The introduction of the A350F means large factory freighters are no longer the prerogative of a single OEM. Latest developments analysed.

Step into the arena: the A350F, Airbus' 109 tonne freighter

Based on the A350 platform, the latest large freighter from Airbus will be capable of a gross payload of 109 metric tonnes. The A350F will have similar payload characteristics to the 747-400F, and more volume than the 777F. The A350F will have a 4,700nm range and low cash operating costs.

According to Crawford Hamilton, head of freighter marketing commercial and international at Airbus, "We are the challenger in this marketplace, so we must ensure the aircraft is right. Furthermore, much about launching a new aircraft is about timing. We have been approached by a number of people saying they would like some competition in this market."

The Airbus A350F has an entry-into-service date (EIS) penned for 2025, and in September 2022 had gained firm orders from Air France (4), Air Lease Corporation (7), CMA CGM S.A (4), Etihad Airways (7), Silk Way West Airlines (2) and Singapore Airlines (7).

Studies into the feasibility of the A350F started in 2015, and Airbus has engaged with many potential customers to learn how best to meet their requirements. Furthermore, the A350F will be the latest addition to a 'family' of Airbus passenger to freighter (P-to-F) conversions, based on the A320/A321/A330 platforms.

Composite materials

The manufacturing of parts for the A350F has begun. These parts are now being evaluated ensuring the materials meet exacting standards. Most of the current engineering pertains to the main cargo door area, and its surrounding structure aft of the fuselage.

The A350 is one of the first Airbus aircraft largely made of carbon-fibre-reinforced polymers, with only 19% of the airframe constructed from aluminium. "The major concern for operators was that the aircraft must be tough enough to withstand the 'rough-and-tumble' of the global freight business," adds Hamilton. "We believe that we have the toughest freighter possible because of its carbon-fibre construction."

The A350F uses a different construction philosophy to the 787, which is also made from composite materials. Critics of a potential 787 P-to-F conversion programme believe its carbon-fibre fuselage will make the modification difficult to achieve, if not impossible.

"The A350 does not have a 'barrel' construction such as the 787s. The Airbus is built with long panels, which make it permissible to vary the thickness of the material in areas where it is most needed. This gives us a high degree of customisation," explains Hamilton. "The A350 panels are affixed to the frame by conventional methods. The result is a strong structure to support the main cargo door. Carbon is resilient, light, and incredibly repairable."

Repairing damage to the carbon structure of the A350 is like repairing a metallic structure. According to Hamilton, non-destructive testing (NDT) equipment is simple to use. However, loaders, dollies and other ground equipment occasionally bump into aircraft, and freighters are subjected to a degree of 'ramp-rash.' After damage analysis sustained by its products during their operational life, Airbus knows which repairs are most common. It has also gained valuable historical insights from its legacy factory freighters, and Airbus aircraft modified with Elbe Flugzeugwerke P-to-F conversions.

"Based on A350 operation data we can start to model what will happen to the A350F. Now we can develop A350F repair schemes. The repairs will be no more complicated than what people already know," adds Hamilton.

High-density cargo means freighter aircraft have a requirement for increased floor loading than passenger aircraft. Unlike the A350, which uses composite material, the A350F will be equipped with metallic floor beams.

According to Hamilton, the A350F's floor loading will be greater than a 747-400F in some areas. Over the wing box area A350F running loads are calculated to be about 260lbs per linear inch, and then 240lbs per linear inch moving further away from the aircraft's centre. At the forward and aft extremities, A350F running loads are expected to decline further, in line with all other freighters.

Choice

With the first 777-300ER converted freighters making their debut in 2023, and the launch of the 777-8F programme *(see 777 cargo conversions readying to replace 747Fs & MD-11Fs),* investors have a wide choice of freighters capable of a 100-tonne payload. There are almost 250 aircraft in the existing 777F fleet, and this number is growing. Furthermore, both 777F and 747-400Fs are proving very popular with operators because of their payload characteristics and size. According to some commentators, this segment may be becoming over-supplied and saturated.

"Essentially there will be a wider choice, and that is different," adds Hamilton. "In its General Market Forecast (GMF), Airbus predicts there is a growing market for large freighter aircraft. Because of a significant requirement there will be a need for both new line-built freighters, and P-to-F cargo conversions."

Fundamentally a P-to-F cargo conversion makes economic sense when the conversion candidate has aged sufficiently, and its residual value is low. The typical feedstock age for an aircraft inducted into a cargo conversion programme is 15-20 years old. Under most market conditions, the typical utilisation rate for a converted freighter is less than a line-build.

"Line-built freighters are operated hard and fly up to 5,500FH per year," adds Hamilton. "For example, utilisation rates for the 777F are higher than most legacy freighters in the fleet. To achieve elevated despatch and utilisation levels, you tend to need a new aircraft because only they can achieve the reliability that you need," explains Hamilton.

"Many 747 freighters will remain in operation because they are a valuable asset. But the simple fact is that many are reaching 30 years of age, and in the near future they will require additional maintenance checks and modifications," adds Hamilton. "Including freighters required for growth, we want to replace the 747 market."

Weights

According to Hamilton, the A350 maintains a 99.5% reliability record across its entire fleet. To achieve high operating hours, there will be a higher capital cost for the line-built freighter than for the P-to-F conversion. New line-built aircraft are also sold with robust warranties, including manufacturing support and big-data analytics to maximise utilisation levels.

The A350F is a long range freighter based on the A350-1000, but with shorter fuselage to optimise cargo loading characteristics. The freighter has an entry into service date planned for 2025, including orders and commitmentes from Air France KLM group, Etihad, and Singapore Airlines. The A350F meets latest ICAO emissions standards that will be introduced in 2027.

In a typical general freight mode, the main deck of the A350F can accommodate 30 main-deck and 12 lower-deck 96-inch x 125-inch PMC pallets. This is five more pallet positions compared to the 777F, and two less than the 777-8F. Another lower-deck configuration can include 40 LD3 universal loading device (ULD) containers.

The main deck can also be loaded with 28 AM350 containers positioned side-by-side, plus a single AMJ and AAY placed in a centerline configuration in the aftmost positions. Using ULDs can improve volumetric payload and loading efficiency, but ultimately the containers increase tare weight when compared to PMC pallets.

Loaded with 32 PMC pallets the freighter will have a total tare weight of 12,460lbs and a maximum revenue payload of 227,700lbs *(see table, page 50)*. Palletised cargo volume will total 25,130 cu ft, plus 399 cu ft of bulk storage. This is 1,423 cu ft and 5.3% less than the 777-8F, greater than the 777F by 2,558 cu ft and 11%, and similar to the 747-400F.

Not including tare weight, the maximum packing density for the A350F is 9.41lbs per cu ft. At a packing density of 7.5lbs per cu ft, a maximum revenue payload of 191,467lbs can be achieved. Loaded to a packing density of 8.5 lbs per cu ft, the A350 can achieve a maximum revenue payload of 216,996lbs. At both these densities, the Airbus is similarly paired to the 747-400F *(see table, page 50)*.

At 7.5lbs and 8.5lbs per cu ft, the A350 outperforms the 777F in terms of maximum revenue payload. At these packing densities the 777-8F can achieve 202,140lbs and 229,092lbs respectively *(see table, page 50)*. The Israel Aerospace Industries (IAI) 777-300ERSF P-to-F conversion will have a maximum revenue payload of 207,900lbs payload at a packing density of 7.5lbs per cu ft, and a maximum revenue packing density of 7.23lbs per cu ft. At a revenue packing density of 6.5lbs per cu ft, the 777-300ERSF can attain a maximum revenue packing density of 186,804lbs; and 20,866lbs greater and 13%, than the A350F at the same packing density.

"eCommerce is typically less dense than traditional heavy freight, and we believe the A350F's maximum packing density allows for a broadness of usage," adds Hamilton. "We are targeting the freight market in its entirety."

Fundamentally, the higher the operating empty weight (OEW), the greater the energy needed to push the 'non-revenue generating' mass through the air. Ultimately, the lower the OEW, the lower the fuel burn. As yet Boeing has not released maximum zero fuel weight (MZFW) and OEW data relating to its 777-8F.

The A350F is estimated to have a typical OEW of 284,400lbs. This is 8.8% lower than the 777F: 15.4% less than the 777-300ERSF, and 18.9% less than the 747-400F. The ratio between OEW and cargo at a packing density of 7.5lbs per cu ft. carried, is 64% OEW and 36% gross payload for a 747-400F. The same ratio of the A350F is 59% OEW and 41% gross payload.

"Other freighters in this category are not made of lightweight carbon," adds Hamilton. "If you can reduce the OEW, the weight taken out of the structure can be converted into payload and efficiency to give you a better economic proposition. The maximum take-off weight (MTOW) is higher for the 747-400F, but the A350 can operate further."

Airbus claims the A350F can return about a 40% improvement in fuel burn compared to the 747-400F, and 20% improvement against the 777F. An effective way to decarbonise, according to Hamilton is to move to new generation aircraft.

In September 2022, Airbus delivered its 500th A350. "The platform is proven to improve sustainability levels and will help business in heading towards a more sustainable future," adds Hamilton.

Fuselage length

The A350F is a shortened version of the A350-1000. The freighter maintains the high take-off weights of the passenger aircraft. The freighter is based on the -1000's fuselage, shortened by five fuselage frames. This puts the fuselage length between the A350-900 and A350-1000. Fundamentally the shorter fuselage improves packing density.

"We could have developed the freighter based on both -1000 and -900 platforms, but a primary focus was getting the packing density right. We also needed the centre of gravity (CG) requirements for loading. It is virtually impossible to tilt the aircraft on its tail because we have the CG in the best place for loading. It is also possible to load upper and lower cargo decks at the same time," explains Hamilton.

The customised CG also helps the freighter to keep fuel burn to a minimum because of its improved aerodynamics in flight. It has been reported that the A350F will achieve 20% lower cash operating costs per tonne per trip compared to the 777F, and 40% lower cash operating cost per tonne compared to the 747-400.

The A350F includes accommodation for 10 additional crew members, and a Federal Aviation Administration (FAA) compliant flightcrew rest compartment. The crew rest compartment features a seat and two beds and is situated before the 9G barrier. This means it does not impede cargo volume in any way. AC