737NG family & CFM56-7B specifications, fleet & developments

There are four main variants of the 737NG family. These are powered by six variants of the CFM56-7B. The main specifications of the aircraft and engine variants, the production line and fleet, product developments, and main product features and performance characteristics are examined here.

The next generation (NG) 737 family was launched in 1993 as a complete new family to replace the earlier 737 Classics, with the first NG being delivered in 1997. The 737NG was developed in response to competition from the A320 family and customer calls for a more advanced aircraft. The NG family includes the -600, -700, -800 and -900 series of aircraft, which are all powered by the CFM56-7B engine series. The 737-600 is the smallest and the -900 is the largest series of 737s.

Fleet demographics

The 737NG is operated globally, with 3,225 in service. About one-third of the fleet is based in North America. The Asia Pacific and Europe account for 28% and 25% of the aircraft, while the Middle East operates just 2%. South America and Africa have small fleets.

Southwest Airlines is the largest operator, with its 343 aircraft accounting for more than 10% of the entire 737NG global fleet. Ryanair is the second largest operator, with 235 737-800s.

The next two largest fleets are with Continental Airlines (186) and American Airlines (119), followed by Gol Transportes Aereos (90), WestJet (88) and Alaska Airlines (83). Air China and Delta Air Lines both have 81 NGs, followed by China Southern airlines (73) and SAS (66). China Eastern Airlines and Turkish Airlines (THY) each have 54. The popularity of the 737NG is reflected in its operation by 240 airlines.

While the 737NG is in many ways a new design of aircraft, it has retained some levels of commonality with the Classic, including the flightdeck layout and the basic airframe design. Differences include the optional addition of winglets, advanced avionics, 30% increased fuel capacity and a new engine.

With the addition of more fuel capacity, winglets and more powerful engines, the NG fuselage was strengthened. In addition, the tail height was increased and the landing struts were lengthened to reduce the possibility of tailstrikes. The result is an aircraft that can deal more easily with hot-and-high airports, has a faster cruise speed of Mach 0.78 and a higher altitude of 41,000 feet. There is no flightdeck commonality with the earlier Classics.

Flightdeck

The 737NG flightdeck includes, as standard, six flat-panel liquid-crystal display (LCD) screens.

In 2002 Boeing introduced a demonstrator 737-900 to showcase nine advanced flightdeck technologies for the aircraft. These are marketed as an improved flightdeck experience in both operation and efficiency, as well as reducing noise and improving safety.

The 737NG was the first commercial aircraft to use military Head-up Display (HUD) technology, although this is still only available as an option. HUD is a glass display positioned at eye level that superimposes an image of the runway over the actual view out of the window during take-off and landing. It also shows critical information such as airspeed, altitude, attitude and flight path. HUD aims to reduce flight delays and cancellations by minimising the effect of poor visibility; it can allow take-off with as little as 300 feet of visibility, despite many regulating bodies requiring a minimum of 600 feet.

Landing can be improved by adding an Integrated Approach Navigation (IAN) system and a Global Positioning Landing System (GLS). IAN integrates 18 approach procedures into one common operational approach, while GLS accurately pinpoints an aircraft's position and enables airports to remain operational in adverse weather conditions.

In 2003, Virgin Blue became the first carrier to use Boeing's Vertical Situation Display (VSD) on its 737s. This display shows, graphically, an aircraft's position within its current and predicted flight path. The system is derived from ground proximity warning systems, and it enables a pilot to be more aware of ground terrain and possible runway overshoots. The use of VSD could mean a more efficient use of airspace in the future, allowing aircraft to fly closer together.

To this end, Boeing believes that its Navigation Performance Scales (NPS) could be able to tell a pilot their position to within 15 feet, by using global positioning technology to locate an aircraft accurately on a pilot's display.

The Quiet Climb System (QCS) reduces the effect that an aircraft's noise has on communities living close to an airport. Engine thrust is automatically reduced during take-off at sensitive airports to reduce pilot workload. The system could enable an airline to increase its payload while still remaining within airport noise limits. This will become more important as an increasing number of airports impose noise restrictions, especially at night.

Winglets

The 737NG's standard wings use advanced technology to ensure an improvement in fuel efficiency and an increase in fuel capacity, thereby increasing the aircraft's range. The wing area of the 737NG is 25% larger than the 737 Classic's, which equates to 30% more fuel volume, or a standard capacity of 6,875US Gallons (USG) on all the series, except the 737-900ER, which also has two auxiliary tanks.

As mentioned, the economy cruise speed is Mach 0.78, compared to Mach 0.74 for the 737 Classics.

The 737NG's performance is

737NG AND CFM56-7B SPECIFICATIONS TABLE

Aircraft Model	Engine options	Maximum take-off thrust lbs	MTOW lbs	MLW lbs	MZFW lbs	Max. fuel capacity USG	Typical seating 1 class	Typical seating 2 class	Max. range 2-class with winglets nm	Typical cruise speed (M)	Cargo volume -cu.ft.	Overall length ft.in.
737-600	CFM56-7B18E	18,400	124,000	120,500	113,500	6,875	132	110	1,310	0.785	720	102'6"
	CFM56-7B20	20,600	145,500			6,875	132	110	3,225	0.785	720	102'6"
	CFM56-7B22E	22,000	145,000	120,500	114,000	6,875	132	110	3,225	0.785	720	102'6"
737-700	CFM56-7B20E	19,700	133,000	128,000	120,500	6,875	149	126	1,580	0.781	966	110'4"
	CFM56-7B20	20,600	154,500			6,875	149	126	3,440	0.785	966	110'4"
	CFM56-7B26E	26,100	154,500	129,200	121,700	6,875	149	126	3,440	0.781	966	110'4"
737-700BBJ	CFM56-7B27E-B3	27,300	171,000	134,000	126,000	10,707 (9 aux. tanks)	8+	n/a	6,235 (1 class, & no aux. tanks)	0.79	169 (9 aux. tank)	110'4"
737-700C	CFM56-7B24E	23,700	154,500	134,000	126,000	6,875	140	126	2,725 (1 class)	0.78	966	110'4"
							-	-	1,775 (cargo)		3,750	
	CFM56-7B24	24,200	171,000			6,875	140	126	3,285 (1-class)	0.78	966	110'4"
	CFM56-7B26E	26,100	171,000	134,000	126,000	6,875		126	3,285 (1-class) 3,000 (cargo)	0.78	966 3,750	110'4"
737-700ER	CFM56-7B24E	23,700	154,500	129,200	121,000	6,875	48	76	3,975 (1 class, & no aux. tanks)	0.777	966	110'4"
	CFM56-7B26E	26,100	171,000	134,000	126,000	10,707 (9 aux. tanks)	48	76	5,775 (1-class & 9 aux. tanks)	0.78	183 (9 aux. tanks)	110'4"
	CFM56-7B27/B1	27,300	171,000			6,875-10,707 (depending on aux. tanks)	48	76	5,775 (1-class	0.78	165-966 (dependant on aux. tanks)	110'4"
737-800	CFM56-7B24	24,200	174,200			6,875	189	162	3,115	0.785	1,555	129'6"
	CFM56-7B24	23,700	155,500	144,000	136,000	6,875	189	162	1,995	0.789	1,555	129'6"
	CFM56-7B27/B1E	28,400	174,200	146,300	138,300	6,875	189	162	3,115	0.789	1,555	129'6"
737-800BBJ	CFM56-7B27E-B3	27,300	174,000	146,300	138,300	10,442 (9 aux. tanks)	8+	n/a	5,620 (1 class & 7 aux. tanks)	0.79	256+	129'6"
737-900ER	CFM56-7B26E	26,100	164,000	149,300	141,300	7,837 (2 aux. tanks)	215	180	1,850	0.79	1,827 (no aux. tanks)	138'2"
	CFM56-7B26/3	26,300	187,700			7,837 (2 aux. tanks)	215	180	3,265	0.78	1,585 (2 aux. tanks)	138'2"
	CFM56-7B27E/B1F	28,400	187,700	157,300	149,300	215 (2 aux. tanks)	180	3,265	0.79	1,585	138'2" (2 aux. tanks)	
737-900ERBBJ3	CFM56-27E-B3	27,300	187,700	157,300	149,300	10,966 (9 aux. tanks)	8+	n/a	5,495 (1 class & 8 aux tanks)	0.79	208+	138'2"

Evolution data source: Boeing

enhanced by the addition of blended winglets, which are extensions to the wings that reduce drag and increase lift. Winglets are now available as a production option on all 737NG variants, except the -600, or as a retrofit option through Aviation Partners Boeing (APB). The possibility of installing winglets on the -600 is currently being examined.

The specific improvements that winglets can offer are: improved climb gradient meaning and a standard take-off weight at hot-and-high, and noise-restricted or limited runways; reduced climb thrust, meaning an extension of engine life and reduction in maintenance costs due to engine de-rate; and reduced fuel burn of up to 4% on longer flights, after the additional weight of the winglets is taken into account. Lower fuel burn will reduce emissions and improve range. Since an aircraft fitted with winglets aircraft can reduce the thrust level it requires during the climb stage, it can also reduce its noise levels, thereby reducing many additional operational and financial restrictions.

Engines

All 737NGs are equipped with CFM56-7B engines. There are six thrust variants of the -7B series, rated at between 19,500lbs and 27,300lbs thrust.

The engine offers 180-minute extended-range twin-engine operations (ETOPs) and full authority digital electronic control (FADEC). The CFM56-7B is a high-bypass, two-shaft engine. It is based on the CFM56-3, but the -7B incorporates many of the developments seen on the CFM56-5A/B series, as well as improvements of its own *(see Operator's & Owner's Guide: CFM56-7B, Aircraft Commerce, June/July 2008, page 10)*.

There are also two main upgrade options available: the 'Tech Insertion' programme, launched in 2004; and the 'CFM56-7B Evolution' upgrade, announced in 2009.

The original CFM56-7B low-pressure shaft consists of a single-stage 61-inch diameter fan and a three-stage low pressure compressor (LPC). The number of fan blades on the -7B is reduced to 24, from 44 on the CFM56-3 series. The -7B's 3-D aero design, increased airflow and wide-chord fan blades, give it higher bypass ratios than the -3 and -5A/B series. The -7B's bypass ratios vary from 5.1, for the highest rated variant, to 5.5 for the lowest thrust rating. This compares to a bypass ratio of 4.9-5.0:1 ratio for the -3 series.

The fan is powered by a four-stage low pressure turbine (LPT).

The high pressure shaft of the original -7B consists of a nine-stage high-pressure compressor (HPC). The HPC has been further developed over the years and the -7B again benefits from 3-D aero design techniques to improve efficiency and aerodynamics. The HPC is powered by the single-stage high-pressure turbine (HPT). The -7B uses single crystal HPT blades.

As an option, the engine is available with a single (SAC) or double annular combustor (DAC). Engines with a DAC are denoted with a /2 suffix, but they have not been as popular as hoped. The DAC offers a reduction of as much as 40% of NOx emissions compared to the

737NG GLOBAL FLEET SUMMARY

Engine Model	Africa		Asia Pacific		Europe		Middle East		North America		South America		Model Total	Series Total
	Active	Parked	Active	Parked	Active	Parked	Active	Parked	Active	Parked	Active	Parked		
737-600	13		1		36				19				69	69
737-700	34		201	3	129	1	9		531	3	111		1,022	
737-700AEW&C			5			1							6	
737-700BBJ	4	1	12	1	11	4	18		27	4	8	1	91	
737-700C	1						2		20				23	
737-700ER			2										2	1,144
737-800	85		625	1	621	7	35		389	5	98		1,866	
737-800BBJ					2		9	1	1		2		15	
737-800P-8A									3	2			5	1,886
737-900			23		5				24				52	
737-900ER			39		2				30				71	
737-900ERBBJ							1		2				3	126
Geo sub-total	137	1	908	5	806	13	74	1	1,046	14	219	1	3,225	3,225

standard -7B combustor, due to a second combustion area used during high-thrust times.

The 'Tech Insertion' programme entered service on all new engines from 2007, and is also available as an upgrade kit for older engines.

It improves fuel burn by 1% and increases exhaust gas temperature (EGT) margins by 10 degrees, which in turn can increase time on-wing by up to 10%. Components of the HPT, LPT and SAC have been improved, while the HPC blades have been redesigned. Those engines that have the 'Tech Insertion' upgrades are denoted with a /3 suffix. 'Evolution' engines will be denoted with an 'E' at the end.

737-600

The 737-600 is the smallest of the NG family, and has the same fuselage length as the earlier -500 and -200 variants. The -600 has 110 seats in a standard US-style two-class configuration, and 132 in an all-economy configuration. This makes it a direct competitor to the A318 and a replacement for the 737-500.

Only 69 of these aircraft are operated by just nine airlines, accounting for just 2% of the fleet. Two large operators are SAS and WestJet. Others include Malev and Air Algerie. The oldest aircraft, still operated by SAS, is over 11 years old.

There are two engine model options for aircraft up to and including line number 447. These are the CFM56-7B20 and the -7B22. Aircraft from line number 510 and above are equipped with the CFM56-7B22.

Over 93% of the former have a maximum take-off weight (MTOW) of 127,500lbs, and are mainly located in Europe. The latter have an MTOW range of 127,500-145,000lbs, and all 19 North American -600s are this variant.

The fleet averages about 1.5 flight hours (FH) per flight cycle (FC). There is a difference in the daily utilisation of the two engine options. The lower-powered aircraft average nearly two hours less utilisation per day than the CFM56-7B22 equipped aircraft.

The range of this series is up to 3,225nm when equipped with winglets and in a two-class configuration.

737-700

The -700 series entered service in January 1998 with Southwest Airlines. It is still the largest operator of the 737NG fleet, and the -700 series in particular, with a total of 343 aircraft. The 737-700 was designed to replace the -300 and compete with the A319. The -700 is powered by two CFM56-7B variants and the standard fuel capacity remains at 6,875USG.

In total there are 1,144 -700s, with just over half of them (585) being operated in North America. Asia Pacific operates 20% of the fleet, Europe 13% and South America 10%.

After Southwest Airlines, the largest operator is WestJet with 64 aircraft, followed by airTran Airways (52), China Eastern Airlines (40), Continental Airlines (36) and Gol Transportes Aereos (29).

There are five models within the series: the standard -700, the -700C convertible version, the executive Boeing Business Jet (BBJ), the AEW&C, and the long range -700ER.

The standard 737-700 typically carries 126 passengers in a two-class configuration, or 149 all-economy seats. Most, 1,022, are the -700 model, with again over 50% being in North America. Operators generally operate the aircraft on flights of 1-3FH, with Southwest generating utilisation of more than 10FH per day. The MTOW varies from 133,000lbs to 154,500lbs. Newer aircraft are more likely to have a higher MTOW, while the thrust of the most powerful engine variant is rated at 26,300lbs.

Up to and including line number 2,465, the -700 is powered by a mixture of CFM56-7B20, -7B22, -7B24, -7B26 and -7B27 engines. Most aircraft are powered by the -7B22 and -7B24.

From line number 2,473, the engine variant selections include the -7B20, -7B22/3, -7B24/3 and -7B26/3. The standard -700 has a range of up to 3,440nm when fitted with winglets.

The 737-700C convertible can be converted from passenger to freighter configuration by removing the seats, although the sidewalls and overhead lockers remain. The wings have been strengthened and are identical to those on the executive BBJ. There is a new cargo handling system and 133.86 inches X 82.68 inches (3.4 x 2.1m) maindeck cargo door, which assists the aircraft in loading up to 40,000lbs (18,200kg) of cargo. In addition to the 966 cubic feet of belly space, the maindeck can accommodate 2,834 cubic feet of cargo. There are 23 examples. The -700C is powered by the -7B24, -7B22/3, -7B26 and -7B27/B1.

The MTOW is higher for the convertible example at 171,000lbs, with the maximum engine thrust also increased to 27,300lbs. In single-class passenger mode, the aircraft has 140 seats and a range of 3,285nm. In freighter mode, range is 3,000nm.

The 737-700ER has an increased MTOW of 171,000lbs: 16,500lbs more than the standard -700. The -700ER

The 737-700 is the second most popular variant of the 737NG family. There are more than 1,100 in service, and the majority of the aircraft are powered by CFM56-7B20 and -7B22 engines. Southwest Airlines operates the largest -700 fleet, with more than 340 aircraft.

utilises the -800's wings and landing gear. All Nippon Airways is the only operator, with two aircraft. They are powered by the -7B27/B1, and the aircraft has a range of 5,775nm when in a one-class configuration and with all auxiliary fuel tanks and winglets. The option for up to nine auxiliary fuel tanks gives a fuel capacity of 10,707USG. This model can seat up to 126 passengers in a two-class layout, or up to 48 with all-premium seating. It is capable of trans-oceanic flights.

737-800

The 737-800 entered service in April 1998 with Hapag-Lloyd of Germany. The variant was seen as a replacement for the 737-400 (although the -800 has a longer fuselage), as well as the MD-80/-90 and 727, and a competitor to the A320. It can carry up to 189 passengers in a one-class layout and up to 162 in a two-class configuration.

The -800 has two more fuselage plugs than the -700, and an extra pair of overwing exits. Additional differences include an increased engine thrust of up to 27,300lbs, with the -7B27, and a resized main landing gear and structure.

The 737NG winglets have been available as a retrofit to the -800 since May 2001. They improve fuel efficiency by up to 7%, and increase the range of the aircraft to 3,115nm when in a two-class configuration.

The 737-800's size has seen it become the most popular and the best-selling variant of the 737NG family, with 1,886 737-800s operating globally. Asia Pacific and Europe each operate 33% of the fleet, while North America has accounts for just 21%.

The -800's popularity is illustrated by the fact that only 16 aircraft are parked, meaning that over 99% are active. The largest operator is Ryanair, with 235, followed by American Airlines with 119 and Continental Airlines with 108. Other large operators include Delta Air Lines (71), Air China (67), Gol Transportes Aereos (61) and Alaska Airlines and Hainan Airlines (52 each). Nearly 90% of the 737-800 North American fleet is with just four operators, while nearly 40% of the European fleet is with only one.

There are three models currently in operation: the standard -800, the BBJ and the -800P-84. The most numerous is the standard -800 of which there are 1,866 aircraft. This accounts for 99% of the -800 series fleet, and 58% of the entire 737NG family.

This model is generally equipped with CFM56-7B26 engines up to and including line number 2,476. The exceptions are: 295 -7B27-powered aircraft, 140 aircraft powered by -7B24 engines, one -7B26/2-powered aircraft, 16 -7B26/3-equipped aircraft and 10 aircraft equipped with -7B27/3 engines. This group of aircraft, numbering just over 1,300, mostly have MTOWs of 172,500, with a range of 155,500lbs to 174,200lbs.

After line number 2,479, aircraft are generally equipped with the CFM56-7B26/3, although 130 aircraft are powered by the -7B24/3, and 71 aircraft have -7B27/3 engines. The later group of aircraft were all delivered from January 2008 onwards, and vary in MTOW from 147,688lbs to 174,163lbs. The lower MTOWs are more popular.

There are another 15 737-800BBJ executive aircraft and five -800P-8A military variants in operation.

737-900

The 737-900 has the longest fuselage barrel of all the NG family variants, being about eight-and-a-half feet longer than the -800.

There are two main sub-variants: the -900 and -900ER.

The standard -900 model could have been considered a competitor to the A321, but the -900 has the same fuel capacity, seat numbers and MTOW as the -800. The -900's limited seat capacity is because it has the same emergency exit configuration as the -800 series. The -900s are powered by the CFM56-7B24 and -7B26 engines, with most having MTOWs of 174,000lbs while a few are as low as 164,500lbs.

As a result of limited seat capacity, there are only 52 -900s in operation. Alaska Airlines was the launch customer for the aircraft in 2001, while the largest operator is Korean Air with 16 aircraft.

Due to poor sales the 737-900 was superseded in 2007 by the -900ER. This variant became a realistic competitor to the A321, while also filling a hole left by the 757-200. The overwing and Type I door exits were kept, but with the addition of two Type II exit doors, it was possible to increase the passenger capacity to a maximum of 215.

With the addition of two auxiliary fuel tanks and winglets, the range is increased to 3,265nm. The landing gear, wingbox and keel beam structure have been strengthened to accommodate the increased MTOW of up to 187,700lbs. In addition there is a two-position tail skid and a flat rear-pressure bulkhead, which makes space for additional passenger seats. All the -900ER aircraft have the blended winglet option as standard. The majority of the aircraft are equipped with CFM56-7B26/3 engines, while six aircraft are equipped with -7B27/3 engines.

There are 47 -900ERs in operation, with 42 operated by Continental and Lion Airlines.

There are an additional three variants of the BBJ version in operation.

In addition to the 3,225 aircraft in service, there are another 2,047 737Gs on firm order. The 737-800 alone will have more than 3,200 examples in operation, and the 737NG will be the most numerous commercial aircraft in service.

Orders

There are currently 2,047 737NGs due for delivery from April 2010. This figure consists of 495 -700s, 1,363 -800s and 189 -900s/-900ERs.

While North America currently has the largest NG fleet, the Asia Pacific has orders for 535 aircraft, 26 units more than North American operators have on order.

This coincides with a large growth in the regional market place for Asian operators, backed up by the increase in, and growth of, low-cost carriers (LCCs). Lion Airlines of Indonesia, for example, has ordered 148 more aircraft to add to its current 36, and Virgin Blue is adding 60.

Of the 495 -700s on order, 473 are for the -700 aircraft, 18 are BBJs, and four are military convertible -700s. The largest customer is currently Southwest, with 87 aircraft due to be delivered by 2017.

Of the 1,363 737-800 aircraft on order, 1,359 are standard -800 models. Most of those that have been ordered are destined for Europe and the Asia Pacific. The largest orders are with Ryanair (104), Virgin Blue Airlines (60), and Air Berlin (51), which also operates 20 737-700s.

Of the 189 737-900s that are on order, 185 of them are -900ERs. There are 152 destined for the Asia Pacific and 22 going to Europe, while the remainder are going to Africa and North America. The biggest order is from Lion Airlines, which has ordered a total of 148 -900ERs.

As well as by airlines, large orders have also been placed by lessors, and many still have a number of aircraft outstanding. Aviation Capital Group has orders for 63, DAE Capital has a backlog of 70, while GECAS is awaiting 66 aircraft.

Developments

There have also been several additions to the 737NG's design during its operation. As mentioned there have been improvements to the flightdeck with many avionic additions as well as the addition blended winglets.

Boeing is considering emerging technology, such as Enhanced Vision Systems (EVS) and Synthetic Vision Systems (SVS), to improve pilots' visibility at night and in bad weather.

In 2008 Delta Air Lines took delivery of a 737-700 with carbon brakes rather than steel. Boeing now offers carbon brakes on all 737NGs, and uses a new product from Messier-Bugatti, which reduces weight by as much as 700lbs.

Boeing acted on the needs of Gol Transportes Aereos, and developed a short-field performance package. With many of Gol's airports being restricted, the airline needed to find ways to improve the aircraft's take-off and landing performance. The package has been made available as an option on all NGs, and is also available as standard on the -900ER.

In April 2009 CFMI and Boeing stated that they would work to reduce fuel consumption by 2% by 2011. The reduction would be achieved through a combination of engine and airframe developments. The airframe will have structural improvements to reduce drag, which should result in a reduction in fuel consumption by 1%.

The engine will produce the other 1% through the 'CFM56-7B Evolution' upgrade. This will involve a reduction in parts, an improved engine cooling system and better aerodynamics on the HPT and LPT. The improvements are expected to provide operators with a 4% reduction in maintenance costs. CFMI has also commented that the expected 1% fuel reduction was shown to be better at 1.6% during tests in 2010. Tests of a twin annular premixing swirler combustor (TAPS), which was first used on the GE90, have been conducted on the CFM56-7B and show a further NOx reduction of at least 20% compared to DAC engines.

Further developments will see the 737 in operation for many more decades to come. One option could involve a re-engining, while another may involve a completely new design. This new design has provisionally been named Y1, and is unlikely to proceed until the 787 has been established in operation.

In the meantime the cabin interior has been updated, with deliveries to be expected from 2010. The new interior will borrow ideas from the 787 dreamliner, and include larger overhead lockers, the use of noise-dampening materials, and the replacement of most lights with LED lighting. This last change will reduce maintenance costs, as will the one-piece sidewalls. Passenger service units and attendant controls have also been updated with touch screen capability for crew and a more simplified layout to assist passengers. The launch airlines include FlyDubai, Continental Airlines, Norwegian Air Shuttle, TUI Travel (London), GOL Airlines and Lion Airlines. AC