The fuel burn and operating performance are key drivers for the success of the 787 family. These are analysed on sets of routes where range is one limiting factor, and the operating environment is the other limiting factor. The 787-8, -9 and -10, with both Trent 1000 or GEnx engines, are examined in these two scenarios.

787 family fuel burn & operating performance

The 787 aircraft family was launched as a response to demand from the market for a mid-size widebody aircraft in the 240-290-seat segment with high operating efficiencies. The 787 was conceived to serve medium-, long- and ultra-long-haul point-to-point routes. These would either be established markets at high frequencies, or thin routes with a minimum of a daily service.

These operating efficiencies were made possible by the introduction of new-generation high-bypass ratio engines, a fuselage built with a one-piece composite barrel section, aerodynamic improvements like high-flex wings with raked wingtips, and a low drag dropped nose. Advanced avionics and new systems were also introduced. The aircraft was conceived to have seat-mile costs comparable to larger types. This includes fuel burn performance per seat-mile that is similar to types such as the 777-300ER. The fuel burn and operating performance of the 787 family is analysed here.

Comparison basis

The 240-seat 787-8 and the larger 296-seat 787-9 were the initial variants offered in 2004. The stretched 336-seat 787-10 variant was launched in 2013 to serve markets requiring up to 340 seats. These three variants are analysed here.

The 787 family was launched with the option of Rolls-Royce Trent 1000 or GEnx engines; both will be used in this analysis. The fuel burn and operating performance of six 787 family variants are examined *(see tables, pages 30, 31, 32 & 34)*.

For performance analysis purposes, two sets of routes were selected. The first set comprises seven long- and ultra-long-haul trans-Pacific missions from Los Angeles (LAX), a benign environment airfield with few limitations on aircraft performance, to main Asia Pacific cities.

The seven routes have tracked route lengths of 4,942nm to 7,668nm, and equivalent still air distances (ESADs) of 5,417nm to 8,086nm *(see first table, page 26)*. The block times to complete these missions range from 11 hours and seven minutes to 17 hours and 25 minutes.

The longest of these seven routes are beyond the aircraft's range at maximum take-off weight (MTOW) with a full load of passengers. They show how its performance is impacted and payload reduced when departing from an airfield with few or no take-off restrictions.

The initial selection of routes included missions that could not be flown by the 787 or were too heavily restricted for any significant conclusions to be drawn. The final selection was reduced from 11 cities in Asia-Pacific to the seven routes described *(see first table, page 26)* .

The performance of the whole 787 family has been analysed in two parts.

The 787-10 has the lowest fuel burn per ASM of all 787 variants. It can accommodate up to 36% more seats than the 787-8 baseline model. It has the best economics on medium- and long-haul routes when operating from unrestricted airfields.

AIRCRAFT SPECIFICATIONS & WEIGHTS

Aircraft type	787-8	787-8	787-9	787-9	787-10	787-10
Engine	GEnx -1B-70	Trent 1000-J	GEnx -1-B-75	Trent 1000-J	GEnx -B-76A	Trent 1000-J3
Engine bypass ratio	9.0	10.0	8.8	10	8.8	10
Max take-off thrust - lbs	69,800	78,129	78,500	78,129	78,500	78,129
Maximum continuous thrust	66,500	71,818	68,600	71,818	68,500	71,818
MTXW - lbs	503,500	503,500	561,500	561,500	561,500	561,500
MTOW - lbs	502,500	502,500	560,000	560,000	560,000	560,000
MLW - lbs	380,000	380,000	425,000	425,000	455,000	455,000
MZFW - lbs	355,000	355,000	400,000	400,000	425,000	425,000
OEW / DOW -lbs	264,500	264,500	284,000	284,000	281,000	281,000
Max payload - lbs	90,500	90,500	116,000	116,900	143,900	143,900
Fuel capacity USG	33,340	33,340	33,340	33,399	33,399	33,399
Dual-class seat count	220	220	266	266	337	337
Passenger payload - lbs	50,820	50,820	61,446	61,446	77,847	77,847
Range with full passenger payload - nm	7,099	7,250	7,750	7,604	7,000	7,000
Gross remaining - lbs	39,680	39,680	54,554	54,544	66,053	66,053
MTOW/seat - lbs	2,284	2,284	2,105	2,105	1,662	1,662
DOW/seat - lbs	1,202	1,202	1,068	1,068	834	834
Maximum number of LD-3 containers	28	28	36	36	40	40
Maximum number of pallets*	8	8	11	11	13	13
Cargo hold volume cu-ft	4,060	4,060	5,220	5,220	5,800	5,800

* 96x 125 inches standard pallets

Full passenger payload

The first analysis is of the aircraft family's performance with just a full load of passengers, to show how the number of allowable passengers would be affected by increasing route length; and the fuel burn consumption and cost per available seat-mile (ASM) of the six variants, and how fuel burn per ASM varies between the three different sized variants, and the two main engine types.

Full structural payload

The second analysis is of the performance of the six variants with a maximum allowable full payload. It shows how much additional belly cargo each variant can carry on each route in addition to a full passenger load. The tare weight of belly unit load devices (ULDs) and pallets is deducted to give a net weight of cargo.

The incremental amount of fuel burned by the same variant on the same route carrying just a passenger load can therefore be calculated. The cost of this incremental fuel burn can be compared to the amount of revenue-generating belly cargo that could be carried. This analysis therefore shows the fuel cost per lb of freight, and how the amount of payload, and therefore cargo, that can be carried declines with increasing route length.

Hot & high performance

The second set of routes originates at El Dorado International Airport, Bogotá (BOG), whose high elevation and ambient daytime temperatures regularly pose significant operational restrictions. This analysis examines the 787 family's performance departing from a hot and high airfield.

The six variants are analysed with a maximum allowable passenger payload on six routes departing from BOG with tracked distances of 1,363-4,337nm, and ESADs of 1,429-4,604nm *(see second table, page 26)*. The analysis shows on what route length the aircraft's passenger payload would be limited due to a possible restricted take-off weight (RTOW) compared to MTOW due to operating conditions at BOG.

Simulation of aircraft performance and the resulting fuel burn was provided by the Lufthansa Systems Lido/Flight 4D flight planning system, with analysis and conclusions made by *Aircraft Commerce*.

Route selection

LAX departures

Given its location, LAX provides a relatively unrestricted environment for aircraft operations at departure. The airfield is virtually located at sea level (elevation of 127ft) with a year-round mild and mostly dry climate, and a yearly average temperature of 17 °C. This makes it possible to plan most aircraft operations under International Standard Atmosphere (ISA) normal conditions.

Also, due to its geographic position, LAX is an important gateway for trans-Pacific flights with significant variations in terms of range. Base ISA conditions are assumed for mission planning from LAX on each route (15°C, sea level, 1,013.2 hPa). Runway 25R, with a length of 12,923 feet, and no obstacles is used for the analysis. Ambient temperature used at take-off for the seven routes is 15 degrees centigrade, with flight plans made on the basis of ISA conditions.

Trans-Pacific flights out of LAX can either benefit from tailwinds, or be impacted by headwinds depending on the route heading and the season. The seven routes from LAX were to Tokyo (NRT), Seoul Incheon (ICN), Beijing (PEK), Shanghai Pudong (PVG), Hong Kong (HKG), Ho Chi Minh (SGN) and Bangkok (BKK). These have ESADs of 5,417-8,086nm *(see first table, page 26)*.

BOG departures

Due to its location, BOG presents a set of limitations for aircraft operations. The airfield has an elevation of 8,361ft and a humid atmosphere; depending on the time of the year temperatures can be as low as 1°C in the early hours, with afternoon temperatures of 24 °C, and 14 °C in the evenings.

Due to its geographic position, BOG is a hub for South-North traffic flows within the Americas, and is also an important hub and focus point for transatlantic missions.

ISA+15 conditions are assumed for mission-planning from BOG on each route. That is, the ambient is 15 degrees higher than the standard temperature for the airfield's elevation. Ambient temperature at take-off for the six routes is therefore 13.7 degrees centigrade, typical of the temperature for evening departures.

Runway 31L with a length of 12,467ft is used for the analysis. A good percentage of long-haul flights out of BOG are scheduled to depart in the evening to minimise take-off weight restrictions on aircraft because of the lower ambient temperatures.

While the temperature is cool and the runway length is not limiting, air density at this elevation is 22% lower than at sea level. This negatively affects an aircraft's performance. The take-off field length is calculated using the higher-thrust engine for each variant.

Departure routeings out of BOG for aircraft are usually performed in a south-east pattern. The Eastern Andes mountain range is just 8nm away from the runway threshold. Steep climb profiles with maximum climb thrust (MCT) and simultaneous sharp left and banking manoeuvres are necessary to clear these obstacles.

Transatlantic flights out of BOG tend to be negatively impacted by prevailing easterly headwinds between the equator and latitudes up to 30 degrees North. This region accounts for most of the tracked distance for the six routes.

The shortest route evaluated in this analysis was BOG-Miami (MIA), with an ESAD of 1,429nm *(see second table, page 26)*. The other five routes from BOG were to New York JFK (JFK), Chicago (ORD), Toronto (YYZ), Seattle (SEA) and Madrid, Spain (MAD). These five routes have ESADs of 2,381-4,604nm *(see second table, page 26)*.

Although the six routes from BOG are all well within every 787 variant's range performance for sea-level departures, BOG's high elevation results in aircraft being unable to operate at MTOW. Lower RTOWs will negatively impact aircraft performance, and therefore will impose limitations on passenger payload.

Aircraft specifications

A total of six aircraft are included in this analysis: three variants with the two engine options. The engine types, specification weights, fuel capacity, passenger payload, and associated range are summarised *(see table, page 24)*.

Aircraft weights are a fundamental input to the analysis. The aircraft MTOW limit is reached by adding the weight of fuel and payload to the operating empty weight (OEW), or aircraft prepared for service (APS) weight. OEW is similar for every aircraft of a particular variant, but it varies with the weight of interior equipment, crew and catering.

The OEW therefore includes all of the

ROUTE CHARACTERISTICS - LOS ANGELES INTERNATIONAL LAX

Route	LAX-NRT	LAX-ICN	LAX-PEK	LAX-PVG	LAX-HKG	LAX-SGN	LAX-BKK
Flight times - mins	661-670	758-768	742-751	799-808	887-904	963-981	989-1008
Taxi out times - mins	22	22	22	22	22	22	22
Taxi in times-mins	15	25	14	17	20	12	15
Block times-mins	698-707	805-815	778-787	838-847	929-946	997-1,015	1,026-1,045
Tracked distances-nm	4,942	5,582	5,616	5,660	6,818	7,539	7,668
Wind components - kts	-43	-52	-43	-52	-27	-19	-25
ESAD - nm	5,417	6,251	6,100	6,565	7,220	7,853	8,086
Alternate airport	HND/90	GMP/90	TSN/102	SHA/74	CAN/125	DAD/347	UTP/89

ROUTE CHARACTERISTICS - BOGOTA BOG

Route	BOG-MIA	BOG-JFK	BOG-ORD	BOG-YYZ	BOG-SEA	BOG-MAD
Flight times - mins	186-194	302-311	329-339	328-338	481-490	575-582
Taxi out times - mins	19	19	19	19	19	19
Taxi in times-mins	18	28	27	18	13	20
Block times-mins	223-231	349-358	375-385	365-375	513-522	614-621
Tracked distances-nm	1,363	2,253	2,441	2,455	3,600	4,337
Wind components - kts	-21	-25	-31	-27	-31	-6
ESAD - nm	1,429	2,381	2,612	2,604	3,849	4,604
Alternate airport	MCO/181	EWR/47	MKE/89	YHM/50	PDX/130	VLC/209
787-8 GEnx RTOW*	418,601	418,601	418,601	418,601	418,601	418,601
787-8 GEnx TOW*	358,435	374,468	381,010	379,565	411,571	418,601
787-8 Trent RTOW*	436,700	436,700	436,700	436,700	436,700	436,700
787-8 Trent TOW*	357,240	373,262	379,757	378,702	409,746	430,084
787-9 GEnx RTOW*	438,901	438,901	438,901	438,901	438,901	438,901
787-9 GEnx TOW*	390,309	407,201	414,105	412,616	438,901	438,901
787-9 Trent RTOW*	436,700	436,700	436,700	436,700	436,700	436,700
787-9 Trent TOW*	390,782	408,239	415,342	413,483	436,700	436,700
787-10 GEnx RTOW*	438,901	438,901	438,901	438,901	438,901	438,901
787-10 GEnx TOW*	405,863	423,247	430,385	428,805	438,901	438,901
787-10 Trent RTOW*	436,700	436,700	436,700	436,700	436,700	436,700
787-10 Trent TOW*	406,290	424,377	431,568	430,052	436,700	436,700

* Units in lbs

operator's items that make the aircraft ready for service. Galley structures, monuments and seats are the elements that generate most weight differences.

A standard OEW is estimated, taking into consideration the typical weights of the operator's items *(see table, page 24)*.

The aircraft's maximum structural payload can be divided between maximum passenger payload and the remaining cargo payload. The remaining gross cargo payload is the difference between maximum allowable payload and passenger payload. The maximum passenger and remaining payloads are illustrated in the specification table *(see table, page 24)*.

The weight of ULDs and pallets for carrying baggage, and freight in the underfloor section has to be deducted to calculate the remaining net payload that can be carried as freight on each mission.

A mix of LD-3 containers and pallets was used for the cargo calculations. All passenger luggage was carried on LD-3 containers. A figure of 231lbs per passenger and their baggage was used to calculate the passenger payload. This figure includes an average passenger weight, irrespective of gender or age. The baggage allowance is an average of 1.2 bags per passenger, stowed as 35 bags per ULD-3 in the cargo hold. With the passenger capacity of each type, the number of LD-3s required for baggage could then be determined. The remaining belly space for cargo can be carried on standard 96- X 125-inch pallets. Tare weights of 187lbs per LD-3 and 285lbs per pallet were used.

All of the 787 variants have a similar split between passenger and belly freight payload. About 53% is passenger payload, and the remaining 47% is available for cargo.

787-8

The relevant specifications for the smallest member of the 787 family, the 787-8 is analysed with two options: the Rolls-Royce Trent 1000-J and the General Electric GEnx-1B-70 engines *(see table, page 24)*.

These engines have a maximum take-off thrust of 78,129lbs and 69,800lbs respectively. The 787-8 has an MTOW of 502,500lbs, an estimated OEW of 264,500lbs (the GE engines are a couple hundred pounds heavier), and a fuel capacity of 33,340USG.

The 787's Aircraft Characteristics for Airport Planning (ACAP) documentation, show that the 787-8 fitted with Trent 1000 engines in an ISA environment, is capable of carrying a maximum passenger payload equivalent to 50,820lbs up to a range of 7,250nm *(see table, page 24)*. In a typical two-class configuration, the total seat count given by Boeing is 248, but the number across the installed fleet is lower with an average of 220 seats. When the aircraft is fitted with GEnx engines, the range reduces slightly to 7,099nm. The total payload for the 787-8 is 90,500lbs.

For 220 passengers, the 787-8 will use eight LD-3s for baggage. This leaves space in the belly for six 96-in X 125-in pallets. These ULDs and pallets have a collective tare weight of 3,206lbs *(see table, page 31)*.

787-9

The 787-9 fitted with GEnx-1B-75 engines has a maximum take-off thrust of 78,500lbs *(see table, page 24)*. The 787-9 has an MTOW of 560,000lbs, an estimated OEW of 284,000lbs, and a fuel capacity of 33,399USG.

The standard seat count is 296 passengers in a typical two-class configuration, but again the in-service fleet has an average of 266 seats. The total payload for the 787-9 is 116,000lbs *(see table, page 24)*.

The 787-9 fitted with GEnx engines is capable of carrying a maximum passenger payload of 61,445lbs, the equivalent of 266 passengers, up to 7,750nm *(see table, page 24)*. The range of the Trent-powered variant is shorter at 7,604nm.

The 787-9 will use nine LD-3s to carry baggage for 266 passengers. This leaves belly space for eight pallets. The nine LD-3s and eight pallets have a collective tare weight of 3,963lbs *(see table, page 31)*.

The 787-8 has the best performance of all the variants when the operating environment is limitating. It is capable of providing good economics in short-, medium and long-haul missions, despite its smaller seat capacity.

787-10

The 787-10 has an MTOW of 560,000lbs, an estimated OEW of 281,000lbs, and a fuel capacity of 33,399USG *(see table, page 24).*

Fitted with Rolls-Royce Trent 1000-J3 engines, the 787-10 has a maximum take-off thrust of 78,129lbs; fitted with General Electric GEnx-1B-76A engines it is 78,500lbs.

The 787-10 is offered in a typical two-class configuration of 336, a 36% higher seat count than the baseline 787-8. Most current operators have chosen the standard 337-seat configuration.

The 787-10 ACAP shows that under normal operations the aircraft is capable of a range of about 7,000nm with a full passenger payload of 336. Range is about 4,100nm with a full payload.

The 787-10 is capable of carrying a passenger payload of 77,847lbs, and a full payload of 143,900lbs *(see table, page 24).*

The 787-10 will use 12 LD-3s for baggage, leaving nine pallets for freight. These have a collective tare weight of 4,809lbs respectively *(see table, page 31).*

Comparison description

In all three main fuel burn analyses, the additional cost of navigation (‘country overflying airspace access cost’), also referred to as Air Traffic Control (ATC) user fees, is also calculated by the Lufthansa Systems’ LIDO/Flight 4D flightplanning solution.

The ESAD is used as the parameter for the distance flown, instead of the tracked great circle distance. The ESAD is the equivalent distance flown by an aircraft, taking into consideration the prevailing winds on the route and the flying altitude. Wind direction affects the aircraft’s ground speed.

Tailwinds, or their vector component, increase an aircraft’s groundspeed and allow it to operate a given distance in a shorter period of time. Conversely, headwinds increase flight times.

Similarly, a flight profile at a higher altitude takes longer than at a lower altitude due to the curvature of the earth. The ESAD is a more accurate input to calculate the actual fuel burn and performance on a particular flight.

The aircraft output in ASMs per flight is the product of the route ESAD and the available seat count on the route. The available seat count, or payload, is as permitted by each variant either operating up to the MTOW, or at a restricted take-off weight (RTOW), depending on the nature of the mission and the conditions at departure.

Assumptions

The analysis takes into consideration a two-class layout of passenger accommodation (LOPA) in line with the average 787 current in-service fleet. The average total seat count is 220 for the 787-8, 266 for the 787-9, and 337 for the 787-10 *(see table, page 24).*

As described, the total ASM output is calculated using the total seat count on non-restricted routes and the number of available seats on payload-restricted routes.

European Aviation Safety Agency (EASA) International Flight Rules (IFR) are used. These include fuel for a suitable alternate, and contingency fuel as 5% of trip fuel. The alternate airports for each route are listed *(see tables, page 26).* For the operation, a fixed-Mach long-range cruise (LRC) of Mach 0.85 is used on all routes, 0% aircraft performance degradation and 85% average winds en-route for June. The input also considers all-engine taxi operations and normal standard operating procedures.

As described, for take-off planning ISA conditions are assumed for LAX, and ISA+15 conditions for BOG.

Final reserve fuel is set as required to hold for 30 minutes at 1,500 feet above ground level. Taxi is with both engines operative. A taxi-out time of 22 minutes is used for LAX, and 19 minutes for BOG *(see tables, page 26).* These times are the typical average for runways 25R and 31L at LAX and BOG. The taxi-in times for each arrival point are also listed *(see tables, page 26).* These taxi times are taken from the Lido database, adding 2,300-2,600lbs of fuel per trip to allow for auxiliary power unit (APU) and taxi out and in fuel consumptions. The associated taxi fuel burns are included in the final results as trip fuel plus taxi fuel to produce block fuel *(see tables, pages 30, 31, 32 & 34).* The block time for each sector is the sum of the trip and taxi times.

This analysis assumes the aircraft is operated by a full-service carrier. The cost of fuel for flights departing from LAX is $1.60 per US Gallon (USG), and $1.58 USG for flights departing from BOG.

Operational parameters

The actual take-off weight (TOW) on a particular mission is the maximum zero fuel weight (MZFW) (OEW plus payload) plus the trip, taxi and reserve fuel. Operational purposes require a maximum taxi weight (MTXW) to be incorporated in the mission planning for aircraft taking off at MTOW, which will leave the gate at the higher MTXW to taxi to the runway. The 787-8’s MTXW is 1,000lbs heavier than the MTOW, while the 787-9’s and 787-10’s MTXW is 1,500lbs heavier than the MTOW.

Performance at LAX

The difference between MTXW and MTOW will be some or all of the fuel burned during taxi out. In fact, the taxi out fuel at LAX for some 787 variants is 130-630lbs more than the difference between MTXW and MTOW. In these

The 787-9 provides operators with the flexibility to be deployed in a variety of medium-, long-haul and ultra-long-haul missions. It has the right seat capacity to generate good economics per ASM, and has good operating performance when operated in restricted environments.

circumstances, the maximum allowable take-off weight (MALTOW) is 130-630lbs lower than MTOW. This is because of the need to not exceed MTXW at pushback.

The 787 variants have no significant restriction on routes departing from LAX. Flights operated by the 787-8 at MTOW from LAX require a take-off field length of 8,780ft, the 787-9 take-off field length from LAX is 8,820ft, and the 787-10 take-off field length from LAX is 9,400ft.

The 787-8's ability to carry a full passenger payload up to 7,250nm affect its performance on the two longest routes to SGN and BKK. These have ESADs of 7,853nm and 8,086nm. The aircraft departs with a full passenger payload on the five shorter routes at a take-off weight that is on average 24,681lbs lower than its MTOW.

The 787-9 departs LAX virtually at MTOW on the sector to BKK. The aircraft departs with a full passenger payload at less than MTOW on the other six shorter routes, at an average take-off weight that is 38,700lbs lower than MTOW.

The 787-10 departs LAX at MTOW on the route to HKG. The aircraft departs with a full passenger payload on the other four shorter routes at a take-off weight that is on average 23,700lbs lower than its MTOW. On the longer routes to SGN and BKK, the 787-10 is too restricted in terms of its passenger payload and with no cargo, thus the reduced TOW on the longer sectors.

On short missions and unrestricted airfields, the aircraft can usually depart at MTOW or a lower weight.

Performance at BOG

There are several conditions which, on their own or in combination, can restrict the aircraft's take-off weight to less than MTOW; referred to as a RTOW. These conditions include limited runway length, high airfield elevation, high ambient temperature, and obstacles in the departure routeing.

The three variants have an operational MTOW penalty on the routes originating from BOG because the low air density results in the aircraft taking a longer distance to reach rotation speed. There is also a restriction on the maximum tyre speed that cannot be exceeded, this is one of the reasons the take-off field length is longer for all the 787 variants in BOG than in LAX.

Finally, the high relative humidity in BOG reduces the performance on the engines. The higher thrust-to-weight ratio on the 787-8 Trent 1000-J variant gives the aircraft some advantage over the other 787 variants when faced with this restrictions. The 787-10, regardless of engine choice, is the aircraft that gets more penalised when operating from restricted airfields like BOG.

A large difference between MTOW and RTOW will mean the airline will have to accept a reduction in payload, translating into fewer seats available for sale and reduced cargo capacity, to complete a route without technical stops. The foregone revenue, and possible increased fuel consumption, will result in higher cost per seat-mile. The six routes from BOG *(see second table, page 26)*, have been chosen to examine the 787's performance in such conditions.

The take-off field required by the 787-8 at a lower RTOW from BOG is 11,800ft, the field length for the 787-9 is 10,290ft, and 10,490ft for the 787-10.

The simulated flight plans for the six

FUEL BURN & OPERATING PERFORMANCE WITH PASSENGER PAYLOAD OF THE 787-8, 787-9 & 787-10 FROM LAX

City-pair	Aircraft variant	Engine variant	Seats	Passenger payload lbs	ESAD nm	ASMs	Block time Hours	Block fuel USG	Fuel burn /ASM	ATC cost $	Fuel & ATC c/ASM
LAX-NRT	787-8	GENX-1B-70	220	50,820	5,417	1,191,740	11:07	18,790	0.0158	786	2.59
	787-8	TRENT 1000-J	220	50,820	5,417	1,191,740	11:44	18,534	0.0156	786	2.56
	787-9	GENX-1B-76	266	61,446	5,417	1,440,922	11:42	19,805	0.0137	827	2.26
	787-9	TRENT-1000-J	266	61,446	5,417	1,440,922	11:47	20,301	0.0141	827	2.31
	787-10	GENX-1B-76A	337	77,847	5,417	1,825,529	11:43	20,605	0.0113	827	1.85
	787-10	TRENT 1000-J3	337	77,847	5,417	1,825,529	11:43	21,508	0.0115	827	1.89
LAX-PEK	787-8	GENX-1B-70	220	50,820	6,100	1,342,500	12:58	21,504	0.0160	5,069	2.94
	787-8	TRENT 1000-J	220	50,820	6,100	1,342,500	13:07	21,171	0.0158	5,069	2.90
	787-9	GENX-1B-76	266	61,446	6,100	1,622,600	13:02	22,550	0.0139	5,252	2.55
	787-9	TRENT-1000-J	266	61,446	6,100	1,622,600	13:06	23,119	0.0139	5,252	2.60
	787-10	GENX-1B-76A	337	77,847	6,100	2,055,700	13:03	23,474	0.0114	5,232	2.08
	787-10	TRENT 1000-J3	337	77,847	6,100	2,055,700	13:02	23,986	0.0117	5,232	2.12
LAX-ICN	787-8	GENX-1B-70	220	50,820	6,251	1,375,220	13:15	21,967	0.0160	1,370	2.66
	787-8	TRENT 1000-J	220	50,820	6,251	1,375,220	13:22	21,652	0.0157	1,370	2.62
	787-9	GENX-1B-76	266	61,446	6,251	1,662,766	13:21	23,120	0.0139	1,419	2.31
	787-9	TRENT-1000-J	266	61,446	6,251	1,662,766	13:25	23,708	0.0143	1,419	2.37
	787-10	GENX-1B-76A	337	77,847	6,251	2,106,587	13:21	24,608	0.0114	1,419	1.90
	787-10	TRENT 1000-J3	337	77,847	6,251	2,106,587	13:22	24,598	0.0117	1,419	1.94
LAX-PVG	787-8	GENX-1B-70	220	50,820	6,565	1,444,300	13:58	23,351	0.0162	2,155	2.74
	787-8	TRENT 1000-J	220	50,820	6,565	1,444,300	14:06	22,983	0.0159	2,155	2.70
	787-9	GENX-1B-76	266	61,446	6,565	1,746,290	14:02	24,498	0.0140	2,318	2,38
	787-9	TRENT-1000-J	266	61,446	6,565	1,746,290	14:07	25,137	0.0144	2,318	2,44
	787-10	GENX-1B-76A	337	77,847	6,565	2,212,405	14:04	25,509	0.0155	2,318	1.95
	787-10	TRENT 1000-J3	337	77,847	6,565	2,212,405	14:04	26,077	0.0158	2,318	1.99
LAX-HKG	787-8	GENX-1B-70	213	49,198	7,220	1,537,704	15:04	26,426	0.0172	447	2.78
	787-8	TRENT 1000-J	220	50,820	7,220	1,588,400	15:46	26,058	0.0164	447	2.65
	787-9	GENX-1B-76	266	61,446	7,220	1,920,520	14:02	27,658	0.0144	447	2,32
	787-9	TRENT-1000-J	266	61,446	7,220	1,920,520	14:07	28,292	0.0147	447	2,38
	787-10	GENX-1B-76A	337	77,847	7,220	2,361,221	14:04	28,516	0.0121	447	1.95
	787-10	TRENT 1000-J3	337	77,847	7,220	2,278,895	14:04	28,948	0.0127	447	2.05
LAX-SGN	787-8	GENX-1B-70	141	32,537	7,853	1,106,117	16:51	28,070	0.0254	1,196	4.17
	787-8	TRENT 1000-J	152	35,208	7,853	1,196,920	16:55	27,758	0.0232	1,196	3.81
	787-9	GENX-1B-76	211	48,839	7,853	1,660,315	16:37	29,795	0.0179	1,231	2.95
	787-9	TRENT-1000-J	174	40,225	7,853	1,367,446	16:47	29,850	0.0218	1,231	3.58
	787-10	GENX-1B-76A	206	47,648	7,853	1,619,826	16:44	29,758	0.0184	1,231	3.02
	787-10	TRENT 1000-J3	178	41,073	7,853	1,396,304	16:43	29,796	0.0213	1,231	3.50
LAX-BKK	787-8	GENX-1B-70	146	33,809	8,086	1,183,461	17:20	28,816	0.0243	1,196	4.08
	787-8	TRENT 1000-J	156	35,989	8,086	1,259,771	17:25	28,510	0.0226	2,191	3.80
	787-9	GENX-1B-76	227	52,406	8,086	1,834,507	17:06	30,758	0.0168	2,191	2.81
	787-9	TRENT-1000-J	183	42,385	8,086	1,483,658	17:04	30,781	0.0207	2,279	3.47
	787-10	GENX-1B-76A	227	52,552	8,086	1,839,547	17,11	30,734	0.0167	2,279	2.80
	787-10	TRENT 1000-J3	190	43,936	8,086	1,537,950	17:11	30,767	0.0200	2,279	3.35

Source: Lufthansa Systems' Lido/Flight

Notes: Lufthansa Systems provided block fuel figures in lbs. These have been converted to USG using 1 USG = 6.55lbs.

787 variants do in fact have RTOWs for the aircraft when departing BOG on these routes. These RTOWs are specified *(see second table, page 26)*. The RTOWS are higher for the Trent-powered -8s, while the GEnx-powered -9s and -10s have a higher RTOW.

The actual required take-off weight for the two 787-8 variants to complete the missions are lower than the RTOW on all six routes, except for one case, and so the aircraft does not suffer any performance degradation.

The GEnx-powered 787-8 has an actual take-off weight the same as the RTOW on the BOG-MAD route. The aircraft thus suffers a payload limitation to complete the mission.

The 787-9 and -10 also have actual required take-off weights lower than the RTOWs on the first four routes, and so do not suffer any performance degradation or payload limitation. All four -9 and -10 variants do, however, have actual take-off weight limited by RTOW on the SEA and MAD routes, and they suffer a degradation in permitted payload as a result.

Route profile

Lufthansa Systems' Lido/Flight 4D is a Flight Planning package that optimises the climb, cruise and descent segments of a flight. This is based on performance specifications (data files) of the particular airframe-engine combinations, as received from the aircraft original equipment manufacturers (OEMs), and specific operating philosophies (flight level caps, performance degradation factors, and amended performance buffers) as requested by its customers.

FUEL BURN & OPERATING PERFORMANCE WITH FULL PAYLOAD OF THE 787-8, 787-9 & 787-10 FROM LAX

City-pair	Aircraft variant	Engine variant	Total payload lbs	Passenger payload lbs	Gross cargo lbs	No. of pallets	Pallet tare lbs	Net cargo lbs	Block fuel USG	Extra fuel USG	Cost extra fuel - $	Fuel cost cents per lb
LAX-NRT	787-8	GENX-1B-70	86,734	50,820	35,914	6	3,206	32,708	20,985	2,195	3,512	10.27
	787-8	TRENT 1000-J	89,052	50,820	38,232	6	3,206	35,026	20,715	2,181	3,490	9.56
	787-9	GENX-1B-76	113,588	61,446	52,142	8	3,963	48,179	22,602	2,797	4,475	8.98
	787-9	TRENT-1000-J	110,852	61,446	49,406	8	3,963	45,443	23,017	2,716	4,346	9.22
	787-10	GENX-1B-76A	115,998	77,847	38,141	9	4,809	33,332	22,649	2,044	3,271	9.19
	787-10	TRENT 1000-J3	113,913	77,847	36,066	9	4,809	31,257	22,986	1,478	2,365	8.27
LAX-PEK	787-8	GENX-1B-70	72,507	50,820	21,687	6	3,206	18,481	23,036	1,532	2,451	12.27
	787-8	TRENT 1000-J	74,954	50,820	24,134	6	3,206	20,928	22,738	1,567	2,508	11.18
	787-9	GENX-1B-76	98,268	61,446	36,822	8	3,963	32,859	24,813	2,263	3,621	10.48
	787-9	TRENT-1000-J	95,303	61,446	33,857	8	3,963	29,894	25,259	2,140	3,423	10.84
	787-10	GENX-1B-76A	100,585	77,847	22,738	9	4,809	17,929	24,870	1,396	2,234	11.07
	787-10	TRENT 1000-J3	98,127	77,847	20,280	9	4,809	15,471	25,249	1,263	2,021	11.41
LAX-ICN	787-8	GENX-1B-70	72,384	50,820	21,564	6	3,206	18,358	23,456	1,489	2,382	12.00
	787-8	TRENT 1000-J	72,384	50,820	21,564	6	3,206	18,358	23,168	1,516	2,426	12.22
	787-9	GENX-1B-76	95,544	61,446	34,098	8	3,963	30,135	25,279	2,159	3,454	10.86
	787-9	TRENT-1000-J	92,369	61,446	30,923	8	3,963	26,960	25,749	2,041	3,266	11.40
	787-10	GENX-1B-76A	97,756	77,847	19,909	9	4,809	15,100	25,352	744	1,191	6.87
	787-10	TRENT 1000-J3	95,371	77,847	17,524	9	4,809	12,175	25,736	1,138	1,820	12.17
LAX-PVG	787-8	GENX-1B-70	63,996	50,820	13,176	6	3,206	9,970	24,446	1,095	1,752	15.28
	787-8	TRENT 1000-J	66,212	50,820	15,392	6	3,206	12,186	24,154	1,171	1,874	13.69
	787-9	GENX-1B-76	88,851	61,446	27,405	8	3,963	23,442	26,364	1,866	2,986	11.88
	787-9	TRENT-1000-J	85,694	61,446	24,248	8	3,963	20,285	26,843	1,706	2,730	12.43
	787-10	GENX-1B-76A	91,111	77,847	13,264	9	4,809	8,455	26,431	922	1,476	13.79
	787-10	TRENT 1000-J3	88,631	77,847	10,784	9	4,809	5,975	26,828	751	1,202	14.62

Source: Lufthansa Systems' Lido/Flight

Notes: Lufthansa Systems provided block fuel figures in lbs. These have been converted to USG using 1 USG = 6.55lbs.

If not creating an optimised route itself, once a route has been decided, Lido/Flight will plan an optimum vertical profile based on parameters applicable to the aircraft and its operator. This is to achieve an overall lowest total cost solution for the planned flight by balancing cost of fuel burn, time-related costs and airspace access costs. It has the capacity to optimise routes with regard to fuel consumption, costs or flying time. The minimum cost track (MCT) is based on the optimum routeing for each of the 787 variants, taking into account fuel, airspace access and operational time costs.

Due to the airfields selected, climb and descent profiles in the analysis differ between aircraft variants.

Full pax payload from LAX

All six variants of the 787 family are capable of completing the first five routes from LAX with a full passenger payload *(see table, page 30)*. The number of seats available is marginally restricted on the LAX-HKG sector for the GEnx 1-7B-70-engined 787-8 to 213; a loss of seven passengers. The Trent 1000-J-powered 787-8, which has a higher payload on this route, can still operate with a full passenger payload.

Available seats are restricted on all other routes departing LAX for sectors longer than 7,220nm for the six variants analysed.

The LAX-SGN route sees limited passenger loads of 141 and 152 for the 787-8. The 787-9 fitted with GEnx 1B-75 loses 55 passengers route, while the Trent-powered aircraft is hit by a loss of 92 passengers down to 174.

The 787-10 gets a restriction of 130 seats if configured with GEnx-1-B76 engines, and a 147 loss for the Trent 1000-J6-powered aircraft.

The BKK route also presents significant restrictions in the number of available seats that can be operated. The 787-9 fitted with the GEnx 1B-75 only gets a 33 passenger reduction, while the Trent-powered aircraft suffers more *(see table, page 30)*. The 787-10 is again the most penalised aircraft, with a 43.6% reduction in available seats when powered by Trent 1000-J3 engines. This clearly indicates the economic range limit for this family of aircraft.

The fuel burn performance is more consistent per ASM, and it is the regional variations in navigation and ATC costs that result in vary costs between routes.

In terms of the cost per ASM for fuel and navigation costs, the 787-10 with GEnx 1-B-76A leads on all five routes from LAX up to HKG. It has unrestricted passenger numbers in all cases. The variant, with both engine types, operates with a cost per ASM of 1.90-2.12 cents per ASM on all five routes. This illustrates a consistent performance between 5,400-7,200nm.

The 787-8, as expected, has the highest cost performance per ASM across the five shortest routes, those within its range performance. This is 2.55-2.95 cents per ASM. This is consistently 0.30-0.40 cents per ASM higher than the 787-9 *(see table, page 30)*.

The 787-9 has a consistent cost per ASM performance of 2.26-2.60 cents per ASM over the five routes. This is 0.40-0.50 cents per ASM higher than the 787-10.

On the payload-restricted SGN and BKK routes from LAX, the 787-9 GEnx 1-7B-65 variant is the most efficient member of the family, although it has an elevated cost per ASM of 3.0-4.0 cents because of the limited payload.

In terms of block fuel, the 787-8 with Trent 1000-J engines has the best performance on all the routes from LAX, with a total fuel burn advantage of 6.01% over the 787-9.

The 787-10 Trent 1000-J6 aircraft also has the highest trip fuel burn with an average of 26,471 USG, compared with

FUEL BURN & OPERATING PERFORMANCE WITH PASSENGER PAYLOAD OF THE 787-8, 787-9 & 787-10 FROM BOG

City-pair	Aircraft variant	Engine variant	Seats	Passenger payload lbs	ESAD nm	ASMs	Block time Hours	Block fuel USG	Fuel burn /ASM	ATC cost $	Fuel & ATC c/ASM
BOG-MIA	787-8	GENX-1B-70	220	50,820	1,429	314,380	03:46	5,023	0.0160	588	2.71
	787-8	TRENT 1000-J	220	50,820	1,429	314,380	03:51	4,945	0.0157	588	2.68
	787-9	GENX-1B-76	266	61,446	1,429	380.114	03:44	5,250	0.0138	588	2.34
	787-9	TRENT-1000-J	266	61,446	1,429	380,114	03:49	5,355	0.0141	588	2.38
	787-10	GENX-1B-76A	337	77,847	1,429	481,573	03:44	5,444	0.0113	588	1.91
	787-10	TRENT 1000-J3	337	77,848	1,429	481,573	03:43	5,591	0.0116	588	1.96
BOG-JFK	787-8	GENX-1B-70	220	50,820	2,381	574,640	05:11	8,045	0.0154	400	2.51
	787-8	TRENT 1000-J	220	50,820	2,381	574,640	05:58	7,941	0.0152	400	2.47
	787-9	GENX-1B-76	266	61,446	2,381	633,346	05:50	8,414	0.0133	455	2.17
	787-9	TRENT-1000-J	266	61,446	2,381	633,346	05:57	8,604	0.0136	455	2.22
	787-10	GENX-1B-76A	337	77,847	2,381	802,397	05:50	8,728	0.0109	455	1.76
	787-10	TRENT 1000-J3	337	77,847	2,381	802,397	05:49	8,950	0.0112	455	1.82
BOG-ORD	787-8	GENX-1B-70	220	50,820	2,612	574,640	06:19	8,788	0.0153	588	2.52
	787-8	TRENT 1000-J	220	50,820	2,612	574,640	06:25	8,690	0.0151	588	2.49
	787-9	GENX-1B-76	266	61,446	2,612	694,792	06:16	9,205	0.0132	588	2.18
	787-9	TRENT-1000-J	266	61,446	2,612	694,792	06:22	9,425	0.0136	588	2.23
	787-10	GENX-1B-76A	337	77,847	2,612	880,244	06:16	9,547	0.0108	588	1.78
	787-10	TRENT 1000-J3	337	77,847	2,604	880,244	06:15	9,779	0.0111	588	1.82
BOG-YYZ	787-8	GENX-1B-70	220	50,820	2,604	572,880	06:09	8,678	0.0151	1,264	2.62
	787-8	TRENT 1000-J	220	50,820	2,604	572,880	06:15	8,553	0.0149	1,265	2.58
	787-9	GENX-1B-76	266	61,446	2,604	692,664	06:07	9,089	0.0131	1,265	2.26
	787-9	TRENT-1000-J	266	61,446	2,604	692,664	06:13	9,281	0.0134	1,265	2.30
	787-10	GENX-1B-76A	337	77,847	2,604	877,548	06:07	9,426	0.0107	1,265	1.84
	787-10	TRENT 1000-J3	337	77,847	2,604	877,548	06:05	9,649	0.0110	1,265	1.88
BOG-SEA	787-8	GENX-1B-70	220	50,820	3,849	846,780	08:10	12,901	0.0152	1,283	2.56
	787-8	TRENT 1000-J	220	50,820	3,849	846,780	08:42	12,713	0.0150	1,283	2.53
	787-9	GENX-1B-76	240	55,465	3,849	924,177	08:33	13,357	0.0145	1,364	2.43
	787-9	TRENT-1000-J	226	52,181	3,849	869,457	08:39	13,553	0.0156	1,364	2.62
	787-10	GENX-1B-76A	250	57,677	3,849	961,034	08:34	13,426	0.0140	1,364	2,35
	787-10	TRENT 1000-J3	236	54,402	3,849	906,464	08:33	13,632	0.0150	1,364	2,53
BOG-MAD	787-8	GENX-1B-70	174	40,293	4,604	803,069	10:15	15,306	0.0191	2,365	3.31
	787-8	TRENT 1000-J	220	50,820	4,604	1,012,880	10:21	15,530	0.0153	2,365	2.66
	787-9	GENX-1B-76	169	39,011	4,604	777,518	10:14	15,617	0.0201	2,522	3.50
	787-9	TRENT-1000-J	154	35,592	4,604	709,375	10:20	15,861	0.0224	2,522	3.89
	787-10	GENX-1B-76A	178	41,665	4,604	820,449	10:15	15,691	0.0191	2,522	3.33
	787-10	TRENT 1000-J3	164	37,789	4,604	753,163	10:15	15,920	0.0211	2,522	3.68

Source: Lufthansa Systems' Lido/Flight

Notes: Lufthansa Systems provided block fuel figures in lbs. These have been converted to USG using 1 USG = 6.55lbs.

23,809 USG against the 787-8 equipped with the Trent 1000-J, a 10% disadvantage.

In terms of block times the 787-8 GEnx 1-B-70 is consistently the fastest variant in trans-Pacific routes and its sibling, the 787-8 Trent 1000-J, tends to take 10-17 minutes longer to complete these sectors.

Shorter block times are important for operators that require faster turnaround in their networks. The GEnx powered 787-9 and 787-10 variants have the shortest block times in all the range of routes selected.

The operating performance of the 787 family starts decreasing on routes longer than 7,220nm. In theory, some of the longer routes from LAX could be operated with a full passenger payload according to the aircraft specifications issued by the OEM. However, the operating conditions of every route present unique challenges for the aircraft and the operator. The principle of the 'longer the route, the lower the cost per ASM' is not always applicable, even if the payload and range on a specific route are within the aircraft's published capabilities.

Full payload from LAX

This analysis has considered an operation with a full payload on the same seven routes from LAX. All six variants are capable of carrying extra cargo on the sectors to NRT, PEK, ICN and PVG which have an ESAD shorter than 6,600nm.

The average extra net cargo carried is 9,970-35,708lbs in the case of the 787-8, 20,285-48,170lbs in the case of the 787-9, and 5,975-33,322lbs in the case of the 787-10 *(see table, page 31)*.

The 787-9 is consistently able to carry more extra cargo payload than either the -8 or -10. This additional freight averages an extra 33%. It is also the only aircraft able to carry a reasonable amount of extra cargo on LAX-HKG. This is an average 12% extra payload with just an extra 2.71% fuel burn.

The 787-8 outperforms the 787-10 by a few thousand lbs.

The fuel required to carry this extra cargo payload is on average 7.18%

higher than when only carrying a maximum payload of passengers *(see table, page 31)*.

The cost of fuel to carry the extra cargo on the four trans-Pacific routes is $1,800-4,500, depending on the cargo load. The highest extra fuel cost is $4,475 on the 6,100nm LAX-NRT sector, for the 787-9 GEnx-1B-76 variant, when carrying 48,179lbs of net cargo.

The cost per lb for carrying extra belly freight, each aircraft's full payload, is 8.0-13.0 cents per lb *(see table, page 31)*. This has to be considered against net cargo rates received and other related costs.

The routes to SGN and BKK are fully restricted by the maximum passenger payload, and so it is not possible for the aircraft to carry extra cargo on these missions. The number of available seats is already restricted on these routes.

Full pax payload from BOG

All six variants of the 787 family have performance well within the range of the routes analysed from BOG. However, all the aircraft have to operate at RTOW, as previously described. The RTOWs for each variant on each of the six routes are listed *(see table, page 32)*.

Of the six aircraft analysed, the Trent 1000-J-powered 787-8 is the only variant that can operate all the routes assessed without any passenger number restrictions *(see table, page 32)*. It is therefore also able to carry a reasonable amount of cargo on the BOG-MAD route. Regardless of engine selection, the 787-9 and 787-10 are passenger payload restricted on the SEA and MAD routes *(see table, page 32)*.

The MIA, JFK, ORD and YYZ routes can be operated from BOG by all six 787 variants analysed with no passenger number restrictions.

On BOG-SEA, the GEnx-powered 787-9 loses 26 passengers, and the Trent 1000-powered 787-8 loses 40 passengers.

On the longest BOG-MAD route, the 787-9 with GEnx 1-7B-76 engines powerplant 97 passengers. The Trent-powered 787-9 variant loses 112 passengers.

The 787-10 also suffers a sever payload reduction. The GEnx-1B-76A variant loses159 passengers, and the Trent 1000-J3 variant suffers a loss of 173 passengers.

The performance of the 787-9 and 787-10 variants starts to be restricted on routes from BOG longer than 3,000-3200nm, with loss of passenger payload on the hot and high missions.

In terms of the cost per ASM for fuel and navigation costs, the 787-10 with GEnx 1-B-76A has the lower cost on the four unrestricted routes with an average cost of 1.827 cents per ASM. This performance is 0.40-0.45 cents per ASM lower than the 787-9, and 0.650.975 cents per ASM lower than the 787-8 *(see table, page 32)*. The 787-9's cost per ASM are 2.17-2.38 cents per ASM.

The 787-8 with GEnx 1-B-70 is the most expensive variant on the same four routes from BOG, with an average of 2.58 cents per ASM. Cost range across the routes is 2.26-2.71 cents per ASM.

The 787-8 powered by the Trent 1000-J on the same routes has an average cost of 2.47 cents, an advantage of 0.11 cents per ASM over the GEnx-powered variant.

The 787-8 Trent 1000-J aircraft is also the aircraft with the lowest total cost per ASM on the MAD route, at 2.66 cents per ASM, since all other 787 variants are restricted on the number of seats available.

Full payload from BOG

All six 787 variants are able to carry some additional payload on the four shortest routes from BOG *(see table, page 34)*.

The extra payload carried is 23,000-

FUEL BURN & OPERATING PERFORMANCE WITH FULL PAYLOAD OF THE 787-8, 787-9 & 787-10 FROM BOG

City-pair	Aircraft variant	Engine variant	Total payload lbs	Passenger payload lbs	Gross cargo lbs	No. of pallets	Pallet tare lbs	Net cargo lbs	Block fuel USG	Extra fuel USG	Cost extra fuel - $	Fuel cost cents per lb
BOG-MIA	787-8	GENX-1B-70	90,500	50,820	39,680	6	3,206	36,474	5,483	460	728	2.00
	787-8	TRENT 1000-J	90,500	50,820	39,680	6	3,206	36,474	5,404	459	726	1.99
	787-9	GENX-1B-76	105,616	61,446	44,170	8	3,963	40,207	5,745	495	784	1.95
	787-9	TRENT-1000-J	103,122	61,446	41,676	8	3,963	37,713	5,843	488	771	2.05
	787-10	GENX-1B-76A	108,061	77,847	30,214	9	4,809	25,405	5,790	346	548	2.16
	787-10	TRENT 1000-J3	105,688	77,847	27,841	9	4,809	23,032	5,886	295	466	2.02
BOG-JFK	787-8	GENX-1B-70	89,274	50,820	38,454	6	3,206	35,248	8,791	746	1,181	3.35
	787-8	TRENT 1000-J	90,500	50,820	39,680	6	3,206	36,474	8,695	754	1,193	3.27
	787-9	GENX-1B-76	89,068	61,446	27,622	8	3,963	23,659	8,944	530	838	3.54
	787-9	TRENT-1000-J	86,191	61,446	24,745	8	3,963	20,782	9,092	488	772	3.71
	787-10	GENX-1B-76A	91,467	77,847	13,620	9	4,809	8,811	8,995	266	421	4.78
	787-10	TRENT 1000-J3	88,584	77,847	10,737	9	4,809	5,928	9,159	209	331	5.58
BOG-ORD	787-8	GENX-1B-70	83,071	50,820	32,251	6	3,206	29,045	9,488	700	1,108	4.81
	787-8	TRENT 1000-J	90,500	50,820	39,680	6	3,206	36,474	9,529	840	1,328	3.64
	787-9	GENX-1B-76	82,764	61,446	21,318	8	3,963	17,355	9,658	453	716	4.13
	787-9	TRENT-1000-J	79,766	61,446	18,320	8	3,963	14,357	9,819	394	623	4.34
	787-10	GENX-1B-76A	85,129	77,847	7,280	9	4,809	2471	9,709	162	256	10.35
BOG-ORD	787-8	GENX-1B-70	84,411	50,820	33,591	6	3,206	30,385	9,398	721	1,140	3.75
	787-8	TRENT 1000-J	90,500	50,820	39,680	6	3,206	36,474	9,390	837	1,324	3.63
	787-9	GENX-1B-76	84,179	61,446	22,733	8	3,963	18,770	9,555	466	737	3.93
	787-9	TRENT-1000-J	81,215	61,446	19,769	8	3,963	15,806	9,703	422	667	4.22
	787-10	GENX-1B-76A	86,562	77,847	8,715	9	4,809	3,906	9,608	182	287	7.35
	787-10	TRENT 1000-J3	83,617	77,847	5,770	9	4,809	961	9,765	116	184	19.10

Source: Lufthansa Systems' Lido/Flight

Notes: Lufthansa Systems provided block fuel figures in lbs. These have been converted to USG using 1 USG = 6.55lbs.

25,000lbs for the 787-10 on the shortest route. The 787-8 is the next best performer, carrying 36,474lbs belly freight, and the 787-9 can carry the highest amount of 37,713-40,207lbs *(see table, this page)*. These payloads are relatively high, but the aircraft is still restricted due to the RTOW.

The incremental cost of carrying this extra payload translates to a rate of 2.0 cents per lb *(see table, this page)*.

The additional payload that can be carried remains relatively high and similar for all four routes in the case of the 787-8. It can still carry belly freight at a rate of 3.0-4.0 cents per lb.

The 787-10's performance declines only after a short distance, illustrating the effect of hot and high conditions on permitted take-off weights.

The 787-9 is able to carry some marginal amount of belly freight, and so may be considered to be economic by some carriers.

Summary

The set of routes from BOG is shorter than the trans-Pacific routes. The six 787 variants, however, have consistent costs across both sets of routes in the case of unrestricted payloads.

The performance and operating costs seem to be more or less constant for the 787 family on a variety of missions. For instance, LAX-NRT, a route with an ESAD range of 6,100nm, has an average cost per ASM of 2.92 cents on the 787-8. The average cost for the 787-8 on the shorter BOG-MIA route with an ESAD of 1,429nm is 2.70 cents.

The 787-9 has an average cost per ASM of 2.28 cents on the BOG-YYZ sector, and of 2.35 cents on the LAX-HKG sector. These routes have ESADs of 2,604nm and 7,220nm.

Similarly the 787-10 has an average cost per ASM of 1.80 cents on the BOG-JFK sector with an ESAD of 2,381nm. The variant has a cost per ASM of 1.92 cents on the LAX-ICN sector which has an ESAD of 6,251nm. This shows that in spite of being designed as a long-haul aircraft, the 787 family is a versatile asset that is able to offer good performance and economics in short-, medium- and long-haul missions.

In terms of fuel burn per ASM, three main variants have consistent performance across a range of sector lengths. In the case of the 787-8, the Trent-powered aircraft has an advantage over the GEnx-powered aircraft. This is less than 2%.

The GEnx provides the better fuel burn performance for the 787-9 and -10 variants. The Trent-powered aircraft's fuel burn is about 2.9 cents per ASM higher. The differential is smaller in the case of the 787-10.

The 787-8 is a capable aircraft for some particular missions. When it is powered by the Trent 1000-J it can operate with full passenger capacity, and still carry extra freight on missions where airfield restrictions affect the performance of the other variants of the 787 family.

The 787-9 is a versatile aircraft, and is more efficient with the GEnx-1B-76 engine. It has the longest range in the family, and it faces fewer payload restrictions on long-range missions departing from average airfields than the larger 787-10. It also encounters fewer limitations when it operates with maximum passenger payload and full payload from restricted airfields compared to the 787-10.

The 787-10 is ideally suited for routes with a high number of premium seats and medium to long distances operating from unrestricted airfields. These are typical transatlantic routes. It has the lowest cost per ASM of all the 787 variants, and also has the capacity to deliver the best operating performance on routes with high-density configurations on medium-haul sectors. AC