cargo facts CONSULTING PRESENTS

FREIGHTER FORECAST 2021-2040

FORECAST THE FUTURE

CFCInsights.com

TWENTY-YEAR

FREIGHTER AIRCRAFT FORECAST

2021-2040

Version 1.0

Published: 26 April 2021

Prepared By:

Cargo Facts Consulting

Cargo Center, Building S-329,

L-1360 Luxembourg

fhorst@cargofacts.com

www.CFCInsights.com

www.cargofactsconsulting.com

Data Usage Restrictions

This freighter forecast document has been prepared by Cargo Facts Consulting (CFC) and is conveyed to you for a fixed fee or as part of an Insights subscription with the understanding that the intellectual property contained herein may be used for internal analysis and business planning purposes only. Such uses may be made without restriction, assuming full attribution is given to CFC. Regarding other uses, the following restrictions apply:

- If the purchaser of this report uses the data in a subsequent analysis for which he or his company is shown as the source, all charts and data must be reproduced as they appear in this analysis with full attribution to CFC.
- CFC must be informed of your intentions to use any extracted material before it is reproduced, published or otherwise disseminated. Permission to use this data accordingly will not unreasonably be withheld by CFC.
- If the purchaser of this report interprets the data, changes the nature of the recommendations contained herein, or in any way alters the recommendations, charts or other ideas contained herein, the purchaser must notify CFC that such action is planned and receive written approval for the use of the material contained herein in the purchaser's format and pro-vide full attribution to CFC.
- Any other use of this intellectual property will result in legal action to recover damages incurred in the unauthorized usage undertaken by the purchaser plus all legal fees and expenses incurred by CFC in defending CFC's property rights as they pertain to this report.

Under all circumstances, any use outside of the purchasers' immediate organization, including reproduction, transmittal or sharing of any portion or the complete report, must be requested in writing to CFC before permission for this usage will be granted. There will be no exceptions. Unauthorized reproduction or transmittal will result in legal action by CFC to recover damages from the purchaser.

The restrictions noted above also apply to the accompanying interactive Freighter Forecast Analysis Tool and Passenger-to-Freighter Feedstock Analysis Tool.

Preparation of this freighter forecast benefits from the contributions of industry participants throughout the world. We welcome and appreciate comments, inquiries, and information from readers of this report.

Safe Harbor Notice

The analysis and conclusions in this report are provided “as is”. We do not represent, warrant, undertake or guarantee that the use of guidance in the report will lead to any particular outcome or result. In no event shall CFC be liable for any direct, indirect, incidental, special, exemplary, or consequential damages, however caused, and on any theory of liability arising in any way from the use of this report.

This report includes forward-looking statements. Because such statements deal with future events, they are subject to various risks and uncertainties, and as such, actual results could differ materially from CFC’s current expectations. Forward-looking statements are identified by words such as “forecasts,” “foresees,” “anticipates,” “projects,” “expects,” “believes,” “estimates,” “targets,” and other similar expressions that indicate trends and future events.

Table of Figures

Contents

Executive Summary

Between 2021 and 2040, we forecast the addition of 2,619 jet freighters and 419 feeder aircraft to cater for both growth and retirements of older aircraft. During this period, we expect the world's jet freighter fleet to grow from 1,981 to 3,390 units, and the world's feeder fleet to grow from 247 to 420. Table 1 provides an overview of the key numbers in our long-term forecast.

Our twenty-year forecast is based on an underlying air cargo traffic growth rate of 4.3%. This is 0.5% higher than last year's forecast, but does not mean our long term growth expectation are actually higher. Traffic declined 10.5% in 2020. The 21 year growth rate off a higher 2019 base is actually only 3.5%. Even though we anticipate a strong rebound in air cargo traffic in 2021 and a constant growth trajectory after the first half of 2022, several years of growth have been lost to the pandemic.

As a consequence of large-scale passenger capacity reductions, cargo capacity continues to be extremely tight, particularly in international markets where passenger flights account for an average of half of traffic moved. This has primarily affected the large widebody and to a lesser extent medium widebody segment. Even though it has been over a year since the COVID-19 crisis started, we do not believe that this impact will significantly change the demand for air cargo operations and freighters in the long-term.

Table 1 - 2021 - 2040 Freighter Forecast Key Numbers

	1Q-21 Fleet	Net Growth	Retired	Total Added	New	P to F	2040 Fleet
Feeders	247	200	219	419	81	338	447
Narrowbody	763	548	589	1137	0	1137	1311
Medium Widebody	589	405	307	712	322	390	994
Large Widebody	629	456	314	770	612	158	1085
Total	2228	1609	1429	3038	1015	2023	3837

Source: Cargo Facts Consulting Freighter Forecast 2021-2040

We expect to see about two thirds of the current jet fleet and almost 90% of the current active feeder fleet retiring over the next 20 years. 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.

Factory-built freighters will add up to 35% of aircraft additions in the jet freighter segment, albeit with large differences across individual categories. Forecast aircraft demand in the narrowbody segment is surely to be met entirely by conversions, whereas we expect the share of conversions in the medium and large-widebody segments to be 54% and 21%, respectively. We foresee about 20% of new additions in the feeder segment to be satisfied by production freighters.

The future fleet composition will depend on the choice of aircraft in each segment. While we have a view on which types are likely to feature in each segment, there are some major uncertainties in this regard:

- The future freighter options in the narrowbody jet segment are well-defined with feedstock constraints limiting future conversions of 737-300s/-400s and 757-200s. The future in this segment will belong to converted 737 NGs and A320/321 family. Currently, the A320 and A321 supply is lagging due to the lack of orders and lack of a full suite of certified conversion programs but we expect this to change, especially after 2025. While the A321 is positioned more as a 757 replacement, the 737-800 and A320 are direct competitors to older 737s.
- The transition from classics to NGs was held back for a while due to the lack of certified conversion programs and high feedstock values but the COVID-19 crisis is freeing up some of the older NGs giving an opportunity for conversions.
- While the medium widebody market has been very active due to e-commerce demand, there are no new developments. There is no end-date to the 27-year 767-300F factory program, but feedstock figures will likely limit conversion numbers for this type as Boeing delivered the last 767-300 passenger aircraft was back in 2014. A330 conversions will be available throughout the forecast period, but no official announcements have been made on new factory-built freighters such as the A330-900F or the 787-9F, as of early 2021.
- The A350 and 777X are the most likely contenders to become future production freighters but neither Airbus nor Boeing have officially launched a program.
- A new 777-300ER conversion program under development by Israel Aerospace Industries (IAI) confirmed plans to induct its conformity aircraft this June, but we do not expect the first deliveries before 2023. This aircraft would compete with a potential A350 or 777X production freighter.

- Despite higher freighter demand 2020 did not lead to a spike of of production freighter orders, partly because of slot availability but also because of the lack of available programs other than the 777-200F and 767-300F.
- After not actively marketing the program for a number of years, in 2020 Boeing announced the end of the 747-8 program, which will cease next year in 2022 after all the twelve unfilled orders are delivered to UPS and Atlas. This has massive implications for the availability of outsize capable freighters in the future given that there is no real alternative to the 747.
- The main player in the feeder segment continues to be the ATR 72 with conversions accelerating over the pandemic due to the increasing demand of express deliveries to remote locations. However, we still see the potential for Dash 8 Q400s and CRJ conversions over the next 20 years.

The forecast for freighter aircraft demand is sensitive to changes in traffic growth and other parameters. A half percentage point change in long-term traffic leads to a shift in the requirement for approximately 325 jet aircraft and 64 feeder aircraft.

Our forecast also assumes that the historical 50:50 freighter-passenger belly split will remain the same. Freighters are a critical link in global supply chains, and we are seeing freighters carrying closer to 60-70% of all moving cargo at the moment due to the lack of belly capacity. Passenger aircraft operating in cargo only missions are providing some relief, but we find the economics of these operations questionable. Freighter operators will continue to do well until passenger capacity is back at pre-COVID levels.

1. Introduction

This report is presents 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 2021, and show predicted changes through to the end of 2040, 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 2040 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.

This report is supplemented with *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), which over the past 12 months has developed into a comprehensive analysis platform for the global air logistics business covering the air cargo, express, e-commerce and freighter business.

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 Never-Ending Pandemic

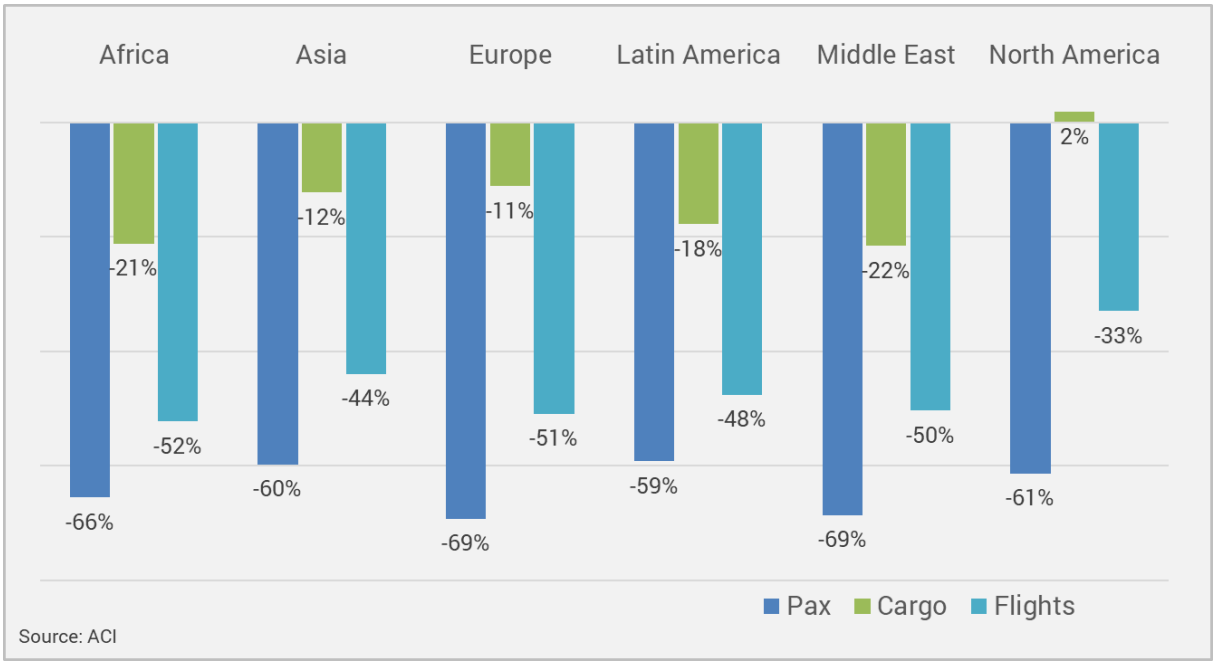
Key Topics:

- After declining by 10.5% in 2020, we expect that worldwide airfreight traffic will grow by 12.2% in 2021 and 4.7% in 2022, bringing traffic back to 2018 levels by the end of 2022.
- For airfreight, the real crisis, however, has been a crisis of capacity not of demand. With 50% of traffic typically moving in the bellies of passenger aircraft, freighter operators have done extremely well.
- Until intercontinental passenger flights return, capacity will remain tight, yields high and passenger freighter operations that were introduced in 2020 will continue.

2.1 Demand

Global cargo traffic in 2020 declined by approximately 10.5%. That was less than the 15% decline that we originally expected at the time we prepared last year's edition of this forecast. However, there were large differences between product groups and geographies. In geographical terms, the biggest declines were in Africa, Latin America and the Middle East. Tonnage handled in North America was up by 2%, whereas the decline in Europe and Asia was not as large as in secondary North-South markets (see Figure 1).

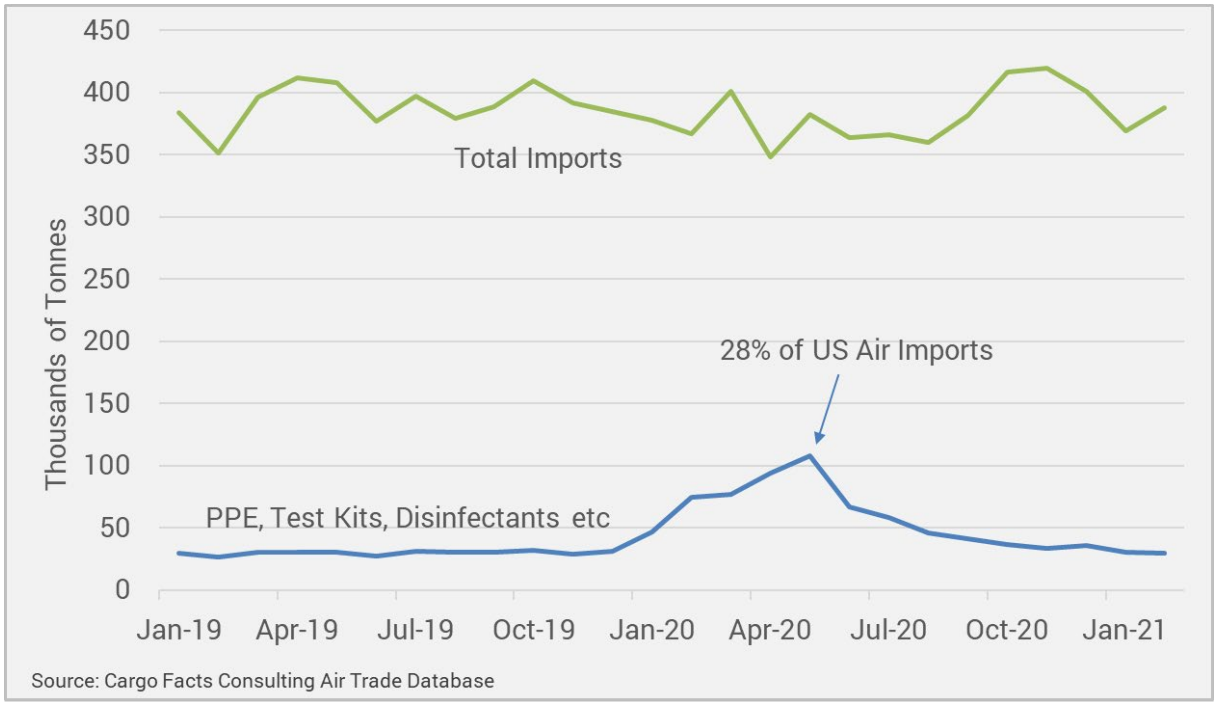
Figure 1 - Passengers, Cargo Tonnage and Flights by Region, Jan-Dec 2020



Unlike previous crises, demand and capacity during the pandemic were intricately linked. The regions with the largest decline in long haul capacity also saw the largest declines in cargo volumes. Regions such as Africa and Latin America were hit twice – once by the loss of passenger capacity and again by freighter operators redeploying capacity on highly profitable East-West lanes (Europe to Asia, the Transpacific and the Transatlantic).

Traditionally, 65-75% of international airfreight consists of primary inputs, intermediate goods, parts and supplies, and capital equipment. This type of supply chain cargo saw big declines in 2020. With less people eating out and tight capacity, perishable traffic also saw a drop. Semiconductors, computers and office equipment, and pharmaceuticals did well. The movement of personal protective equipment, test kits and other COVID-19 related commodities provided a strong lift for air freight volumes – initially into China and then starting in March from China to the rest of the world. As a case in point, in April and May 2020, almost 30% of US air import tonnage consisted of personal protective equipment and other goods imported to deal with the pandemic (see Figure 2).

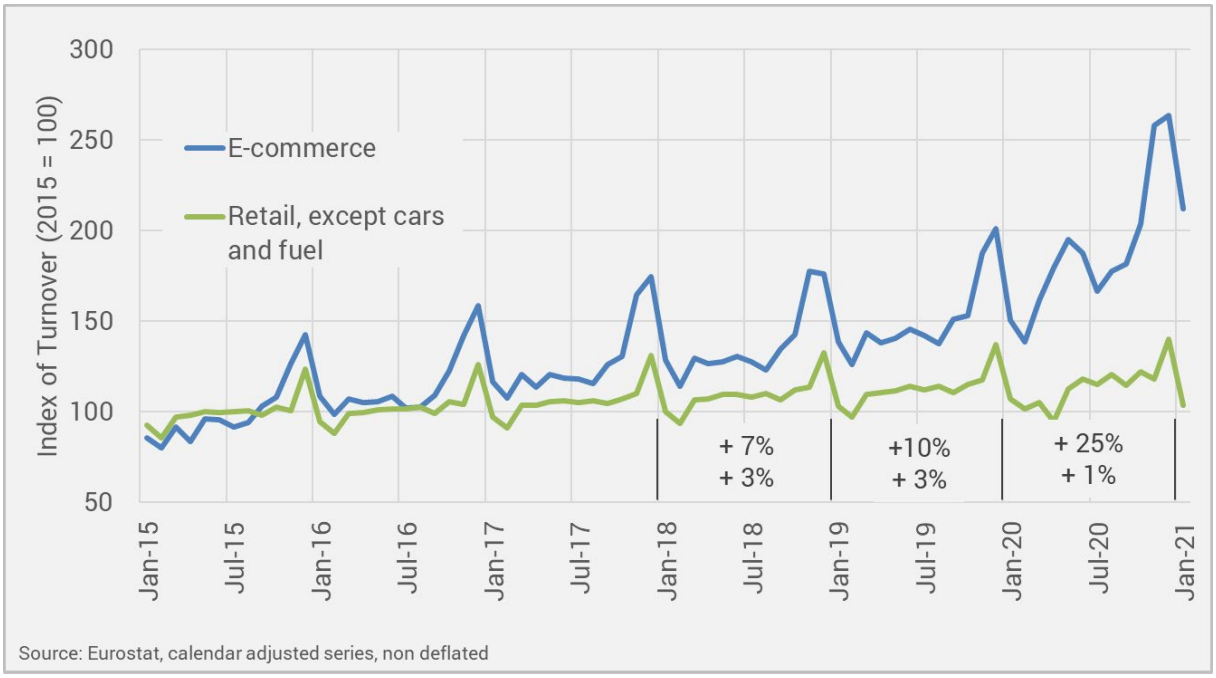
Figure 2 - US Monthly Air Imports of COVID Commodities Jan 2019 – Feb 2021



The other defining feature of 2020 was the surge in e-commerce demand. E-commerce growth outpacing retail growth has been going on for some time, but with lockdowns and large-scale retail shutdowns online shopping received an extra boost. The trends were similar across the Americas, Asia, and Europe. Figure

3 shows the development in the European Union, where e-commerce sales grew by 25%. This high level of activity has continued in 2021.

Figure 3 - EU-27 Retail and E-Commerce Sales Index Jan 2015 – Jan 2021

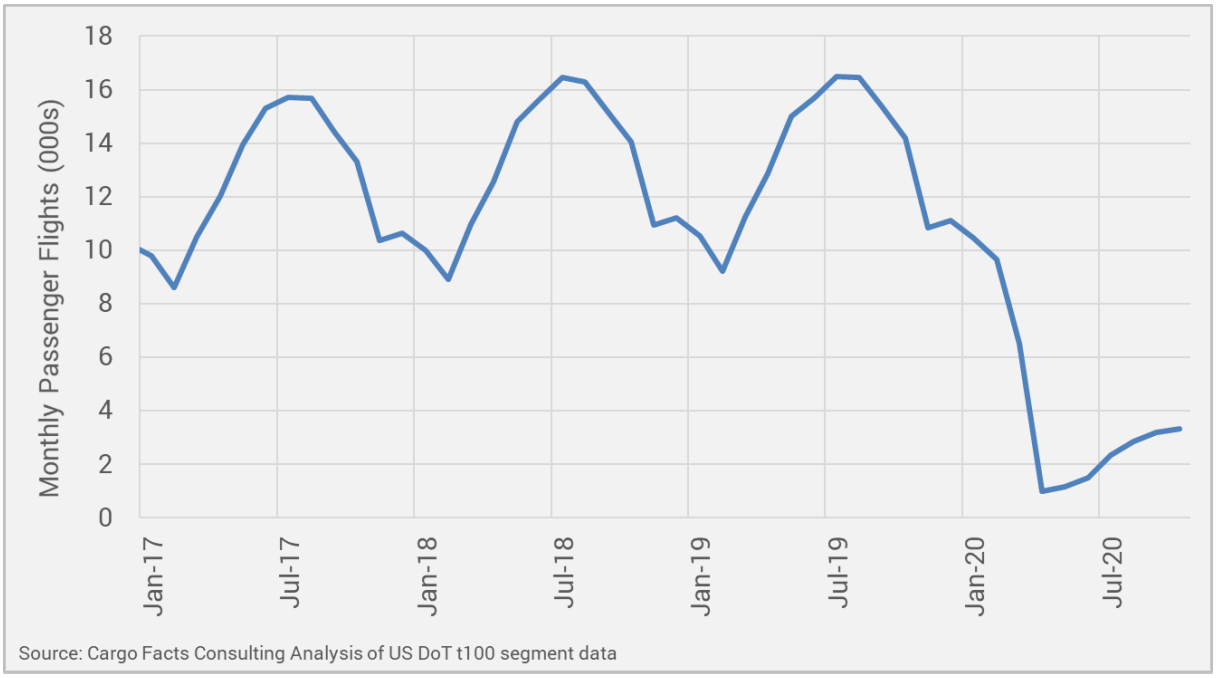


The consequence of this has been a higher business to consumer share of traffic moving through express networks which normally account for about 16-17% of global cargo traffic and almost all domestic traffic. This explains why cargo volumes across major US and European express hubs have increased as the business was operating in peak season mode all throughout the year.

2.2 Supply

The capacity situation throughout 2020 remained tighter than we had optimistically expected earlier that year. Widebody passenger capacity remained largely absent from most intercontinental lanes. The transatlantic, for example saw a capacity reduction of approximately 70% in 2020 (see Figure 4). Normally 65% of Europe to North America traffic is carried in the bellies of passenger aircraft.

Figure 4 - Transatlantic Passenger Flights Jan 2017 – Oct 2020



The consequence of this large-scale passenger capacity reduction was fourfold:

- Rate levels were and continue to be extremely elevated: somewhere in the order of 60-70% above normal levels. Freighter operators have done extremely well financially.
- Freighters are operating at higher utilization levels to create additional capacity.
- Older mothballed capacity has been reactivated and retirements delayed. This includes MD-11s, converted 747 – 400s and even 747 classics.
- Combination carriers have been operating passenger aircraft in cargo only missions. While the economics of these operations is somewhat questionable, the reality is that most major trade lanes still are seeing significant passenger freighter operations (about 200 a week between China and Europe, 340 a week on the transatlantic and about 130-150 on the transpacific).

Over the past 14 months we have seen roughly 200 airlines operate passenger aircraft in freighter configuration, with around 60 removing the seats in some of their aircraft to increase usable volume. Figure 5 provides a geographical overview of airlines around the world that were passenger aircraft in cargo only missions during the pandemic. Ethiopian Airlines, China Eastern and Emirates were the carriers that were the most aggressive in removing seats from a number of their aircraft.

Figure 5 - Airlines with Passenger Freighter Operations in 2020/21

Table 2 shows an overview of passenger-freighter operations from over twenty airlines with the number of flights from March 2020 to Mid-March 2021. The table also displays the type of aircraft these carriers have reconfigured with the 777-300ER being the most common type used for cargo-only operations, being capable of carrying up to 25-30 tonnes.

Table 2 - Passenger-freighter Operations from Selected Airlines

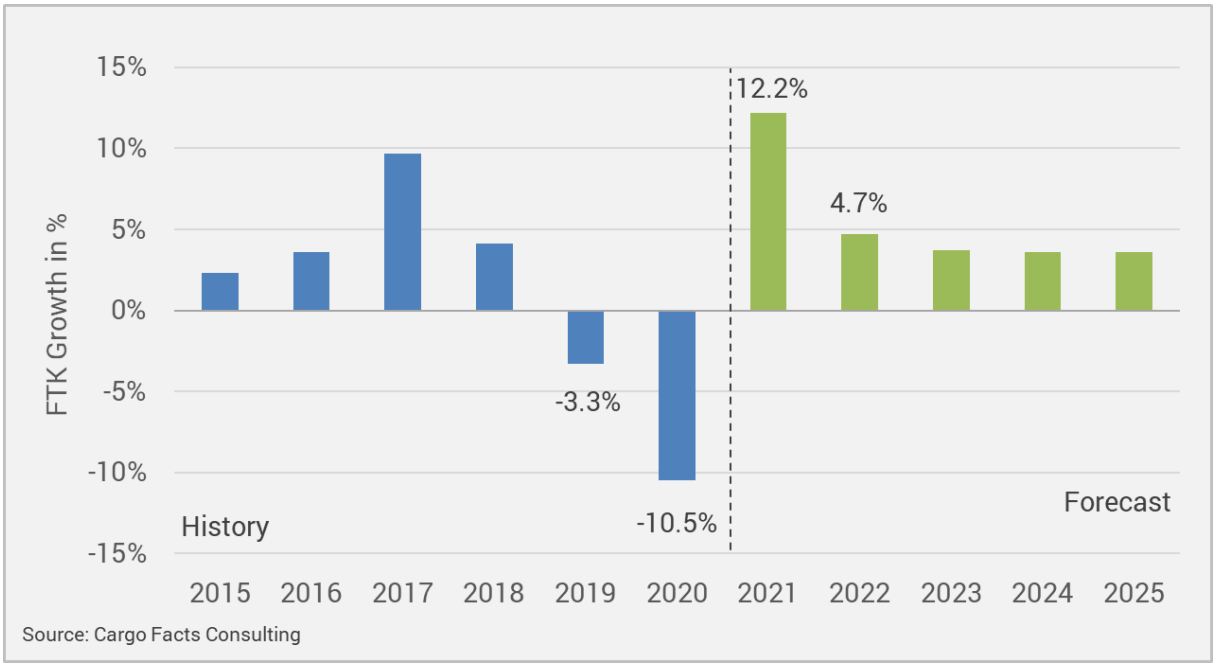
Carrier	# Flights	Reconfigured Types
Emirates	27,800	777-300ER
Qatar Airways	25,200	777-300ER
Japan Airlines	13,686	None
China Airlines	11,880	None
Cathay Pacific	11,296	777-300ER
United Airlines	11,000	None
Air France-KLM	10,500	777-300ER
ANA	8,285	None
American Airlines	7,823	None
Turkish Airlines	7,062	None
Singapore Airlines	6,600	777-300ER, A320
Korean Air	6,500	777-300ER
Air Canada	6,000	777-300ER, A330-300
Ethiopian Airlines	5,645	777-300ER, A350-900, 787-9, 767-300ER, 737-800, Q400
Virgin Atlantic	5,344	None
Delta Air Lines	2,500	777-200ER
Finnair	1,700	A330-300
Air New Zealand	1,624	None
Swiss	1,600	777-300ER
Aeroflot	1,530	None
Asiana Airlines	1,400	A350-900
TUI	680	None
Avianca	400	None
LOT	300	None

Source: Cargo Facts Consulting Analysis of Passenger-Freighter Database, Carriers, FlightRadar24, as of March 2021

2.3 Outlook for 2021-2025

At his stage we expect that worldwide airfreight traffic will grow by 12.2% in 2021 and 4.7% in 2022. This would mean traffic would be back at 2019 levels by the end of 2021 and back at 2018 levels by the end of 2022 (see Figure 6). By comparison, IATA expects 13.3% growth in 2021.

Figure 6 - Global Air Cargo Traffic History and Forecast 2015 - 2025



Overall, 2021 is turning out to be a continuation of 2020 – both from a supply and demand perspective, but with some added complications.

- Lockdowns will continue to affect economic activity. Travel restrictions will be particularly hard for countries that rely strongly on tourism.
- Vaccination rates will be key in developing more reliable passenger traffic forecasts and predicting the return of passenger capacity.
- Supply and demand will continue to be out of balance and freighter operators - particularly those with large widebodies - will again do very well. Air cargo rates continue to be much higher than normal.
- There is little opportunity to increase widebody supply – most aircraft that can have been reactivated and are flying and it will be a number of years before any large widebody conversion programs become available.
- Trade tensions with China are back on the agenda and may cast a cloud over worldwide trade recovery.

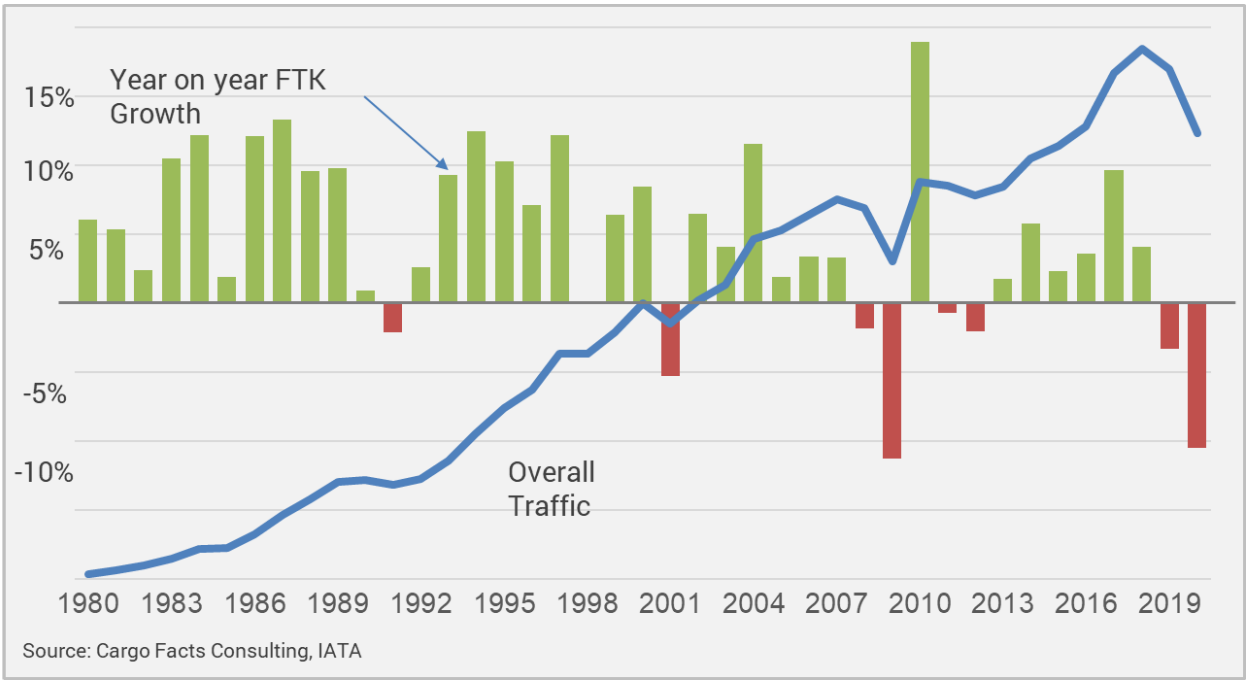
3. Long Term Air Freight Demand

Key Topics:

- 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 4.3% off a 2020 base and 3.5% off a higher 2019 base.

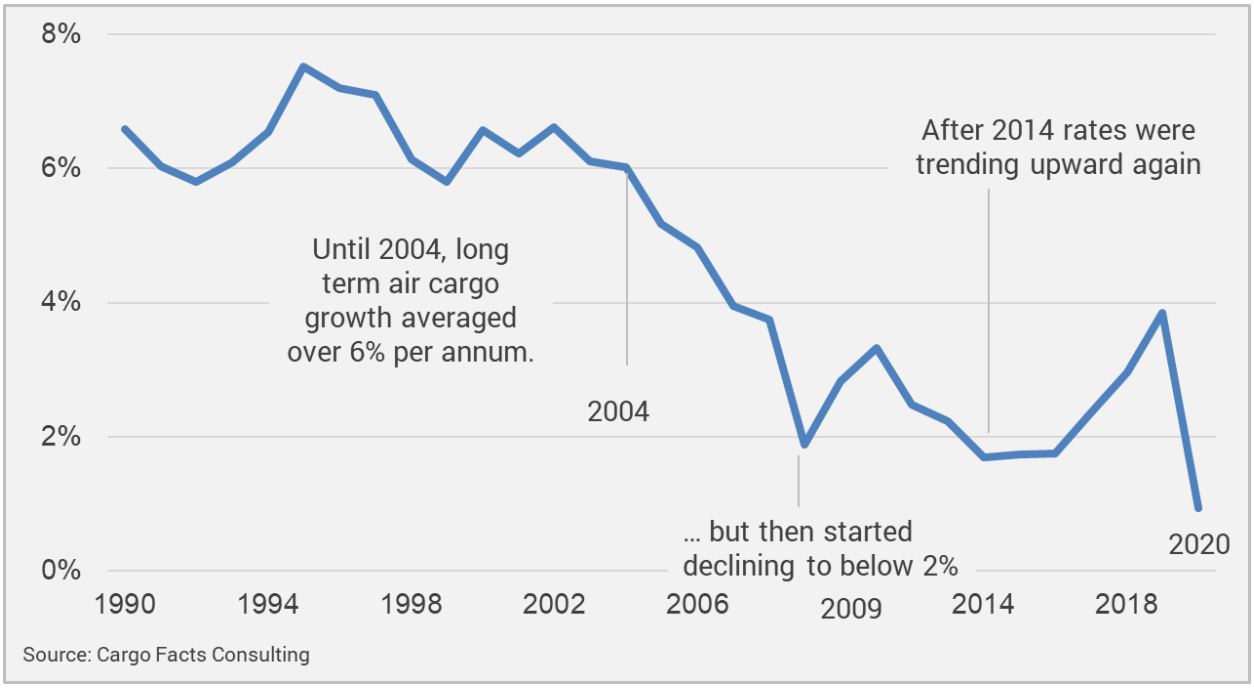
Since 1980, the air freight business has only experienced eight years of declining traffic. Most recently in 2020 (the first year of the pandemic) and 2019 (an economically weak year). The last major decline was during the 2008 financial crisis, whereby the end of 2009 traffic had fallen back to 2004 levels. Year end 2020 traffic levels were comparable to 2016 – a loss of four years of growth (see Figure 7).

Figure 7 - Air Freight Traffic Growth 1980 – 2020



Until about 2004 long term air cargo growth averaged around 6% per annum, but then started declining to below 2% per year as a result 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 8 - Ten Year Moving Average Air Cargo Traffic Growth 1990 – 2020



In the long term, we expect global air cargo traffic to grow by 4.3% per year between to 2040 off a 2020 base or at 3.5% off a higher 2019 base. In absolute terms this would imply that air cargo traffic doubles over the next 20 years compared to 2019. Table 3 provides a comparison of our forecast with other commonly referenced forecasts.

Table 3 - Cargo Facts Consulting vs Other Traffic Forecasts

Forecast	Baseline	Date Published
Cargo Facts Consulting 2021 – 2040	4.3% (3.5% from 2019)	April 2021
Cargo Facts Consulting 2020 – 2039	3.8%	April 2020
Cargo Facts Consulting International Express 2021 – 2025	4.9%	Oct 2020
IATA 2019 – 2028	4.2%	March 2019
Boeing 2020 – 2039	4.0%	Nov 2020
Airbus 2019 – 2038	3.8%	September 2019

The most recent other forecast, the Boeing World Air Cargo Forecast (WACF) was published in November 2020. Airbus and IATA have not published cargo forecasts since 2019. Overall, we expect express and e-commerce demand to outpace general cargo growth in both the medium and the long term. Our Air Express Market Outlook (published in October 2020) provide more detail on the current state of play and expected developments in each of this business segment.

4. Jet Freighter Fleet Analysis and Forecast

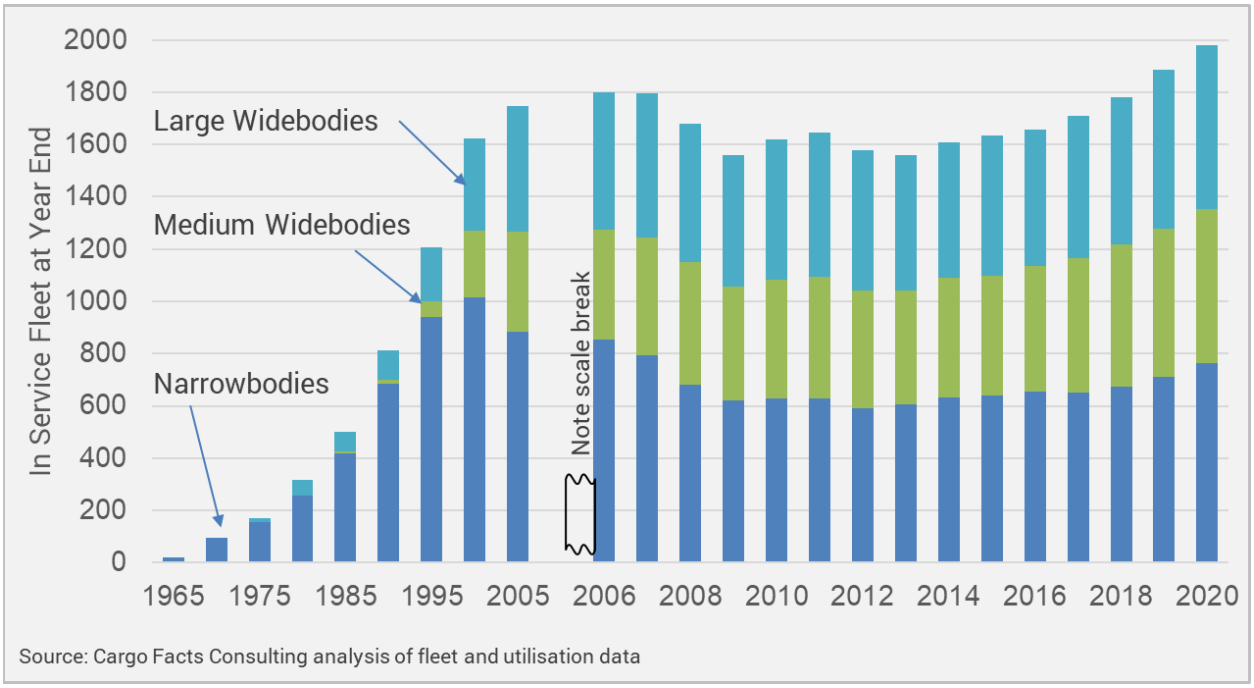
Key Topics:

- The active jet freighter fleet grew by 5% in 2020, with the largest growth in the narrowbody segment.
- Over the coming 20 years we expect the world's freighter fleet to grow by just over 70% or 2.7% per year.
- Compared to previous forecasts, we believe the biggest upside will be in the large widebody segment, but here there is great uncertainty about future aircraft choices.
- 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 5% last year as freighter demand stayed high thanks to a massive loss of belly capacity. While in 2019 the biggest increase was in the large widebody segment, in 2020 the biggest growth was in the narrowbody segment. Figure 9 provides an overview of the evolution of the worlds freighter fleet since 1965 and Table 4 show the current Q1 2021 breakdown of the fleet by type.

Figure 9 - Jet Freighter Fleet Evolution 1965 - 2020



Source: Cargo Facts Consulting analysis of fleet and utilisation data

As of April 2021, there were 1,981 jet freighters in active operation ranging from Bae146s through 747-8Fs. The breakdown includes 629 large widebodies (mostly 777s, 747s and MD-11s), 589 medium widebodies (mostly A300s, 767s and a few A330s) and 763 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.

Table 4 - In Service Jet Freighter Fleet, Q1 2021

Narrow Body 1Q 2021	Medium Widebody 1Q 2021	Large Widebody 1Q 2021
< 85,000 lbs (< 40 tonnes)	*85,000 – 180,000 lbs (40 - 80 tonnes)*	*> 180,000 lbs (> 80 tonnes)*
763 Total Units (+7%)	**589 Total Units (+4%)**	**629 Total Units (+5%)**
14 BAe 146	4 A310-300F	14 MD/DC-10-30/-40
23 DC-9, 19 MD-80	5 A300B4, 164 A300-600	110 MD-11
13 B737-200	38 A330-200F, 3 -200P2F	200 B777
28 B727-100/-200	6 A330-300P2F	5 747-200F, 1 747-300F
125 737-300, 161 737-400	57 B767-200	49 747-400SF/BCF
8 B737-700, 51 737-800	189 767-300F	157 B747-400F/ERF
2 A321-200F	119 767-300BCF/BDSF	93 B747-8
4 TU-204C, 315 757-200	4 MD/DC-10-10	

Source: Cargo Facts Consulting, Cargo Facts, Ch-Aviation. Refers to operating fleet in Mar 2021.

High feedstock values for newer generation aircraft, low fuel prices as well as pending STC approvals have slowed the transition from older to newer generation types in the ***narrow body*** segment.

- The 737-700 fleet increased by 2 units and the 737-800 fleet by 31 units to a total of 8 -700s and 51 – 800s. Our estimate shows backlog quantities of over 70 units for the -800 fleet. The lack of passenger belly capacity has not resulted in a large growth for carriers in this segment.
- Demand for 737 Classic freighters persists even with the new types available with the active 737-400 growing by 16 units. Currently, there are 286 737-300/400 in operation.

- We have seen the first two A321P2Fs delivered by EFW and we assume further diversification of the fleet, with an acceleration of the A321 and A320 conversions. 321 Precision Conversions expects an STC from the FAA for its program during the first half of this year.
- 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 19 units.
- The number of in-service Bae 146 freighters increased by three units while we saw the DC-9 fleet declining by 4 units.
- The 757-200 remains the most popular aircraft in this segment, with numbers increasing marginally by four units to 315.

Feedstock values have also had an effect on capacity additions in the ***medium widebody*** segment.

- The 767-300 freighter fleet grew from 277 to 308 units. This included an additional 21 production freighters and 10 conversions.
- Airbus A330-200 freighter program's backlog fell to zero units. The A330-200F never became an attractive option for express operators. It seems like the design cargo density of this type was a mismatch with the requirements of express and general cargo operators. Four of the thirty-eight A330-200Fs exited the Qatar Airways fleet in February 2021.
- Turkmenistan Airlines ordered two A330-200P2F conversions from EFW in early 2021 while there was a total of three redeliveries of the A330-300P2F to DHL. As feedstock becomes scarcer and A330 feedstock becomes cheaper, we expect a shift to more A330 conversions.
- Meanwhile, a number of older generation type were parked or retired – this includes 4 A300B4 and 10 MD-10-10Fs that were retired from the FedEx fleet. The number of 767-200 in operation decreased by one unit.

Activity in the ***large widebody*** segment is currently being driven by the 777-200F, but also by the reactivation of several previously parked aircraft:

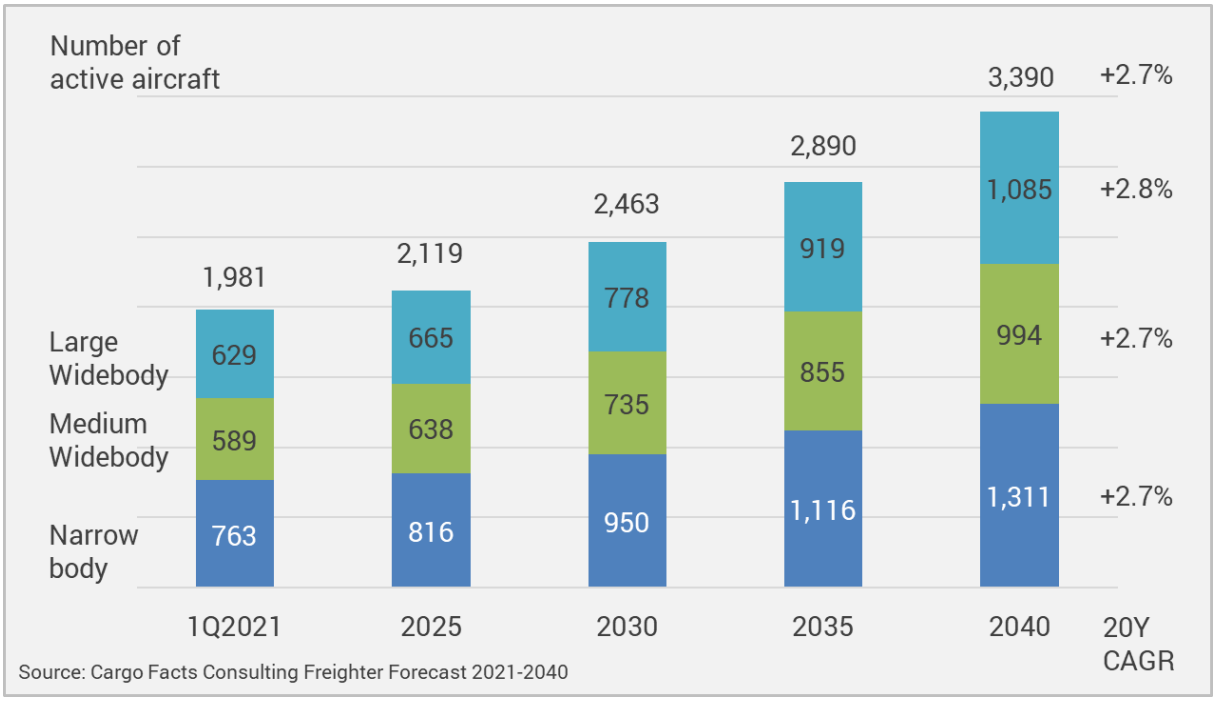
- The number of 777 freighters in operation increased by 21 units to a total of 200 aircraft.
- An additional 7 747-8F were delivered bringing the in-service fleet to 90 units. The remaining backlog for this type is 12 aircraft and Boeing has announced the end of this program by 2022.
- A number of 747-400Fs were reactivated over the last 12 months. Even with passenger travel market showing signs of recovery, 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 declined by three aircraft in net terms as both Lufthansa Cargo and FedEx parked aircraft of the type.

4.2 Twenty Year Jet Freighter Forecast

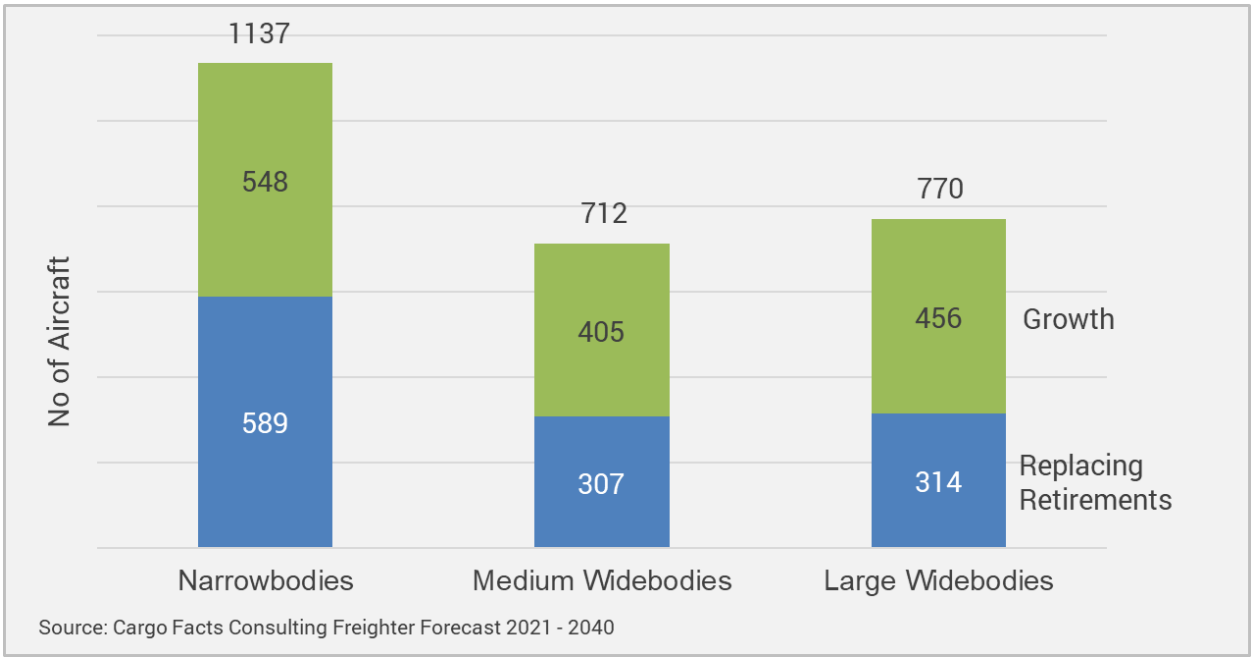
Over the next 20 years we expect the world's jet freighter fleet to grow by about 71%, from 1,981 units today to 3,390 units at the end of 2040 (Figure 10). The biggest change compared to previous years forecasts is that we are much more bullish on the demand for large widebody freighters. The primary driver for this is that we no longer believe that the freighter share of total traffic will decline, but remain constant over the forecast period at approximately 50% of all traffic carried. This has a large impact on the demand for aircraft particularly in the large widebody segment, where the competition with belly capacity is the greatest.

Figure 10 - Baseline Jet Freighter Fleet Forecast 2021 - 2040



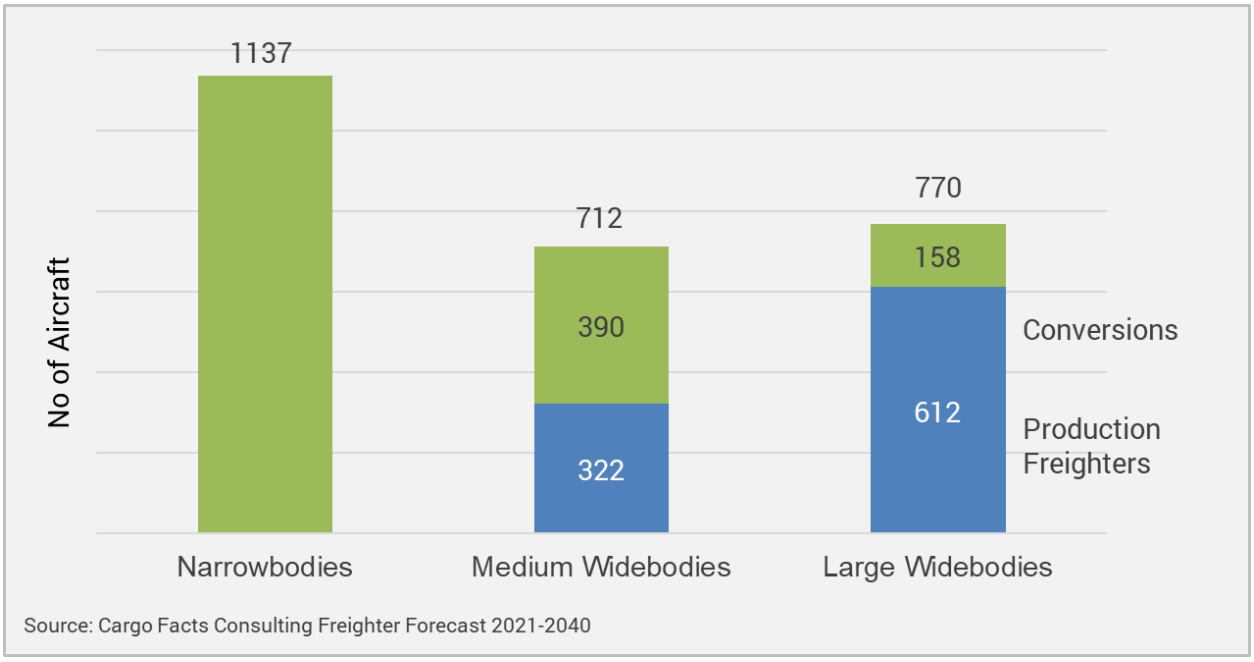
The net growth in fleet size is 1,409 (of all sizes), which when combined with 1,210 retirements, produces the overall need for 2,619 freighters through 2040. This total fleet requirement equates to an average of 131 units per year. Figure 11 shows the details of the new and replacement aircraft added for each size category through 2040.

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



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 12).

Figure 12 - New and Converted Jet Freighters Added 2021- 2040



We expect that about 65% of the production freighters will be large widebodies and the share of production freighters in the large widebody space will be 80% 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 5 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 5 - 2040 Baseline Jet Freighter Fleet

Narrowbody *< 40 tonnes*	Medium Widebody *40 - 80 tonnes*	Large Widebody *> 80 tonnes*
1311 Total Units	**994 Total Units**	**1085 Total Units**
18 MD-80	25 A300-600	689 777
16 737-300/400	524 A330	42 747-400
620 737-700/800	362 767-300	107 747-8
514 320/321	83 787/ 767XF	247 A350
143 757-200		

Source: Cargo Facts Consulting Freighter Forecast 2021-2040

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 potentially 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 2040 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 particular 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 6 provides and overview of the current and future freighter aircraft supply situation which drives our future fleet composition estimates.

Table 6 - Aircraft Available to Operators During the Forecast Period

	Narrowbodies	Medium Widebodies	Large Widebodies
Facing near-term extinction	DC-9, 727, Bae 146, 737-200	DC/MD10-10, A300B4, A310	747F Classic, DC-10-30F/40F
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
Expanding role going forward	737-700/800, A321	767-300F/BDSF/BCF, A330-200/300P2F)	777F, 747-8F
Future aircraft	A320, 737-900	787-9F, 767XF, A330-900F	777-300ERSF, A350 F/P2F, 777XF

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

- Feedstock availability and higher maintenance cost 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 available starting 2021 as conversion companies receive 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 within the next 10 years and the 767-300 P2F programs within the next 15 years. 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.

- Feedstock supporting A330-200 and -300 freighter conversions are available throughout the whole forecast period.
- An A330-900F becoming available within the next five 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 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 787-9F becoming available after 2028. The launch and viability of such a program would depend on the availability of a stretched and upgraded 767. We feel that a stretched an upgraded 767 would be more attractive to operators than a higher capital cost 787 freighter.

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 11 aircraft and last production. Unless Boeing were to secure a large order from the US military for this aircraft, we would expect the program would become inactive after 2022.
- A transition from a 777-200F to a 777XF after 2025. At this stage we think a 777-8F would be more likely than a 777-9F as the aircraft represents a natural extension of the 777-200F. By comparison a 777-8F is expected to have 29 main-deck positions compared to 27 on the 777-200F. A potential 777-9F would have 35 main-deck positions and consequently compares more to a 777-300ERSF with 33 pallet positions. Boeing has so far not many any specific commitment regarding a 777-8 or 777-9F.
- An A350-900/1000F becoming available within the next 5 years. While Airbus has been courting customers with different concepts, the manufacturer has yet to launch a program.
- A 777-300ER conversion available from 2022, following the official launch of the Israel Aerospace Industries (IAI) - GECAS program in late 2019. Two further programs are being pursued by alternative consortia who have also signed data sharing agreements with Boeing. 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 October

2020. A further program is being pursued by the Mammoth consortium, also with private equity backing.

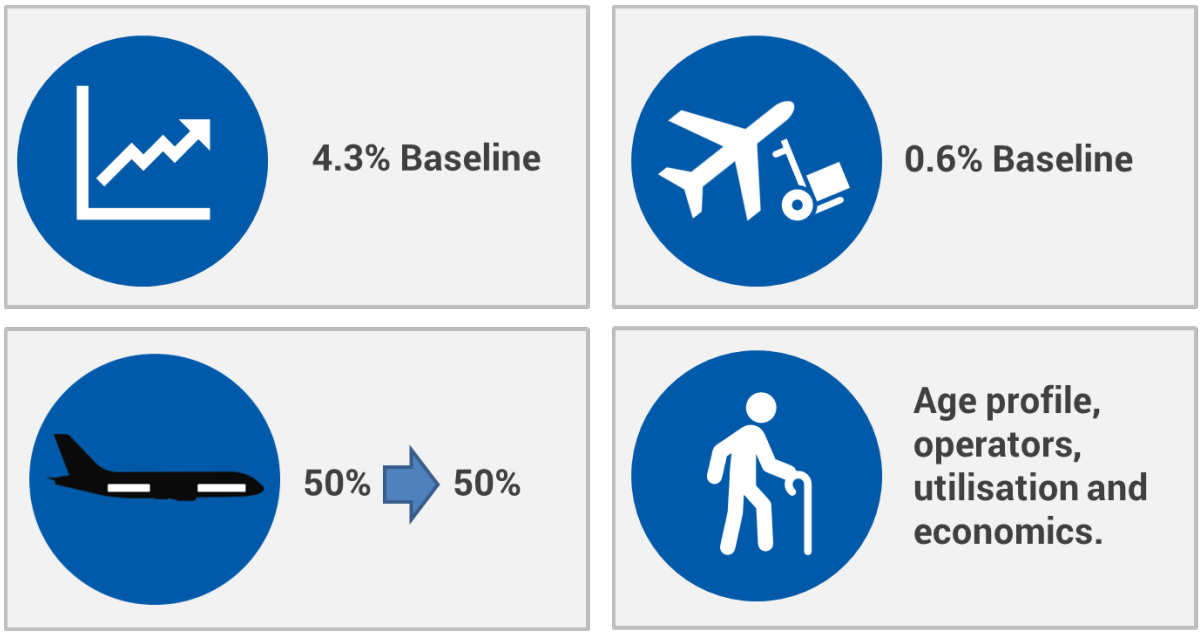
- We did not assume any 777-200ER becoming available as the declining feedstock situation as of 2022 would affect the long-term viability of the program. In contrast the feedstock for the 777-300ER will increase over the next 15 years and due to a recent drop in aircraft values 777-300 feedstock is likely to be cheap and plentiful going forward.

Regarding retirements, we recognize that freighter aircraft types typically have useful economic lives in excess of 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 60 jet freighters per year. Over the next twenty years more than 1,200 freighters from the current fleet (about two thirds of those now in operation) will be retired.

4.4 Jet Freighter Baseline Assumptions and Sensitivity

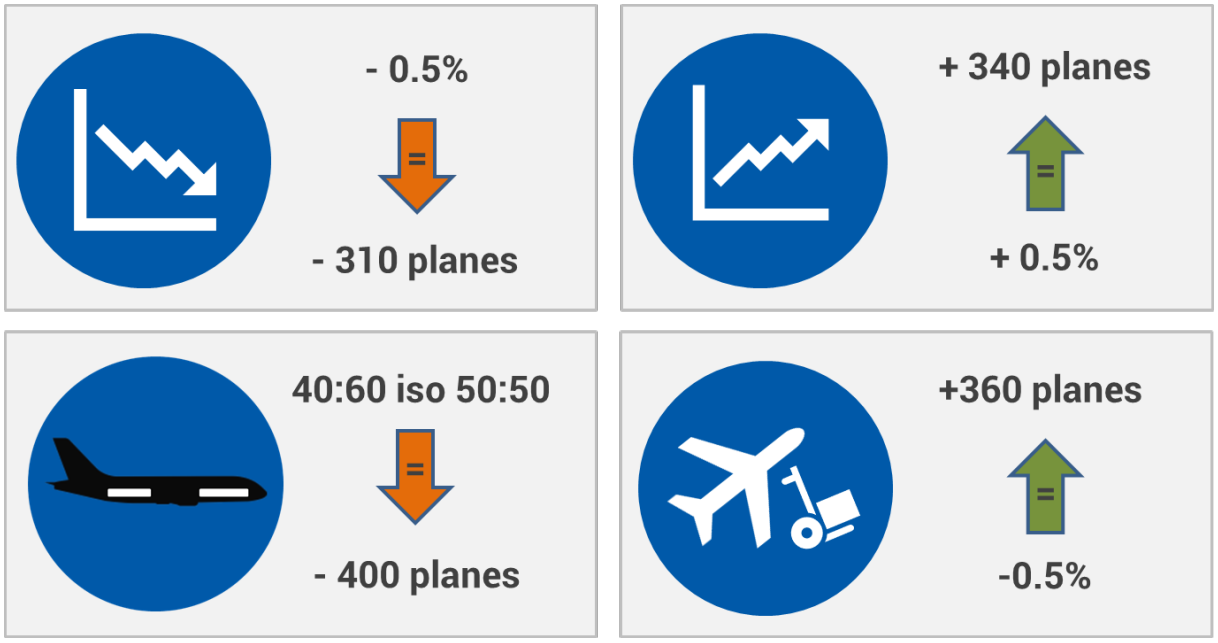
Our analysis technique allows us to determine the impact on freighter requirements given various assumed levels of demand growth, changes in freighter productivity, and shifts in the ratio of freighter-to-belly use. Small changes in assumptions can have large impacts in terms of fleet requirements. Figure 13 provides an overview of the baseline assumption of the forecast and Figure 14 illustrates the impact of changes in key assumptions.

Figure 13 - Baseline Assumptions



For each half a percentage point increase or decrease the number of jet freighters required changes by over 300 aircraft. Every half a percentage point decrease in productivity increases the number of aircraft required by 360. If the freighter share of total traffic were to decline to only 40% of freight carried, then this would lead the requirement for 400 less aircraft over a 20-year period – primarily in the large widebody segment.

Figure 14 - Forecast Sensitivity to Changes in Baseline Assumptions



5. Feeder Freighter Fleet Analysis and Forecast

Key Topics:

- Feeder freighters play a supplemental role to larger jet aircraft in Europe, North America and smaller markets around the world.
- We expect the fleet in this segment to grow by about 80% 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 turboprop as well as larger jets.

5.1 Current Fleet and Recent Developments

Currently there are approximately 250 feeder aircraft in operation (see Table 7). 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 7 - Current Feeder Freighter Fleet

Feeders (Turboprops and Regional Jets) *8,500 – 20,000 lbs (3.8 – 9 tonnes)*
247 Total Units
35 ATR 42
88 ATR 72
4 Dash 8-100/Q300
4 Dash 8-Q400
16 CRJ 200
12 ATP, 11 HS 748
19 CV 580/5800, 8 F27/50
38 Saab 340
10 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 it is included in our count. Currently, there are a significant number of passenger aircraft operating in a cargo configuration we have attempted to exclude these aircraft from our baseline, as we do not believe this will continue indefinitely.

Compared to last year, we have seen a slight uptick of aircraft, the modest change in fleet size in the last year hides some of the changes taking place in this segment, specifically:

- On July, 2020, a Bluebird Aviation Dash 8-400PF crash-landed in Beletwein, Somalia. The Kenyan plane was operating a cargo flight from Djibouti to Beledweyne Airport when it crashed and caught fire. The aircraft was subsequently written off. This incident is surrounded in speculation, but it appears that the crew were avoiding an animal on the runway.
- Two ex-ASL Ireland ATR72-200Fs, re-entered service with Morningstar in October 2020.
- On December 2020, FedEx took delivery of its first ATR72-600F in Toulouse, France. This aircraft is the first of 30 ATR72-600Fs that FedEx will take delivery of.
- Last month, ASL ended FedEx ATR42F ops after its last ATR42-300F was ferried to Kelowna, Canada (YLW) and will reenter service with Yukon based Air North.

2020 will likely be remembered as the year of the "Passenger Freighter" along those adaptions we saw other interesting developments:

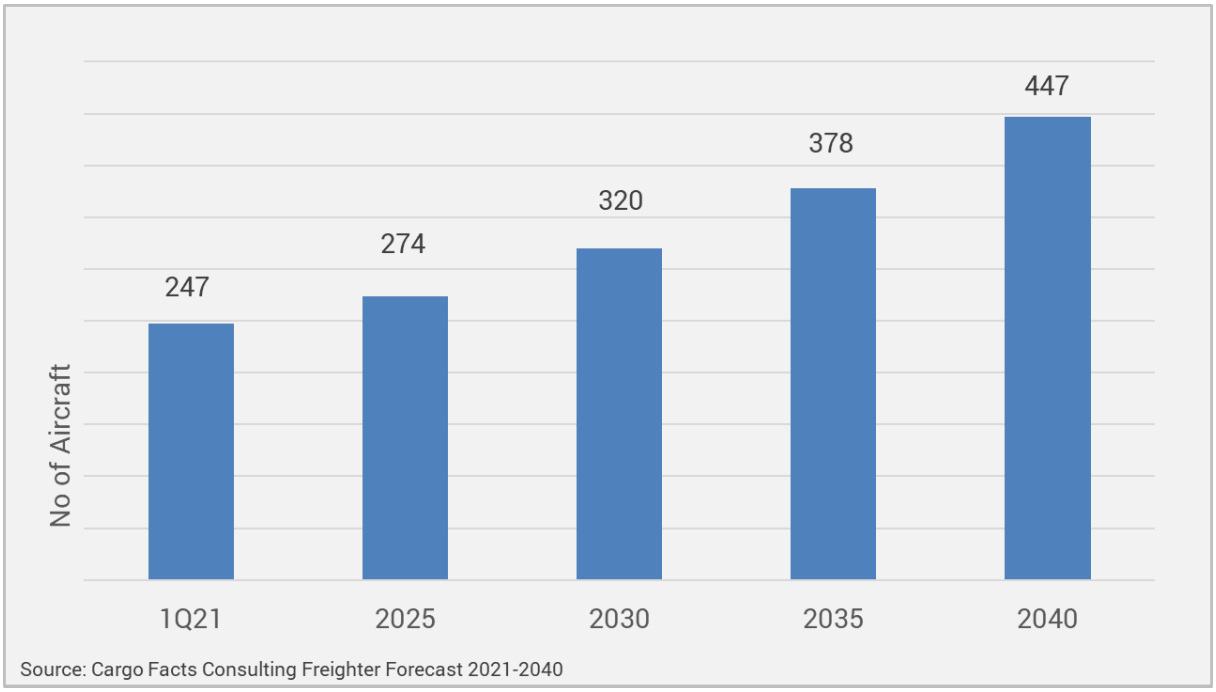
- On April 2020, De Havilland Aircraft of Canada Limited announced the Transport Canada approval of their Dash 8-400 Simplified Package Freighter conversion kit in response to the COVID-19 pandemic. This was followed up by the approval of their Dash 8-100/200 and Dash 8-300 Simplified Package Freighter on May, 2020. Jazz Aviation agreed to purchase 13 conversion kits, and was the launch customer for this product.
- Though outside the parameters of this forecast, one aircraft that we are keeping an eye on is the Cessna 408 Skycourier. On May 2020, the first prototype took to the air from Beech Factory Airport. With FedEx ordering 50 aircraft, with an option for an additional 50, it is unclear at this point what impact they will have on existing feeders.
- As a result of the COVID-19 pandemic and exemptions by Brazil's civil aviation authority, in the summer of 2020, Azul Linhas Aereas began to operate cargo only flights on Embraer E190

passenger aircraft. This has many wondering if we will see a E190 or E195 P-to-F conversion program anytime soon.

- In early April 2021, UPS announced that it is purchasing 10 Alia-250C electric vertical takeoff and landing (eVTOL) aircraft made by Vermont based Beta Technologies. With a payload of 1,400 lbs, UPS aims to replace "small feeder aircraft" in the 500 to 3000 lbs. range. Being that these drones are able to take off and land vertically they are able to land directly at UPS facilities and will help work toward UPS' goal of reducing total emissions.

The expected evolution of the turboprop/RJ freighter fleet over the next twenty years is depicted in Figure 15. The fleet is shown to increase from 247 units in Q1 of 2021, to 447 units at the end of 2040.

Figure 15 - Baseline Feeder Freighter Fleet Forecast 2021 - 2040



Overall, the total number of turboprop/RJ freighters in 2040 is forecast to be about 1.8 the baseline quantity of 247 units. The net growth in the turboprop/RJ fleet size is 200, which when combined with 224 retirements, produces the overall need for 419 freighters through 2040. This total fleet requirement equates to an average of 21 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 16).

Figure 16 - Feeder Freighter Forecast Fleet Development 2021-2040

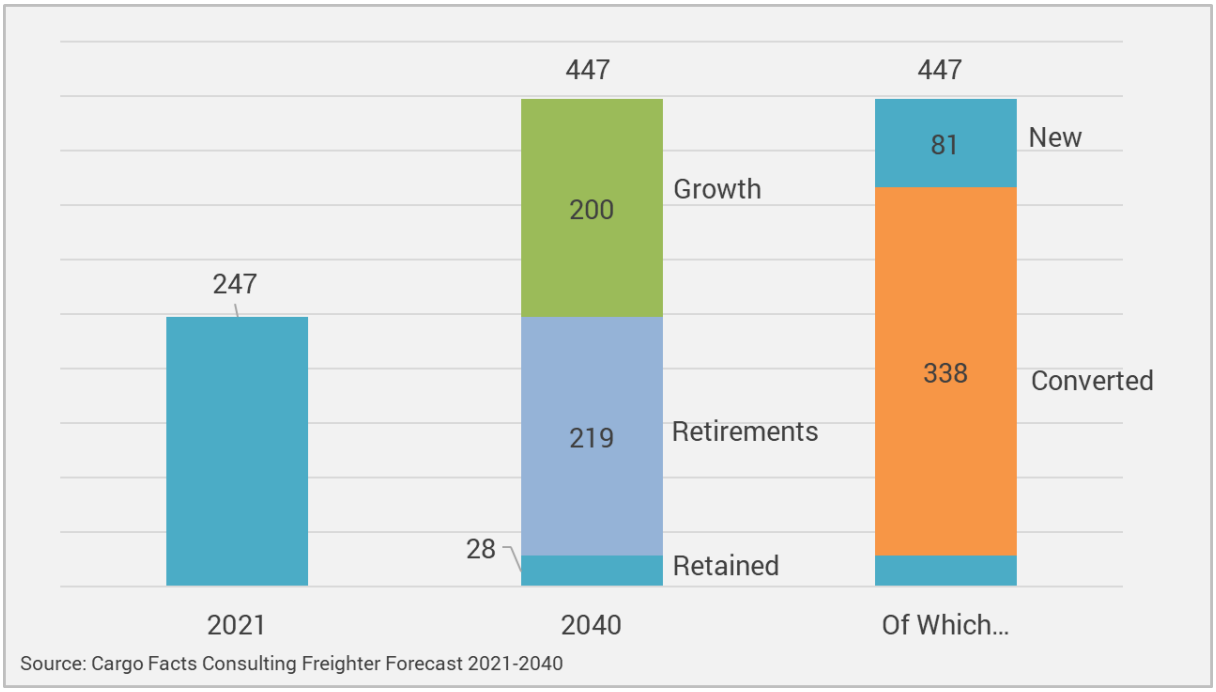


Table 8 shows the detailed composition of the turboprop/RJ freighter fleet on a model-by-model basis at the end of forecast period in 2040 under our baseline scenario. Based on our assessment, we see the ATR 72 being the single dominant type in the feeder segment, followed by the Dash 8 series, with upside for both if the CRJ 700/900 program does not materialize.

Table 8 - Feeder Freighter Fleet in 2040

Feeders (Turboprops and Regional Jets) *8,500 – 20,000 lbs (3.8 – 9 tonnes)*
447 Total Units
0 ATR 42s 215 ATR 72s 25 Dash 8-Q300s 122 Dash 8-Q400s 36 CRJ 200s 42 CRJ 700/900s

Source: Cargo Facts Consulting Freighter Forecast 2021-2040

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 9, 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, although the STC that was expected in late 2020 has still not been approved). 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 9 - Feeder Freighter Fleet Available to Operators

	Turboprops/ Regional Jets
Facing near-term extinction	Saab 340, CV 580, HS 748, Fokker F27/50, Bae ATP, AN26/32/74
At peak use, or with little future growth potential	ATR 42
Expanding role going forward	ATR 72-600F, ATR 72, Dash 8-Q300, Dash 8-Q400, CRJ 200
Future aircraft	CRJ 700/900, E190/195

Note that there are no active nor launched programs for the CRJ700/900 or the Embraer 190/195 program, although there has been some discussion about launching programs for these aircraft. As stated

previously there is currently a passenger E190 operating in an all-cargo configuration. We have not considered an E170/175 program as we feel the aircraft would be too small to effectively compete with turboprops.

6. Freighter Usage Analysis

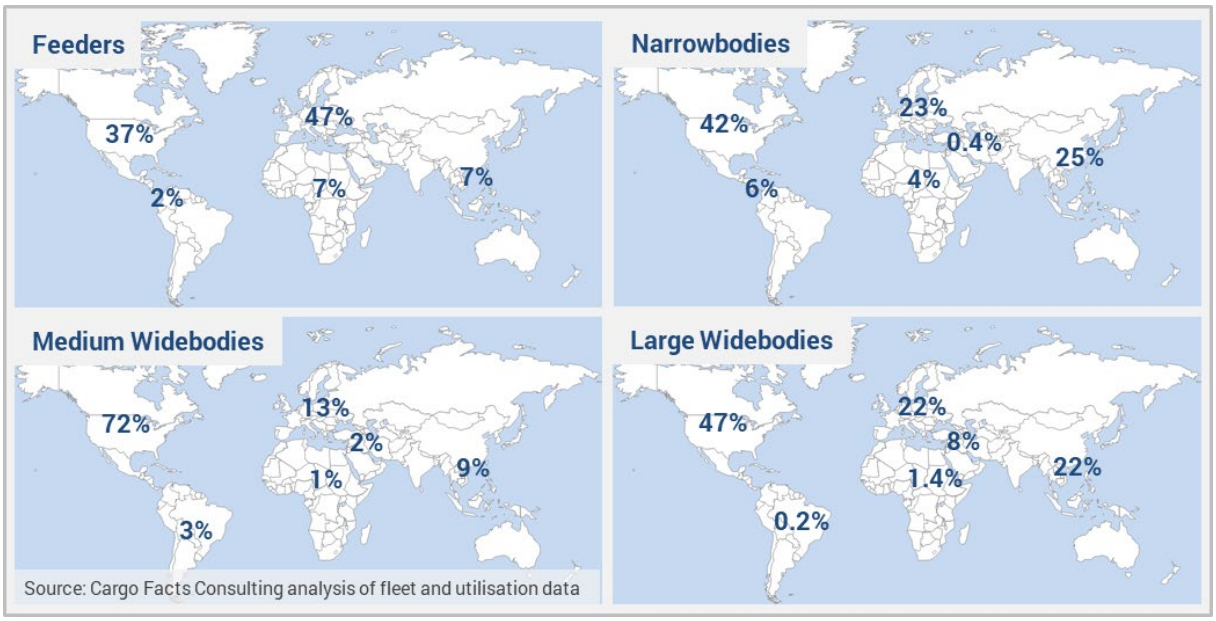
Key Topics:

- Due to FedEx and UPS and other large contract airlines such as Atlas and ATSG a large portion of the world's narrow and medium widebody jet fleet is concentrated in North America
- Europe has the highest share of feeder aircraft operated by a mix of smaller operators and larger airline groups such as ASL or Swift/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.

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 17 provides an overview of the regional distribution of the world's fleet by category.

Figure 17 - Freighter Fleet by Operator Domicile Q1 2021

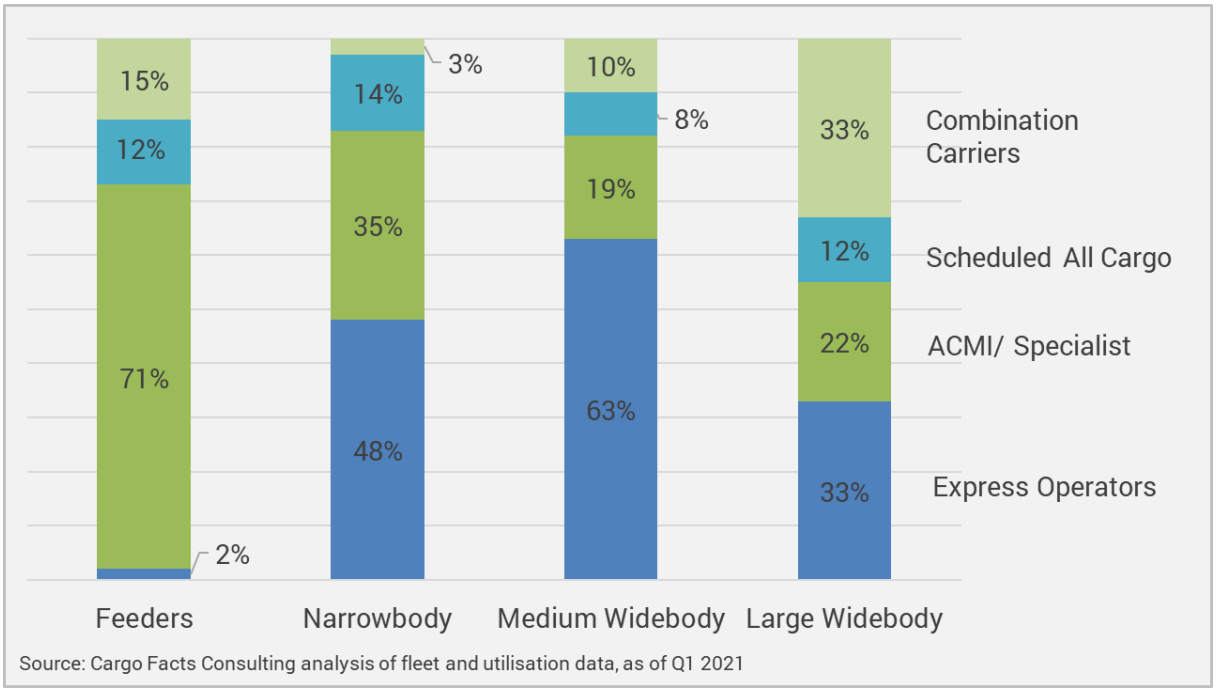


About half of the world's widebody fleet is operated by North American operators, with European and Asian operators accounting for most of the balance. Over time we have witnessed a towards Gulf based

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 similar to 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.

Figure 18 illustrates the differences in operator type within each freighter aircraft category. Across the feeder, narrowbody and medium widebody segments, the majority 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 18 - Freighter Fleet by Operator Business Model Q1 2021



Source: Cargo Facts Consulting analysis of fleet and utilisation data, as of Q1 2021

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 of its dedicated air operations to third party operators.

6.2 E-Commerce and Freighter Demand

We estimate that around 16% 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.

Sofar only Amazon has run a substantial own controlled network. At the end of 2020, the e-commerce platform had over 80 aircraft operating in North America and Europe and by the end of this year, we expect it will be at least 100 (see Table 10). We estimate that the company's spend on dedicated air is currently in the order of between $1.1 and $1.2 billion per year.

Table 10 - Amazon Dedicated Aircraft Fleet Overview

Company	Aircraft Type and Number
ATSG (CAM)	*Previous arrangements* - 12 767-200 - 8 767-300 *Dec 2018 Deal* - 6/4 767-300 *May 2020 Deal* - 1 767-300 - 11 767-300 - Warrant incentives to lease up to 5 additional freighters **Total: 31 767-200/300 (End of 2020)** - 42 (end of 2021), Possible increase to 47 thereafter
Atlas (Titan)	- 1 767-300 - 10 767-300 (11 – 1 hull loss) - 8 767-300 **Total: 19 767-300 (End of 2020)**
Gecas	- 5 737-800BCF - 17 737-800BCF (2 operated in Europe) **Total: 22 737-800BCF (End of 2020)**
ASL	- 11 737-400 on wet lease (in Europe)
Purchased Aircraft - Ex Westjet - Ex Delta	 - 4 Confirmed (All registered with NXXXAZ Registrations, various stages of conversion) - 7 aircraft confirmed (All stored, two ferried to MEX in Jan)
Total (Leased and Owned)	- End 2020: 83 (12 767-200, 38 767-300 and 22 737-800, 11 737-400) - End 2021: 100 (12 767-200, 49 767-300 and 22 737-800, 11 737-400 + 6 owned 767s) - End 2022: At least 105 (12 767-200, 49 leased 767-300, 11 owned 767s plus 737s)

Source: Cargo Facts Consulting analysis of company reports and fleet data, as of April 2021

Sofar, the large Chinese e-commerce platforms Alibaba and Jd.com have not operated dedicated capacity but have procured air capacity either through charters or through partnerships with air carriers. And express carriers – particularly UPS in the US have been seeing strong volume growth (coupled with yield

declines) in their networks as a consequence of a surge in business to consumer traffic. For example, in 2020 UPS generated 13% of its revenue with Amazon while 18% of Amazon's shipping spend went to UPS.

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. In 2020, Jd.com invested the equivalent of $300 million into a new Chinese based company to set up own airline operations. Meanwhile Alibaba's logistics arm Cainiaio increased its charter activity. In Latin America, we saw Mercado Libre commit to dedicated narrowbody aircraft capacity. 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 Topics:

- With increasing new generation conversion program availability and strong express and e-commerce growth expectations, activity has picked up substantially for both narrowbodies and medium widebodies
- The 737 NG and 767-300 have been the main focus of activity. Classic narrowbody conversion activity is winding down, and A330s have yet to pick up.
- 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 take into account the number of aircraft of a particular type that were produced in passenger configuration and the period of time 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 Feedstock Market Trends

2020 saw the redelivery of about forty-six to forty-eight narrowbody conversions and about seventeen medium widebody conversions. That is roughly in line with the annual figure foreseen in our 2020-2039 Freighter Forecast, published in May 2020, and which forecasted an average of forty-eight narrowbodies per year and about fifteen medium widebodies. Freighter retirements, on the other hand, have been below average since at least 2017, since the demand for freighters has remained high. Last year only seventeen jet freighter aircraft were permanently withdrawn from service and thirty-four were withdrawn the previous year. This is much lower than the average of about eighty-five per year during the last fifteen years.

Judging by recent announced and unannounced order activity and slot availability, we expect to see continued above-average narrowbody and medium widebody passenger-freighter conversion activity in 2021 and 2022. At this stage, approximately seventy narrowbody freighter conversions and thirty medium widebody conversions appear likely for 2021, and about the same is expected for 2022. Most narrowbody conversions in 2021 will focus on the 737-800, and most medium widebody conversions will center around the 767-300. Part of that is driven by supply, as in the case of the A321, and part is driven by demand, as in the case of the A330. For the 737 NG and 767 conversion programs, slots are tight despite extra line capacity added in 2020.

A secondary constraint has been the lack of available conversion programs. Since 2020, there are now three certified conversion programs for the 737-800 (Boeing, AEI and IAI) and one program for the A321. We believe the MAX reentry will support lower feedstock prices for the 737-800. Deliveries of the A321 are being held back by supply constraints and the fact that STC approval dates continue moving to the right for those programs. As such, we don’t expect more than a handful of A321 redeliveries this year. The 737 classics and 757 remain attractive because of low on-ramp costs compared to NG options, but viable feedstock is coming to an end. Table 11 shows an overview of currently active, in development, launched and planned jet freighter conversion programs.

Table 11 - Current and Future Jet Freighter Conversion Programs as of April 2021

	AEI	IAI	Boeing	EFW	PEMCO	321/ Precision	ST Aerosp.	Sine Draco	C3
MD-80	X								
737-300	X				X				
737-400	X				X				
737-700		X			Jul 2020				
737-800	X	Apr 2020	X						
A320				Launched					2021
A321				Feb 2020		Q2 2021		2022	Planned
757-200						X	X		
767-200		X							
767-300		X	X						
A330-200				X					
A330-300		Planned		X					
777-300		2022/23							

Source: OEMs, Conversion Houses, Cargo Facts Consulting estimate, as of April 22, 2021

The 767 continues to power along on the medium widebody side, and conversion capacity from both Boeing and IAI will support additional redeliveries to DHL, ATSG, SF and Amazon, as well as to some smaller customers.

- ATSG is committed to twenty additional conversions over the next eighteen months.
- DHL has committed to seven conversions by end of 2021; there will be at least forty-six new 767s for FedEx during the next three and a half years, and UPS and SF are also adding capacity.
- Amazon will account for fifteen to twenty additions during the next couple of years.

We expect A330P2F orders and redeliveries will continue to be sluggish for the next couple of years since most of the main customers remain committed to the 767, and feedstock prices are attractive relative to the A330-200 and A330-300.

While there is a lot of interest from both leasing companies and operators in freighter conversions, the actual customer base is well-defined, consisting of express companies (DHL, FedEx, UPS, SF Express, China Postal Airlines), Amazon, contract operators to express and e-commerce companies, and a handful of smaller express companies. While there are some general cargo operators with narrowbodies and medium widebodies, they do not drive large-scale aircraft demand in this segment. The large widebody segment is more diverse, but until the 777-300ERSF hits the market after 2022, there are no conversion

options available, unless one takes into account IAI's 747-400 conversion program, which has not redelivered any aircraft for several years.

While FedEx is bringing more 737-800s into its European network via ASL and West Atlantic, DHL has been placing additional 737-800s across its network in the Americas, Africa and Asia through an array of subcontractors. This trend is likely to continue and will provide new opportunities for leasing companies and conversion houses.With Amazon's purchase of 11 767-300s, the opportunities in the leasing market for this type are changing but, given that the express business has been operating at higher volume levels since the onset of the pandemic, the demand base for medium widebodies has changed.

It is worth noting that while new generation feedstock will come down in price, old generation feedstock will also see drops in value. In the current low fuel price environment, there is little incentive to accelerate retirements of older freighter aircraft in favor of newer, more efficient capacity.

7.3 Average Age at Conversion

The average age at conversion has been trending upwards. 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 a large number of 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 19 and Figure 20 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 75 aircraft over the next two years and this higher than average number is reflected in the 2021 orders shown below.

Figure 19 - Narrowbody Conversions and Average Age at Conversion 2000 - 2021

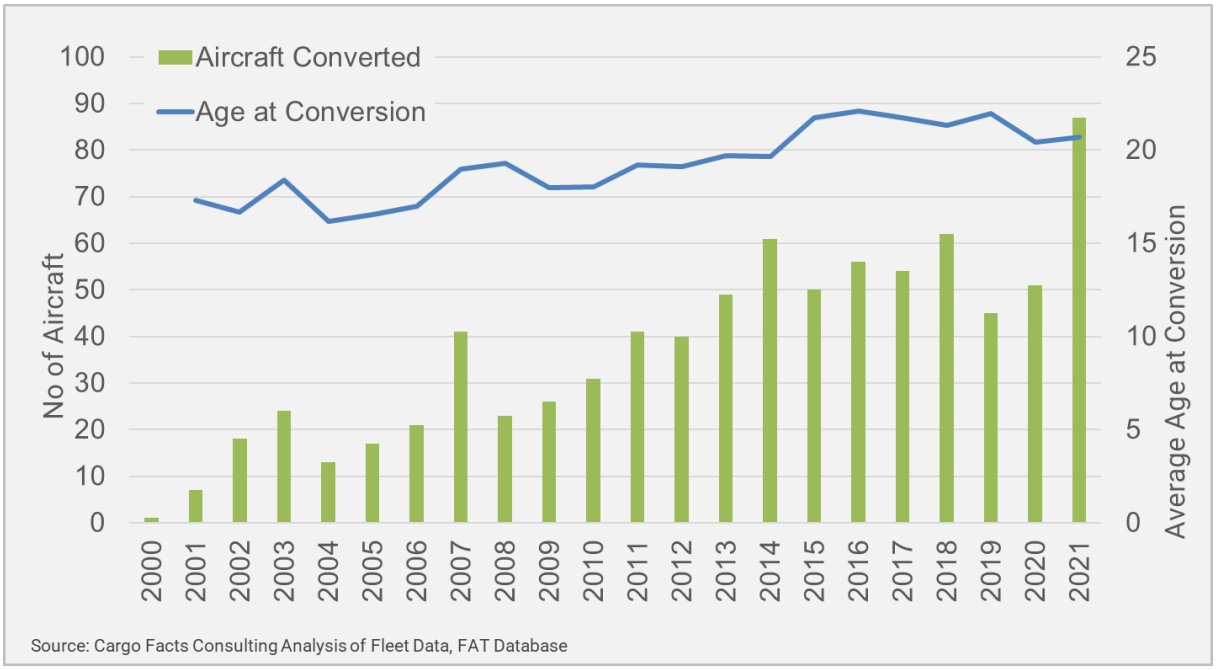
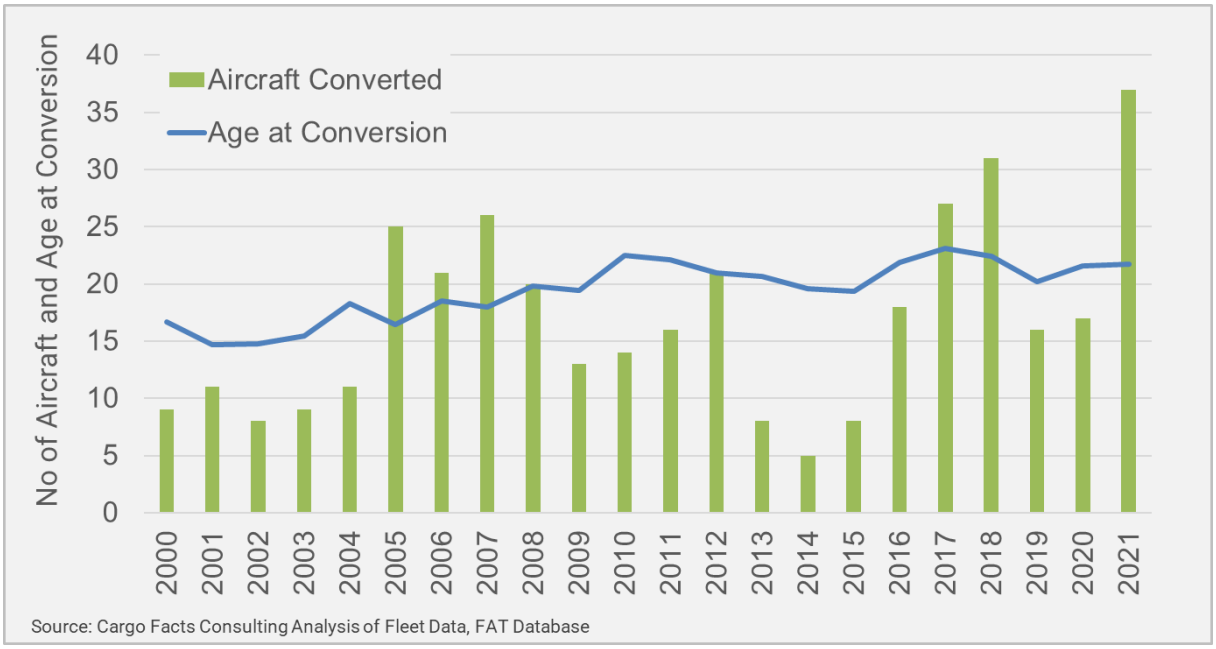


Figure 20 - Medium Widebody Conversions and Average Age at Conversion 2000 - 2021



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.

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.

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 12, Table 13, and Table 14, 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.

7.4 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 12 - Narrowbody Feedstock Summary

Model	Production Years	Passenger Deliveries	Feedstock Quantities for 16-25 years old aircraft		
			2021	2024	2027
737-300	1984 – 1999	1,113	121	17	0
737-400	1988 – 2000	486	23	8	1
737-700	1997 – 2019	1,285	596	803	710
737-800	1998 – 2019	5,135	816	1,317	1,773
737-900	2001 – 2019	564	52	50	31
757-200	1982 – 2005	995	193	122	14
757-300	1998 – 2004	55	55	53	31
A320-200	1998 – 2020	4,695	860	1,283	1,804
A321-200	1996 – 2020	1,661	229	347	465
MD-82/-83/-88	1981 – 1999	330	55	25	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 12, there are no such young units. The pool declines by 85% from 121 to 17 in 2024 and by then, all of 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 othe rhand, the feedstock for the newer generation 737 and A320/A321 family will increase in the coming years. As shown in Table 12, 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.

7.5 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 13 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 13 - Medium and Large Widebody Feedstock Summary

Model	Production Years	Passenger Deliveries	Feedstock Quantities for 16-25 years old aircraft		
			2021	2024	2027
767-300ER	1988 – 2014	667	163	125	88
A330-200	1998 – 2020	645	160	273	309
A330-300	1993 – 2020	771	125	166	255
777-200ER	1997 – 2013	422	369	283	144
777-300ER	2004 – present	807	29	163	303

Source: Cargo Facts Consulting Feedstock Analysis Tool

7.6 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 14).

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 14 - Turboprop/ RJ Feedstock Summary

Model	Production Years	Passenger Deliveries	Feedstock Quantities for 16-25 years old aircraft		
			2021	2024	2027
ATR 42-300/-500	1984 – present	417	81	54	43
ATR 72-200/-500/-600	1988 – present	562	92	146	249
Bombardier Dash 8-Q300	1998 – 2007	267	74	87	62
Bombardier Dash 8-Q400	2000 – present	601	79	191	315
Bombardier CRJ 200	1991 – 2006	939	759	713	497
Bombardier CRJ 700	2001 – 2018	346	212	247	287
Embraer E-190	2005 – present	584	11	184	381
Embraer E-195	2006 – 2019	181	0	26	84

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. Since 2019, we are based in Luxembourg, with offices in New York and Seattle.

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-kilometres (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 take into account 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 final 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:

- 4.3% 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, 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, 777-8/9F, A350-900/100F, and 777-200ER and 777-300ER conversions.

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 15 - 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 (est)	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 16 - Narrowbody 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)
BAe 146-300QT	44,225	25,333	8	70	none	23	93	10,501	960	10,226	113
737-200F	56,472	0	7	79	none	25	104	17,327	1,175	11,440	167
MD-83SF	72,575	34,881	12	125	none	0	142	20,457	1,200	15,649	144
737-300F	63,276	30,436	8+	104	none	30	134	19,278	1,600	14,771	144
737-400F (LGW)	65,091	31,706	10+	129	none	39	168	19,550	1,250	18,476	116
737-400F (HGW)	68,039	32,160	10+	129	none	39	168	21,364	1,725	18,476	127
737-700BDSF	70,080	34,791	8+	104	none	0	131	20,412	2,100	14,460	155
737-800SF	79,016	38,828	11+	142	none	44	186	23,904	2,000	20,406	129
737-800BDSF	79,016	38,691	11+	142	none	44	186	24,040	2,000	20,406	130
737-900F (est)	85,139	39,700	12+	156	none	44	210	28,112	2,000	20,406	152
A320-200F (est)	77,020	41,500	10+	133	26	6	164	21,899	2,000	18,090	133
A321-200F (est)	89,040	46,800	14	171	37	6	214	27,896	1,850	23,522	130
727-200F	92,125	44,724	12	149	none	43	193	25,583	1,650	21,184	133
757-200SF	108,862	52,617	15	187	none	51	234	31,752	2,400	25,745	136
757-300SF (est)	122,924	58,967	18	224	none	67	292	36,287	2,400	32,070	124

Table 17 - 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 18 - 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 19 - 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
A350-900F (est)	617,295	n.a.	27	18,385	4,465	403	22,850	187,393	n.a.	159,950	8.2
A350-1000F (est)	696,661	n.a.	33	22,440	6,496	403	28,936	209,439	n.a.	202,552	7.2
777F production	766,000	299,500	27	18,385	4,465	600	22,850	236,200	4,965	159,950	10.3
777-8F (est)	775,000	n.a.	29	19,720	5,295	547	25,015	n.a.	n.a.	175,105	n.a.
777-9F (est)	775,000	n.a.	35	23,832	8,131	547	31,963	n.a.	n.a.	223,744	n.a.
777-200ERSF (est)	650,000	305,000	27	18,385	4,465	600	22,850	190,000	4,000	159,500	8.3
777-300ERSF (est)	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 20 - 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
A350-900F (est)	280,001	n.a.	27	520	126	11	647	85,000	n.a.	71,132	131
A350-1000F (est)	316,000	n.a.	33	635	184	11	819	95,000	n.a.	90,078	116
777F production	347,452	135,851	27	520	126	17	647	107,139	4,965	71,132	166
777-8F (est)	351,535	n.a.	29	558	150	15	708	n.a.	n.a.	77,872	n.a.
777-9F (est)	351,535	n.a.	35	674	230	15	905	n.a.	n.a.	99,502	n.a.
777-200ERSF (est)	294,835	138,346	27	520	126	17	647	86,183	4,000	71,132	133
777-300ERSF (est)	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 21 - 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 22 - 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 19 MD-80s (all MD-82 and MD-83 types) since 2013. Aeronaves TSM is the largest MD-83F operator with fourteen units, with two of these units redelivered in 2021. 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 68 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.

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. AEI has converted

six 737-800s so far and has plans to convert about ten more units through the end of 2022. 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 indicated some time ago that it was also interested in this market, so it 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. So far, they have converted 17 aircraft and its conversion backlog is over 60 units. More recently, PEMCO announced 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. The current 737 NG backlog stands at about 70-75 aircraft, and is largely speculative driven by funds and leasing companies. As conversion of 737 NGs ramps up, recent conversions aren't being picked up as quickly, indicating the velocity of new lease agreements for speculative conversions is slowing and the demand for 737 classic freighter has persisted even with the new types available. 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 March 2020. 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. Elsewhere, Sine Draco has disclosed plans to develop an A321 conversion program, and there are rumors that IAI and one or two other parties are also interested in the A320/321 conversion market. 321 Precision Conversions has completed the Federal Aviation Administration (FAA) flight testing program for the first freighter-converted A321-200PCF in late Q1 2021. EFW redelivered the first A321-200P2F to Vallair last year, and the aircraft is now operating in the Qantas Freight fleet. EFW redelivered a second A321-200P2F to Titan Airways in January, on-lease from BBAM. With one conversion program certified and a second imminent, output will gradually ramp up as the year progresses.

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 315, 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 come to a close around 2023. 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 redelieveyr of the latst 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, or will soon see, output increases. There were about twenty transactions involving 767-300 freighters just in the month of February 2021, showing the popularity of this segment. Both Boeing and Israel Aerospace Industries have recently added conversion capacity and it is not possible to induct a 767-300 until mid-2022 unless a conversion slot has already been reserved. In the last month LATAM placed an order with Boeing for four 767-300BCF conversions and added options for four more, while DHL Express continued its process of adding freighter converted 767-300s to its fleet.

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 (similar to 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 has fallen to zero units. 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. DHL placed orders for eight -300 conversions (plus ten options) while five of those have been redelivered as of April 2021. Turkmenistan Airlines has ordered two A330-200P2F conversions from EFW, becoming the second customer of the type while Sichuan Airlines plans to add an A330-200F to its fleet this year, growing its freighter fleet to four A330-200Ds. Israel Aerospace Industries (IAI) announced that its next passenger-to-freighter conversion program will be the A330-300 and plans to be in ther market by Q4 2023 with the goal of aligning the declining availability of the 767-300 feedstock and lower values for the A330-300 units avaialble for conversion. 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. In 2014, Airbus announced the A330NEO (New Engine Option) family, featuring the A330-800 and the larger A330-900. The -900 entered service in late 2018 with TAP Portugal. There have been rumors that Airbus is considering an A330 neo production freighter, perhaps based on a -900 platform. At the time of writing 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, Lufthansa, FedEx and Western Global.

777F (including 777X 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. This program is in early planning and budgeting stages and no details on dates or potential customers have been disclosed yet. Sequoia Aircraft Conversions will market the P2F conversions, and the Kansas Modification Centre will own the STC and license the

conversions. In the last twelve months, we have seen that the most commonly utilized airframe for cargo-only operations was the 777-300ER, with thirty carriers operating over 300 777-300ERs in cargo-only configuration. 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 is moving forward with the enhanced 777X version of the passenger model for introduction by early 2023. We presume that a follow-on 777XF production freighter will be developed as well, but with service introduction after 2025. Boeing has not disclosed details about the transition of production from the current 777 model to the new 777X, nor for how long after 777X production begins that it will continue to build the existing 777F model.

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 any more -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.

747-8

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. First deliveries of the 747-8F took place in the fourth quarter of 2011, and 90 units had been delivered by the end of March 2020. Boeing has recorded 107 orders for the freighter version from eleven airline customers (this number includes the recent order from UPS for a total of 28), leaving a backlog of 17 units as of April 2020. 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. We believe the -8 model will be produced mainly in freighter configuration through about 2023, although limited demand for the 747-8I (only 47 units delivered) passenger version could force Boeing to end the 747 program sooner. Combined production of both models dropped to 0.5 units per month in 2016, and Boeing disclosed it might be forced to terminate the program due to a lack of sales. Currently, there are 4 unfulfilled orders for Atlas Air and 7 for UPS Airlines. Freighter conversion of passenger-configured 747-8s could be a possibility after 2025, 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.

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 2019 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 twelve aircraft through April 2021 and there is one more unit undergoing conversion at the moment and that will be delivered to Aeronaves TSM in May 2021. 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 1,1200of 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. 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. 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. These ATR freighters will incorporate Large Cargo Door and Structural Tube Modifications from IPR (noted above).

Bombardier 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 Bombardier Aerospace. 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. On April 2020, De Havilland Aircraft of Canada Limited announced the Transport Canada approval of their Dash 8-400 Simplified Package Freighter conversion kit in response to the COVID-19 pandemic. This was followed up by the approval of their Dash 8-100/200 and Dash 8-300 Simplified Package Freighter on May, 2020. Jazz Aviation agreed to purchase 13 conversion kits, and was the launch customer for this product.

Cargo Facts Consulting SARL
Cargo Center
Building S-329
L-1360 Luxembourg

+352-691-137150
fhorst@cargofacts.com
www.cargofactsconsulting.com
www.cfcinsights.com