MD-11 fuel burn performance

The fuel burn performance of the MD-11 in passenger and freighter configuration is analysed on routes of 3,600-5,800nm.

The MD-11 fleet is dominated by the MD-11ER and MD-11F/CF freighter variant. There are only two engine types offered, from General Electric (GE) and Pratt & Whitney (PW): the CF6-80C2D1F engine from GE; and the PW4462 from PW. GE's is the predominant engine type. There are four maximum take-off weights (MTOWs) for all variants of aircraft, but most aircraft in the fleet have been upgraded to 625,500lbs or 630,500lbs. The fuel burn of the MD-11ER and MD-11F/CF are analysed.

MD-11 variants

The MD-11ER is the passenger version of the aircraft with an MTOW of 630,500lbs for both the CF6-80C2D1F and the PW4462 engine variants. It is predominantly a long-haul aircraft and has a standard fuel capacity of 38,615 US Gallons (USG). Although there are auxiliary tank options for the aircraft, the majority were delivered in standard configuration and have not been upgraded.

Most of the converted and factory freighters have an MTOW of 630,500lbs for both the CF6-80C2D1F and the PW4462 engine variants. The fuel burn difference between the engine variants depends on their fuel burn efficiency. Aircraft with a high fuel burn will require a total higher weight of fuel, which will have an impact on the payload that can be carried when the aircraft is being operated at its MTOW on relatively long routes.

Most MD-11ERs have an MTOW of 625,500lbs or 630,500lbs. The passenger aircraft have a standard tri-class passenger load of 298.

Fuel burn performance

The fuel burn analyses have been conducted on typical long distance routes for the MD-11. These are representative of both the passenger and freighter routes operated by many of these aircraft.

The routes for the passenger aircraft are Copenhagen (CPH) - Shanghai (PVG), and Madrid (MAD) - Buenos Aires (EZE). The aircraft have been analysed with a full load of 298 passengers, unless the aircraft is payload limited.

The routes used for the freighter aircraft are London Gatwick (LGW) - Nairobi (NBO) and Miami (MIA) - Sao Paulo (GRU), which are typical freight routes.

To illustrate the effects of wind speed and direction, the performance of the aircraft have been analysed for operations in both directions. The differentials on some of these city-pairs have an impact on flight time, available payload and fuel burn.

The tracked distance for the sectors is as follows:

- 4,714nm for CPH-PVG
- 5,486nm for MAD-EZE
- 3,557nm for MIA-GRU
- 3,665nm for LGW-NBO.

Flight plans have been prepared by Navtech, Canada to analyse the fuel burn and payload-carrying performances. The standard weight for each passenger plus baggage has been assumed to be 220lbs. It is assumed that all the engine configurations incorporate all the performance improvement modifications.

The performance of all aircraft has been analysed with the aircraft operating at long-range cruise, annual 85% winds and a taxi time of 25 minutes.

MD-11ER

The specification weights of the MD-11ER are shown *(see table, this page)*, and are identical for each engine variant. The aircraft is assumed to fly with a full load of 298 passengers in tri-class, giving it a total payload of 65,560lbs. The aircraft has an MTOW of 630,500lbs, an operating empty weight (OEW) of 291,120lbs, and a fuel capacity of 38,615 USG *(see table, this page)*.

The two routes used for the analysis have a tracked distance that is 1,000-2,000nm shorter than the aircraft's 6,500nm range capability with a full passenger payload.

The first route examined for the MD-11ER was CPH-PVG. This has a tailwind of 11 knots, decreasing the tracked distance of 4,714nm to an equivalent still air distance (ESAD) of 4,608nm *(see table, page 18)*.

Flying west, the aircraft experiences a headwind of 49 knots flying towards CPH. This increases the tracked distance to an ESAD of 5,179nm.

The take-off weights (TOW) of the two engine variants differ due to differences in engine fuel burn, resulting in different block fuel for the sector.

The TOW of the PW4462 powered aircraft is 550,725lbs, compared to a TOW of 536,754lbs for the CF6-80C2D1F-powered aircraft *(see table, page 18)*.

The second route examined is MAD-EZE. This is a good example of the long-range routes the aircraft was designed for. The tracked distance of 5,486nm in a westerly direction to EZE faces a headwind of 30 knots. This increases the ESAD to 5,855nm. Going east, to MAD, there is an average 5 knot tailwind that reduces the tracked distance to an ESAD of 5,494nm *(see table, page 18)*.

MD-11F/CF

The freighter aircraft have an OEW of 248,567lbs, and maximum zero fuel weight (MZFW) of 461,300lbs. This gives the aircraft a gross structural payload of 212,733bs and a fuel standard capacity of 38,615 USG.

The freighter aircraft (F and CF) have been analysed in both directions on MIA-GRU and LGW-NBO as representative of a long-haul freight routes. Both these routes have a tracked distance similar to the freighter's range of about 3,600nm with a maximum payload.

WEIGHT SPECIFICATIONS OF ANALYSED MD-11 VARIANTS

Aircraft type	MTOW lbs	MZFW lbs	OEW lbs	Payload lbs	Seats	Fuel USG	Engine model
MD-11ER	630,500	400,000	291,200	108,880	298	38,615	PW4460/62/ CF6-80C2D1F
MD-11F/CF	630,500	461,300	248,567	209,880	N/A	38,615	PW4460/62 CF6-80C2D1F

FUEL BURN PERFORMANCE OF MD-11

City-pair	Aircraft variant	TOW lbs	Engine model	Block fuel USG	Block time	Passenger payload	Fuel USG per passenger	ESAD nm	Wind speed factor
CPH-PVG	MD-11ER	550,725	PW4462	24,642	10:11	298	82.7	4,608	+11
CPH-PVG	MD-11ER	536,754	CF6-80C2D1F	23,226	10:14	298	77.9	4,608	+11
PVG-CPH	MD-11ER	578,925	PW4462	28,403	11:22	298	95.3	5,179	-49
PVG-CPH	MD-11ER	564,056	CF6-80C2D1F	26,728	11:18	298	89.7	5,175	-49
MAD-EZE	MD-11ER	607,979	PW4462	32,663	12:47	298	109.6	5,855	-30
MAD-EZE	MD-11ER	590,211	CF6-80C2D1F	30,703	12:43	298	103.0	5,853	-30
EZE-MAD	MD-11ER	590,598	PW4462	30,224	12:01	298	101.4	5,493	5
EZE-MAD	MD-11ER	574,071	CF6-80C2D1F	28,439	11.58	298	95.4	5,494	5

Source: Navtech

FUEL BURN PERFORMANCE OF MD-11

City-pair	Aircraft variant	TOW lbs	Engine model	Block fuel USG	Block time	Freight payload lbs	Fuel USG per ton-mile	ESAD nm	Wind speed factor
MIA-GRU	MD-11F/CF	630,500	PW4462	22,853	7:59	200,044	0.071	3,595	-5
MIA-GRU	MD-11F/CF	630,500	CF6-80C2D1F	22,080	7:56	207,783	0.066	3,594	-5
GRU-MIA	MD-11F/CF	630,500	PW4462	23,508	8:14	195,693	0.073	3,724	-16
GRU-MIA	MD-11F/CF	630,500	CF6-80C2D1F	22,739	8:11	203,235	0.068	3,723	-16
LGW-NBO	MD-11F/CF	630,500	PW4462	26,362	9:28	175,323	0.090	4,295	-70
LGW-NBO	MD-11F/CF	630,500	CF6-80C2D1F	25,497	9:22	183,701	0.083	4,288	-70
NBO-LGW	MD-11F/CF	630,500	PW4462	22,768	7:58	200,653	0.067	3,582	20
NBO-LGW	MD-11F/CF	630,500	CF6-80C2D1F	22,001	7:55	208,536	0.062	3,583	20

Source: Navtech

En-route winds are not significant for MIA-GRU as this is a North-South route. There is a five-knot headwind in a southerly direction to GRU, increasing the tracked distance to an ESAD of 3,595nm.

North to MIA, the tracked distance increases from 3,600nm to an ESAD of 3,724nm due to a 16-knot headwind.

On LGW-NBO, the winds are significantly different in each direction. South towards NBO the 70-knot headwind adds 630nm making the ESAD 4,295nm. North towards LGW the 20-knot tailwind reduces the ESAD to 3,582nm.

Fuel burn results

The passenger variants of the MD-11 with PW4462 or CF6-80C2D1F engines have different fuel burn performance. The PW4462-powered aircraft burns just over 6% more fuel on the CPH-PVG route than the CF6-80C2-powered aircraft *(see table, this page)*, which is even more noticeable on the westerly routeing against a strong headwind. Going in an easterly direction towards PVG, the difference in fuel burn per passenger is 4.75 USG *(see table, this page)*, which is equal to an additional cost of $9.5-10.5 per seat at current fuel prices. This clearly illustrates the economic advantage of the CF6-80C2D1F-powered aircraft.

Going west towards CPH the difference increases to over 5.6 USG and $12.4 per seat. This is also a consideration when looking at freighter conversion of the passenger aircraft, as fuel burn differences translate directly into revenue payload differences.

Similar differences in fuel burn between the two engines types are seen on the MAD-EZE route.

The aircraft with both engine types operate at a take-off weight lower than MTOW, but the lower fuel burn of the CF6-80C2-powered aircraft requires a lower total fuel load, which is reflected by a lower take-off weight *(see table, this page)*.

Despite these differences in fuel burn, the aircraft are carrying relatively low payloads and are not limited in the payloads they can carry.

The ESADs of the MIA-GRU and LGW-NBO routes mean that both engine variants of the MD-11F/CF operate at the aircraft's MTOW of 630,500lbs.

The lower fuel burn of the CF6-80C2-powered aircraft is reflected in its superior operating performance at MTOW on these long routes. It can carry close to a maximum payload in both directions on the MIA-GRU route *(see table, this page)*. The northerly direction has an ESAD of 3,724nm, and the aircraft can carry a payload of 207,783lbs, which is only about 5,000lbs less than maximum. The PW4462-powered aircraft, however, requires a high fuel load and correspondingly has a 9,750lbs lower payload. The CF6-80C2D1F-powered aircraft has a fuel burn of 0.066 USG per available ton-mile *(see table, this page)*. The PW4462 burns 0.071 USG per available ton-mile.

The PW4462-powered aircraft has a similar payload deficit operating in the other direction. Both aircraft carry lower payloads because of the longer ESAD.

LGW-NBO is about 700nm longer than MIA-GRU because of the stronger headwind. This illustrates the effect of lower payload, while again the CF6-80C2 powered aircraft has a superior performance. This aircraft can carry about 8,400lbs more freight, but it is still about 29,000lbs less than a maximum payload. The PW4462-powered aircraft can carry about 37,000lbs less than a maximum payload.

The CF6-80C2-powered aircraft has a similar advantage operating in a northerly direction *(see table, this page)*.

In the northerly direction with a tailwind, the CF6-80C2D1F can carry only about 4,000lbs less than a maximum payload, while the PW4462 has a restriction of about 12,000lbs *(see table this page)*. AC