Freight airlines now have five narrowbody aircraft to choose from. Part of the selection process should include an assessment of their fuel burn and operating performance on a range of mission lengths and challenging operating conditions. The performance of the 737-300F, 737-400F, MD-83F, A320F and 757-200F are analysed and compared.

Narrowbody freighter fuel burn & operating performance

Narrowbody freighter selection should involve more than just comparing the payload capacities of several aircraft types. Some airlines will want to purchase freighters at a low acquisition price, which will favour older aircraft, although these will have older technology and higher cash operating costs. They may also have poorer operating performance than younger types. The operating performance of candidate aircraft should be assessed, especially where particular airports or routes on an airline's network present operational challenges.

The passenger-to-freighter conversion programme selected, as well as the original weight of an aircraft when it was a passenger model, will affect a freighter's payload and therefore its revenue-earning capabilities.

Freight carriers now have several narrowbody aircraft types to choose from. There are a number of older options, such as the 737-300, 737-400, 757-200 and the MD-80 family, as well as a new entrant: the A320 passenger to freighter (P2F). The operating performance, available payload and fuel burn of the freighter variants of these aircraft is analysed here on a range of route lengths and under challenging operating conditions.

Freighter options

The newly offered A320P2F could have one of the highest acquisition costs, because potential conversion aircraft have higher market values than the alternatives. This, however, can be offset by operational savings from greater fuel economy. The MD-80, however, is available at particularly low market values and in large numbers.

The highest specification weights available for the converted aircraft have been used for this analysis, although the exact weights of an aircraft will be affected by those from its life as a passenger aircraft.

AEI conversion programme weights have been used as a baseline for the 737-300 and -400, which are powered by CFM56-3B2 engines. Several of the specification weights will be identical for aircraft converted to freighter under the Pemco or Bedek Aviation programmes. These weights include maximum take-off weight (MTOW). The operating empty weight (OEW), maximum zero fuel weight (MZFW), and therefore the payload, will vary with the conversion programme used. The payload will also be affected by an aircraft's previous weights in passenger configuration.

The MTOWs used here are 139,500lbs for the 737-300, and 143,500lbs and 150,000lbs for the 737-400. The maximum structural payload for the 737-300 is 42,900lbs, while it is 44,100lbs and 47,100lbs for the two variants of the 737-400 *(see table, page 58)*.

The structural payload of the 737-300 converted with the Bedek Aviation modification is 43,100lbs with a 9g net, and 42,300lbs with a 9g barrier. The respective weights for aircraft converted under the Pemco modification are 43,635lbs and 43,200lbs. Three of these four versions therefore have a higher payload than aircraft modified under the AEI programme.

The 737-400 has a structural payload of 44,200lbs and 47,200lbs when converted with the Bedek Aviation modification, and 47,140lbs when converted with the Pemco modification. These are close to the payload of aircraft modified with the AEI programme.

The MD-80 variant analysed is the MD-83, because of its high fleet numbers. The analysis again uses the weights of an aircraft converted by AEI. This is the first and only company to provide a passenger-to-freighter conversion for the MD-80. The aircraft is the oldest being analysed, but it has low capital costs, a durable airframe and engines that tend to incur low shop-visit costs.

The MD-83's MTOW and MZFW are higher than those of both 737 variants, although the MD-83's resultant structural payload is similar to the 737-400SG's; the -400 with the lower MTOW.

There are two engine options for the 757-200s: the Rolls Royce (RR) RB211-535; and the Pratt & Whitney (PW) PW2000. Most PW engines are PW2037s, and many operators have de-rated PW2040s to PW2037 thrust ratings to prolong on-wing life and reduce engine maintenance costs.

The analysis includes two 757-200 freighter variants, both converted using the Precision Conversions modification. These are designated the 757-200PCF, and are equipped with RB211-535E4 and PW2037 engines.

The PW2037-powered aircraft has been analysed with a higher MZFW, although it has a lower engine thrust rating than the RB211-535E4.

A third 757-200, the Alcoa/Pemco conversion, has RB211-535E4 engines. The main difference between it and the 757-200PCF is that the Pemco-converted aircraft has a higher OEW.

To fully analyse these freighter aircraft, it is also important to assess how the maximum allowed take-off weight (MATOW) and the resultant available payload are affected on a range of challenging routes. Challenging missions include routes that depart from hot-and-high airports, as well as those with long flight times. Aircraft flying from airports with high elevations and high ambient temperatures will have their take-off weights limited, and so potentially their structural payload.

Miami (MIA) has been chosen as the starting point for all five routes, with each destination being a hot-and-high airport in Central or South America. All five

NARROWBODY FREIGHTER SPECIFICATIONS

Aircraft type	Engine	MTOW lbs	MZFW lbs	OEW lbs	Structural payload lbs
737-300	CFM56-3B2	139,500	109,600	66,690	42,900
737-400SG	CFM56-3B2	143,500	114,000	69,900	44,100
737-400HG	CFM56-3B2	150,000	117,000	69,900	47,100
MD-83	JT8D-219	160,000	122,000	77,380	44,620
A320-P2F	V2500-A1	169,750	134,480	87,525	46,955
757-200 Pemco	RB211-535E4	250,000	188,000	119,850	68,150
757-200PCF	RB211-535E4	250,000	188,000	116,100	71,900
757-200PCF	PW2037	250,000	194,000	115,900	78,100

SUMMARY OF AIRPORT OPERATING PARAMETERS

	Runway	Runway length (ft)	Daily mean temperature. in July (deg.C.)	Airport terminal elevation (ft)
Miami, Florida, USA (MIA)	9/27	13,016	25	9
	8R/26L	10,506		
	12/30	9,355		
	8L/26R	8,600		
Memphis, TN, USA (MEM)	18C/36C	11,120	23	341
	18R/36L	9,320		
	18L/36R	9,000		
	9/27	8,946		
San Jose, Costa Rica (SJO)	07/25	9,882	22	3,021
Mexico City, Mexico (MEX)	05R/23L	12,795	18	7,316
	05L/23R	12,966		
Bogota, Colombia (BOG)	13L/31R	12,467	13	8,361
	13R/31L	12,467		
Quito, Ecuador (UIO)	17/35	10,236	15	9,228

routes were analysed with the aircraft operating in both directions. MATOWs and available payload weights will be most challenged by flight and operating conditions on the return flights.

MIA has an elevation of just nine feet above sea level, compared to over 3,000ft for most of the other airports.

MIA to Memphis (MEM) is the shortest route, with MEM having an elevation of 341 feet. A daily mean temperature in July of 23 deg.C has been used for MEM, with 25deg.C. for MIA.

MIA to San Jose Airport in Costa Rica (SJO) is the second longest route. SJO has an airfield elevation of 3,031 feet, and mean temperatures in July of 22deg.C.

MIA to Mexico City (MEX) is the third longest route. MEX has an altitude of 7,316 feet above sea level, and has a daily mean temperature in July of 18.

MIA to Bogota, Colombia (BOG) is the fourth longest route. The temperature used for BOG was 13deg.C, and the airport's elevation is 8,361 feet.

The longest route is MIA to Quito (UIO), with flight times of just over 210 minutes. The mean temperatures in July are 15deg.C. at UIO, which has the highest elevation of 9,228 feet.

The last three airports (MEX, BOG and UIO), in particular, have high temperatures for their elevations, with average daily highs being even more than the average mean temperature used for this analysis. The combination of high temperatures and high elevation will reduce air density, which in turn limits an aircraft's allowable take-off weight. This problem can be exacerbated further if the runway is relatively short.

If an aircraft's performance is reduced by take-off weight restrictions due to a hot-and-high airfield, then the payload could also be reduced.

A freighter's maximum structural payload is a vital element of economics for any operator. A freighter aircraft will also have a certain amount of volumetric space available, determined by fuselage dimensions and contours, and the pallets or containers the aircraft can carry.

Typical packing densities mean that the maximum structural payload may not be reached, even if all available volume is utilised.

Another reason why the payload may not be fully utilised is because the combined tare weight of pallets and containers has to be subtracted from any available payload in order to get the remaining true revenue payload that can be carried. Even with the limitations of hot-and-high airports, an operator might still not completely use all of an aircraft's available payload, especially if the cargo requires a lot of volume but is light. The chances are, however, that an operator will see revenue limitations on these sorts of routes, with cargo of various weights.

The reduction of an aircraft's payload, on any particular route, will depend on the aircraft's available take-off weight (ATOW) or MATOW. The ATOW will often be the same as the MTOW, but it is likely to be limited for most aircraft at hot-and-high airports. The extent to which the take-off weight is limited depends on the airport and the aircraft's configuration and specification.

On some shorter routes from hot-and-high airports, large fuel reserves are not needed, so payload will be less limited. On the longer routes, the weight of larger fuel requirements may eat into the available payload, especially when the aircraft is operating at the edge of its payload-range envelope. In some cases a payload can be reduced to less than half of the aircraft's maximum.

Most freighters are converted from passenger aircraft, so they have smaller structural payloads than factory-built freighters. All the narrowbody types being analysed here are converted aircraft. Factory-built freighter aircraft have higher capital costs, however.

Operating conditions

The analysis has been completed using average temperatures for the month of July at each of the departing airports, because July is the hottest month, and will provide the most challenging test.

In addition, 85% annual average winds have been used in the flight planning process, using the PPS flight planning system from Air Support. An additional 25 minutes' taxi time has been used for the block times and total trip fuel burn.

Analysis

The characteristics of the airports used in this analysis, as well as the specifications of the particular aircraft used, are summarised *(see tables, this page)*. The performance of the aircraft variants was then assessed on each route, in terms of flight time, fuel burn and available payload *(see table, page 62)*.

The A320-P2F's weights are more than those of the 737s being analysed and are similar to the MD83's. The A320-P2F could indeed be seen as a more modern replacement for the 737-300/-400 and MD-83 aircraft, although it should be remembered that some A320s are over 20 years old, and potential conversion feedstock relies on passenger retirements. The 757-200 is a popular freighter and passenger aircraft, with more stock now becoming available for conversion as passenger fleets are updated. It is unlikely that 757-200s will be replaced as freighters, so the still very new A321P2F programme is unlikely to directly affect it just yet.

Routes

The shortest route is MIA-MEM with a tracked distance of 799nm outbound (OB) and 808nm inbound (IB). Strong winds in opposite directions result in an increased ESAD of 870nm OB (due to headwinds) and 730nm IB (due to tailwinds). Flight times average just over two hours, with the A320 and 757s being the quickest. In particular, the 757-200s with RR engines perform very well on both sectors. On both sectors the A320 burns the least fuel, while the 757s, especially the 757-200PCF with RR engines, carry the most payload. At this point no aircraft in either direction has its TOW or payload limited.

The second route, MIA-SJO, has some limitations put on the TOW of the 737s, MD-83 and 757s on the IB sector *(see table, page 62)*. Only the two 737-400 variants, however, have their payload reduced, by just 3,725lbs on the 737-400SG, and by 3,000lbs on the -400HG.

The tracked distance for this route is 1,049nm on the OB sector and 1,090nm on the IB sector. The ESAD changes slightly to 1,060nm, both OB and IB.

The fastest flight times are again seen with the 757-200s with RR engines. The A320 has a fuel burn of 2,376USG OB and 2,386USG IB, which is again the lowest across the eight aircraft models. The available payload, however, is average, with the 757-200PCFs again carrying maximum payloads.

The third route is MIA-MEX, with a tracked distance of 1,233nm OB and 1,277nm IB. Headwinds of 19 knots and tailwinds of 20 knots increase the OB ESAD to 1,290nm and decrease the IB ESAD to 1,215nm.

The 757-200s with RR engines have increased their flight time lead by a fraction, while retaining full payload capabilities. The MD-83 and A320 have also completed both sectors with a full payload.

The IB 737s show the lowest fuel burn, but this is assisted by the reduced payload. In fact, the lowest fuel burn for an aircraft with unrestricted payloads is that of the A320 IB, which is about 1,000USG less than the 757 on the same routes.

On the return sector while the 737s have the lowest fuel burn, and the 757 the highest, the 757s carry at least double the payload for just 50% additional fuel on the IB sector.

The fourth route is MIA-BOG. The tracked distance is 1,376nm OB and 1,492nm IB, with the ESADs being 1,365nm OB and 1,525nm IB. All the aircraft are again affected by the route on the IB sector with regard to reduced TOWs. Only the A320 sees an unaffected maximum payload on the IB sector. The 737s' IB payloads, in particular those of the 737-400s, are now so low that they are roughly half of the A320's and a third of the 757's. The quickest flight times are seen on the 757-200s with RR engines, although they are also some of the highest fuel burners, especially on the return sector. This is offset again by the fact that they carry by far the biggest payload.

The longest, and fifth route, is MIA-UIO. With hardly any wind IB and zero winds OB, the ESAD is 1,653nm OB and 1,650nm IB. Flight times vary more on this longer route, with a difference of about 20 minutes seen between aircraft on each sector. Again the 757 is the fastest and carries the largest payload, although it is now greatly reduced from its maximum payload on the IB sectors.

The 737s have the smallest fuel burn,

NARROWBODY FREIGHTER FUEL BURN PERFORMANCE - OUTBOUND FROM MIA

Route	Aircraft model	Engine model	Tracked distance (nm)	ESAD (nm)	Wind (kts)	Block time (mins)	Fuel burn (USG)	MTOW (lbs)	Maximum allowed TOW (lbs)	Available Payload (lbs)	Fuel burn lbs per ton-mile
MIA-MEM	737-300	CFM56-3B2	799	870	-43	133	2,103	139,500	139,500	42,900	0.8456
	737-400SG	CFM56-3B2	799	870	-43	133	2,139	143,500	143,500	44,100	0.8367
	737-400HG	CFM56-3B2	799	870	-43	133	2,163	150,000	150,000	47,100	0.7922
	MD-83	JT8D-219	799	870	-43	131	2,308	160,000	160,000	44,620	0.8923
	A320-P2F	V2500-A1	799	870	-43	121	1,997	169,750	169,750	46,955	0.7337
	757-200 Pemco	RB211-535E4	799	870	-43	119	2,705	250,000	250,000	68,150	0.6847
	757-200PCF	RB211-535E4	799	870	-43	119	2,705	250,000	250,000	71,900	0.6490
	757-200PCF	PW2037	799	870	-43	125	2,758	250,000	250,000	71,800	0.6626
MIA-SJO	737-300	CFM56-3B2	1,049	1,060	-5	159	2,440	139,500	139,500	42,900	0.8053
	737-400SG	CFM56-3B2	1,049	1,060	-5	160	2,536	143,500	143,500	44,100	0.8142
	737-400HG	CFM56-3B2	1,049	1,060	-5	160	2,566	150,000	150,000	47,100	0.7714
	MD-83	JT8D-219	1,049	1,060	-5	157	2,786	160,000	160,000	44,620	0.8840
	A320-P2F	V2500-A1	1,049	1,060	-5	146	2,376	169,750	169,750	46,955	0.7164
	757-200 Pemco	RB211-535E4	1,049	1,060	-5	144	3,233	250,000	250,000	68,150	0.6717
	757-200PCF	RB211-535E4	1,049	1,060	-5	145	3,233	250,000	250,000	71,900	0.6366
	757-200PCF	PW2037	1,049	1,060	-5	150	3,276	250,000	250,000	71,800	0.6460
MIA-MEX	737-300	CFM56-3B2	1,233	1,290	-19	192	2,872	139,500	139,500	42,900	0.7789
	737-400SG	CFM56-3B2	1,233	1,290	-19	192	2,990	143,500	143,500	44,100	0.7888
	737-400HG	CFM56-3B2	1,233	1,290	-19	192	3,024	150,000	150,000	47,100	0.7470
	MD-83	JT8D-219	1,233	1,290	-19	189	3,318	160,000	160,000	44,620	0.8651
	A320-P2F	V2500-A1	1,233	1,290	-19	178	2,804	169,750	169,750	46,955	0.6948
	757-200 Pemco	RB211-535E4	1,233	1,290	-19	173	3,821	250,000	250,000	68,150	0.6523
	757-200PCF	RB211-535E4	1,233	1,290	-19	173	3,821	250,000	250,000	71,900	0.6183
	757-200PCF	PW2037	1,233	1,290	-19	179	3,850	250,000	250,000	71,800	0.6238
MIA-BOG	737-300	CFM56-3B2	1,376	1,365	3	203	3,045	139,500	139,500	42,900	0.7804
	737-400SG	CFM56-3B2	1,376	1,365	3	203	3,174	143,500	143,500	44,100	0.7913
	737-400HG	CFM56-3B2	1,376	1,365	3	203	3,210	150,000	150,000	47,100	0.7493
	MD-83	JT8D-219	1,376	1,365	3	200	3,539	160,000	160,000	44,620	0.8720
	A320-P2F	V2500-A1	1,376	1,365	3	189	2,982	169,750	169,750	46,955	0.6983
	757-200 Pemco	RB211-535E4	1,376	1,365	3	185	4,071	250,000	250,000	68,150	0.6568
	757-200PCF	RB211-535E4	1,376	1,365	3	185	4,071	250,000	250,000	71,900	0.6225
	757-200PCF	PW2037	1,376	1,365	3	191	4,096	250,000	250,000	71,800	0.6272
MIA-UIO	737-300	CFM56-3B2	1,653	1,653	0	244	3,608	139,500	139,500	42,900	0.7636
	737-400SG	CFM56-3B2	1,653	1,653	0	244	3,751	143,500	143,500	42,784	0.7960
	737-400HG	CFM56-3B2	1,653	1,653	0	244	3,778	150,000	150,000	44,707	0.7672
	MD-83	JT8D-219	1,653	1,653	0	240	4,261	160,000	160,000	44,620	0.8670
	A320-P2F	V2500-A1	1,653	1,653	0	227	3,546	169,750	169,750	46,955	0.6857
	757-200 Pemco	RB211-535E4	1,653	1,653	0	222	4,852	250,000	250,000	68,150	0.6464
	757-200PCF	RB211-535E4	1,653	1,653	0	222	4,852	250,000	250,000	71,900	0.6127
	757-200PCF	PW2037	1,653	1,653	0	228	4,859	250,000	250,000	71,800	0.6144

Source: PPS flight planning system and Aviation Software System's Payload And Costing System (PACS)

but the A320 has the lowest actual fuel burn per unit of payload, since the 737's payload on this route is about half of its original maximum.

The A320 again seems to have no reduction in payload, despite its TOW weight reduction, because this reduction is the smallest of all the aircraft.

The 757s are still the most efficient in terms of payload carried. The payload is reduced by 18,700lbs and 25,600lbs on this route on the IB sector. Compared to the 737s, the 757s now carry about two and a half times the payload for just over 16% additional fuel burn.

Aircraft

Overall, the A320 performed well, since the payload was never subject to reductions, although the available take-off weight was. As far as the final fuel burn in lbs per ton-mile is concerned, its performance was average. It did better than the 737s and MD83, but not quite as well as the larger 757 variants. As the routes lengthen, the fuel burn efficiency improves, although it can be seen to plateau on the last three routes.

The 737s were the first to have their payload limited, and by a big percentage. The 737-400s started to lose payload when the ESAD was 1,090nm on the second MIA-SJO route, while the -300 didn't suffer payload reductions until the next route: MIA-MEX.

The 737s were consistently the slowest aircraft on each route, despite having the least payload. On all OB flights and the first route's IB flight, the 737-300 was unable to carry as much payload as the -400. On the four other IB sectors, however, the 737-300 had a larger payload capability, with slightly smaller fuel burns. When considering the 737s' fuel burn per ton-mile, it performs better than the MD-83, but not as well as

NARROWBODY FREIGHTER FUEL BURN PERFORMANCE - INBOUND TO MIA

Route	Aircraft model	Engine model	Tracked distance (nm)	ESAD (nm)	Wind (kts)	Block time (mins)	Fuel burn (USG)	MTOW (lbs)	Maximum allowed TOW (lbs)	Available Payload (lbs)	Fuel burn lbs per ton-mile
MEM-MIA	737-300	CFM56-3B2	808	730	51	113	1,867	139,500	139,500	42,900	0.8947
	737-400SG	CFM56-3B2	808	730	51	113	1,901	143,500	143,500	44,100	0.8862
	737-400HG	CFM56-3B2	808	730	51	113	1,924	150,000	150,000	47,100	0.8398
	MD-83	JT8D-219	808	730	51	111	2,023	160,000	160,000	44,620	0.9321
	A320-P2F	V2500-A1	808	730	51	103	1,776	169,750	169,750	46,955	0.7776
	757-200 Pemco	RB211-535E4	808	730	51	103	2,413	250,000	250,000	68,150	0.7279
	757-200PCF	RB211-535E4	808	730	51	103	2,413	250,000	250,000	71,900	0.6900
	757-200PCF	PW2037	808	730	51	108	2,477	250,000	250,000	71,800	0.7093
SJO-MIA	737-300	CFM56-3B2	1,090	1,060	14	160	2,447	139,500	132,619	42,900	0.8076
	737-400SG	CFM56-3B2	1,090	1,060	14	160	2,508	143,500	132,619	40,375	0.8795
	737-400HG	CFM56-3B2	1,090	1,060	14	160	2,508	150,000	132,919	40,375	0.8795
	MD-83	JT8D-219	1,090	1,060	14	157	2,786	160,000	158,290	44,620	0.8840
	A320-P2F	V2500-A1	1,090	1,060	14	147	2,386	169,750	169,750	46,955	0.7195
	757-200 Pemco	RB211-535E4	1,090	1,060	14	145	3,250	250,000	249,514	68,150	0.6752
	757-200PCF	RB211-535E4	1,090	1,060	14	145	3,250	250,000	249,514	71,900	0.6400
	757-200PCF	PW2037	1,090	1,060	14	150	3,294	250,000	238,850	71,800	0.6496
MEX-MIA	737-300	CFM56-3B2	1,277	1,215	20	182	2,658	139,500	117,546	27,482	1.1947
	737-400SG	CFM56-3B2	1,277	1,215	20	183	2,666	143,500	117,546	24,221	1.3596
	737-400HG	CFM56-3B2	1,277	1,215	20	183	2,666	150,000	117,546	24,221	1.3596
	MD-83	JT8D-219	1,277	1,215	20	180	3,197	160,000	151,197	44,620	0.8850
	A320-P2F	V2500-A1	1,277	1,215	20	169	2,714	169,750	168,460	46,955	0.7140
	757-200 Pemco	RB211-535E4	1,277	1,215	20	167	3,704	250,000	235,533	68,150	0.6714
	757-200PCF	RB211-535E4	1,277	1,215	20	167	3,704	250,000	235,533	71,900	0.6363
	757-200PCF	PW2037	1,277	1,215	20	172	3,728	250,000	227,620	77,295	0.5958
BOG-MIA	737-300	CFM56-3B2	1,492	1,525	-8	225	3,176	139,500	118,460	24,874	1.2566
	737-400SG	CFM56-3B2	1,492	1,525	-8	225	3,184	143,500	118,460	21,607	1.4502
	737-400HG	CFM56-3B2	1,492	1,525	-8	225	3,184	150,000	118,460	21,607	1.4502
	MD-83	JT8D-219	1,492	1,525	-8	221	3,819	160,000	150,794	40,145	0.9362
	A320-P2F	V2500-A1	1,492	1,525	-8	209	3,271	169,750	166,960	46,955	0.6856
	757-200 Pemco	RB211-535E4	1,492	1,525	-8	204	4,460	250,000	226,416	67,493	0.6503
	757-200PCF	RB211-535E4	1,492	1,525	-8	204	4,460	250,000	226,416	71,232	0.6162
	757-200PCF	PW2037	1,492	1,525	-8	210	4,323	250,000	221,176	66,800	0.6369
UIO-MIA	737-300	CFM56-3B2	1,634	1,650	-3	225	3,391	139,500	117,650	22,594	1.3651
	737-400SG	CFM56-3B2	1,634	1,650	-3	225	3,399	143,500	117,650	19,336	1.5989
	737-400HG	CFM56-3B2	1,634	1,650	-3	225	3,399	150,000	117,650	19,336	1.5989
	MD-83	JT8D-219	1,634	1,650	-3	221	4,086	160,000	150,535	37,886	0.9810
	A320-P2F	V2500-A1	1,634	1,650	-3	209	3,526	169,750	163,920	46,955	0.6830
	757-200 Pemco	RB211-535E4	1,634	1,650	-3	204	4,546	250,000	208,938	49,431	0.8365
	757-200PCF	RB211-535E4	1,634	1,650	-3	204	4,546	250,000	208,938	53,170	0.7777
	757-200PCF	PW2037	1,634	1,650	-3	210	4,432	250,000	207,604	52,484	0.7681

Source: PPS flight planning system and Aviation Software System's Payload And Costing System (PACS))

the 757s and A320. On the shorter routes, the 737-400HG gives the best result, but on the last route, the 737-300 is fractionally more efficient.

Despite its older technology, the MD-83 potentially holds its own, since it does not lose payload until BOG-MIA. Here, the aircraft's TOW is limited to 10,000lbs and its payload to 4,500lbs.

While it began by having the smallest payload after the 737-300, by the last route the MD-83 was right in the middle of the pack, having only lost 15% of its payload. The fuel burn efficiency per ton-mile however, is the worst in this analysis.

The 757-200s have the highest fuel burn of all eight aircraft, the shortest flight times and the largest payloads. The RR-powered 757-200s are slightly faster than the PW-powered 757-200. This is also the first 757-200 to be payload restricted.

On the first three routes, the PW-powered 757 burns more fuel than the RR alternative. For the longer two routes, the PW aircraft burns less on the IB flights than the RR-powered 757s. While the Pemco 757-200 with RR engines has flight times and fuel burns consistently the same as the Precision Conversions' alternative, the latter has a higher maximum payload. In terms of fuel burn per ton-mile, both the 757-200PCFs perform better than the Pemco aircraft. The two PCF options have similar fuel burn per ton-mile efficiencies on the first two routes, but differ widely on the third, when the PW-powered -200PCF's has a distinctly better fuel burn. The two aircraft then have similar fuel efficiencies on the last two routes. AC