With new freighter types, such as the A330-200F and 777F, entering service in recent years freight, carriers have more choice than before in terms of aircraft selection. How do the new generation freighters perform compared to older types? The operating performance of the A330-200F, DC-10-30CF, MD-11F and 777F are compared.

A330-200F, DC-10-30CF, MD-11F & 777F fuel burn & operating performance

A freight operator must make a balance between an aircraft's acquisition cost, cash operating costs, and payload-range and operating performance when making fleet selections. Older types, such as the DC-10-30CF and MD-11F, generally have lower acquisition costs or lease rentals than the A330-200F and 777F. This has to be considered against the probable superior operating performance, and therefore payload-generating capacity of current generation aircraft.

The DC-10-30CF and MD-11F have been the only types in the 65- to 95-ton category, but may suffer payload limitations on more challenging routes compared to the A330-200F and 777F, which have payloads of 60 tons and 104 tons respectively. The older types may therefore not be suitable if a freight carrier wishes to operate long-range routes, or with particularly heavy loads, or a combination of the two.

Older types can have payloads limited on a larger number of routes, particularly from hot-and-high airports in areas like South America, than modern freighters.

Older types also suffer from rising maintenance costs due to the higher number of flight hours (FH) and flight cycles (FC) they have accumulated. They also generally have higher fuel burn, and some types have higher crew costs. The freight operator must analyse the potential for higher revenue-earning capacity of newer types, together with their higher acquisition costs or lease rentals and lower cash operating costs during the fleet selection process.

Operating performance

The operating performance of these four types is examined on a group of challenging routes. This will detail their permitted take-off weight, required fuel load and so allowable payload performance and fuel burn across these routes under different operating conditions.

The DC-10-30CF has been included as the benchmark, since it is the oldest type and may be expected to have the weakest operating performance. The larger MD-11F may be expected to have a superior performance to the DC-10-30CF, while the current generation A330-200F and 777F are positioned as direct replacement candidates for the two older types.

Aircraft specifications

The weight and payload specifications for these four freighters are summarised *(see table, this page)*. The four aircraft can be sub-divided in two ways. First, by new generation versus old generation. Despite being a successor to the DC-10-30CF, the MD-11F will be considered older generation due to its tri-jet design, and the fact that production ceased in 2000. Moreover, passenger-to-freighter conversions for the type have ceased. The 777F and A330-200F are still new aircraft, the first being delivered as factory-built freighters in 2009 and 2010. Passenger-to-freighter conversion programmes for these types do not exist.

60- TO 100-TON FREIGHTER SPECIFICATIONS:

	777F	MD-11F	A330-200F	DC-10-30CF
Engine type	GE90	CF6-80C2D	RRT772B60	CF6-50C2
MTOW (lbs)	766,800	630,500	513,680	565,000
MLW (lbs)	575,000	491,500	401,240	411,000
MZFW (lbs)	547,000	461,300	381,400	391,000
OEW (lbs)	318,350	251,550	244,050	246,000
Max payload (lbs)	228,650	209,750	137,350	145,000
Tare weight (lbs)	23,689	23,152	19,575	19,399
Net structural payload (lbs)	204,961	186,598	117,775	125,601

DEPARTURE AIRPORT INFORMATION:

AIRPORT	ICAO	IATA	RUNWAY (FT)	ELEVATION (FT)	TEMP DEG C	MATOW (LB) A330-200F	MATOW (LB) 777F	MATOW (LB) MD-11F	MATOW (LB) DC-10-30CF
Anchorage	PANC	ANC	10,897	144	15	513,680	766,800	630,500	565,000
Buenos Aires	SAEZ	EZE	10,827	66	22	513,680	754,790	630,500	565,000
Sao Paolo	SBGR	GRU	12,336	2,459	27	488,670	714,220	608,100	544,820
Brasilia	SBBR	BSB	10,827	3,474	27	481,100	685,040	553,510	509,480

Second, although there are large differences between all four aircraft in terms of maximum take-off weight (MTOW), these freighters have two distinct weight classes in terms of payload. The 777F has a maximum structural payload of 228,650lbs, with the MD-11F's is 209,750lbs *(see table, page 55)*. These form one weight class.

Below these are the A330-200F, with a maximum payload of 137,350lbs, and the DC-10-30CF, with a maximum payload of 145,000 lbs *(see table, page 55)*. These two aircraft form the second weight class. These divisions are made to better compare aircraft in their relevant weight and gross payload classes and see how they match up against each other.

It is important to note that in this analysis the lower MTOW A330-200F variant has been analysed. Airbus offers a higher gross weight version which can carry about 12,000lbs more payload. This analysis examines the performance of aircraft on routes that are at the edge of the A330-200F's payload-range envelope. At these extended missions lengths, the difference in available payload between the lowest and highest MTOW variants of the A330-200F is minimal. This is because the aircraft departs at MTOW on most missions, and so is on the edge of its payload-range profile where payload is limited to less than maximum.

The combined tare weights of pallets and containers will also be included in this analysis. This weight does not generate revenue for a freight carrier, and so has to be subtracted from the available gross payload on each route to give the true remaining revenue-generating, net structural payload that can be carried.

The tare weights of all pallets and containers are very similar for the 777F and MD-11F at 23,689lbs and 23,152lbs respectively. This gives a net structural payload of 204,961lbs for the 777F and 186,598lbs for the MD-11F.

The tare weights are also very similar for the A330-200F and DC-10-30CF. The tare weights of containers for the A330-200F is 19,575lbs, giving a net structural payload of 117,775lbs. For the DC-10-30CF, the tare weight is 19,399lbs, giving a net structural payload of 125,601lbs.

Performance testing

Challenging missions for freighter aircraft can generally be divided into two categories: long-distance routes; and routes that present airfield restrictions (often due to hot-and-high operations).

This analysis examines the four aircraft's payload-carrying performance, as well as fuel burn comparison on two very different sets of routes.

Five routes from the freight hub of Anchorage (ANC) to destinations in the Asia Pacific are analysed. These destinations are 3,100-5,900nm away from ANC, and have been chosen to show how these aircraft suffer payload restrictions at the edge of their payload-range performance profiles. This is because as mission length increases, and aircraft reach the edge of their payload-range profiles and depart at MTOW, they are forced to reduce payload to complete the mission non-stop.

The equivalent still air distance (ESAD) is also an important factor on route length, and therefore the available payload. The ESAD takes into account the effect of headwinds or tailwinds on the tracked route distance. In a strong headwind, an aircraft burns more fuel to cover the same tracked distance, so ESAD is longer than tracked distance. The reverse happens for tailwinds, when the ESAD is shorter than the tracked distance.

85% annual winds show a significant headwind on routes operating in a westerly direction on routes flown from ANC. This means the aircraft face headwinds, so the ESAD is longer than actual tracked distance on westerly routes flown from ANC.

This adds a further criterion to testing the operating performance of these aircraft. The routes chosen are from ANC to Tokyo Narita (NRT), Shanghai Pudong (PVG), Hong Kong (HKG), Bangkok (BKK) and Singapore (SIN). Analysis of these routes will show how the DC-10-30CF, MD-11F, A330-200F and 777F perform on long- and extremely long-range routes, and how their payloads become increasingly restricted with increasing mission length. This is an important consideration for freight operators on long-range route networks.

Second, routes from major South American cities to Miami (MIA) will be analysed. Routes chosen are Brasilia (BSB), Sao Paulo (GRU) and Buenos Aires (EZE) to MIA. These routes raise different issues for all four aircraft, because the departure airfields are all major freight airfields, and have hot-and-high characteristics. The routes from MIA and ANC will give an overall comparison in terms of varying distances, winds, temperatures and airfield restrictions.

Airports at a higher elevation have a lower air density, so aircraft need a longer take-off run to get the required lift than at sea-level airfields. Lower air density at high airfield elevation places limitations on engine thrust, which reduces aircraft acceleration at take-off, so more runway length is required. This is exacerbated by high ambient temperatures, which further reduces air density, and therefore engine thrust, aircraft acceleration and wing lift. This is why hot-and-high operations are more challenging for aircraft.

This analysis uses the following assumptions: 85% annual winds for each departure airport; average summer temperatures at each departure airport; full tare weight of all pallets and containers is carried; reserve fuel for 30 minutes holding; 3% navigation and diversion fuel; 15 minutes taxi-out and 10 minutes taxi-in fuel; and each aircraft is flown at economical cost cruise speed.

Airports and routes

Information on the four departure airports is shown in the table *(see table, page xx)*, as well as the maximum allowed take-off weight (MATOW) for each aircraft from each airport.

The difficulties faced by aircraft departing from ANC are caused by the range of the routes flown to the Asia Pacific, and not by the airfield at ANC itself. ANC has a runway length of 10,897 feet and an elevation of 144 feet, which do not affect the MATOW of any aircraft analysed here.

An average summer temperature of 15°C (59°F) in June is used here. This is a

The MD-11F has strong operating performance on long-range routes, and is only surpassed by the 777F which has a larger payload-range envelope and longer range.

lower temperature than many places in summer, due to ANC's Northern latitude, so ambient temperature is not a limiting factor for any aircraft. Therefore aircraft are only adversely affected by the route lengths on departures from ANC.

Routes from ANC, therefore, were chosen based on increasing route length and are representative of the routes flown by these freighters from North America to destinations in the Asia Pacific. The great circle distances on routes from ANC are: NRT 2,984nm; PVG 3,743nm; HKG 4,415nm; BKK 5,227nm; and SIN 5,792nm.

Each aircraft analysed would be expected to suffer larger payload restrictions as route length increases. It is important to note here that tracked distance is always longer than the great circle distance. This is due to Air Traffic Control (ATC) and extended-range twin-engine operations (ETOPs) requirements, as well as the effects of curved departure and arrival routeings. The tracked distance (that is, actual distance flown) is used in the flight plans generated to make the analysis. The tracked distances, from the flight plans from Aviation Software Systems, for these routes are 3,086nm for ANC-NRT, 3,946nm for ANC-PVG, 4,735nm for ANC-HKG, 5,507nm for ANC-BKK and 5,912nm for ANC-SIN *(see table, page 59)*. This represents increases in the great circle distances on these routes of 102nm for ANC-NRT, 203nm for ANC-PVG, 320nm for ANC-HKG, 80nm for ANC-BKK and 120nm for ANC-SIN.

85% annual winds for these routes show strong headwinds over these routes as well, with an average headwind of 40.8 knots. This makes the ESAD almost 500nm longer than the tracked distances over the longest routes, which will further impact the payload carried by these aircraft.

The routes from South America to MIA, however, face difficulties due to the high average ambient temperature at take-off, high elevation above sea-level and more restrictive runway length. At both GRU and BSB for example, the average summer ambient temperature is 27°C (80.6°F) in January. It is also high for EZE at 22°C (71.6°F).

GRU and BSB are also considered relatively high airports, because they have elevations of 2,459 feet and 3,474 feet above sea level *(see table, page 59)*. This is certainly a factor in the performance degradation of these aircraft types on routes from these airports. This is compounded by the runway length at BSB being 10,827 feet. This is almost the same runway length as at ANC, yet BSB sits almost 3,500 feet higher, and can therefore be considered a relatively short runway due to reduced air density. GRU is less affected by this, since it has a longer runway length of 12,336 feet. EZE, however, will not have an adverse affect due to runway length or elevation, because it sits at just 66 feet above sea level with the same runway length as ANC and BSB of 10,827 feet length *(see table, page 56)*.

Similarly, on routes from ANC, these routes to MIA were also chosen due to increasing route length to show how these freighters performed from hot-and-high conditions over longer route lengths. Great circle distances are: 3,127nm for BSB-MIA; 3,539nm for GRU-MIA; and 3,829nm for EZE-MIA; Tracked distance is again slightly longer than this at 3,229nm for BSB-MIA, 3,684nm for GRU-MIA and 3,965nm for EZE-MIA *(see table, page 59)*. 85% annual winds for these routes also show significant headwinds with an average headwind of 22.3 knots for all of these routes. This further adds to the tracked distance for these routes, and will further impact the payload restrictions for these freighters.

Aircraft performance

The available payloads for each aircraft for each route are summarised *(see table, page 59)*. Routes are listed both from ANC and to MIA in descending order of increasing route length, allowing the effect of route length on the payload performance of these aircraft to be shown.

From Anchorage (ANC)

From ANC, none of the aircraft is restricted in any way on the shortest route listed, ANC-NRT. Even with the headwind giving an ESAD of 3,395nm compared to the tracked distance of 3,086nm, this route is well within the reach of all four aircraft. Since ANC is neither hot or high, the NRT route does not present a challenge to these aircraft and all four aircraft can carry 100% of their net structural payload.

Payload restrictions begin to be seen on ANC-PVG. ESAD is 4,320nm for this route, almost 1,000nm longer than to NRT. Only the 777F does not suffer a payload restriction on this route. The MD-11F, with the second-highest MTOW, has a small payload restriction, but can still carry 98% of its available payload. The A330-200F and DC-10-30CF, with lower MTOWs, suffer higher restrictions, carrying 82% and 77% of their net structural payloads respectively.

As route length increases for ANC-HKG, the 777F loses 5% of its net payload to complete the route. The MD-

The A330-200F has similar structural payload characteristics to the DC-10-30CF. The A330-200F outperforms the DC-10-30CF, although this is not surprising given the difference in vintage between the two.

11F suffers a little more, losing 14% of its net payload. The A330-200F and DC-10-30CF suffer further restrictions, carrying 62% and 59% of their possible net structural payloads.

Increasing route length further reduces available payload for all four aircraft. On ANC-BKK, the 777F and MD-11F still performed strongly, carrying 80% and 72% of their net structural payloads *(see table, page 59).*

The A330-200F and DC-10-30CF suffer, however, because this route lies near the end of their payload-range envelopes. The A330-200F can only carry 39% of its net structural payload on ANC-BKK, and the DC-10-30CF has just 29% of its net structural payload *(see table, page 59).*

For the longest route, ANC-SIN, there is an even larger difference between the 777F/MD-11F and A330-200F/DC-10-30CF weight classes. Both the 777F and MD-11F can still carry significant payloads over a route length with an ESAD of 6,395nm. The 777F can carry 73% of its net payload, with the MD-11F carrying 64% of its net payload *(see table, page xx).* The A330-200F continues to be restricted, being able to carry just 27% of its net payload. The DC-10-30CF, however, can only complete this mission empty and with maximum fuel tanks, and has therefore reached the end of its payload-range curve.

Routes from ANC, therefore, show a clear size divide between these four types. The 777F and MD-11F are in one size group, with the A330-200F and DC-10-30CF in a smaller class. This is due to the relatively comparable MTOWs of the 777F and MD-11F, and the comparable MTOWs of the A330-200F and DC-10-30CF. The two aircraft in each group also have similar payloads.

Taking the 777F and MD-11F as one group, and the A330-200F and DC-10-30CF as another, it is clear that this is a comparison between new and old generation freighters.

To better compare these aircraft against each other, fuel burn for these routes was also calculated. Fuel burn here is classified as US gallons (USG) per revenue ton-mile (RTM). That is, the fuel burnt to transport one ton of revenue-generating payload each mile.

The fuel burn comparison of the 777F and MD-11F shows that these aircraft have an almost identical fuel burn per RTM on all sectors from ANC. In fact, the MD-11F has a lower burn per RTM on three out of five routes, with the 777F only being the most efficient on the two longest routes to BKK and SIN. These differences are marginal though. For example, for ANC-NRT, the fuel burn for the 777F is 0.0652USG per RTM, compared to 0.0629USG per RTM *(see table, page 59).* This is a difference of just 0.0023USG per RTM.

This difference is even smaller for ANC-HKG, with the fuel burn figures with a difference of just 0.0006USG per RTM between the 777F and MD-11F. On routes from sea-level departures over long distances, therefore, the fuel burn efficiency of the 777F and MD-11F is almost identical.

A similar comparison can be made for the new generation A330-200F versus the old generation DC-10-30CF, which have similar MTOW and payload capacity. It is worth noting, however, that the fuel burn per RTM for both of these aircraft was significantly higher than both the 777F and MD-11F. This is mostly explained by the lower MTOWs, and therefore the lower available payload carried over the same distances, as the 777F and MD-11F. It is still an important consideration for operators that need to operate routes of this length, particularly with heavy loads.

Comparing just the A330-200F and DC-10-30CF, however, the A330-200F consistently outperforms the DC-10-30CF by a significant margin in terms of fuel burn. On the shortest ANC-NRT route, the A330-200F burns 0.0935USG per RTM compared to 0.1159USG per RTM for the DC-10-30CF. This is a saving of 0.0224USG per RTM.

This difference becomes ever larger as route length increases with the difference as high as 0.1188USG per RTM, in the A330-200F's favour on ANC-BKK. This difference can be attributed to the newer airframe and engines of the A330-200F. In terms of fuel efficiency the A330-200F performs better than the DC-10-30CF.

To Miami (MIA)

Similarly to the routes from ANC, payloads and fuel burn are summarised for the routes to MIA *(see table, page 59).* The effects of the departure airport, combined with mission length, on payloads can be clearly seen.

The only route where any of the aircraft analysed operate without payload restrictions is EZE-MIA. These are the 777F and MD-11F. EZE-MIA is the longest route of the three from South American cities to MIA, with an ESAD of 4,155nm.

As discussed earlier, EZE is just 66 feet above sea level, and a lower take-off summer temperature of 22°C (71.6°F) compared to 27°C (80.6°F) at BSB and GRU. There is, therefore, a smaller payload restriction at EZE than at BSB or GRU, so these freighters can carry a

OPERATING & FUEL BURN PERFORMANCE OF 60- TO 104-TON FREIGHTERS

Aircraft type	Tracked distance (nm)	ESAD (nm)	Wind (kts)	Block time	MATOW (lbs)	Actual TOW (lbs)	Max payload (lbs)	Available payload (lbs)	Tare weight (lbs)	Net payload (lbs)	Payload %	Block fuel (USG)	USG fuel burn
Route: ANC-NRT													
A330-200F	3,086	3,395	-45	07:45	513,680	502,258	137,350	137,350	19,575	117,775	100%	16,691	0.0935
777F	3,086	3,395	-45	07:38	766,800	694,724	228,650	228,650	23,689	204,961	100%	20,264	0.0652
MD-11F	3,086	3,395	-45	07:42	630,500	599,137	209,750	209,750	23,152	186,598	100%	17,800	0.0629
DC-10-30F	3,086	3,395	-45	07:49	565,000	550,874	145,000	145,000	19,399	125,601	100%	22,072	0.1159
Route: ANC-PVG													
A330-200F	3,946	4,320	-42	09:42	513,680	513,680	137,350	115,629	19,575	96,054	82%	20,968	0.1132
777F	3,946	4,320	-42	09:33	766,800	745,194	228,650	228,650	23,689	204,961	100%	26,968	0.0682
MD-11F	3,946	4,320	-42	09:40	630,500	630,500	209,750	206,227	23,152	183,075	98%	22,607	0.0640
DC-10-30F	3,946	4,320	-42	09:47	565,000	565,000	145,000	116,541	19,399	97,142	77%	27,460	0.1466
Route: ANC-HKG													
A330-200F	4,735	5,180	-42	11:31	513,680	513,671	137,350	92,575	19,575	73,000	62%	24,876	0.1474
777F	4,735	5,180	-42	11:20	766,800	766,800	228,650	217,677	23,689	193,988	95%	32,378	0.0722
MD-11F	4,735	5,180	-42	11:30	630,500	630,500	209,750	183,427	23,152	160,275	86%	26,521	0.0716
DC-10-30F	4,735	5,180	-42	11:37	565,000	565,000	145,000	93,585	19,399	74,186	59%	31,599	0.1842
Route: ANC-BKK													
A330-200F	5,507	5,980	-38	13:12	513,680	513,680	137,350	65,602	19,575	46,027	39%	28,423	0.2313
777F	5,507	5,980	-38	12:59	766,800	766,800	228,650	188,000	23,689	164,311	80%	36,239	0.0826
MD-11F	5,507	5,980	-38	13:12	630,500	630,500	209,750	156,996	23,152	133,844	72%	30,020	0.0840
DC-10-30F	5,507	5,980	-38	13:17	565,000	546,255	145,000	55,586	19,399	36,187	29%	33,821	0.3501
Route: ANC-SIN													
A330-200F	5,912	6,395	-37	14:05	513,680	513,680	137,350	51,239	19,575	31,664	27%	30,313	0.3353
777F	5,912	6,395	-37	13:52	766,800	766,800	228,650	172,686	23,689	148,997	73%	38,226	0.0899
MD-11F	5,912	6,395	-37	14:06	630,500	630,500	209,750	141,967	23,152	118,815	64%	31,862	0.0939
DC-10-30F	5,912	6,395	-37	14:10	565,000	502,494	145,000	11,825	11,825	0	0%	33,501	0.9923
Route:BSB-MIA													
A330-200F	3,229	3,405	-25	07:46	481,100	481,100	137,350	112,610	19,575	93,035	79%	16,607	0.1174
777F	3,229	3,405	-25	07:39	685,040	685,040	228,650	215,814	23,689	192,125	94%	19,986	0.0684
MD-11F	3,229	3,405	-25	07:43	553,510	553,502	209,750	166,513	23,152	143,361	77%	17,086	0.0784
DC-10-30F	3,229	3,405	-25	07:51	509,480	509,480	145,000	109,526	19,399	90,127	72%	20,298	0.1482
Route: GRU-MIA													
A330-200F	3,684	3,840	-20	08:41	488,670	488,670	137,350	106,237	19,575	86,662	74%	18,647	0.1255
777F	3,684	3,840	-20	08:34	714,220	714,220	228,650	222,391	23,689	198,702	97%	23,304	0.0684
MD-11F	3,684	3,840	-20	08:39	608,100	608,100	209,750	201,096	23,152	177,944	95%	20,023	0.0656
DC-10-30F	3,684	3,840	-20	08:46	544,820	544,820	145,000	118,920	19,399	99,521	79%	24,107	0.1413
Route: EZE-MIA													
A330-200F	3,965	4,155	-22	09:21	513,680	513,680	137,350	120,404	19,575	100,829	86%	20,238	0.1082
777F	3,965	4,155	-22	09:12	754,690	737,965	228,650	228,650	23,689	204,961	100%	25,872	0.0681
MD-11F	3,965	4,155	-22	09:18	630,500	629,219	209,750	209,750	23,152	186,598	100%	21,854	0.0631
DC-10-30F	3,965	4,155	-22	09:26	565,000	565,000	145,000	121,539	19,399	102,140	81%	26,684	0.1408

higher payload on the EZE-MIA route than on the shorter BSB-MIA and GRU-MIA routes *(see table, this page)*.

As mentioned previously, the 777F and MD-11F operate without restriction for EZE-MIA, but the A330-200F and DC-10-30CF both suffer payload limitations. The A330-200F can operate EZE-MIA with 86% of its net structural payload, while the DC-10-30CF can carry 81% of its net structural payload on this route.

For BSB-MIA, all freighters suffer a payload restriction. The 777F performs best with 94% of its net structural payload available. Unlike other routes, however, the A330-200F outperforms both tri-jets on this route, carrying 79% of its net payload compared to 77% for the MD-11F and 72% for the DC-10-30CF *(see table, this page)*.

This shows the improvements of the more modern, twin-engine A330-200F over the tri-jets on the most challenging mission analysed. Brasilia is the highest departure airport in this analysis, with the highest temperature and a comparatively shorter runway. This gives a higher payload restriction on a tri-jet over the twin-engine aircraft. The A330-200F is therefore able to perform more strongly than both tri-jets on this route.

The status quo of the ANC routes and EZE-MIA is restored for GRU-MIA. Here, the 777F and MD-11F are the strongest performers in terms of available payload percentage, carrying 97% and 95% of their net payloads. On this route, the A330-200F is the weakest performer by this measure, carrying 74% of its net payload compared to 79% for the DC-10-30CF *(see table, this page)*.

In terms of fuel burn, a similar pattern to those routes from ANC can be seen, with a distinct gap in fuel efficiency between the higher MTOW 777F/MD-11F and A330-200F/DC-10-30CF.

Comparing the 777F and MD-11F, the 777F outperforms the MD-11F by 0.01USG per RTM on the more challenging BSB-MIA. On the longer, but less challenging, routes of GRU-MIA and EZE-MIA, the older MD-11F burns less fuel per RTM than the 777F, although

The 777F has strong operating performance, and is a consequence of its high MTOW and engine thrust. The aircraft is also in a class of its own; its structural payload falling between the MD-11F and the 747.

only by a small percentage *(see table, page 59)*. As on the routes from ANC, however, the fuel efficiency of the 777F and MD-11F are almost identical.

When comparing the A330-200F and DC-10-30CF in terms of fuel efficiency, again the A330-200F burns significantly less fuel per RTM than the DC10-30F. Across these three routes, the A330-200F burns an average of 0.0264USG per RTM less than the DC-10-30CF, which represents significant reductions in fuel costs when operating the A330-200F instead of the DC-10-30CF.

Summary/Conclusions

This analysis shows that freighters suffer different payload restrictions dependent on several factors. When mission length is the defining factor, the highest MTOW aircraft, the 777F and MD-11F, perform best. When departing from hot-and-high airports, however, twinjets, including the A330-200F, perform better.

The 777F is the best performer in this analysis. This is to be expected, since it has the highest MTOW of all aircraft compared here, and as a twinjet, performs better in hot-and-high airports. The 777F also showed the best fuel efficiency over long distances.

The MD-11F, however, was the surprise performer in this analysis, as a descendant of the DC-10-30, with an older generation tri-jet design, and the last MD-11 aircraft produced over 11 years ago. The 777F was superior in terms of available net payload on these routes, but the MD-11F was only marginally second best in most cases. This can perhaps be explained by the fact that its the MTOW is 130,000lbs less than the 777F, but the MD-11F's maximum payload is only 18,000lbs less *(see table, page 59)*.

The MD-11F's fuel efficiency is almost identical to the 777F. The MD-11F in fact has lower burn than the 777F on routes where mission length and take-off restrictions were less of a factor affecting performance. This was on shorter routes from ANC, and GRU- and EZE-MIA.

With fuel prices ever rising, and aircraft acquisition costs also forming a significant percentage of a freighter's total operating costs, the MD-11F may be a preferable choice for a freight carrier.

This analysis shows that the 777F and MD-11F have an almost identical fuel burn, so fuel costs will be similar to operate these two aircraft. The MD-11F, as an older design, is no longer in production, so its acquisition and lease rentals are likely to be lower than the 777F's, thus meaning the MD-11F is still a desirable aircraft.

Although the 777F outperforms the MD-11F in terms of payload available over increasing route lengths, this increase is fairly marginal and is only of true benefit to airlines that consistently need to transport heavy and dense loads over very long distances.

Aircraft maintenance costs, however, need to be taken into account, and this is where the MD-11F may lose out to the 777F. Some maintenance cost elements for these older aircraft may be higher than those of new types because the older aircraft have accumulated more FH and FC. There are also the added costs of maintaining three engines instead of two, with spare parts becoming harder to come by as the aircraft nears the end of its useful life. This is the balance that a freight operator has to make in deciding which type is best for its operation.

The A330-200F is in a lower weight class than the 777F and MD-11F, and so is better compared to the DC-10-30CF. The A330-200F suffered significant payload restrictions in comparison with the higher MTOW aircraft; the 777F and MD-11F. Using a higher MTOW version of the A330-200F would not have made much difference to this analysis. This is because the A330-200F was pushed to the end of its payload-range envelope with these routes. This means that less than maximum payload had to be carried for the aircraft to complete the missions non-stop. At this extended range, the differences in net payloads between the high and low MTOW versions of the A330-200F is very minimal.

The A330-200F, however, did outperform the DC-10-30CF in all aspects across all routes. The A330-200F suffered less than the DC-10-30CF as mission length increased from ANC, and offers significant fuel efficiency improvements over the DC10-30F. The A330-200F, therefore, is the ideal candidate to replace DC-10-30CFs. The A330-200F is also useful when volume of cargo, rather than weight, is of concern. The A330-200F, therefore, is better for medium- and long-thin routes, just like the passenger variant.

The DC-10-30CF was the poorest performer in this analysis. This is to be expected, since it has the oldest design. It was included as the benchmark against its successor, the MD-11F and its potential replacement, the A330-200F. Many DC-10-30CFs are now being retired from service, and few freighter operators would consider a DC-10 for their fleets in the future. AC