GE90 Growth fuel burn performance

The GE90 Growth engine exclusively powers the 777-200LR and -300ER, which are mainly used for long-haul and ultra long-haul operations. The fuel burn and operating performance of the aircraft with these engines is examined on routes between 3,500nm and 9,200nm.

The GE90 family of engines was developed specifically for Boeing's 777 family. The most powerful variant is the GE90-115B, which is the only powerplant available for the 777-300ER. There is also an option to fit this to the 777-200LR, although this aircraft and the 777-200F are normally equipped with the de-rated GE90-110B1.

The fuel burn performance of the GE90-110BL-, GE90-115B- and GE90-115BL-powered 777-200LR and 777-300ER are analysed here. Six sample routes, or city-pairs, of increasing distance from 3,500nm to 9,200nm have been selected. The 777-200LR and -300ER have been examined on four routes from 3,500nm to 6,045nm, and the 777-200LR has been analysed on two ultra-long-haul routes of 7,000nm and 9,000nm.

Aircraft analysed

The specifications of the aircraft analysed here are summarised *(see table, this page)*. A manufacturer's standard three-class configuration has been used to determine the maximum passenger payload.

The 777-200LR used for the shorter distance routes including Frankfurt (FRA) - New York (JFK) is equipped with GE90-110Bs. It has a maximum take-off weight (MTOW) of 766,800lbs and a fuel capacity of 48,533 US Gallons (USG) *(see table, this page)*. The passenger capacity for this aircraft is 301 seats.

The 777-300ER used here is equipped with GE90-115Bs. It has an MTOW of 775,000lbs and a fuel capacity of 48,533 USG *(see table, this page)*. The passenger capacity for this aircraft is 365 seats.

The 777-200LR variant used for the ultra-long-distance sectors of Hong Kong (HKG) to Toronto (YYZ), and Singapore (SIN) to JFK, is equipped with GE90-115BLs engines. It has an MTOW of 766,800lbs and a fuel capacity of 53,440 USG *(see table, this page)*. The passenger payload is 301 seats. However, this is more than typical airline configurations when using the aircraft on ultra-long-haul routes, since airlines will want to configure their aircraft to provide a greater level of comfort for these services. The flight plans conducted for the analysis, however, indicate the available payload that the aircraft is capable of carrying in both directions on each route. The weight for the passenger payload is deducted from the available payload that the aircraft can carry on the route in order to leave the available freight payload that could be carried *(see table, page 10)*.

777-200LR & 777-300ER CONFIGURATIONS

Aircraft Engine variant	777-200LR GE90-110B1/B	777-300ER GE90-115B
Engine thrust - lbs	110,100	115,300
Long-range cruise speed	Mach 0.84	Mach 0.84
Seats-tri-class:	301	365
Weights:		
MTOW-lbs	766,800	775,000
MLW-lbs	492,000	554,000
MZFW-lbs	461,000	524,000
OEW-lbs	320,000	370,000
Fuel capacity - USG	48,533/53,440	48,533
Belly freight containers	32 LD-3s	44 LD-3s

Routes analysed

The routes chosen for the analysis include a selection of existing long-haul city-pairs. They will demonstrate the fuel burn performance of the aircraft in terms of the total USG used, and the rate of USG used per available seat-mile (ASM).

Three of the first four city-pairs analysed originate in FRA and operate to JFK, Chicago O'Hare (ORD) and Los Angeles (LAX) *(see table, page 10)*. The fourth operates between SIN and London Heathrow (LHR). These four routes have a tracked distance of 3,501nm to 6,157nm. On these routes the performance of the 777-200LR equipped with GE90-110B1s will be compared with the 777-300ER equipped with GE90-115Bs *(see table, page 10)*.

For the 777-200LR equipped with the GE90-115BL, four longer-distance missions have been considered. These are the operations in each direction on the YYZ-HKG routes, with tracked distances of 7,293nm and 6,955nm; and the SIN-JFK routes, with tracked distances of 8,615nm and 9,187nm *(see table, page 10)*. The two operations on the SIN-JFK route are on the edge of the 777-200LR's payload-range performance.

The tracked distance between two points, provided by the flight plan, has been used in the analysis. Due to air traffic control (ATC) following airways and transatlantic tracks, extended range twin engine operations (ETOPS) requirements and departure and arrival routeings, aircraft cover a longer tracked distance than the great circle distance between the origin and destination.

The equivalent still air distance (ESAD) is also shown. This takes into account the affect of en-route winds so that subsequently the ESAD will be longer than the tracked distance when there is a headwind, and shorter when

The 777-200LR is utilised on some of the world's longest routes, which have tracked distances exceeding 8,000nm.

there is a tailwind. The ESAD indicates the effective distance that the aircraft has flown, and this is the figure that should be considered against the aircraft's payload-range curve.

Other assumptions for these flight plans include average temperatures from the month of June, 85% reliability winds, the use of International Flight Rules and standard assumptions relating to fuel reserves, diversion fuel and contingency fuel. The total additional fuel carried for diverting to an alternative airfield, holding prior to landing at the destination, and reserve fuel ranges from 3,382USG to 5,683USG for the flightplans performed.

Long-range-cruise (LRC) speed has been used for each mission. The 777-200LR's and -300ER's LRC is Mach 0.84, but the actual Mach number used varies throughout the flight according to operating conditions.

LRC allows the aircraft to achieve the most efficient fuel burn rate per ASM. Optimum routes and flight levels have been used where possible in the flight plans. A total taxi time of 30 minutes per flight has been assumed, making block time equivalent to flight time plus 30 minutes. Total fuel burn is calculated as the sum of taxi fuel burn and fuel burn during flight.

The great circle distance on the FRA-JFK sector is 3,350nm, while the tracked distance is 3,501nm *(see table, page 10)*. A headwind of 29-30 knots (kts) means that the ESAD for this route ranges from 3,727nm when flown by the 777-200LR, to 3,733nm when operated by the 777-300ER. There is little difference in the block time for the two aircraft, with the 777-200LR taking eight hours and 17 minutes (08:17) and the 777-300ER taking two minutes longer *(see table, page 10)*. Variances in block times between aircraft are caused by differences in climb, cruise and descent speeds.

On the FRA-ORD route the great circle distance is 3,774nm, while the tracked distance is 3,964nm. Due to headwinds of 19kts the ESAD for both aircraft is 4,127nm *(see table, page 10)*. The difference in block time is again minimal with the 777-200LR taking 09:05, and the larger 777-300ER taking 09:03.

A great circle distance of 5,045nm compares to a tracked distance of 5,279nm on the FRA-LAX route. Headwinds of 17kts lead to an ESAD of 5,473nm for the 777-200LR and 5,471nm for the 777-300ER. The 777-200LR again has the longer block time, taking 11:54 compared to the 11:48 achieved by the 777-300ER.

On the SIN-LHR route the great circle distance is 5,879nm and the tracked distance is 6,045nm. With a 9kt headwind the ESAD for both aircraft is 6,157nm. The difference in block time is extremely small with the 777-200LR taking 13:03 and the 777-300ER taking 13:02.

Where the extra-long-haul routes flown by the 777-200LR are concerned, YYZ-HKG has a great circle distance of 6,787nm and a tracked distance of 7,099nm. A headwind of 13kts contributes to an ESAD of 7,293nm and a block time of 15:14.

In the opposite direction, HKG-YYZ, the great circle distance remains the same but the tracked distance increases to 7,156nm. In this direction the aircraft benefits from a tailwind of 14kts reducing the ESAD to 6,955nm and the block time to 14:29.

On the SIN-JFK route the great circle distance is 8,288nm and the tracked distance 8,826nm. A tailwind of 12kts leads to an ESAD of 8,615nm and a block time of 17:43.

The opposite direction, JFK-SIN, has the same great circle distance but a longer tracked distance of 9,375nm. A tailwind of 10kts contributes to an ESAD of 9,187nm and a block time of 19:01; being the longest mission analysed.

Fuel burn performance

Total fuel burn (block fuel) and fuel burn per ASM are shown for each aircraft and engine combination, for each route *(see table, page 10)*. The block fuel used is dependent on aircraft weights and route distance. The longer the route, the greater the amount of block fuel used. A more accurate comparison of performance, therefore, can be drawn from the fuel burn per ASM.

Across the four city-pairs on which they are compared, the 777-300ER uses a greater amount of block fuel than the 777-200LR, but the -300ER has a slightly lower fuel burn per ASM. A significant contributing factor to this is that the

FUEL BURN PERFORMANCE OF THE GE90-110B/-115B-POWERED 777-200LR & 777-300ER

Route	Aircraft type	Engine model	Available payload (lbs)	Passenger payload (seats)	Available freight payload (lbs)	Tracked distance (nm)	ESAD (nm)	Wind (kts)	Block time (hr:min)	Block fuel (USG)	Fuel burn USG per seat-mile
FRA-JFK	777-200LR	GE90-110B	141,000	301	74,780	3,501	3,727	-29	8:17	18,754	0.0178
	777-300ER	GE90-115B	204,000	365	123,700	3,501	3,733	-30	8:15	21,850	0.0171
FRA-ORD	777-200LR	GE90-110B	141,000	301	74,780	3,964	4,127	-19	9:05	20,928	0.0175
	777-300ER	GE90-115B	204,000	365	123,700	3,964	4,127	-19	9:03	24,372	0.0168
FRA-LAX	777-200LR	GE90-110B	137,924	301	71,704	5,279	5,473	-17	11:54	29,193	0.0184
	777-300ER	GE90-115B	193,927	365	113,627	5,279	5,471	-17	11:48	33,392	0.0173
SIN-LHR	777-200LR	GE90-110B	140,171	301	73,951	6,045	6,157	-9	13:03	33,516	0.0184
	777-300ER	GE90-115B	173,478	365	93,178	6,045	6,157	-9	13:02	37,019	0.0168
YYZ-HKG	777-200LR	GE90-115BL	131,743	301	65,523	7,099	7,293	-13	15:14	40,706	0.0190
HKG-YYZ	777-200LR	GE90-115BL	141,000	301	74,780	7,156	6,955	14	14:54	38,431	0.0178
SIN-JFK	777-200LR	GE90-115BL	102,146	301	35,926	8,826	8,615	12	18:08	46,524	0.0175
JFK-SIN	777-200LR	GE90-115BL	68,021	301	1,801	9,375	9,187	10	19:21	47,756	0.0169

Source: Navtech

larger aircraft has the capacity for 64 additional passengers. The larger 777-300ER also has a greater available freight payload across all four routes. This freight payload is calculated by subtracting the weight of the passengers from the total available payload. The total available payload is defined by the aircraft's performance limitations within the mission criteria.

On the FRA-JFK route the 777-300ER burns 0.0171 USG per ASM in comparison to a 0.0178 burn per ASM on the 777-200LR. The larger aircraft has the ability to carry an additional 48,920lbs of freight than the 777-200LR. This represents an additional 65% of freight payload.

On the FRA-ORD route the 777-300ER has a fuel burn per ASM of 0.0168 USG, in comparison to a burn rate of 0.0175 USG per ASM on the 777-200LR. The difference in available freight payload is identical to the FRA-JFK route. The larger aircraft is again able to carry an extra 48,920lbs or 65% more of freight payload.

The FRA-LAX route saw the 777-300ER use 0.0173 USG per ASM, compared to a 0.0184 USG burn per seat mile on the 777-200LR. The disparity in available freight payload was 41,923lbs in favour of the larger aircraft. This represents an additional 58% of freight payload.

On the SIN-LHR route the 777-300ER has a fuel burn per ASM of 0.0168 USG. This compares to a burn of 0.0184 USG per ASM on the 777-200LR, and represents the biggest disparity in performance between the two types on the routes analysed. The difference in available freight payload between the two aircraft is reduced to 19,227lbs in favour of the 777-300ER on this longest route. This represents 26% of additional freight payload, the smallest difference across the routes compared.

The 777-300ER's fuel burn per ASM ranged from a minimum of 0.0168 USG on the FRA-ORD and SIN-LHR routes to a maximum of 0.0173 USG on the FRA-LAX city pair. This compared with a minimum burn of 0.0175 USG per ASM by the 777-200LR and a maximum of 0.0184 on the FRA-LAX and SIN-LHR routes.

As route length increased, the difference in fuel burn per ASM grew in favour of the 777-300ER, due in part to its additional capacity. Despite consistently offering a greater potential, the -300ER's available freight payload reduced as route length increased.

On the ultra-long-haul routes the 777-200LR is analysed alone. On the YYZ-HKG route the aircraft burns 0.0190 USG per ASM and has an available freight payload of 65,523lbs. In the HKG-YYZ direction, with a slight increase in tracked distance, but with the benefit of a tailwind, the aircraft burned 0.0178 USG per ASM, with an increased available freight payload of 74,780lbs.

On the longest SIN-JFK sector the 777-200LR's burn per ASM improved again to 0.0175 USG, but there is a significant reduction in available freight payload with only 35,926lbs available.

In the opposite JFK-SIN direction, the longest of all tracked distances and ESADs analysed, the fuel burn per ASM improves to 0.0169 USG, but the available freight payload is minimal. It shrinks to a mere 1,801lbs. This is hardly surprising given that the aircraft is operating at the edge of its payload-range profile.

In general as the route length increased, the 777-200LR equipped with GE90-115BLs and a full passenger payload saw improved performance in terms of fuel burn per ASM. This would be expected, unless the aircraft was only able to carry a restricted number of passengers on the longer routes, in which case the burn per ASM would be higher. The available freight payload decreased to the extent that on the JFK-SIN route there was little in the way of potential commercial freight capacity. AC