The A320F & A321F represent the first all-new narrowbody freighters to enter the market for several years. Their payload capacities put them between the 737-400 & 757-200, and close to the 727-200. The payload and conversion characteristics of the A320F & A321F are examined.

Assessing the A320F & A321F freighters

The choice of narrowbody aircraft types for conversion to freighter has been limited to the 737-300, 737-400 and 757-200 in recent years. This has now widened to five aircraft types with the launch of the A320 and A321 passenger-to-freighter conversion programme by Airbus Freighter Conversion (AFC) GmbH. The first conversions will enter service in early 2012.

Market position

The payload and volumetric capacity of the A320F and A321F fits between the 737-400SF and 757-200PCF. The 757-200PCF has capacity for 15 maindeck 88-inch deep ULD containers. The 737-400 can accommodate nine or 10 of these, depending on the conversion programme used *(see The costs of acquiring narrowbody freighters, Aircraft Commerce, April/May 2008, page 59)*. The 727-200, which has been the most popular narrowbody freighter, has capacity for 12 of these containers, and there has been debate about which type is the most suitable replacement candidate.

The A320F will carry 10 of these 88-inch containers on its maindeck plus a smaller pallet at the rear of the fuselage. The longer A321F will accommodate 13 88-inch containers, and a smaller pallet at the rear. The A320F's and A321F's capacities are therefore closer to the 727-200's than those of the 737-400 and 757-200. The A320F and A321F also fill a gap between the 737-400 and 757-200.

Freight carriers carry two main types of freight: express packages and general freight. Express packages and documents have lower packing densities of lbs per cubic foot than general freight, but express packages have higher yields. Express packages therefore are more dependent on volume, while general freight will generate a higher revenue for an aircraft with a higher weight capacity.

A freighter's most important features are its: gross structural payload; net structural payload; total available freight carrying volume; and volumetric payload with freight packed at a specific density.

Gross structural payload is the difference between maximum zero fuel weight (MZFW) and operating empty weight (OEW). The OEW excludes the tare weight of freight containers or pallets. Several specification versions of MZFW and OEW exist for each freighter type, and several factors affect OEW.

Net structural payload is gross structural payload less the tare weight of the containers or pallets. Net payload limits the maximum weight of freight an aircraft can carry, and is affected by the number and type of containers or pallets carried, which in turn is influenced by the type of freight being carried.

Maximum packing density is the net structural payload divided by the volume available for carrying freight. If the packing density of the freight is higher than the maximum possible packing density, then the aircraft's weight payload limit will be reached before all volume is used. If the density of the freight is less than the maximum density then all the available volume will be filled before the structural payload limit is reached.

The A320F has a gross structural payload of 46,525-49,823lbs. This puts it between the 737-400 and 757-200, and close to the 727-200.

A320F & A321F FREIGHTER MODIFICATION SPECIFICATIONS

Aircraft type	A320F up to line no 1,081	A320F from line no 1,082	A321-100F	A321-200F
MTOW-lbs	162,040-169,750	162,040-169,750	183,000-196,200	196,200-206,130
MZFW-lbs	134,505	137,812	157,658	162,729
OEW-lbs	87,979	87,979	99,666	99,887
Gross structural payload-lbs	46,525	49,823	57,992	62,843
Main & lower deck containers				
Volume-cu ft	5,343-5,497	5,343-5,497	6,933-7,198	6,933-7,198
Tare weights-lbs	5,507-7,470	5,507-7,470	7,322-9,819	7,322-9,819
Net structural payload-lbs	39,055-41,018	42,353-44,316	48,173-50,670	53,024-53,024
Packing density-lbs/cu ft	7.10-7.67	7.70-8.29	6.69-7.30	7.36-7.64
Main deck container & belly pallets				
Volume-cu ft	5,343-5,497	5,343-5,497	6,933-7,198	6,933-7,198
Tare weight-lbs	5,073-7,036	5,073-7,036	6,702-9,199	6,702-9,199
Net structural payload-lbs	39,489-41,452	42,787-44,750	48,793-51,290	53,644-56,141
Packing density-lbs/cu ft	7.18-7.76	7.78-8.37	6.77-7.39	7.45-8.09
Main & lower deck pallets				
Volume-cu ft	4,797-5,633	4,797-5,633	6,288-7,310	6,288-7,310
Tare weights-lbs	2,934-3,556	2,934-3,556	3,803-4,675	3,803-4,675
Net structural payload-lbs	42,969-43,591	46,267-46,889	53,317-54,189	58,168-59,040
Packing density-lbs/cu ft	7.62-9.08	8.21-9.77	7.29-8.61	7.95-9.38
Main deck pallets & lower deck bulk				
Volume-cu ft	5,022-5,858	5,022-5,858	6,638-7,660	6,638-7,660
Tare weights-lbs	2,101-2,723	2,101-2,723	2,613-3,485	2,613-3,485
Net structural payload-lbs	43,802-44,424	47,100-47,722	54,507-55,379	59,358-60,230
Packing density-lbs/cu ft	7.47-8.84	8.04-9.50	7.11-8.34	7.74-9.07

A320F

Another important specification is the maximum take-off weight (MTOW). The A320 has three MTOW options of 162,040lbs, 166,440lbs and 169,750lbs.

The MZFW of the converted A320-200F is 134,505lbs for aircraft up to line number 1,081, which was built in October 1999. Aircraft from line number 1,082 onwards have a higher MZFW of 137,812lbs *(see table, this page)*.

The OEW of the basic converted aircraft is 87,979lbs, for an aircraft that has a maindeck cargo loading system and bulk space in its underfloor compartment.

These MZFW and OEW specification weights give aircraft up to line number 1,081 a gross structural payload of 46,525lbs *(see table, this page)*. Aircraft from line number 1,082 have a higher gross structural payload of 49,823lbs.

By comparison, the 737-400F's gross structural payload is 44,200-47,200lbs.

The three MTOW versions of the A320-200F give the aircraft a range with maximum payload of 1,500nm, 1,800nm and 2,000nm. The additional 500nm range of the highest-weight aircraft over the lowest MTOW version provides more than an hour's flight time. This may be suitable for operators carrying general freight, while lower MTOW versions will be suited to express package operators that do not need long-range performance and might save on weight-related airport and user charges.

A321F

There are two A321F variants: the A321-100F and A321-200F.

The A321-100F has three MTOWs of 183,000lbs, 187,400lbs and 196,200lbs *(see table, this page)*. The A321-100F also has a higher MZFW and payload compared to the A321-200F. The A321-100F's MZFW is 157,658lbs, and its OEW is 99,666lbs. This gives the aircraft a gross structural payload of 57,992lbs. The three MTOW versions of the A321-100F have range capabilities with a full payload of 1,350nm, 1,650nm and 2,100nm.

The A321-200F has three MTOW versions of 196,200lbs-206,130lbs. The A321-200F's MZFW is 162,729lbs, and its OEW is 99,887lbs. This gives it a gross structural payload of 62,843lbs *(see table, this page)*, compared to the 757-200PCF's gross structural payloads of 67,500-80,000lbs *(see The used market potential of 757-200s, Aircraft Commerce, February/March 2009, page 7)*.

Payload accommodation

The main and lower decks of the A320F and A321F can carry a variety of containers and pallets. The A320F and A321F are the only narrowbody freighters to give the option of using bulk or containerised freight in the underfloor or belly compartment.

Each container or pallet type has a different tare weight, and so will result in a different net structural payload. The type of container or pallet used may also have to interline with other freighter types. It is therefore not always possible to achieve the highest possible available freight volume and lowest tare weight.

Express package operators tend to use containers, while general freight carriers use pallets. Containers are contoured, and can use the maximum amount of available space in the aircraft, so they provide the highest possible volumes. As they are heavier than pallets, they result in lower net structural payloads than pallets or bulk loading. Lower net structural payloads as a result of using containers is less of an issue with express package carriers, because express packages have a lower packing density. Containers can be filled and emptied, and loaded and unloaded from the aircraft more quickly than pallets. Most express operators use containers to expedite turnaround times at freight hubs.

Pallets are lighter, resulting in higher net structural payloads, so they are more suited to the higher packing densities of general freight. They take longer to pack and unpack, however, and so have tended to be used only by general freight carriers.

Maindeck

Six different types of containers or pallets can be used on the maindeck.

A320F & A321F PAYLOAD CARRIAGE CONFIGURATIONS

Container/pallet type	Unit volume-cu ft	Unit tare-lbs	Number A320F	Total volume-cu ft A320F	Total tare-lbs A320F	Number A321F	Total volume-cu ft A321F	Total tare-lbs A321F
Main deck								
AAY 88" X 125"	440	424	10	4,400	4,240	13	5,720	5,512
SAA 88" X 125"	427	575	10	4,270	5,750	13	5,551	7,475
AYY 88" X 62"	201.5	301	20	4,030	6,020	26	5,239	7,826
Pallet 62" X 88"	216	183	1	216	183	1	216	183
Total				4,246	6,203		5,455	8,009
ULD 88" X 125"	432	254	10	4,320	2,540	13	5,616	3,302
Pallet 62" X 88"	216	183	1	216	183	1	216	183
Total				4,536	2,723		5,832	3,485
ULD 96" X 125"	465	282	9	4,185	2,538	12	5,580	3,384
ULD 88" X 108"	370	201	10	3,700	2,010	13	4,810	2,613
Lower deck								
Bulk freight			N/A	1,322/1,369	0	N/A	1,828/1,875	0
LD3-45W & rear bulk	127	181	7	1,097	1,267	10	1,478	1,810
PK 60.4" X 61.5 pallet & rear bulk	85	79	7	803	553	10	1,058	790
PKX 60.4 X 61.5 winged pallet & rear bulk	127	119	7	1,097	833	10	1,478	1,190

These have different dimensions, and consequently provide different internal volumes.

The maindeck container providing the most volume is the AAY. This is 125 inches abreast, with the base of the container fitting across the maximum width possible of the A320F's and A321F's maindeck floor. The container is contoured to fit the profile of the A320F/A321F maindeck freight compartment. The container is 81.5 inches tall and 88 inches deep, and is commonly used by United Parcel Service (UPS) and DHL. Each one provides a volume of 440 cubic feet and has a tare weight of 424lbs *(see table, this page)*.

The 88-inch depth allows 10 of these containers to be loaded on the A320F's maindeck. The 10 containers therefore provide a total volume of 4,400 cubic feet and tare weight of 4,240bs *(see table, this page)*.

The A321F can carry 13 of these, plus the smaller pallet at the rear. This provides a total volume of 5,720 cubic feet and tare weight of 5,512lbs *(see table, this page)*.

A second container type is the SAA. This has an 88-inch depth and 125-inch width, but a height of 79 inches, which is two-and-a-half inches less than the AAY. The SAA container is used extensively by FedEx. This has a unit volume of 427 cubic feet and tare of 575lbs.

The A320F maindeck can carry 10 SAAs, and so provide a total volume of 4,270 cubic feet and tare of 5,750lbs *(see table, this page)*. The A321F can carry 13 of these, so providing a volume of 5,551 cubic feet and tare of 7,475lbs *(see table, this page)*.

The third main container type is the AYY. This is a 'half' or 'demi' container, meaning that two of these side by side take up the same space as one SAA container. The AYY is 88 inches deep and 79 inches tall, but 62 inches wide at the base. The A320F maindeck can hold 20 of these, while the A321F can carry 26. These AYY containers are also used by FedEx. While a narrowbody aircraft can fit two AYY abreast or one SAA container on its maindeck, FedEx has to interline containers between types. These AYY containers can be loaded three abreast on the maindeck of its widebodies.

The AYY containers have a unit volume of 201.5 inches and tare weight of 301lbs. This provides the A320F with a volume of 4,246 cubic feet and tare of 6,203lbs. The A321F has 5,455 cubic feet and tare of 8,009lbs with this configuration *(see table, this page)*.

Freight operators also have the choice of pallets or unit load devices (ULDs) that can be used on the A320F's and A321F's maindeck.

The first of these is 88 inches deep, 125 inches wide at the base and 82 inches tall. It provides an internal volume of 432 cubic feet and has a tare weight of 254lbs. The A320F can carry 10 of these, providing a total of 4,320 cubic feet and total tare of 2,540lbs. In addition, there is also room for a small half-pallet of 62 inches by 88 inches that provides a further 216 cubic feet and has a tare of 183lbs. The total volume on the A320F is 4,536 cubic feet, and tare is 2,723lbs *(see table, this page)*.

The A321F can carry 13 such pallets, plus the small half-pallet, which provides a total volume of 5,832 cubic feet and a tare of 3,485lbs *(see table, this page)*.

The second type of maindeck ULD is 96-inch deep X 125-inch abreast, and has a unit volume of 465 cubic feet and tare weight of 282lbs. This container is also contoured to fit the profile of the cargo compartment.

The A320F's maindeck can hold nine

of these, providing a total volume of 4,185 cubic feet and total tare weight of 2,538lbs *(see table, page 54)*.

The A321F can hold 12 ULDs providing a total of 5,580 cubic feet and tare of 3,384lbs *(see table, page 54)*.

The third type of ULD has a narrower base of 108 inches. While it is contoured, it does not make maximum use of the aircraft's available space. The pallet is 88 inches deep, and has a unit volume of 370 cubic feet and tare of 201lbs. The A320F main deck can accommodate 10 of these. The total volume is therefore 3,700 cubic feet, and tare weight is 2,010lbs *(see table, page 54)*.

The A321F maindeck can carry 13 ULDs, which provides a total volume of 4,810 cubic feet and tare of 2,613lbs *(see table, page 54)*.

Lower deck

There are also several choices for loading freight in the underfloor or belly compartment. Airlines can load freight in bulk, in pallets or in containers.

Like all other narrowbodies, the A320F and A321F can carry freight in bulk in the lower deck. Depending on the rear bulk compartment, the A320F has a bulk capacity of 1,322 cubic feet or 1,369 cubic feet. The A321F has a bulk capacity of 1,875 or 1,828 cubic feet *(see table, page 54)*. Clearly there is no tare weight.

There are several options for loading bulk freight. Original passenger aircraft were offered to airlines with the option of a plain bulk compartment, or a cargo loading system (CLS). Aircraft without a CLS have provisions for installing one, so that the aircraft can be modified quickly, including during conversion to freighter. Some airlines have a CLS on their aircraft, but cover it up with a plain floor.

A CLS can be used to expedite the loading and unloading of bulk freight, as well as belly containers and pallets.

A supplemental type certificate has also been developed to install a sliding carpet on the floor of the belly compartment. This reduces the height of the belly compartment by a few inches, and decreases the bulk volume by 20-30 cubic feet. It can expedite bulk loading for aircraft without a CLS, and is a compromise between bulk and using a CLS. Containers or pallets cannot be used on aircraft with a sliding carpet.

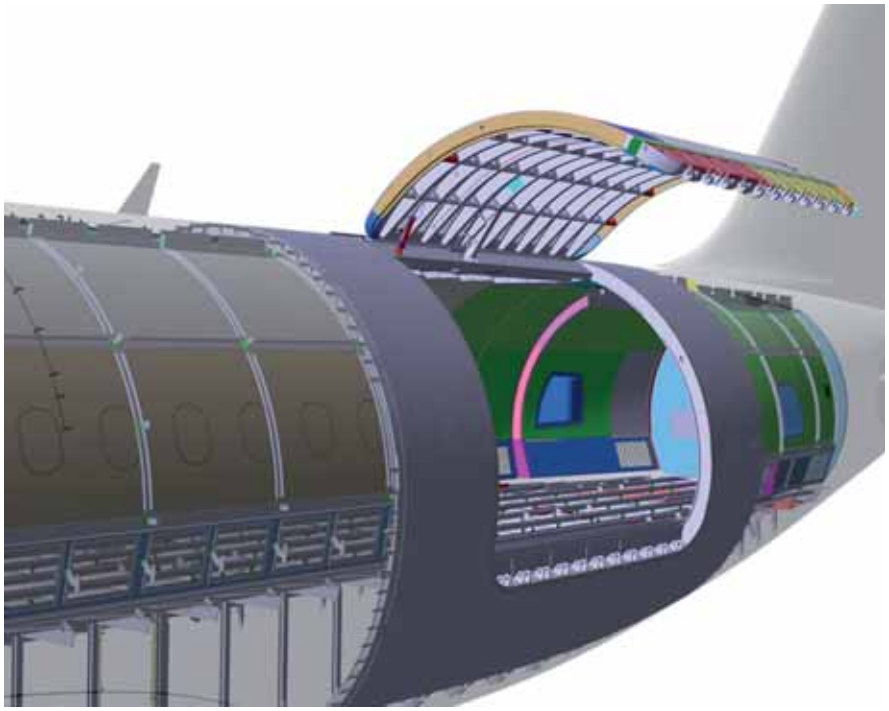
A CLS is required for airlines that want to use pallets or containers.

The LD30-45W maximises the belly volume by its dimensions and shape matching the sloping sides of the belly compartment. The LD3-45W is 96 inches wide at the top, and 45 inches deep. It has a unit volume of 127 cubic feet and tare of 181lbs. The A320F can carry seven of these, providing 1,097 cubic feet with a tare of 1,267lbs *(see table, page 54)*. The A321F can carry 10, providing a volume of 1,478 cubic feet with a tare of 1,810lbs *(see table, page 54)*.

One type of pallet is a 60.4-inch X 61.6-inch device, known as the PK, which provides a unit volume of 85 cubic feet and has a tare weight of 79lbs. This is a rectangular profile pallet, and does not use all the available volume in the sloping sides of the aircraft belly.

The A320F can carry seven of these. With bulk at the rear of the fuselage added, the total volume of the lower deck in the A320F is 803 cubic feet and tare is 553lbs *(see table, page 54)*. The A321F can carry 10 of these, and together with the bulk compartment, total underfloor volume is 1,058 feet and tare is 790lbs *(see table, page 54)*.

A second pallet type is a winged ULD, known as the PKX. This folds and takes the same profile as the aircraft's underfloor space. It has a unit volume of 127 cubic feet, the same as the LD-45W



There are several configurations for accommodating freight on the main and lower decks. These vary on volume and tare weight, providing option suitable for most operators and types of freight.

container, but a lower tare of 119lbs.

The A320F can carry seven PKX ULDs, and the total volume is 1,097 cubic feet and tare is 833lbs. The A321F can carry 10, providing a volume of 1,478 cubic feet and tare of 1,190lbs with this pallet *(see table, page 54)*.

Total capacity

With six choices for the maindeck and four for the belly compartment, there are a large number of permutations an airline can use for payload carriage. Airlines also use a mix of pallets and containers.

There are four main combinations of loading freight. The first uses containers on the maindeck and LD3-45W containers in the belly. This results in the highest total tare weights of 5,507-7,470lbs and total container volume of 5,343-5,497 cubic feet for the A320F *(see table, page 54)*. The AYY demi and SAA containers are the heaviest, with tares of more than 7,000lbs. The AAY provide the highest volume of 5,497 cubic feet and tare of 5,507lbs.

The same pattern is followed with the A321F. Total volumes with containers are 6,933-7,198 cubic feet, while total tares are 7,322-9,819lbs *(see table, page 54)*. Again the AAY provides the best combination.

The second main loading configuration combines containers on the maindeck plus PKX winged pallets in the belly, which reduce belly container tare by about 400lbs on the A320F and 600lbs on the A321F, while total volume is unchanged *(see table, page 54)*.

The third main loading configuration uses pallets in both compartments to provide volumes of 4,797-5,633 cubic feet and total tare weights of 2,934-3,556lbs for the A320F *(see table, page 54)*. This configuration results in volumes of 6,288-7,310 cubic feet and tares of 3,803-4,675lbs for the A321F.

The highest possible net payloads come from using pallets on the maindeck and the bulk space in the belly. This provides volumes of 5,022-5,858 cubic feet and total tare of 2,101-2,723lbs for the A320F, and 6,638-7,660 cubic feet and a total tare of 2,613-3,485lbs on the A321F *(see table, page 54)*.

Net structural payloads

The net structural payloads and packing densities that arise from using these four combinations of main and lower deck payload accommodations are summarised *(see table, page 53)*.

The lower tare weights of using bulk and pallets instead of containers are clearly illustrated. The A320F has net structural payloads up to 5,000lbs higher when using pallets rather than containers. The lower weight of pallets allows higher maximum packing densities that would permit the aircraft to carry a full payload of general freight in most circumstances.

The A320F also has high enough packing densities when using containers on both decks to allow a full payload when carrying express packages. The A320F also has an ample packing density for general freight.

The A321-100F's net payloads are 4,000-5,000lbs higher, while the A321-200F has net payloads that are 5,000-6,000lbs higher when using pallets instead of containers *(see table, page 53)*. The A321-200F's net structural payloads are 7,700-10,200lbs lower than the 757-200PCF with MZFWs of 186,000-188,000lbs.

The packing densities of the A321-100F are 0.30-0.40lbs per cubic foot lighter compared to the earlier A320F models, and 1.0lb per cubic foot lighter than the later A320F examples. The A321-200F's payload is 5,000lbs higher than that of the A321-100F.

Weight upgrades

The issue of weight upgrades is complex. There are 11 different weight specification variants of the A320 up to line number 1,081, which are permutations of MTOW, MZFW and OEW. The specific permutation depends on engine type, as well as other factors such as line number. It is possible to go up to an MTOW of 169,750lbs. Some operators may choose a lower MTOW to save some operating charges.

Conversion economics

Conversion of the first aircraft will start in 2011. Once the production line has matured, AFC estimates conversion downtime will be about 65 days. The 2009 list price for conversion is $4.1 million for the A320 and $4.5 million for the A321. The cost of the maindeck CLS is an additional $100,000-130,000.

The timing of conversion in relation to the aircraft's maintenance status is also an important consideration. The A320 family's maintenance programme includes a base check programme of eight checks, with the fourth and eighth ones including structural checks. The basic base check interval has evolved from 12 months to 18, putting the fourth and eighth check intervals at six and 12 years. It is advisable to convert aircraft when one of these structural checks is coming due. The converted aircraft will therefore not require a heavy base check for the first six years of operation.

Customer and engineering support is also an issue. Upgrades and modifications similar to those for passenger aircraft are used for converted freighters, if they are applicable, using Airbus service bulletins (SBs). The conversion cost also includes the same levels of customer support that operators of passenger aircraft receive, including: use of an aircraft-on-ground (AOG) hotline; supply of constantly updated manuals for the freighter variants; and engineering support. AC