions



For each half a percentage point increase or decrease the number of jet freighters required changes by over 355 aircraft. Every half a percentage point decrease in productivity increases the number of aircraft required by 387. If the freighter share of total traffic were to decline to only 40% of freight carried, then this would lead the requirement for 408 less aircraft over a 20-year period – primarily in the large widebody segment.

Figure 13 - Forecast Sensitivity to Changes in Baseline Assumptions



5. Feeder Freighter Fleet Analysis and Forecast

Key Findings:

- Feeder freighters play a supplemental role to larger jet aircraft in Europe, North America, and smaller markets around the world.
- Embraer has launched a new conversion program for its E190 and E195 passenger aircraft.
- We expect the fleet in this segment to grow by about 60% over the next 20 years.
- However, this segment is much more fluid than the jet segment – with 4-9 tonne aircraft competing with much smaller turboprops as well as larger jets.

5.1 Current Fleet and Recent Developments

Currently there are approximately 260 feeder aircraft in operation (see Table 6). This fleet, which forms the point of departure for our twenty-year turboprop/RJ freighter forecast, contains a mix of older technology models nearing retirement and newer, modern aircraft including the ATR72-600F Production Freighter.

Table 6 - Current Feeder Freighter Fleet

Feeders (Turboprops and Regional Jets) *8,500 – 20,000 lbs (3.8 – 9 tonnes)*
261 Total Units
40 ATR 42
98 ATR 72
7 Dash 8-100/Q300
4 Dash 8-Q400
20 CRJ 200
10 ATP, 11 HS 748
17 CV 580/5800, 4 F27/50
49 Saab 340
3 AN 26/32

Source: Cargo Facts, Cargo Facts Consulting analysis of fleet, transaction and utilisation data

When determining whether an aircraft is active or not, we analyze CH Aviation, Cargo Facts, and other fleet data, as well as radar data to determine whether an aircraft has flown in the last 365 days. Only aircraft that have flown in the last 365 days are included in our count. We have not included passenger aircraft that have undergone temporary conversion during the pandemic. Compared to last year, we have seen an increase of about 5% in the total number of aircraft. In 2021 we saw some significant changes for some operator and new entrants to the market, specifically:

- On March 4th, 2021, West Atlantic ATP (SE-MAO) veered off runway as crew landed in heavy crosswinds. SE-MAO did return to service but was later stored in January 2022.
- Brazil's Modern Logistics, announced in March 2021, that they planned to add two ATR72-500(F)s to its existing fleet.
- On April 1st, 2021, ASL Airlines Ireland ends operated its last flight utilizing the ATR42. ATR42s had been in service with ASL since 2003. Two out of the last three aircraft were scrapped by ASL, but EI-FXD (MSN 273) managed to find a new home in Canada with Air North.
- In April 2021, Voyageur Airways began a three-year cargo contract with Canadian logistics integrator Purolator Courier utilizing two DHC-8-100(PF) converted aircraft.
- On May 27th, 2021, Empire Airlines received its first FedEx ATR 72-600F. However, at the time of writing neither of the two aircraft received have entered service. Many speculate that this is due to some form of training delays.
- In May 2021, Tunisair announced the will be converting two aircraft into freighters. We know that one of these aircraft will be a former Tunisair Express ATR72-500 (TS-LBE, MSN 794).
- In July 2021, Sky Cana launched cargo operation with ATR72 freighter.
- In August 2021, Wadadli Cargo rebranded as Island Cargo, they also made modifications to their original operating plans. Island Cargo had originally announced that they would launch utilizing CRJ(F) aircraft, however their operations will now include a leased B737-800 and an owned ATR72-200(F).
- In September 2021, Air Wisconsin added a CRJ200ER(SF) to it fleet, this aircraft was the first dedicated freighter in their fleet and entered service prior to the 2021 peak rush.
- Florida's Legends Airways acquires six Saab 340 freighters in October of 2021, as of January 2022 two of these aircraft have entered service
- In November of 2021, Amazon commenced ATR72F ops with Silver Airways, Silver’s fleet operating for Amazon has not grown to 5 aircraft.
- British charter airline RVL Aviation added two Saab 340B(F)s to their fleet in 2021.

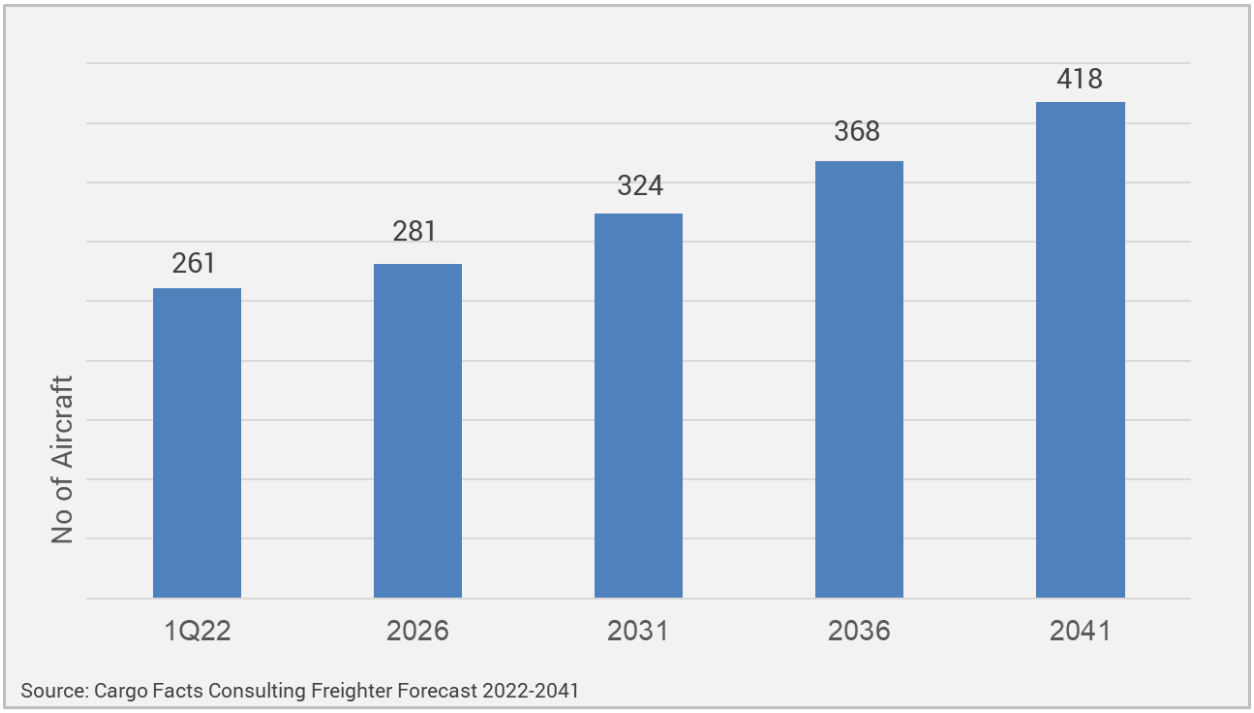
With the Covid-19 pandemic spilling over into 2021 we have seen continued reliance on passenger freighter, however there were other turboprop developments that we feel are worth noting:

- In February Sikorsky and FedEx announced that they are working on single-pilot ATR42F.
- In 2021 ZeroAvia signed agreements with both De Havilland and ASL. ZeroAvia plans to develop a hydrogen-electric engine program for the Dash 8-400 and a fuel cell-powered ATR72F for ASL.
- On November 3rd, 2021 the Air Inuit's first large cargo door Q300 took flight. It is reported that this aircraft will remain in Air Inuit's fleet and, but future aircraft will offer a solution to repla aging HS748 aircraft in the industry.

The market for feeder aircraft has long been a slow-growth business driven by the decision of a few key operators. Turboprop cargo aircraft entering operations, predominately through conversions, are generally replacing aging aircraft. The combination of these factors is likely the main driver behind the trend of OEMs shying away from offering new production freighters. As we saw with the ATR72-600F and the Cessna SkyCourier, large launch orders from FedEx have not spurned others to also place orders.

The expected evolution of the turboprop/RJ freighter fleet over the next twenty years is depicted in Figure 14. The fleet is shown to increase from 261 units in Q1 of 2022, to 418 units at the end of 2041.

Figure 14 - Baseline Feeder Freighter Fleet Forecast 2022 - 2041



Overall, the total number of turboprop/RJ freighters in 2041 is expected to be about 1.6 the baseline quantity of 261 units. The net growth in the turboprop/RJ fleet size is 157, which when combined with 229 retirements, produces the overall need for 386 freighters through the end of 2041. This total fleet requirement equates to an average of 19 turboprop/RJ units per year. All of the added feeder freighters in the forecast, with the exception of 81 ATR 72-600s (about 19% of all additions), will be freighter conversions (see Figure 15).

Figure 15 - Feeder Freighter Forecast Fleet Development 2021-2040

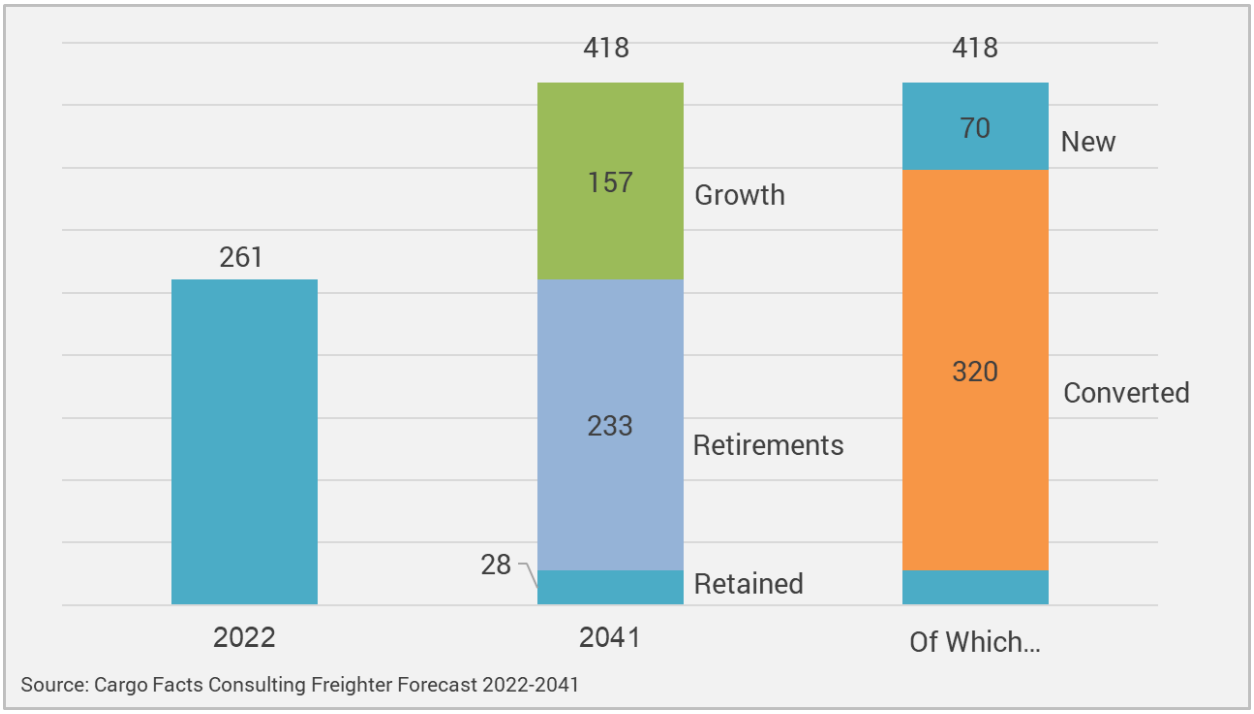


Table 7 shows the detailed composition of the turboprop/RJ freighter fleet on a model-by-model basis at the end of forecast period in 2041 under our baseline scenario. Based on our assessment, we see the ATR 72 being the single dominant type in the feeder segment, followed by the Dash 8 series, followed by the newly announced Embraer program.

Table 7 - Feeder Freighter Fleet in 2041

Feeders (Turboprops and Regional Jets) *8,500 – 20,000 lbs (3.8 – 9 tonnes)*
418 Total Units
0 ATR 42s 222 ATR 72s 10 Dash 8-Q300s 95 Dash 8-Q400s 18 CRJ 200s 63 EMB 190/195 10 Saab 340

Source: Cargo Facts Consulting Freighter Forecast 2022-2041

5.2 Feeder Freighter Forecast Assumptions

As with the Jet Freighter forecast (Chapter 4), the turboprop and regional jet ("feeder") freighter forecast reflects our assessment of future product strategies and aircraft availability over the next twenty years. Some models shown in our forecast may not become available in freighter configuration, while some that we do not show may be introduced. This is unlikely to affect overall demand within the segment but most certainly will affect the relative market shares of different types.

The main types of aircraft that will be involved in the future evolution of the turboprop/RJ freighter fleet over the next twenty years can be broken down into four sub-groups. As shown in Table 8, three of these groups contain aircraft currently in service, while the fourth group contains aircraft under development for later entry into service. The aircraft types are all passenger-to-freighter (P-to-F) conversions, except the ATR 72-600 which is a new production model. There are currently active large cargo door conversion programs for the CRJ 200 (AEI), ATR 72/42 (IPR) and Dash 8 Q300 (Air Inuit/ Collins). There is no large cargo door program available for the Dash 8-Q400, but we expect one to become available over the forecast period.

Table 8 - Feeder Freighter Fleet Available to Operators

	Turboprops/ Regional Jets
Facing near-term extinction	CV 580, HS 748, Fokker F27/50, Bae ATP, AN26/32/74
At peak use, or with limited future growth potential	ATR 42, CRJ-200, Saab340/2000, Dash 8-Q300
Expanding role going forward	ATR 72-600, ATR 72 conversions
Future aircraft	Dash 8-Q400, E190/195

Source: Cargo Facts Consulting Freighter Forecast 2022-2041

Note that there are no active nor launched programs for the CRJ700/900, but Embraer has recently launched a new freighter conversion program for the E190 and E195. Embraer is expecting to redeliver the first units in 2024. Embraer has stated that the freighters will be able to carry between 10 to 12 tonnes of payload, with the E190F offering a volume of 3,630 ft^3 and 2,300 nautical miles of range while the E195F offering a volume of 4,170 ft^3 (for a range of 2,100 nm). The Embraer 190/195 program announced will also feature a door capable of accommodating 96 x 125" ULDs.

We have not modelled the potential effects of individual company decisions in this segment. For example, Amazon's commitment for a few ATR-72 freighters could lead to a large order for the type to support its logistics operation. Individual company decisions may not necessarily be in line with underlying market demand.

6. Freighter Usage Analysis

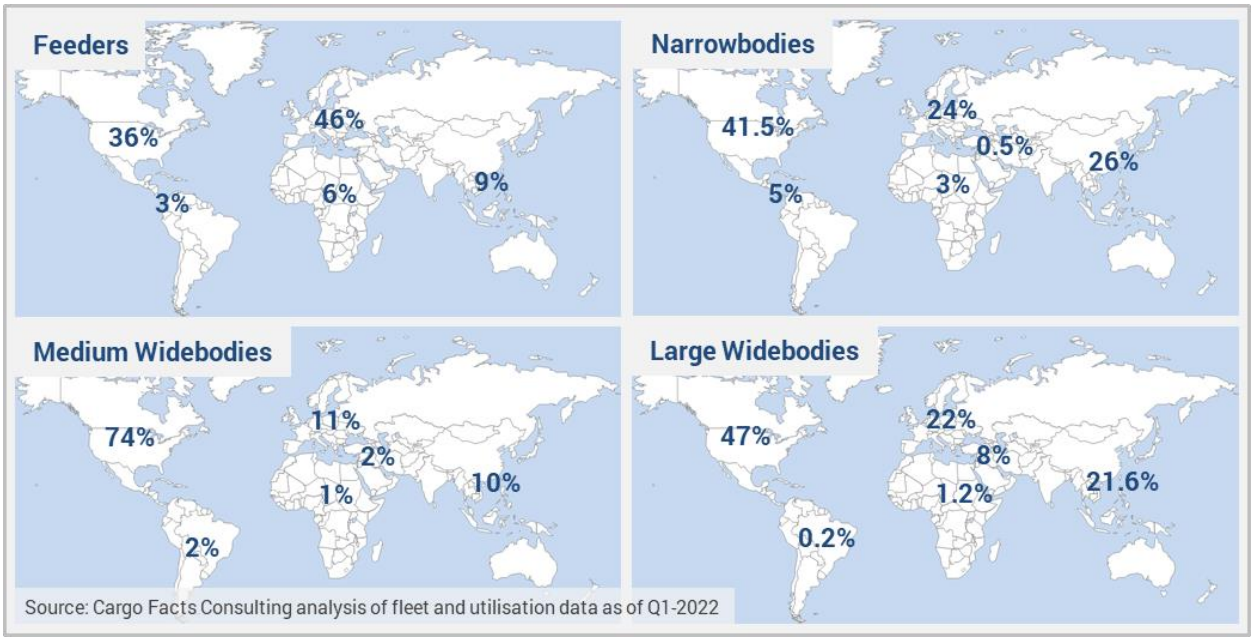
Key Findings:

- A large portion of the world's narrowbody and widebody jet fleet is concentrated in North America due to the presence of FedEx, UPS, and other large contract airlines such as Atlas and ATSG.
- Europe has the highest share of feeder aircraft operated by a mix of smaller operators and larger airline groups such as ASL or Swiftair/West Atlantic.
- The large widebody segment is the most diverse in terms of operators and geography. Most of the world's freighter tonne kilometres are generated on large widebody aircraft on intercontinental services.
- E-Commerce platforms are emerging as large direct aircraft customers, but Amazon continues to be the only major global platform committed to dedicated air capacity and has seen a rapid expansion of its network in the US and Europe.

6.1 Usage by Geography and Business Model

The geographical distribution of the world's freighter fleet varies significantly by aircraft category and is driven both by market size and business model of the operators domiciled in each region. Figure 16 provides an overview of the regional distribution of the world's fleet by category.

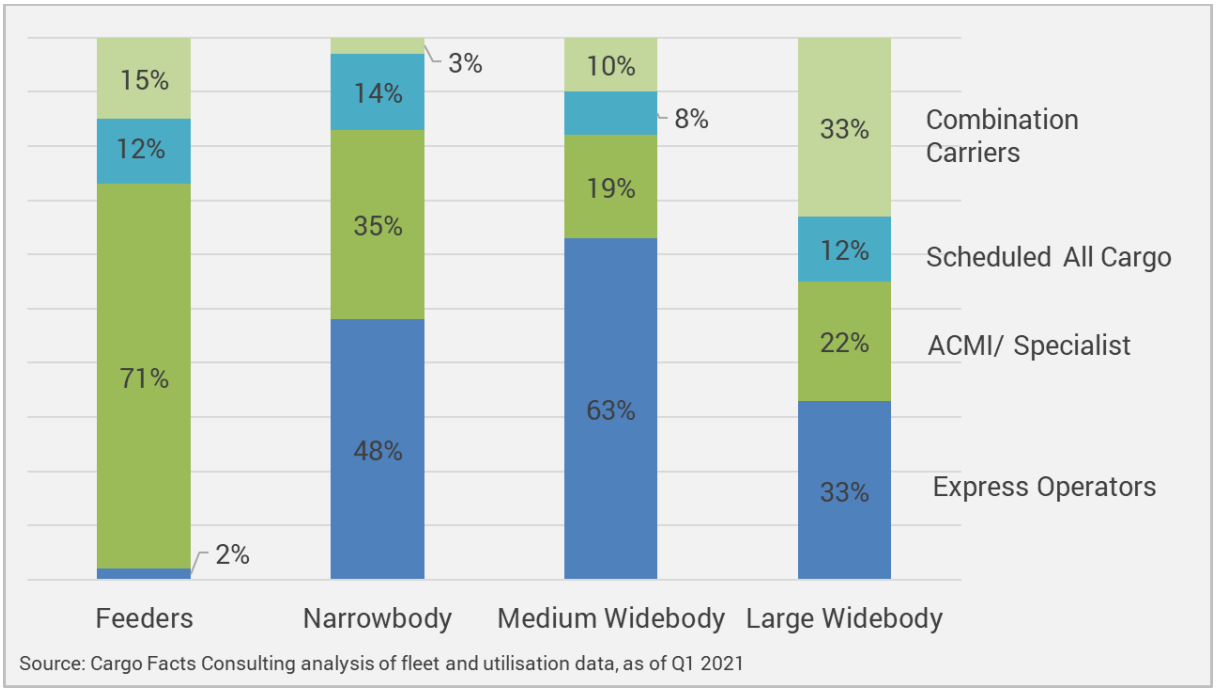
Figure 16 - Freighter Fleet by Operator Domicile Q1 2022



About half of the world's widebody fleet is operated by North American operators, with European and Asian operators accounting for most of the balance. Over time we have witnessed a towards Gulf based carriers as these have expanded their fleets and networks. The vast majority of medium widebody aircraft are operated in North America – primarily for and by the FedEx, UPS, Amazon, and DHL. European and Asian express companies also operate medium widebodies, with Airbus types being more dominant in Europe and Boeing 767s more dominant in Asia. The distribution of narrowbodies is like the large widebody segment, with North America, Europe, and Asia accounting for 90% of aircraft operated. Over time the share of Asian operated narrowbodies has grown. Feeder aircraft remain largely concentrated in the US and Europe, where they provide support to express networks. Operators domiciled in Europe and Asia-Pacific recorded year-on-year growth in the share of medium widebody aircraft in service.

Figure 17 illustrates the differences in operator type within each freighter aircraft category. Across the feeder, narrowbody and medium widebody segments, most of the fleet is operated either by or for express operators and e-commerce platforms. In fact, seven companies – FedEx, UPS, DHL, SF Express, China Postal Airlines, YTO and Amazon account for 60% of narrowbody and 80% of medium widebody aircraft demand. Most feeders are operated either for FedEx or DHL. The large widebody segment is more diverse with all cargo and combination carriers accounting for almost half of aircraft operated.

Figure 17 - Freighter Fleet by Operator Business Model Q1 2022



Because of scope clauses in FedEx and UPS pilot contracts, outsourcing to third party operators is limited to the jet segment, but allowed in the feeder segments, which explains the prevalence of ACMI contract operators. DHL does not have such limitations and makes wide use of subcontractors. Amazon so far has also outsourced all its dedicated air operations to third party operators.

6.2 E-Commerce and Freighter Demand

We estimate that around 17% of world air cargo is e-commerce traffic which moves through multiple networks: intercontinentally as general cargo consolidations or express, domestically as express, and both domestically and internationally on dedicated operations. E-commerce is a growth segment and both airlines can position themselves to take advantage of this growth by moving beyond being mere capacity providers. The global cross-border e-commerce market is growing fast, and the momentum of new aircraft leasing continues as logistics providers keep seeking more international capacity on behalf of their clients while they grow their reach in the growing cross-border e-commerce market.

So far only Amazon has run a substantial own controlled network. At the end of the first quarter of 2022, the e-commerce platform had ninety-two active aircraft in the US, two active aircraft in Canada and twelve aircraft in Europe. We that the company's spend on dedicated air is currently around $1.5 billion per year. The lack of air capacity and supply chain disruptions were good for international air express volumes and yields. Domestic U.S. volume growth has underperformed international growth, but per-package yields also increased. Part of this is due to the changing mix of B2B vs B2C traffic.

The large Chinese e-commerce platforms, Alibaba and JD.com have not operated dedicated capacity but have procured air capacity through different partnerships with air carriers. However, we are seeing an increasing willingness of e-commerce platforms to commit to dedicated capacity and this is driving increased freighter demand which may create additional upside particularly in the early years of our 20-year forecast. Alibaba's logistics arm, Cainiao, has announced multiple long-term contracts with carriers such as Atlas Air to boost international capacity with the goal of supporting cross-border e-commerce activity.

Latin America focused e-commerce platform Mercado Libre has been expanding its dedicated narrowbody network and will soon have three operators providing DC9, 737 Classic and 737 NG capacity. This includes Aeronaves TSM (Mexico), Sideral (Brazil) and GOL (Brazil).

We think this trend will continue as e-commerce platforms expand their own controlled distribution networks. Our Global E-Commerce Logistics Outlook, published every year in October takes a deeper look at the emerging trends e-commerce logistics and what it means for aircraft demand.

7. Conversion Market Dynamics

Key Findings:

- With increasing new generation conversion program availability and continuous strong express and e-commerce growth expectations, activity remains strong for both narrowbodies and medium widebodies.
- The 737 NG and 767-300s have been the main focus of activity. Classic narrowbody conversion activity is winding down, and A330s and A321s are starting to pick up.
- Although the market for the converted 757 is expected to weaken, there is still demand with some units acquired for conversions.
- While 767 conversion activity has been customer driven, most of the new generation narrowbody passenger to freighter aircraft commitments are speculative by funds and leasing companies.

7.1 Conversion Market Drivers

Passenger-to-Freighter (P-to-F) conversion is an essential element in the development of the global fleet of freighter aircraft. Historically, the option of acquiring production freighters has been available in the widebody, but not in narrowbody or feeder market. But even in the widebody segment about half of the freighters have been converted from passenger configuration.

Three primary factors are essential to support P-to-F conversion:

- The availability of used passenger aircraft "feedstock" of suitable age, hours, and cycles,
- Suitable feedstock prices, and
- The existence of certified freighter conversion programs.

In assessing the likelihood of P-to-F conversions, we consider the number of aircraft of a particular type that were produced in passenger configuration and the period over which production took place. That explains, for example, why the 767-300ER (with over 500 built, mostly over sixteen years from 1988 through 2004) is popular for future P-to-F conversion, while the A300-600 (with fewer than 200 built, mostly over twelve years from 1984 through 1996) will see no further conversion activity.

Also important in assessing P-to-F opportunities is understanding that most conversions are done on aircraft between 16 and 25 years, although there are cases of both younger as well as older aircraft being converted.

7.2 Conversion Market Trends

With strong air cargo, express and e-commerce market performance, demand for cargo conversions is at an all-time high — particularly for the 737-800, 757-200 the 767-300. Activity for the A321 and A330-300 is also picking up.

After around fifty narrowbody redeliveries in 2020, over 80 in 2021, we expect to see around 130 narrowbody conversions in 2022. This level of activity is expected to continue into 2023 and beyond judging by the current backlog. This is much higher than the long-term average of about 40-50 per year and higher than our forecast average of about 60 per year over the next 20 years. The current backlog for narrowbody freighters is around 200 aircraft, mainly 737-800s.

Although the market for the converted 757 is expected to weaken, there is still demand with some units acquired for conversions. If operated at low utilization, this aircraft still has much to offer and even the older production 757-200 freighters will have many years of useful life remaining. With the A321 conversions becoming more popular, this aircraft represents a solid competitor, but its success will depend on the A321 market values prior to conversion and the ability to find 757 engines at reasonable prices. The 757-freighter program remains a success story and values have been able to stay unchanged for some time.

In the medium widebody space, historical conversion activity has been in the order of about 15 units per year. 2021 saw over 30 medium widebodies converted and 2022 is expected to see double that as order activity and capacity has ramped up to meet demand. The current backlog for 737 conversions stands at over 100 aircraft and the A330 backlog has grown to similar levels. Ad with the narrowbody space, current activity is out of line with what we expect in terms of long-term demand. Our 20-year forecast expects additions of about 36 per year in this segment, about two thirds of which would be conversions.

The large widebody segment has seen less activity to date, mainly because of choice. However, now there are three conversion programs under development for the 777-300ER and one for the 777-200LR. All three providers – IAI, Mammoth and Kansas Modification Center (KMC) have all secured orders. The known backlog for these programs is in the order of 70 units.

Table 9 shows an overview of currently active, in development, launched and planned jet freighter conversion programs. Following a number of new STC in the last 12 months and new program announcements, freighter customers now have a wide choice of options available.

Table 9 - Current and Future Jet Freighter Conversion Programs as of May 2021

	AEI	IAI	Boeing	EFW	PEMCO	321/ Precision	ST Engin-eering	Sine Draco	C3	Mammoth	KMC
MD-80	X										
737-300	X				X						
737-400	X				X						
737-700		X			X						
737-800	X	X	X								
A320				Mar 2022					2H-2022		
A321				Feb 2020		Apr 2021		3Q2022	2023		
757-200						X	X				
767-200		X									
767-300		X	X								
A330-200				X							
A330-300		Late 2024		X							
777-200LR										3Q 2023	
777-300ER		Late 2022								3Q 2023	2Q-2024

Source: OEMs, Conversion Houses, Cargo Facts Consulting estimate, as 1 May 2022

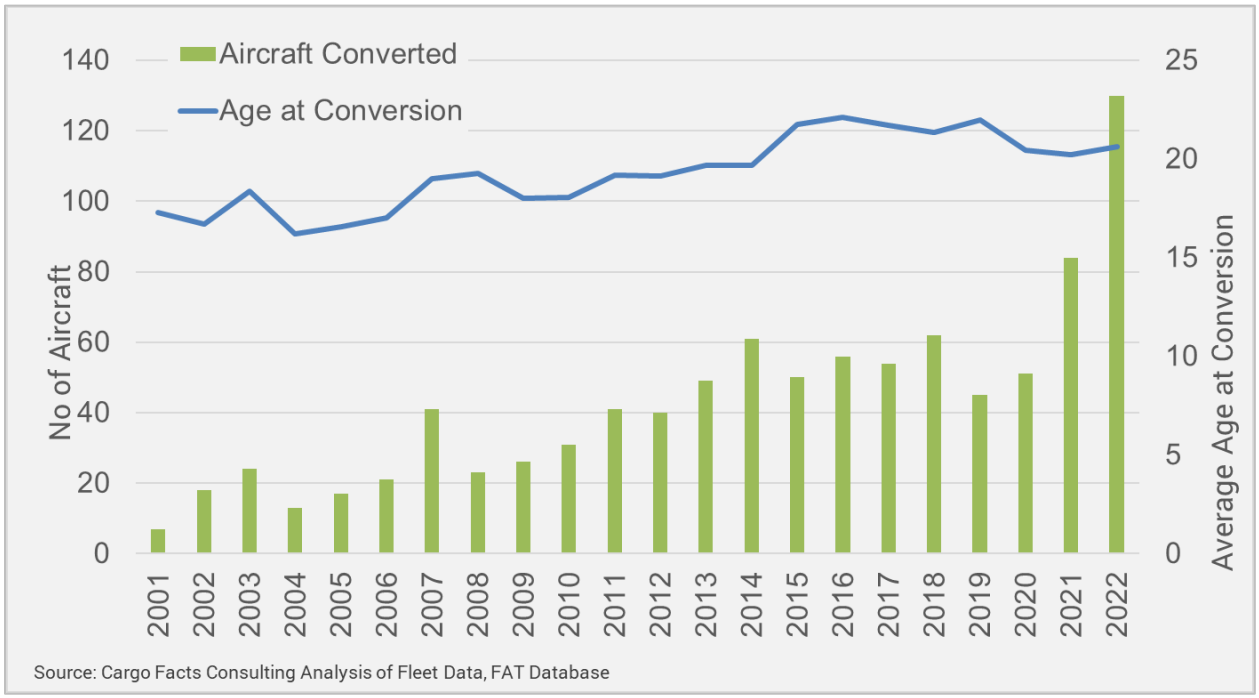
With demand, conversion capacity has also been increasing with a number of new lines opening in China, the Americas as well as Europe. Our Insights product (www.cfcinsights.com) provides an interactive dashboard showing conversion locations and capacity. Current 737-800 conversion capacity across Boeing, AEI and IAI has increased from about 50 per year to over 70 per year. Once additional facilities and lines are opens there will be capacity for approximately 110 units per year. A321 capacity has also been expanding and currently stands at about 25 units per year. 767 conversion capacity has expanded and stands at about 40-45 units per year and 330 capacity at around 20 units per year.

The average age at conversion has been rising. The reason behind this occurrence is the popularity of older generation aircraft such as the 757, 767 and 737 classics. However, this will change as feedstock for this group starts to diminish and the A320 family, 737 NG and A330 conversion activity becomes predominant. Redeliveries of freighter converted A321Fs have started but we will not see many A321s in the near term due to the high feedstock values and continued availability of 757-200 feedstock.

Currently, narrowbody freighters (such as the 737, 757 and MD-80) are being converted at ages of between 21 and 22 years and medium widebody freighters (767 or A330) at between 20 and 23 years. During the first decade of this century, the customary age for narrow-bodies was between 17 and 19 years, and 15 to 20 years for medium wide-body freighters.

Figure 18 and Figure 19 provide an overview of the number of narrowbody and medium widebody conversions and the average age at conversion, between 2000 and 2020, as well as scheduled completions in 2021. The current 737 NG backlog stands at about 110 aircraft over the next two years and this higher than average number is reflected in the 2022 planned orders shown below.

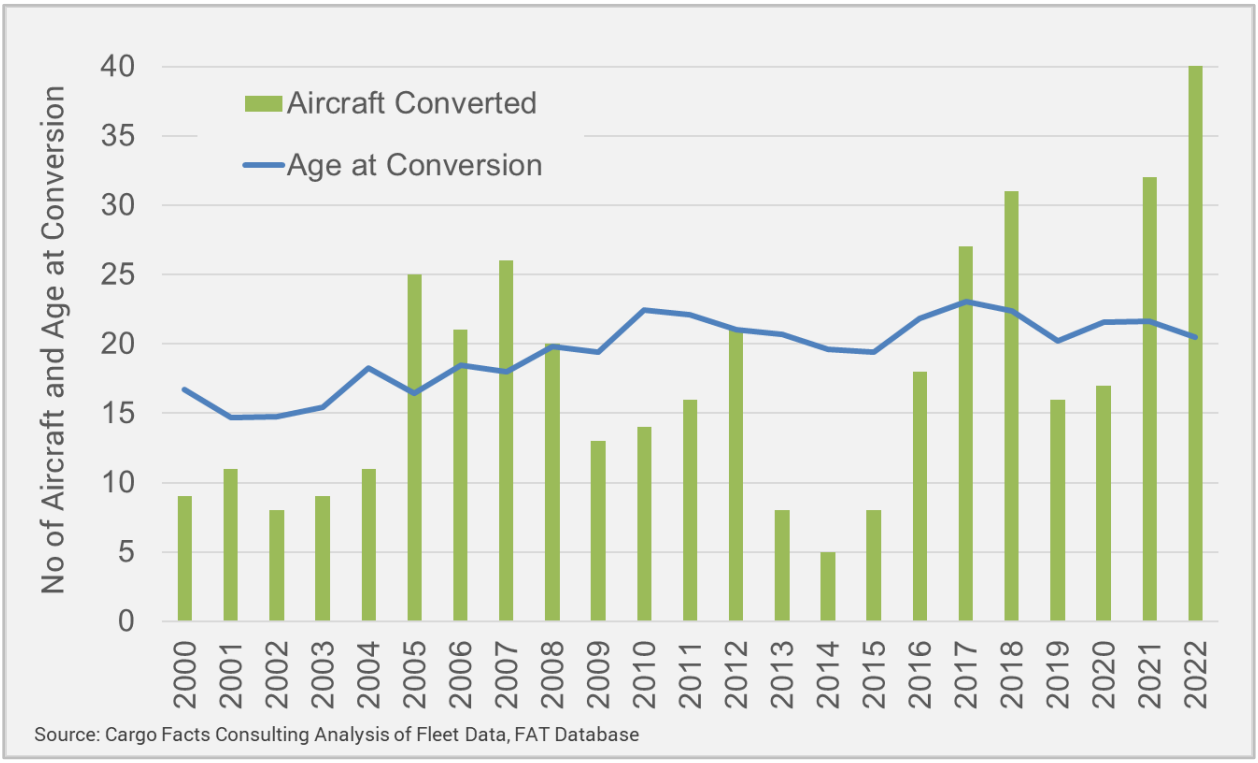
Figure 18 - Narrowbody Conversions and Average Age at Conversion 2000 - 2022



Source: Cargo Facts Consulting Analysis of Fleet Data, FAT Database

We have observed an upward trend in the average age at conversion of narrowbody aircraft since the early 2000s, but this trend has remained flat since 2014. The 757s and 737 classics have seen an upward trend as feedstock is less available, with conversion taking place in the 23-25 age range. The conversion age range for the MD-83s tends to be in the 25-27-year range while most 737 NG conversions are in the 17-18-year age range.

Figure 19 - Medium Widebody Conversions and Average Age at Conversion 2000 - 2022



For the medium widebody segment, the average age at conversion has been rising since the early 2000s but has remained flat since then, between 21 and 23 years. In the past five years, we have seen some units getting converted over the age of 25. This average will likely start to come down with the A330-200 and A330-300 values dropping and on ramp costs for the two types becoming more attractive to customers. We have not included a chart for large widebody equipment since the activity in this segment has been limited. The last two 747-400s were converted by Israel Aerospace Industries (IAI) in 2017.

7.3 Passenger to Freighter Feedstock Availability

The following section examines the quantities in the feedstock pool for various freighter conversion candidates – not all of which currently have active conversion programs. In reviewing the material that follows it is important to keep in mind the production periods and the quantities that have been produced for each model under discussion.

Table 10, Table 11, and Table 12, provide an overview of production periods, production quantities, and feedstock totals in the 16-25 year age bracket now and into the future for narrowbody, widebody and

feeder aircraft. Note that for the older types that are out of production feedstock declines going forward, while for the newer types of feedstock will increase in the future.

Please note that all aircraft quantities below include aircraft in storage, maintenance or under repair in addition to all the active units at the time of this analysis (April 2021). The *Feedstock Analysis Tool* is provided as a supplement to this forecast and hosted on the Cargo Facts Consulting Insights site (www.cfcinsights.com) provides additional detail by aircraft type and split in 16-20 and 21-25 year age brackets for 21 different aircraft types, ranging from turboprops to large widebody jets.

7.3.1 Narrowbody Freighter Feedstock

The narrowbody freighter market is in transition from older to new generation aircraft types. The suitable feedstock pool for 737-300, 737-400 and 757-200 aircraft is declining, while the feedstock of 737 NGs and A320 family aircraft increases.

Table 10 - Narrowbody Feedstock Summary

Model	Production Years	Passenger Deliveries	Feedstock Quantities for 16-25 years old aircraft		
			2022	2025	2028
737-300	1984 – 1999	1,113	110	14	0
737-400	1988 – 2000	486	17	4	0
737-700	1997 – 2019	1,285	621	832	701
737-800	1998 – 2019	5,135	885	1,430	1,931
737-900	2001 – 2019	564	51	46	27
757-200	1982 – 2005	995	178	103	7
757-300	1998 – 2004	55	54	50	28
A320-200	1998 – 2020	4,695	912	1,408	1,996
A321-200	1996 – 2020	1,661	241	363	484
MD-82/-83/-88	1981 – 1999	330	48	22	0

Source: Cargo Facts Consulting Feedstock Analysis Tool

To be more specific, the pool reduces in future years as aircraft that become 26 years old in each succeeding year are removed from the pool. Such reductions in theory would be offset by aircraft 14 years of age that would be added to the pool in each succeeding year. But for example, in the case of 737-300, as shown in Table 10, there are no such young units. The pool declines by 85% from 121 to 17 in 2024 and

by then, all the 17 available 737-300 aircraft are in the 21-25-year age bracket. Similarly, the conversion for the 737-400 (with only 486 deliveries from 1988 to 2000) will be coming to an end in the near term because there are currently around twenty units in the 21-25-year age bracket. By 2027, there will be no 737 Classics in the prime conversion range. The MD-80 family shows no units available in the prime conversion range beyond 2027.

On the other hand, the feedstock for the newer generation 737 and A320/A321 family will increase in the coming years. As shown in Table 10, Boeing stopped production of the 737 NGs in 2019 while Airbus still produced a limited number of CEOs in 2020. The current production totals are 1,285 for 737-700, 1,661 for the A321-200, and around 5,000 each for the 737-800 and A320-200. These high quantities result in a favorable feedstock situation today for these models, with improving conditions going forward. Somewhat of an exception is the A321, for which low production totals in the late 1990s constrain age-appropriate feedstock today and through 2024. It is important to note that the individual quantities for the 737-800 and A320-200 are roughly double the quantities of the 737-300, 737-400 and 757-200 combined.

As for the most popular aircraft in the narrowbody segment, feedstock keeps declining for the 757-200 and 757-300 passenger aircraft. The overall feedstock amount for 757-200 is larger than -300 due to the larger production amount. We also note that there has so far been no program announced for the 757-300 since it would be hard to justify with only 55 aircraft in active operation. We believe that conversions of 757s will be feasible from a feedstock perspective until 2025, several years longer than the case for the 737-300 or 737-400 models. Nevertheless, the two 737 Classic types and the 757-200 will still dominate the worldwide freighter composition in the short term.

7.3.2 Widebody Freighter Feedstock

In the medium widebody aircraft segment, 767-300ER feedstock availability drops over the period from 2021 to 2035, during which the feedstock in the older age bracket is larger than the younger ones because of the production years. Over one-third of the total produced are now over 25 years old. In contrast, the total feedstock quantities for A330-200/-300 in the age bracket of 16-25 years old are growing over the next fifteen years. Note that the feedstock in the older year age bracket for A330-200 is also growing over the time, while the feedstock in the younger age bracket are growing over the time for A330-300. Table 11 summarizes the feedstock quantities in the 16-25 year age bracket but for more details, please consult the Feedstock Analysis Tool available on the Cargo Facts Consulting Insights site.

In the large widebody aircraft segment, the feedstock situation for the 777-200ER and 777-300ER are developing in opposite directions. The feedstock in the conversion zone for 777-200 steadily declines beyond 2023. This can be explained by the production years of this type, from 1997 to 2013. Its feedstock in the younger year age bracket is declining while the older year age has a growth at the beginning before the number drops. The feedstock availability for 777-300 shows an opposite trend: both the feedstock in the older year age bracket and the younger year age bracket are growing over the time period from 2020 to 2035 and after 2025, the available feedstock is sufficient to ensure the success of a P2F program.

Table 11 - Medium and Large Widebody Feedstock Summary

Model	Production Years	Passenger Deliveries	Feedstock Quantities for 16-25 years old aircraft		
			2022	2025	2028
767-300ER	1988 – 2014	667	151	111	79
A330-200	1998 – 2020	645	196	270	312
A330-300	1993 – 2020	771	136	171	264
777-200ER	1997 – 2013	422	357	267	139
777-300ER	2004 – present	807	47	186	327

Source: Cargo Facts Consulting Feedstock Analysis Tool

7.3.3 Turboprop/ Regional Jet (Feeder) Freighter Feedstock

Regarding feedstock in the turboprop/ regional jet segment, our analysis is focused on the ATR 42/72, Dash 8-Q300 and -Q400, the Bombardier CRJ 200 and CRJ 700 and the Embraer E-190 and E-195 (Table 12).

We see feedstock for ATR 42 and Dash 8-Q300 declining and feedstock for all other segments increasing. This will likely limit the potential for additional ATR 42 and Dash 8 Q300 conversions in favour of higher volume 19,000 lbs (8.5 tonne) aircraft, which will become the reference in this segment, replacing both existing 8,500 – 1,4000 lbs (3.8 – 5 tonne) aircraft currently in operation. It is likely the regional freighter fleet will continue to see plenty of new ATR 72 conversions going forward since demand for this model is especially strong for large-door conversions, thanks to the flexibility it gives to easily move containerized cargo without returning cargo to warehouses for sorting. An exception is the CRJ 200 which shows steady feedstock but declining in 2027 and losing about 100 units available per year. We have

excluded the Saab 340 from our feedstock analysis as we foresee very little development for this aircraft. However, we have included the Embraer E-190 and E-195 as there has been some interest in pursuing the development of a conversion program for this aircraft.

Table 12 - Turboprop/ RJ Feedstock Summary

Model	Production Years	Passenger Deliveries	Feedstock Quantities for 16-25 years old aircraft		
			2022	2025	2028
ATR 42-300/-500	1984 – present	417	74	41	36
ATR 72-200/-500/-600	1988 – present	562	98	155	268
Bombardier Dash 8-Q300	1998 – 2007	267	74	85	60
Bombardier Dash 8-Q400	2000 – present	601	84	209	340
Bombardier CRJ 200	1991 – 2006	939	740	695	475
Bombardier CRJ 700	2001 – 2018	346	224	259	291
Embraer E-190	2005 – present	584	14	184	401
Embraer E-195	2006 – 2019	181	5	37	91

Source: Cargo Facts Consulting Feedstock Analysis Tool

8. About Cargo Facts Consulting

Cargo Facts Consulting is a specialized air logistics advisory and research firm. Formerly also known as Air Cargo Management Group, we have been in business since 1978.

Our clients turn to us for deep advice, data, and insights on key aspects that effect product development, marketing, fleet planning and strategy in air logistics. These clients come from across the whole air cargo and express business and include financial institutions and investment firms, leasing companies, government, aircraft manufacturers and conversion companies, airlines, express companies, airports, and other service providers.

Our consulting experience spans projects that encompass airline network planning, fleet planning, due diligence, route development, investment assessment, air cargo and express market analysis, and aircraft technology. Our data and forecasts populate financial models related to many facets of the business, and our analysis is used in product development by a wide range of company. We also provide deep analytics for the type of data- and mission-related marketing in the aviation sector.

We strive to be the most knowledgeable and highly valued provider of strategic advice to the global air freight transportation and logistics industry. We provide actionable solutions, not just data and research based on critical needs and business objectives. We facilitate business evolution that yields greater profits and efficiency. And we do so often through long-term relationships that create a deep and more-meaningful dialogue with our customers.

Through Cargo Facts and Air Cargo World, our sister media organizations, we have a unique and high-visibility insight into industry trends and market developments as they happen.

Appendix 1 – Freighter Forecast Assumptions

In developing our predictions, we adopt a top-down forecasting method. We begin by establishing a baseline level of freight-tonne-kilometers (FTKs) for the total group of freighters within each size category in the base year. We then determine the number of FTKs required at the end of each five-year period based on three important input variables:

- future growth in air freight demand
- assumed shifts in freighter productivity
- changes in the ratio of freighter-to-belly use

This approach allows us to determine the required jet freighter fleet quantity in each of the three size groups at the end of each five-year period.

We then consider the specific freighter models that will be available during the forecast period and make a detailed prediction of the make-up of the fleet by aircraft type. As noted previously, we account for additions to the freighter fleet (new production deliveries and added P-to-F conversions), along with reductions in the fleet (from retirements), to meet the needed FTK growth for the period.

The target growth can be met by a variety of combinations of additions and retirements of specific jet freighter types, so the results reflect our best judgment about the relative popularity of the competing models. More narrative on this can be found in Chapters 4.3 (Jets) and 5.2 (feeders).

Our baseline assumptions are as follows:

- 3.3% annual growth in air freight demand.
- 0.5-0.7% annual increase in freighter productivity, depending on the aircraft segment.
- No shift over 20 years in the fleet-wide freighter-to-belly use ratio. This is driven primarily by the availability of more freight capable passenger aircraft.

Previous forecasts assumed a shift away from freighters into the bellies of passenger aircraft, but we no longer believe this to be a realistic assumption. However, our forecast does model the impact of different shift scenarios.

Appendix 2 – Freighter Aircraft Characteristics

In this appendix we provide an overview of the indicative weights for both existing and future aircraft types in all four segments (feeders, narrowbody, medium widebody and large widebody). The data reflects manufacturers' or converters' information as interpreted by Cargo Facts Consulting.

For some aircraft types with unknown freighter capability or where programs have not yet been launched, we have made our own indicative estimates of weights, volume, and basic performance data. This includes aircraft such as a 757-300, 737-900, 787-9F, A330-900F.

We have included information on maximum takeoff weight (MTOW), Operating Empty Weight (OEW), Structural Payload and Volumes. We have not included indicative tare weights as these will depend on whether aircraft are being operated in palletized configuration. To get to revenue payload, readers will need to subtract tare weight. Cargo Design Density equals max structural load divided by total cargo volume. This figure represents the design loaded density including the tare weight of containers. A “+” symbol in main deck positions for narrowbodies signifies a "half-sized" pallet.

Note that Operating Empty Weight (OEW) often includes tare weight. In our assessment OEW would include cargo loading systems but not the tare weight of containers and pallets. The same applies to

Weights and volumes are provided both in lbs. and kgs, and ft^3 and m^3.

We welcome feedback on any of these characteristics, particularly for aircraft types that have not yet been launched.

Table 13 - Narrowbody Freighter Characteristics (Imperial)

Model	Maximum Takeoff Weight (lbs)	Operating Empty Weight (lbs)	Main Deck Pallet Positions	Main Deck	Belly Holds (Contain-erized)	Bulk	Total Cargo Volume (ft^3)	Max Structural Payload (lbs)	Range with Max Payload (naut mi)	Volume Limited Payload at 7.0 lbs/ft^3 (lbs)	Design Cargo Density (lbs/ft^3)
BAe 146-300QT	97,500	55,850	7.5	2,475	none	810	3,285	23,150	960	22,995	7.0
737-200F	124,500		7	2,800	none	875	3,675	38,200	1,175	25,725	10.4
MD-83SF	160,000	76,900	12	4,400	none		5,027	45,100	1,200	35,200	9.0
737-300F	139,500	67,100	8+	3,680	none	1,065	4,745	42,500	1,600	33,215	9.0
737-400F (LGW)	143,500	69,900	10+	4,560	none	1,375	5,935	43,100	1,250	41,545	7.3
737-400F (HGW)	150,000	70,900	10+	4,560	none	1,375	5,935	47,100	1,725	41,545	7.9
737-700BDSF	154,500	76,700	8+	3,680	none		4,645	45,000	2,100	32,515	9.7
737-800SF	174,200	85,600	11+	5,000	none	1,555	6,555	52,700	2,000	45,885	8.0
737-800BDSF	174,200	85,300	11+	5,000	none	1,555	6,555	53,000	2,000	45,885	8.1
737-900F (est)	187,700	87,524	12+	5,500	none	1,555	7,055	61,976	2,000	45,885	9.5
A320-200F (est)	169,800	91,492	10+	4,693	910	208	5,811	48,280	2,000	40,677	8.3
A321-200F	196,300	103,176	14	6,048	1,300	208	7,556	61,500	1,850	52,892	8.1
727-200F	203,100	98,600	12	5,280	none	1,525	6,805	56,400	1,650	47,635	8.3
757-200SF	240,000	116,000	15	6,600	none	1,790	8,270	70,000	2,400	57,890	8.5
757-300SF (est)	271,000	130,000	18	7,920	none	2,382	10,302	80,000	2,400	72,114	7.8

Table 14 - Narrowbody Freighter Characteristics (Metric)

Model	Maximum Takeoff Weight (lbs)	Operating Empty Weight (lbs)	Main Deck Pallet Positions	Main Deck	Belly Holds (Contain-erized)	Bulk	Total Cargo Volume (ft^3)	Max Structural Payload (lbs)	Range with Max Payload (naut mi)	Volume Limited Payload at 7.0 lbs/ft^3 (lbs)	Design Cargo Density (lbs/ft^3)
BAe 146-300QT	97,500	55,850	7.5	2,475	none	810	3,285	23,150	960	22,995	7.0
737-200F	124,500		7	2,800	none	875	3,675	38,200	1,175	25,725	10.4
MD-83SF	160,000	76,900	12	4,400	none		5,027	45,100	1,200	35,200	9.0
737-300F	139,500	67,100	8+	3,680	none	1,065	4,745	42,500	1,600	33,215	9.0
737-400F (LGW)	143,500	69,900	10+	4,560	none	1,375	5,935	43,100	1,250	41,545	7.3
737-400F (HGW)	150,000	70,900	10+	4,560	none	1,375	5,935	47,100	1,725	41,545	7.9
737-700BDSF	154,500	76,700	8+	3,680	none		4,645	45,000	2,100	32,515	9.7
737-800SF	174,200	85,600	11+	5,000	none	1,555	6,555	52,700	2,000	45,885	8.0
737-800BDSF	174,200	85,300	11+	5,000	none	1,555	6,555	53,000	2,000	45,885	8.1
737-900F (est)	187,700	87,524	12+	5,500	none	1,555	7,055	61,976	2,000	45,885	9.5
A320-200F (est)	169,800	91,492	10+	4,693	910	208	5,811	48,280	2,000	40,677	8.3
A321-200F	196,300	103,176	14	6,048	1,300	208	7,556	61,500	1,850	52,892	8.1
727-200F	203,100	98,600	12	5,280	none	1,525	6,805	56,400	1,650	47,635	8.3
757-200SF	240,000	116,000	15	6,600	none	1,790	8,270	70,000	2,400	57,890	8.5
757-300SF (est)	271,000	130,000	18	7,920	none	2,382	10,302	80,000	2,400	72,114	7.8

Table 15 - Medium Widebody Freighter Characteristics (Imperial)

Model	Maximum Takeoff Weight (lbs)	Operating Empty Weight (lbs)	Main Deck Pallet Positions	Main Deck	Belly Holds (Contain-erized)	Bulk	Total Cargo Volume (ft^3)	Max Structural Payload (lbs)	Range with Max Payload (naut mi)	Volume Limited Payload at 7.0 lbs/ft^3 (lbs)	Design Cargo Density (lbs/ft^3)
A310-200F	313,000	165,920	16	7,960	2,169	610	10,129	89,000	2,200	70,903	8.8
A310-300F	346,100	169,920	16	7,960	2,169	610	10,129	86,700	3,350	70,903	8.6
767-200ERF	351,000	165,000	20	9,896	2,485	430	12,381	101,400	2,840	86,667	8.2
A300B4-200F	363,760	172,100	20	9,950	2,894	565	12,844	97,900	2,100	89,908	7.6
A300-600RF	375,900	179,230	21	10,450	3,708	610	14,158	107,400	2,650	99,106	7.7
A300-600F (production)	375,900	175,420	21	10,450	3,708	610	14,158	111,180	2,750	99,106	7.7
767-300BCF	412,000	181,520	24	11,884	3,396	430	15,280	127,480	3,100	106,960	8.1
767-300BCF (winglets)	412,000	185,720	24	11,884	3,396	430	15,280	124,580	3,150	106,960	8.2
767-300SF	412,000	180,800	24	11,884	3,396	430	15,280	128,200	3,100	106,960	8.1
767-300SF (winglets)	412,000	183,800	24	11,884	3,396	430	15,280	125,200	3,150	106,960	8.2
767-300F (production)	412,000	181,000	24	11,884	3,153	430	15,037	127,000	3,250	105,259	8.4
787-9F (est)	560,000	235,000	26	14,040	5,688	402	20,130	165,000	n.a.	140,910	8.2
A330-200F production	513,700	238,100	22	11,880	3,572	610	15,452	143,300	4,000	108,164	9.3
A330-200P2F	513,700	242,508	22	11,880	3,572	695	15,452	132,300	3,900	108,164	8.6
A330-300P2F	513,700	251,327	26	14,040	5,098	695	19,138	134,500	3,600	133,966	7.0
A330-900F (est)	553,000	260,366	26	14,040	5,098	695	19,138	138,634	n.a.	133,966	7.2

Table 16 - Medium Widebody Freighter Characteristics (Metric)

Model	Maximum Takeoff Weight (kg)	Operating Empty Weight (kg)	Main Deck Pallet Positions	Main Deck	Belly Holds (Contain-erized)	Bulk	Total Cargo Volume (m^3)	Max Structural Payload (kg)	Range with Max Payload (naut mi)	Volume Limited Payload (kg) at 110 kg/m^3	Design Cargo Density (kg/m^3)
A310-200F	141,975	75,260	16	225	61	17	287	40,370	2,200	31,532	141
A310-300F	156,989	77,075	16	225	61	17	287	39,327	3,350	31,532	137
767-200ERF	159,211	74,843	20	280	70	12	350	45,994	2,840	38,542	131
A300B4-200F	164,999	78,063	20	282	82	16	363	44,407	2,100	39,983	122
A300-600RF	170,506	81,297	21	296	105	17	401	48,716	2,650	44,074	122
A300-600F (production)	170,506	79,569	21	296	105	17	401	50,430	2,750	44,074	126
767-300BCF	186,880	82,336	24	336	96	12	432	57,824	3,100	47,567	134
767-300BCF (winglets)	186,880	84,241	24	336	96	12	432	56,509	3,150	47,567	131
767-300SF	186,880	82,010	24	336	96	12	432	58,151	3,100	47,567	134
767-300SF (winglets)	186,880	83,370	24	336	96	12	432	56,790	3,150	47,567	131
767-300F (production)	186,880	82,100	24	336	89	12	426	57,606	3,250	46,810	135
787-9F (est)	254,012	106,594	26	397	161	11	570	74,843	n.a.	62,665	131
A330-200F production	233,011	108,000	22	336	101	17	437	65,000	4,000	48,102	149
A330-200P2F	233,011	110,000	22	336	101	20	437	60,010	3,900	48,102	137
A330-300P2F	233,011	114,000	26	397	144	20	542	61,008	3,600	59,577	113
A330-900F (est)	250,837	118,100	26	397	144	20	542	62,884	n.a.	59,577	116

Table 17 - Large Widebody Freighter Characteristics (Imperial)

Model	Maximum Takeoff Weight (lbs)	Operating Empty Weight (lbs)	Main Deck Pallet Positions	Main Deck	Belly Holds (Contain-erized)	Bulk	Total Cargo Volume (ft^3)	Max Structural Payload (lbs)	Range with Max Payload (naut mi)	Volume Limited Payload at 7.0 lbs/ft^3 (lbs)	Design Cargo Density (lbs/ft^3)
MD-11F	630,500	241,395	26	15,718	4,702	510	20,420	208,705	3,650	142,940	10.2
MD-11SF	630,500	246,200	26	15,718	4,702	510	20,420	203,900	3,550	142,940	10.0
A350F	696,661	284,700	30	20,151	4,980	399	25,530	240,000	4697	202,552	9.4
777F production	766,000	299,500	27	18,385	4,465	600	22,850	236,200	4,965	159,950	10.3
777-8F	775,000	301,000	31	21,061	5,995	600	27,056	261,000	4410	175,105	9.6
777-200LRMF	766,000	308,000	27	18,385	4,465	600	22,971	233,000	4,900	159,500	8.3
777-300ERSF	775,000	336,000	33	22,440	6,496	600	28,936	222,000	4,800	202,552	7.7
747-400SF	870,000	357,000	30	20,674	3,735	520	24,409	253,000	4,100	170,863	10.4
747-400BCF	870,000	360,640	30	20,674	3,735	520	24,409	250,500	4,100	170,863	10.3
747-400F	875,000	349,700	30	21,462	4,085	520	25,547	260,300	4,450	178,829	10.2
747-400ERF	910,000	350,400	30	21,462	4,085	520	25,547	260,600	4,970	178,829	10.2
747-8F	987,000	420,400	34	24,462	5,330	520	29,792	306,600	4,390	208,544	10.3

Table 18 - Large Widebody Freighter Characteristics (Metric)

Model	Maximum Takeoff Weight (kg)	Operating Empty Weight (kg)	Main Deck Pallet Positions	Main Deck	Belly Holds (Contain-erized)	Bulk	Total Cargo Volume (m^3)	Max Structural Payload (kg)	Range with Max Payload (naut mi)	Volume Limited Payload (kg) at 110 kg/m^3	Design Cargo Density (kg/m^3)
MD-11F	285,990	109,495	26	445	133	14	578	94,667	3,650	63,567	164
MD-11SF	285,990	111,675	26	445	133	14	578	92,488	3,550	63,567	160
A350F	316,000	129,100	30	571	142	11	723	109,000	4697	90,078	151
777F production	347,452	135,851	27	520	126	17	647	107,139	4,965	71,132	166
777-8F	351,535	136,600	31	596	170	17	766	118,300	4410	77,872	155
777-200LRMF	294,835	138,346	27	520	126	17	650	86,183	4,000	71,132	133
777-300ERSF	351,534	152,407	33	635	184	17	819	100,698	4,800	90,090	123
747-400SF	394,626	161,933	30	585	106	15	691	114,759	4,100	75,985	166
747-400BCF	394,626	163,584	30	585	106	15	691	113,625	4,100	75,985	164
747-400F	396,894	158,621	30	607	116	15	723	118,070	4,450	79,528	163
747-400ERF	412,770	158,939	30	607	116	15	723	118,206	4,970	79,528	163
747-8F	447,696	190,690	34	692	151	15	843	139,072	4,390	92,742	165

Table 19 - Feeder Freighter Characteristics (Imperial)

Model	Maximum Takeoff Weight (lbs)	Operating Empty Weight (lbs)	Total Cargo Volume (ft^3)	Max Structural Payload (lbs)	Range with Max Payload (naut mi)	Volume Limited Payload at 7.0 lbs/ft^3 (lbs)	Design Cargo Density (lbs/ft^3)
Saab 340	28,000	17,200	1,470	8,500	335	10,290	5.8
CRJ 200SF ER	51,250	29,426	1,356	14,574	700	9,492	10.7
CRJ 200SF LR	53,250	29,426	1,356	14,574	1,100	9,492	10.7
CRJ700 (est)	75,000	43,142	2,525	19,158	900	17,675	7.6
ATR-42-300	37,300	22,812	2,000	14,000	460	14,000	7.0
ATR-72-500	48,500	26,933	2,700	19,000	520	18,900	7.0
Dash 8-Q300	43,000	26,000	1,865	13,500	750	13,055	7.2
Dash 8-Q400	65,200	35,200	2,730	19,800	1,100	19,110	7.3

Table 20 - Feeder Freighter Characteristics (Metric)

Model	Maximum Takeoff Weight (kg)	Operating Empty Weight (kg)	Total Cargo Volume (m^3)	Max Structural Payload (kg)	Range with Max Payload (naut mi)	Volume Limited Payload (kg) at 110 kg/m^3	Design Cargo Density (kg/m^3)
Saab 340	12,701	7,802	42	3,856	335	4,576	93
CRJ 200SF ER	23,247	13,347	38	6,611	700	4,221	172
CRJ 200SF LR	24,154	13,347	38	6,611	1,100	4,221	172
CRJ 700 (est)	34,019	19,569	72	8,690	900	7,865	122
ATR-42-300	16,919	10,347	57	6,350	460	6,226	112
ATR-72-500	21,999	12,217	76	8,618	520	8,405	113
Dash 8-Q300	19,504	11,793	53	6,124	750	5,806	116
Dash 8-Q400	29,574	15,966	77	8,981	1,100	8,498	116

Appendix 3 – Aircraft Program Summaries

This section contains descriptive profiles of the most popular aircraft in narrowbody, medium widebody, large widebody and feeder segments.

Narrowbodies

MD-80 Family

The MD-80 was produced in significant quantities from 1980 through 1999. More than 1,100 of several sub-variants were built, all in passenger configuration. Somewhat surprisingly, no P-to-F conversion program was launched for the MD-80 until early in 2010, when Aeronautical Engineers, Inc. (AEI) announced plans to convert the aircraft. AEI succeeded in gaining FAA certification for its MD-80 P-to-F program in the first quarter of 2013. Four MD-80 variants, the -81, -82, -83, and -88 versions, have the same external dimensions, but have differences in engine variants, take-off weights and cockpit configurations. A shorter-fuselage MD-87 was also produced but is not considered a candidate for freighter application. The fuselage of the MD-80 is narrower than the fuselage of other commonly used narrowbody aircraft such as 727s, 737s, 757s and DC-8s. As a result, to maximize space utilization MD-80s carry pallets/containers with 88-inch x 108-inch base dimensions. The use of such non-standard pallets/containers for many years discouraged the development of an MD-80 P-to-F program. MD-80s, which are powered by two Pratt & Whitney JT8D-200 series engines, have relatively high fuel consumption and noise compared to other two-engine narrow-body models of the same vintage, which are equipped with newer-technology higher bypass engines (e.g., the 737-300 equipped with CFM-56 engines). However, there are a lot of positive at-tributes of the MD-80, including high production quantities, and the Douglas aircraft heritage that carries a reputation for structural integrity and low maintenance cost. In addition, the value of used MD-80s has fallen significantly in recent years, which means that a freighter-converted MD-80 has a lower price than 737-300F/-400F models which offer similar capability. Despite such attributes, demand for MD 80 freighter conversions has been slow to develop, indicating the MD-80 will play a niche role in the narrowbody segment. Aeronautical Engineers, Inc. has converted a total of 23 MD-80s (all MD-82 and MD-83 types) since 2013. Aeronaves TSM is the largest MD-83F operator with fifteen units. Everts Air Cargo is the second largest operator with 5 MD-83s.

737-300/-400 Classic Family

737-300 and 737-400 model aircraft (also referred to as 737 Classic models) were built during 1984-1999. Approximately 1,100 of the -300 type and approximately 500 of the -400 were constructed, all in passenger configuration. The -300 and -400 are similar, although the -400 type has a stretched fuselage. PEMCO has had a 737-300 conversion program since the early 1990s, developed using Boeing engineering data, and it certified a 737-400 P-to-F program in 2006. PEMCO also offers a 737-400 passenger-to-combi conversion program (certified in 2007). Israel Aerospace Industries (IAI) certified a P-to-F program for the 737-300 in 2004, and for the 737-400 early in 2009. Aeronautical Engineers, Inc. certified a 737-300 P-to-F program in 2005, and a 737-400 P-to-F program in 2007. The 737-300/-400 types, along with the 757-200 are newer alternatives to the outgoing three-engine 727-100/200 freighter models. The relatively small size of freighter-converted 737 Classics (8-10 pallets) results in attractive cost-per-trip but places them at a disadvantage on a cost-per-ton-mile basis against the larger 757-200. AEI offers a 737-400 conversion that can accommodate 10 full-size pallets/containers (plus an 11th smaller-sized pallet). The diminishing feedstock of these aircraft has not stopped some carriers to keep adding 737 Classics to their fleets over the last year and there are currently about five units under conversion. The classic market consists primarily of owner operators, with a total of 55 operators and due to low cost of fuel, the classic series are still attractive for the immediate future. Carriers looking for medium term solutions turn to the Classic series since they offer lower commercial risk and lease terms while the transition to NGs will continue to take some time. In 2022, the 737 Classic fleet has continued to be popular in Southeast Asia and we have seen some operators in the region adding Classics over the last twelve months.

737-700/-800/-900/-900ER Next Generation Family

The Next Generation 737 700/ 800 models succeeded the 737 300/ 400 models after 2000, with over 6,700 units of both types delivered by the end of 2020 and with production continuing while the shift to the newest 737 passenger type – the 737MAX family – began in 2017 (Boeing has now over 4,600 orders on the books for this family type). The Next Generation models have entered the prime period for P to F conversion and will be popular for conversion beyond 2035. The 737-700 has the same fuselage dimensions as the 737-300, while the fuselage of the 737-800 is about ten feet longer than that of the 400. The greater capacity of the longer 800 (11 full-size pallets/containers) will likely make it the preferred model for freighter conversion. Boeing offers a production 737-700C (Military C-40) as a convertible aircraft with a large main-deck door, but deliveries thus far mostly have been to government and private (non-airline) customers. In April 2014, AEI announced it was moving forward with development of a 737-

800 P to F program and received FAA STC for the converted 737-800 in February 2019. Israel Aerospace Industries (IAI) disclosed in mid-2015 that it was also entering 737-700/-800 freighter conversion market, starting with the -700 variant. The first IAI-converted 737-700BDSF was delivered to launch customer Alaska Airlines in September 2017, Alaska Airlines now operates three 737-700BDSF. IAI received its 737-800 STC from the FAA in April 2020. Boeing formally launched a 737-800 P to F program in February 2016 and delivered the first converted 737-800BCF to GECAS / West Atlantic on April 2018. PEMCO announced in 2021 that it was moving forward with a 737 NG conversion program, starting with the -700 model and flight testing for its 737-700 FlexCombi was completed in late 2019. Just over four years after the first converted 737-800 entered service, we now have 105 737-800Fs in service across the globe and an additional forty-five aircraft in various stages of conversion. The 737-800F has been strong competition for its predecessor, the 737-400F, with an additional container position as well as an extra 4,800 to 5,900 lbs. of payload. The -800 also features technological upgrades as well as improvements in fuel consumption over the -400. The current 737 NG backlog stands at about 114 aircraft and is largely speculative driven by funds and leasing companies. We feel that the rapid addition of conversion lines and narrowbody capacity is both unprecedented and unsustainable. At the time of writing, it appears that all conversions are entering straight into service with operators, but we question how long demand will outpace supply. Also, of potential interest for P-to-F conversion are two variants of the 737-900: the basic -900 & the higher weight -900ER. The -900 retains the MTOW and fuel capacity of the -800, trading range for payload. Since this variant was not very successful (only 52 units were delivered), Boeing decided to introduce the -900ER in 2007, a variant that meets the range and capacity of the 757-200 and competes with the A321. A total of 505 units of the 900ER and have been delivered to date but no programs for this type have been announced yet.

A320/A321 Family

The A320 family has proven to be extremely popular in the 100-185 seat category of narrow body passenger aircraft. The two most popular variants are the A320 introduced in 1988, and the A321 introduced in 1994. Both current-engine-option (CEO) models remain in serial production, but they have been joined by the so-called NEO (new-engine-option) versions that incorporate the new PW1000 geared turbofan engine or the new CFM LEAP-1A engine. Delivery of A320 NEOs began in 2016. Nearly 4,700 A320s and 1,700 A321s (CEO types alone) were delivered through the end of 2021. No production freighter exists for any A320 family model. Airbus, EADS-EFW and two Russia-based partners formed a joint venture partnership in 2008 called Airbus Freighter Conversion GmbH to design, certify, and

manufacture a freighter conversion program for A320 and A321 aircraft. That program was unexpectedly suspended in mid-2011, at which time Airbus stated that the popularity and value of A320/A321 passenger aircraft remained too high to support a viable P to F program. There also was speculation that technical issues played a role in the decision to cancel the program. More recently, in September 2014 little-known US-based PACAVI Group, Inc. announced it was "spearheading a new program for conversions of Airbus A320 and Airbus A321 aircraft from passenger to freighter con-figuration." Certification for the PACAVI A320 freighter was planned for 2017. As it turned out, PACAVI ran into financial problems, and by October 2016 had ceased operations before it had certified any P-to-F program. Separately, Airbus, this time in conjunction with EFW and ST Aero, launched a new A320 family P to F program in mid-2015. The A320 (with 10+ pallet positions) and A321 (with 14 pallet positions) have more capacity than the 737-700 and -800 models, which carry only 8 and 11 pallets, respectively. The Airbus models also are equipped to handle containers in the lower-deck compartments while the 737 NGs are not. This P to F effort is headed by Dresden-based EFW, which is now a 45:55 joint venture between Airbus (with the minority share) and ST Aero. During 2017 a new entity, 321 Precision, joined the A321 freighter conversion race. The company is a joint venture between Precision Aircraft Solutions (well known for its successful 757 P-to-F program), and ATSG (known primarily for the leasing and operation of 767 freighters, but also the new parent company of PEMCO). C3 Aero (C-cubed Aero) announced in September 2017 it was moving forward with a program to convert both the A320 and A321 and in September 2019, C3 acquired an A320 airframe and inducted the aircraft for conversion to freighter configuration at FMS in Kansas City. The A321 conversions are gaining momentum ant just after two years of the first freighter entering service, EFW and Precision have completed a total of eight conversions with at least another ten currently in conversion. Sine Draco will be the third A321 freighter STC holder, expecting certification of its A321-200SDF by the end of 2022.

757- 200

Production of the 757-200 and 757-300 extended from 1982-through-2005, during which 914 passenger units and 80 freighters were built. The freighters were built from 1987-1999, mostly for UPS. The factory-built freighters can accommodate 15 main-deck pallets. Boeing developed a freighter conversion program for DHL and modified 34 aircraft in 2001-2003. The Boeing program found no additional customers due in part to its high price for conversion ($7.5 million). Precision Aircraft Solutions certified a 757-200 P-to-F program in 2005, and Alcoa-SIE completed certification of a competing program in 2006. The Precision and Alcoa-SIE conversion programs were priced more favorably in the range of $4-$5 million. Late in 2009

PEMCO World Air Services acquired the Alcoa-SIE 757 P-to-F STC but had no success in the market with this program, and no longer offers 757 conversions. Singapore-based ST Aero, and its Mobile Aerospace unit in the US, developed another 757-200 P-to-F program using data licensed from Boeing. The ST Aero program was certified in mid-2008, and ST was selected by FedEx to convert approximately ninety (later raised to 119) 757s to freighter configuration through 2016. The total quantity of in-service 757-200 freighters stands at 345, including more than 200 converted units. The in-service quantity considers retirement of a significant number of the units converted for DHL over fifteen years ago. The companies involved in P-to-F conversion of 757s also developed programs to convert 757-200s into combi aircraft that accommodate a mix of passengers and freight on the main deck. A small number of combi conversions have been completed, mainly for use in military and government support. The 757 is the largest of the competing narrowbody freighter candidates. It offers two-crew, two-engine economics with cargo volume about 25% more than the 727-200F. The 20+ year production period is an advantage for future freighter conversions. Converted 757s been used mainly as 727-200F replacement aircraft, but the relatively high cost of acquisition and conversion, plus the high cost of engine maintenance, places the higher-performance 757 at a disadvantage compared to the lower priced 737-300/-400 of similar age for applications outside the networks of major express companies. Thus, the main use of 757-200Fs to date has been in express network operations. In a similar manner to the 737 Classic models, the feedstock pool of 757s for freighter conversion is shrinking. We believe the period for conversion of 757s will end around 2023. However, the interest of 757 conversions does not cease among some operators and AerSale recently added six more firm conversion orders and four options for a total of sixteen orders. In addition, Kenya-based Astral just received its first 757-200PCF and plans to receive another two before June. There has been some discussion about the potential launch of a 757-300 conversion program, but feedstock quantities do not justify the launch of such program. We have seen some aircraft traders and operators of freighter-converted 757-200s evaluating 757 conversions for growth or replacement of ageing 757 freighters in their fleets. Many 757-200 carriers such as United Airlines or Delta are looking to accelerate the retirement of these units, which could result in an attractive feedstock situation for this type. However, the 757-200 conversions continue to be limited due to the availability of engines (PW2000 and RB211).

Medium Widebody

767-200 and -200ER

Production of the twin-engine 767 began in 1982 with the 767-200 model; the higher-weight -200ER was introduced in 1984. Approximately 120 of each of the -200 and -200ER types were built. All the 767 200/ 200ERs built for the commercial market were passenger aircraft, none were freighters. Most of the -200s were built from 1982 through 1985, and most -200ERs were built from 1984 to 1993 (although twenty-five commercial -200ERs were built from 1994 through 2008). Beginning in 1998 ABX Air converted 24 767 200s to "package-freighter" configuration, without installing a large main deck cargo door, for use in the Airborne Express/DHL US express network. Israel Aerospace Industries later (in 2004) certified a large-door conversion program for the 767-200/-200ER model. Approximately 60 767 200/ 200ERs have undergone P-to-F conversion by IAI, including the 24 ABX Air "small-door" units in which large cargo doors have now been installed. Boeing in partnership with Aeronavali developed a competing 767 200SF conversion program; however, the Boeing/Aeronavali program encountered delays, and only one such conversion of this type was ever completed. Freighter-converted 767 200/ 200ERs offer similar cargo capacity to the Airbus A300 freighter family but provide somewhat greater range capability. All 767 models are limited to pallets/containers with 88-inch x 125-inch base dimensions for loading in a side-by-side arrangement (they cannot accommodate side-by-side 96-inch x 125-inch ULDs). Note: the lower decks of all 767Fs are not as cargo friendly as other widebodies due to their narrower width. Cargojet Airways took redelivery of the latest 767-200BDSF in May 2020 and given the low production quantities of the -200 and -200ER models, along with the effective end of their production period in 1993, we don't expect to see further freighter conversion of the-200 or -200ER models.

767-300 and -300ER

The Boeing 767-300 is a widebody twin engine aircraft. The 767 family was Boeing's first two-crew glass cockpit jetliner. Boeing has produced three different series of the 767, the -200, -300 and -400. The 767-300ER entered service in 1988 as an updated extended range version of the 767-300. The MTOW of the 767-300ER was originally 407,000 lbs. but later increased to 412,000 lbs. in 1993. The 767-300ER can be outfitted (and freighter converted) with or without winglets. Freighter conversion of the 767-300ER got off to a slow start due to 787 delivery delays preventing some airlines from releasing their aging 767-300ER passenger aircraft as planned. In 1995 Boeing introduced the 767-300F, the production freighter version of the 767-300ER. The 300F has a main deck capable of holding up to 24 88x125-inch pallets and up to 30

LD2s (a container unique to the 767 fuselage and belly contour) on the lower deck. The 767-300F is still in production, with a backlog of 49 orders as of April 2021 for FedEx and UPS. Boeing certified a 767-300BCF (Boeing Converted Freighter) program in June 2008, with conversions done at ST Aero (Singapore). Israel Aerospace Industries completed development and certification late in 2009 of a competing P-to-F program (the 767-300BDSF), marketed on a joint venture basis with Mitsui under the M&B Conversions name. Conversion activity on the 767-300ER model was weak at first but has picked up significantly over the past five years. We expect that conversion activity will remain strong for several years, but feedstock limits will become more problematic around 2025. Orders by FedEx for more than 100 units since 2011 will keep 767-300F production going for several years, as will orders by the US Air Force for an aerial tanker based on the 767-200. Boeing decided to increase its production rate of 2.5 to 3 aircraft per month in early 2020. To help improve efficiency as rate increases, Boeing transferred the assembly of 767's forward fuselage to AeroSystems in Wichita, KS. Production 767-300ER freighters were the largest, most capable of the twin-engine medium-capacity widebody freighters available in the market until the A330-200F entered service in mid-2010. The 767-300F has greater payload-range capability than the A300-600F, but less than the A330-200F. A major benefit of the 767 300ER as a conversion candidate is its high production totals over an extended period (nearly 600 units built over more than 20 years). P-to-F conversion of 767 300ERs is expected to extend beyond 2025. In response to heightened demand for freighter aircraft, several programs have already seen output increases.

A300-600 and -600R

Airbus freighters (A300B4, A300-600 and A310-200/-300) long dominated the medium-widebody segment of the freighter aircraft market. The A300-600 is the largest of these Airbus models, and it has proven popular mainly in regional express networks. The A300-600 was developed as a follow-on type to the A300B2/B4 that had been the first Airbus models. Airbus produced 293 A300-600 and higher-weight -600R units from 1984 through 2007, of which 106 were production freighters. The A300-600 (like other Airbus freighters) can accommodate 96-inch x 125-inch pallets/containers in a side-by-side arrangement on the main deck. The lower deck can handle 96-inch x 125-inch pallets and industry-standard LD-3 containers. The A300-600 is restricted to regional operations based on its relatively limited range capability with a full load. Approximately 60 A300-600s have been converted to freighter configuration in a P to F program developed by EADS EFW (Dresden). US-based Flight Structures, Inc. achieved certification of a competing A300-600 P-to-F program in December 2008, but just five FSI A300-600 conversions have been completed. Production of passenger-configured A300-600s totaled fewer than 200 units, and less

than 20 such aircraft were delivered after 1995, so the supply of suitable feedstock has dropped to near zero, and as a result P-to-F conversion of A300-600s has ended.

A330-200/-300 and A340

Airbus introduced the two-engine A330 and the four-engine A340 as companion models in 1993. Both were originally offered with two fuselage lengths, carrying the -200 and -300 model designations. The A330 proved to be more popular than the A340 because of its two-engine operating economics. More than 1,500 passenger-configured A330s have been built (split about 45:55 between the -200 and -300 types). A total of 377 A340s were built (including about 220 A340-300s) in the period from 1993 through 2010; A340 production ended in 2010. (Note that this A330/340 overview excludes the stretched A340-500 and -600 types, which are not expected to become freighter conversion candidates.) EADS/Airbus announced the launch of a production A330 200F program in 2007. This type, an all-cargo derivative of the A330-200 capable of carrying 65 tonnes over 4,000 Nm or 70 tonnes up to 3,200 Nm. To overcome the standard A330's nose-down body angle on the ground, the A330-200F uses a revised nose undercarriage layout to provide a level deck during cargo loading and unloading. The normal A330-200 undercarriage is used, but its attachment points are lower in the fuselage. The A330-200F is easily identifiable by the distinctive “bulge” surrounding the nose gear. The freighter has not been a commercial success. As of April 2021, 38 A330-200Fs had been delivered, while the backlog for this production type fell to zero units in 2020. The production A330-200F has not gained market acceptance, despite the significant gains in both payload and range capability it offers compared to the competing 767-300F. The A330/340 have the same fuselage cross-section as the A300/310. They have wider fuselages than the 767, but narrower fuselages than the MD-11, 777 and 747 models. A330 models can carry side-by-side 96-inch x 125-inch pallets/containers (22 total for the A330 200F). The A330 models are also smaller and have lower takeoff weights than competing 777 models. Thus converted 777 freighters (none of which exist today), are expected to offer greater payload-range capability than the A330 freighters. In addition to the production A330-200 freighter, in mid-2012 Airbus, EADS-EFW and ST Aerospace formed a joint venture to develop a P-to-F program for the A330 type. In conjunction with this endeavor, ST Aero took a 35% stake in EFW (later increased to 55%). First up for the venture was development of a P-to-F program for the A330 300 model, followed closely by a conversion program for the A330-200. Late in 2014 EgyptAir became the launch customer for the program, signing an agreement for conversion of two A330-200 aircraft from its own passenger fleet. Egypt Air operates now three A330-200Fs. DHL became the launch customer for the -300 in 2016, and it took re-delivery of the first newly certified A330-300P2F late in 2017.

Israel Aerospace Industries (IAI) has secured Avolon as the partner and launch customer of its A330-300BDSF conversion program and IAI is targeting STC for this type by the end of 2024. The converted A330-300 is aimed at express operators, which have low density cargo, and want to take advantage of the stretched fuselage of the -300 model. After 2022, we expect to see a noticeable decrease in the price of feedstock in combination with an increased number of airframes available, creating more favorable conditions for A330P2F conversions. There have been rumors that Airbus is considering an A330 neo production freighter, perhaps based on a -900 platform but with the launch of the A350F, it remains unclear whether Airbus will invest in the design of a new medium widebody freighter.

Large Widebody

MD-11F

The MD-11 never achieved widespread popularity as a passenger model but has proven popular as a freighter. Two-hundred MD-11s were produced from 1989-through-2001. Of these, 64 were de-livered as freighters or combis. McDonnell Douglas developed a freighter conversion program that Boeing continued after the McDonnell Douglas/Boeing merger in 1997, and about 120 units underwent conversion. Touch labor on most of the conversions was done by Aeronavali or Singapore Technologies (SASCO). Boeing stopped offering the MD-11 freighter conversion program, due to lack of demand and lack of feedstock. The MD 11F remains popular in express network applications, but its use in the general cargo market declined significantly after the 2008/09 recession. Carriers have reactivated MD-11Fs over the past year due to the capacity shortage caused by the pandemic. Currently, there are still 100 active units with four carriers: UPS, FedEx and Western Global. Lufthansa stopped being an operator late last year and the old Lufthansa units are now in the fleets of the other carriers.

777F (including 777-8F and 777 P-to-F conversions)

Boeing launched a production 777 freighter program in 2005 based on the 777-200LR passenger model. To date Boeing has delivered 202 units for twenty-seven customers and it has currently a backlog of 40 aircraft to be delivered through 2025. The 777F offers enhanced capability compared to the MD-11 freighter. The 777F has a wider fuselage than the A330, and it can accommodate 10-foot-high pallets on the main deck. The 777F is the only large capacity, twin-engine freighter. Boeing's interest in a 777 P-to-F program appears to have declined over the past few years based on a lack of enthusiasm in the concept by potential customers. However, GECAS and IAI partnered in late 2019 to announce the launch of a 777-300ER P2F program. With a portfolio of more than thirty-five 777-300ERs, GECAS is also providing the conformity aircraft as part of its launch order for up to thirty 777-300ERSF conversions, including 15 firm and 15 options. Due to enter service in 2023, this aircraft can carry 25% more volume than the 777F, retaining the engine, pallets, and containers commonality. Kalitta Air will be the launch operator for this freighter-converted 777-300ERSF and will lease three units from GECAS. With a total cargo volume of 29,000 cubic feet and its range capability, this aircraft is well positioned to replace aging 747-400 and MD-11 freighters. IAI expects this STC for 2022. The National Institute for Aviation Research (NIAR) at Wichita State University partnered with Sequoia Aircraft Conversions and the Kansas Modification Center to launch a 777-300ER P2F program in late 2020. The 777-300ER, capable of carrying up to 25-30 tonnes, is well known for being an excellent cargo hauler even in regular passenger operations. Boeing has started

offering the new 777X-based freighter to customers and is ramping up 777 output in response to booming freighter demand and Qatar Airways became the first customer to commit to Boeing's new 777-8F with a firm order for thirty-four and options for sixteen more for delivery starting in 2027. The 777-8F has a maximum revenue payload of 112.3 tonnes and a range of 4,410 nautical miles, according to Boeing and has a total cargo volume of 766.1 cubic meters, which Boeing says is 17% more than the 777F. The 777-8F will carry thirty-one pallets on its main deck: twenty-six 96" x 125" x 118", four 96" x 125" x 116", and one 96" x 125" x 96", along with thirteen 96" x 125" x 64" pallets in the lower hold.

747-400 and -400ER

Boeing produced the 747-400 model from 1989 through 2009, during which time it delivered 508 passenger and combi units, and 165 freighters (these totals include the extended range, ER, versions). Approximately 245 747-400 freighters were built (including the production -400F and -400ERF units, plus P-to-F conversions). Boeing certified a 747-400BCF passenger-to-freighter conversion program in December 2005 and a combi-to-freighter conversion program in 2007. Israel Aerospace Industries (IAI) certified a competing program for both passenger- and combi-configured 747-400s in 2006. Boeing's conversions have been performed by TAECO (China), although Boeing sold kits to Korean Airlines and Singapore Airlines, through which the engineering units of these carriers completed some installation/conversion work. No 747-400 P-to-F conversions were completed from 2010 through 2016, and Boeing announced in 2016 that it had officially suspended its -400BCF program. Surprisingly, IAI announced about the same time that it had received an order (from EVA Air) for conversion of two combi-configured 747-400s, which were re-delivered in 2017. In theory the 747-400 remains a candidate for P-to-F conversion through 2021 based on the production period for the passenger version, although we doubt that anymore -400 P-to-F conversions will be completed. The roughly 80 conversions that have been done is a much smaller quantity than originally anticipated before the 2008/09 recession and subsequent period of weakness in global air cargo demand. Until the 747-8F went into service late in 2011, the 747-400 and -400ER freighters were the largest, most capable commercial freighter aircraft. Compared to the earlier-generation 747-200/-300 models, the -400/-400ER feature a two-person flight crew, enhanced payload-range performance, lower fuel consumption and reduced noise. Production 747 freighters are equipped with side cargo doors and top-hinged nose cargo doors; converted passenger aircraft have side cargo doors only. The newer model freighters – the 747-8F and 777F – offer bigger size and/or better operating economics. The 747-400F and ERF have lost their status as "top-of-the-line" freighters, but they will play a significant role in the freighter aircraft market for many years, given that

these production freighter models represent about 25% of all large freighters currently in operation. The production -400F offers the nose door and sufficient performance enhancement to distinguish it from the P-to-F versions. Thus, retirements among the 747-400 freighter family mainly have been units of the converted 747-400BCF and 747-400BDSF types. In 2020 there were about 747s reactivated but we saw around sixteen of this type coming out of hibernation and we may even see a few more before the end of 2022.

747-8F

Boeing launched the 747-8 program in 2005 based solely on orders for the freighter version (ten firm orders from Cargolux and eight firm orders from Nippon Cargo). The 747-8F's first flight took place in February 2010, and FAA certification was achieved in September 2011. The -8F incorporates 787 technology to provide enhanced performance and lower operating cost than the prior generation 747-400F/ERF models. The longer fuselage provides four extra main-deck pallet positions, plus three extra belly pallet positions versus the -400F/ERF. UPS received its final 747-8F in March 2022 while Atlas Air has placed all four of the final production 747-8Fs that it will receive from Boeing in 2022 under commercial agreements. Atlas Air will operate two 747-8Fs on behalf of forwarder Kuehne+Nagel under a long-term agreement. Boeing will then close its logbook after delivering a total of 107 aircraft of this type. Freighter conversion of passenger-configured 747-8s could be a possibility but this is considered unlikely given the small quantity of -8I passenger units expected to be produced. In any case, an operator wishing to add 747-8Fs to their fleet will only be able to do it by acquiring from another lessor or carrier.

A350F

Airbus decided to move ahead with the development of a freighter version of the A350. The A350F will have a maximum structural capacity of 109 tonnes at 4,700 nautical miles, or 92 tonnes of volumetric capacity at 6,000 nautical miles, with the higher-thrust Rolls-Royce Trent XWB-97 engines that also power the A350-1000 variant. Airbus is currently working on developing a multi-configuration cargo loading system to accommodate outsized cargo pieces but the main deck is expected to support up to 30 pallet positions, three more than the current 777F. Entering into service in 2025, Airbus has recorded a total of 29 orders and commitments from different airlines customers including Etihad Airways, Air France-KLM, Singapore Airlines, Air Lease Corporation and CMA CGM.

Feeders

Bombardier CRJ Series

The Bombardier CRJ series began as the Canadair Regional Jet program in 1989. The CRJ100 model, which entered service in 1992, was a modified Canadair Challenger business jet with twenty-foot longer fuselage. The CRJ100 had typical seating for 50 passengers. The CRJ200 is identical to the 100 model except it has more efficient engines. Production of the CRJ200 continued through 2005, by which time over 900 of the 100s/200s had been built. These 50-seaters fell out of favor as regional airlines turned attention to larger models. Following the success of the CRJ100/200 series, Bombardier produced larger variants in anticipation of increasing seat limits in US airline pilot union scope clauses in competition with Embraer's E-Jets. The CRJ700, which entered service in 2001, is a stretched 70-seat derivative of the CRJ200 that also featured a new wing, and slightly widened fuselage. The CRJ700 was followed by the higher capacity CRJ900 and 1000 models, the latter of which entered service in 2010, with up to 100 seats. Through the end of 2021 a total of nearly 900 of the CRJ700/900/1000 family had been produced, including about 330 CRJ700s and 430 CRJ900s. The CRJ700/900/1000 family directly competes with the Embraer 170/175/190 models. Until 2015 the only application of the CRJ models in a freighter role was a package freighter modification for the CRJ200 developed by Cascade Aerospace in 2007. The CRJ200PF (Package Freighter) was developed at the request of West Air Sweden to respond to a demanding request for proposal from the Norwegian Post. The CRJ200PF is not equipped with a large cargo door and as a result all cargo is bulk loaded through the original aft baggage door. A large-door CRJ200SF freighter conversion was certified by Aeronautical Engineers, Inc. late in 2016. The first CRJ200SF was delivered to Gulf & Caribbean Cargo in December of that year and AEI has converted sixteen aircraft through April 2022 and there are two more units undergoing conversion now. The program was developed in conjunction with the manufacturer, Bombardier. The converted CRJ200 can carry eight 88x61.5-inch pallets.

ATR 42/72 Series

The ATR 42 is a twin-turboprop, short-haul regional airliner built in France and Italy by ATR (Avions de Transport Régional). The ATR 42 entered service in December 1985. In addition to the passenger 300 model, an ATR 42 300QC quick-change (convertible) freight/passenger version was offered. An upgraded 500, incorporating higher performance engines and other system enhancements, entered service in 1995, and the latest model, the -600, with further upgrades including a glass cockpit, was introduced in 2012.

By April 2021, a total of 521 ATR 42s had been built, along with more than 1,120 of the larger ATR 72 model. The ATR 72, a stretched variant of the ATR 42 model, entered service in 1989. Seating is available for up to 78 passengers in a single-class configuration. The ATR 72 incorporates a 15 ft. fuselage stretch, increased wingspan, and more powerful engines than the ATR 42. As with the smaller companion model, passengers are boarded using the rear door, which is unusual for a passenger aircraft, and the front door is used to load cargo. That configuration feature has helped support freighter conversion of both the ATR 42 and 72 types. The original -100 and -200 versions of the ATR 72 were augmented by upgraded -500 and -600 models from 2010. Quick change and cargo versions of the ATR models were offered but saw limited acceptance. However, several freighter conversion programs by third parties have been developed. The most successful was a program for both a bulk-load and a large door modification developed by Alenia Aermacchi. In 2015 Switzerland-based IPR Conversions acquired Alenia Aermacchi's passenger-to-freighter conversion STCs for both types of modifications. Subsequently, IPR received EASA certification to convert the newer-generation ATR 42/72-500 models, in addition to the earlier-generation ATR 42-300 and ATR 72-200 models. With an average age of thirty-one years for active aircraft, we see the ATR 42-300F nearing the end of its operating life. First delivery of a converted -500 model took place in 2017. Other bulk load ATR freighter conversions were developed by US-based M-7 (which converted ATR 42s and 72s for FedEx), and by France-based Aeroconseil. M-7 has since left the freighter conversion market, but Aeroconseil appears still to be offering ATR conversions. We count fifty-four active ATR72-200Fs, with twenty-three flown by various operators on behalf of FedEx. They are slightly younger than the ATR42-300Fs with an average age of twenty-nine years. It is also reported that there are twenty-fix of the younger ATR-500Fs active. Swiftair is operating six of these aircraft, but the most notable aircraft are the two new entrants operated by Silver Airways on behalf of Amazon. A major development for freighter application of the ATR 72 took place in late in 2017 when FedEx announced plans to acquire factory-built ATR 72-600s in freighter configuration. The express company placed a firm order for 30 units (plus options for 20 more) for delivery. The ATR 72-600F obtained EASA certification in November 2020 while the first ATR-72-600F was redelivered to FedEx in December 2020 and expects to receive between six and seven units per year until the end of 2025. Of the additional twenty-six yet-to-be-delivered aircraft, we believe that four will land with ASL Airlines Ireland and the other twenty-two have yet to be determined. FedEx is expecting an additional eight aircraft in 2022. These ATR freighters will incorporate Large Cargo Door and Structural Tube Modifications from IPR (noted above).

De Havilland Dash 8 Series

The Bombardier Dash 8 (Q-Series) began as the de Havilland Canada DHC-8 or Dash 8. It comprises a family of twin-engine, medium-range, turboprop airliners first introduced in 1984. Dash 8s are now produced by De Havilland Aircraft of Canada, owned by private equity firm Longview. The aircraft has been delivered in four series: the -100 with maximum seating for 39; the -200 with the same capacity but more powerful engines, the -300 with a stretched fuselage and 50-seat capacity, and the -400 with a further stretch that can carry 78 passengers. Models delivered after 1997 have cabin noise suppression and are designated with the prefix "Q" (quiet). Production of the -100 series ceased in 2005, and the Q200 and Q300 in 2009. A total of 671 Dash 8 -100/-200/-300s were produced; production of the -400 series reached about 630 by the end of 2018. To date, only a total of ten Dash-8 aircraft have been converted to cargo configuration but we have observed a large quantity of feedstock units currently in storage, at about 220 aircraft, all less than 20 years old. Various carriers also reconfigured their Q400 and Q100 aircraft for cargo operations during the pandemic, mostly for temporary missions. Collins Aerospace is in final stages of developing a large cargo door conversion for Air Unit's Q300. This design has the door in the back instead of the front. Since this structural modification requires a high investment and long time, it should be easy for Collins to offer large cargo door conversion for the Q400, being able to accommodate the movement of large or palletized cargo. De Havilland is also planning several freighter solutions for the Dash-8-400 in addition to the combi option of the Q400, in service with Japan-based Ryukyu Air Commuter and a large cargo door freighter conversion. Other programs for Dash 8 aircraft include a package-freighter conversion of the Q400 by Cascade Aerospace, and a package-freighter conversion based on the smaller Dash 8-100 by Voyageur Aviation Corp. To meet the air cargo demands of the Covid-19 pandemic, in April 2020 De Havilland Aircraft of Canada Limited announced the Transport Canada approval of its Dash 8-400 simplified package freighter conversion kit. This was followed up by the approval of their Dash 8-100/200 and Dash 8-300 simplified package freighter in May 2020. Jazz Aviation agreed to purchase thirteen conversion kits and was the launch customer for this product. As of publication, we are showing eleven still in service: nine -400s and two -100s.

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