

= Boeing 777 =

The Boeing 777 is a family of long @-@ range wide @-@ body twin @-@ engine jet airliners developed and manufactured by Boeing Commercial Airplanes . It is the world 's largest twinjet and has a typical seating capacity for 314 to 451 passengers , with a range of 5 @,@ 235 to 9 @,@ 500 nautical miles (9 @,@ 695 to 17 @,@ 594 km) . Commonly referred to as the " Triple Seven " , its distinguishing features include the largest @-@ diameter turbofan engines of any aircraft , six wheels on each main landing gear , fully circular fuselage cross @-@ section , and a blade @-@ shaped tail cone . Developed in consultation with eight major airlines , the 777 was designed to replace older wide @-@ body airliners and bridge the capacity difference between Boeing 's 767 and 747 . As Boeing 's first fly @-@ by @-@ wire airliner , it has computer @-@ mediated controls . It was also the first commercial aircraft to be designed entirely with computer @-@ aided design .

The 777 is produced in two fuselage lengths as of 2014 . The original 777 @-@ 200 variant entered commercial service in 1995 , followed by the extended @-@ range 777 @-@ 200ER in 1997 . The stretched 777 @-@ 300 , which is 33 @.@ 25 ft (10 @.@ 1 m) longer , followed in 1998 . The longer @-@ range 777 @-@ 300ER and 777 @-@ 200LR variants entered service in 2004 and 2006 respectively , while the 777F , a freighter version , debuted in February 2009 ; these variants all feature General Electric GE90 engines and extended raked wingtips . The earlier 777 @-@ 200 , -200ER and -300 versions are equipped with GE90 , Pratt & Whitney PW4000 , or Rolls @-@ Royce Trent 800 engines . The 777 @-@ 200LR is the world 's longest @-@ range airliner , able to fly more than halfway around the globe , and holds the record for the longest distance flown non @-@ stop by a commercial aircraft .

The 777 first entered commercial service with United Airlines on June 7 , 1995 . It has received more orders than any other wide @-@ body airliner ; as of June 2016 , 60 customers had placed orders for 1 @,@ 893 aircraft of all variants , with 1 @,@ 412 delivered . The most common and successful variant is the 777 @-@ 300ER with 660 delivered and 800 orders ; Emirates operates the largest 777 fleet , with 144 passenger and freighter aircraft as of July 2015 . The 777 has been involved in five hull losses as of October 2015 ; the Asiana Airlines Flight 214 accident in July 2013 was its first fatal crash in 18 years of service .

The 777 ranks as one of Boeing 's best @-@ selling models . Airlines have acquired the type as a comparatively fuel @-@ efficient alternative to other wide @-@ body jets and have increasingly deployed the aircraft on long @-@ haul transoceanic routes . Direct market competitors include the Airbus A330 @-@ 300 , newly launched Airbus A350 XWB , and the out @-@ of @-@ production A340 and McDonnell Douglas MD @-@ 11 . The 787 Dreamliner , which entered service in 2011 , shares design features with the 777 . In November 2013 , Boeing announced the development of upgraded 777 @-@ 8 and 777 @-@ 9 variants , collectively named 777X , featuring composite wings and GE9X engines and further technologies developed for the 787 . The 777X series is planned to enter service by 2020 .

= = Development = =

= = = Background = = =

In the early 1970s , the Boeing 747 , McDonnell Douglas DC @-@ 10 , and the Lockheed L @-@ 1011 TriStar became the first generation of wide @-@ body passenger airliners to enter service . In 1978 , Boeing unveiled three new models : the twin @-@ engine Boeing 757 to replace its venerable 727 , the twin @-@ engine 767 to challenge the Airbus A300 , and a trijet 777 concept to compete with the DC @-@ 10 and L @-@ 1011 . The mid @-@ size 757 and 767 launched to market success , due in part to 1980s extended @-@ range twin @-@ engine operational performance standards (ETOPS) regulations governing transoceanic twinjet operations . These regulations allowed twin @-@ engine airliners to make ocean crossings at up to three hours ' distance from emergency diversionary airports . Under ETOPS rules , airlines began operating the

767 on long @-@ distance overseas routes that did not require the capacity of larger airliners . The trijet 777 was later dropped , following marketing studies that favored the 757 and 767 variants . Boeing was left with a size and range gap in its product line between the 767 @-@ 300ER and the 747 @-@ 400 .

By the late 1980s , DC @-@ 10 and L @-@ 1011 models were approaching retirement age , prompting manufacturers to develop replacement designs . McDonnell Douglas was working on the MD @-@ 11 , a stretched and upgraded successor of the DC @-@ 10 , while Airbus was developing their A330 and A340 . In 1986 , Boeing unveiled proposals for an enlarged 767 , tentatively named 767 @-@ X , to target the replacement market for first @-@ generation wide @-@ bodies like the DC @-@ 10 , and to complement existing 767 and 747 models in the company lineup . The initial proposal featured a longer fuselage and larger wings than the existing 767 , along with winglets . Later plans expanded the fuselage cross @-@ section but retained the existing 767 flight deck , nose , and other elements .

Airline customers were unimpressed with the 767 @-@ X proposals , and instead wanted an even wider fuselage cross @-@ section , fully flexible interior configurations , short- to intercontinental @-@ range capability , and an operating cost lower than any 767 stretch . Airline planners ' requirements for larger aircraft had become increasingly specific , adding to the heightened competition among aircraft manufacturers . By 1988 , Boeing realized that the only answer was a new design , which became the 777 twinjet . The company opted for the twin @-@ engine configuration given past design successes , projected engine developments , and reduced @-@ cost benefits . On December 8 , 1989 , Boeing began issuing offers to airlines for the 777 .

= = = Design effort = = =

The design phase for the new twinjet was different from Boeing 's previous commercial jetliners . For the first time , eight major airlines ? All Nippon Airways , American Airlines , British Airways , Cathay Pacific , Delta Air Lines , Japan Airlines , Qantas , and United Airlines ? had a role in the development . This was a departure from industry practice , where manufacturers typically designed aircraft with minimal customer input . The eight airlines that contributed to the design process became known within Boeing as the " Working Together " group . At the first group meeting in January 1990 , a 23 @-@ page questionnaire was distributed to the airlines , asking what each wanted in the design . By March 1990 , Boeing and the airlines had decided upon a basic design configuration : a cabin cross @-@ section close to the 747 's , capacity up to 325 passengers , flexible interiors , a glass cockpit , fly @-@ by @-@ wire controls , and 10 percent better seat @-@ mile costs than the A330 and MD @-@ 11 . Boeing selected its Everett factory in Washington , home of 747 production , as the 777 's final assembly site .

On October 14 , 1990 , United Airlines became the 777 's launch customer when it placed an order for 34 Pratt & Whitney @-@ powered aircraft valued at US \$ 11 billion with options on an additional 34 . The development phase coincided with United 's replacement program for its aging DC @-@ 10s . United required that the new aircraft be capable of flying three different routes : Chicago to Hawaii , Chicago to Europe , and non @-@ stop from Denver , a hot and high airport , to Hawaii . ETOPS certification was also a priority for United , given the overwater portion of United 's Hawaii routes . In January 1993 , a team of United developers joined other airline teams and Boeing designers at the Everett factory . The 240 design teams , with up to 40 members each , addressed almost 1 @-@ 500 design issues with individual aircraft components . The fuselage diameter was increased to suit Cathay Pacific , the baseline model grew longer for All Nippon Airways , and British Airways ' input led to added built @-@ in testing and interior flexibility , along with higher operating weight options .

The 777 was the first commercial aircraft designed entirely by computer . Each design drawing was created on a three @-@ dimensional CAD software system known as CATIA , sourced from Dassault Systemes and IBM . This lets engineers assemble a virtual aircraft , in simulation , to check for interference and verify that the thousands of parts fit properly ? thus reducing costly rework . Boeing developed their own high @-@ performance visualization system , FlyThru , later called IVT

(Integrated Visualization Tool) to support large @-@ scale collaborative engineering design reviews , production illustrations , and other uses of the CAD data outside of engineering . Boeing was initially not convinced of CATIA 's abilities and built a physical mock @-@ up of the nose section to verify its results . The test was so successful that additional mock @-@ ups were canceled .

= = = Production and testing = = =

The production process included substantial international content , an unprecedented level of global subcontracting for a Boeing jetliner , later exceeded by the 787 . International contributors included Mitsubishi Heavy Industries and Kawasaki Heavy Industries (fuselage panels) , Fuji Heavy Industries , Ltd . (center wing section) , Hawker de Havilland (elevators) , and Aerospace Technologies of Australia (rudder) . An agreement between Boeing and the Japan Aircraft Development Corporation , representing Japanese aerospace contractors , made the latter risk @-@ sharing partners for 20 percent of the entire development program . The initial 777 @-@ 200 model was launched with propulsion options from three manufacturers , General Electric , Pratt & Whitney , and Rolls @-@ Royce , giving the airlines their choice of engines from competing firms . Each manufacturer agreed to develop an engine in the 77 @,@ 000 lbf (340 kN) and higher thrust class (a measure of jet engine output) for the world 's largest twinjet .

To accommodate production of its new airliner , Boeing doubled the size of the Everett factory at the cost of nearly US \$ 1 @.@ 5 billion to provide space for two new assembly lines . New production methodologies were developed , including a turn machine that could rotate fuselage subassemblies 180 degrees , giving workers access to upper body sections . Major assembly of the first aircraft began on January 4 , 1993 . By the start of production , the program had amassed 118 firm orders , with options for 95 more from 10 airlines . Total investment in the program was estimated at over US \$ 4 billion from Boeing , with an additional US \$ 2 billion from suppliers .

On April 9 , 1994 , the first 777 , line number WA001 , was rolled out in a series of 15 ceremonies held during the day to accommodate the 100 @,@ 000 invited guests . The first flight took place on June 12 , 1994 , under the command of chief test pilot John E. Cashman . This marked the start of an 11 @-@ month flight test program that was more extensive than testing for any previous Boeing model . Nine aircraft fitted with General Electric , Pratt & Whitney , and Rolls @-@ Royce engines were flight tested at locations ranging from the desert airfield at Edwards Air Force Base in California to frigid conditions in Alaska , mainly Fairbanks International Airport . To satisfy ETOPS requirements , eight 180 @-@ minute single @-@ engine test flights were performed . The first aircraft built was used by Boeing 's nondestructive testing campaign from 1994 to 1996 , and provided data for the -200ER and -300 programs . At the successful conclusion of flight testing , the 777 was awarded simultaneous airworthiness certification by the U.S. Federal Aviation Administration (FAA) and European Joint Aviation Authorities (JAA) on April 19 , 1995 .

= = = Entry into service = = =

Boeing delivered the first 777 to United Airlines on May 15 , 1995 . The FAA awarded 180 @-@ minute ETOPS clearance (" ETOPS @-@ 180 ") for the Pratt & Whitney PW4084 @-@ engined aircraft on May 30 , 1995 , making it the first airliner to carry an ETOPS @-@ 180 rating at its entry into service . The first commercial flight took place on June 7 , 1995 , from London Heathrow Airport to Dulles International Airport near Washington , D.C. Longer ETOPS clearance of 207 minutes was approved in October 1996 .

On November 12 , 1995 , Boeing delivered the first model with General Electric GE90 @-@ 77B engines to British Airways , which entered service five days later . Initial service was affected by gearbox bearing wear issues , which caused British Airways to temporarily withdraw its 777 fleet from transatlantic service in 1997 , returning to full service later that year ; General Electric subsequently announced engine upgrades .

The first Rolls @-@ Royce Trent 877 @-@ powered aircraft was delivered to Thai Airways

International on March 31 , 1996 , completing the introduction of the three powerplants initially developed for the airliner . Each engine @-@ aircraft combination had secured ETOPS @-@ 180 certification from the point of entry into service . By June 1997 , orders for the 777 numbered 323 from 25 airlines , including satisfied launch customers that had ordered additional aircraft . Operations performance data established the consistent capabilities of the twinjet over long @-@ haul transoceanic routes , leading to additional sales . By 1998 , the 777 fleet had approached 900 @,@ 000 flight hours . Boeing states that the 777 fleet has a dispatch reliability (rate of departure from the gate with no more than 15 minutes delay due to technical issues) above 99 percent .

= = = Initial derivatives = = =

After the original model , Boeing developed an increased gross weight variant of the 777 @-@ 200 with greater range and payload capability . Initially named 777 @-@ 200IGW , the 777 @-@ 200ER first flew on October 7 , 1996 , received FAA and JAA certification on January 17 , 1997 , and entered service with British Airways on February 9 , 1997 . Offering greater long @-@ haul performance , the variant became the most widely ordered version of the aircraft through the early 2000s . On April 2 , 1997 , a Malaysia Airlines -200ER named " Super Ranger " broke the great circle " distance without landing " record for an airliner by flying eastward from Boeing Field , Seattle to Kuala Lumpur , a distance of 10 @,@ 823 nautical miles (20 @,@ 044 km) , in 21 hours and 23 minutes .

Following the introduction of the -200ER , Boeing turned its attention to a stretched version of the airliner . On October 16 , 1997 , the 777 @-@ 300 made its first flight . At 242 @.@ 4 ft (73 @.@ 9 m) in length , the -300 became the longest airliner yet produced (until the A340 @-@ 600) , and had a 20 percent greater overall capacity than the standard length model . The -300 was awarded type certification simultaneously from the FAA and JAA on May 4 , 1998 , and entered service with launch customer Cathay Pacific on May 27 , 1998 .

From the program 's start , Boeing had considered building ultra @-@ long @-@ range variants . Early plans centered on a 777 @-@ 100X proposal , a shortened variant of the -200 with reduced weight and increased range , similar to the 747SP . However , the -100X would have carried fewer passengers than the -200 while having similar operating costs , leading to a higher cost per seat . By the late 1990s , design plans shifted to longer @-@ range versions of existing models . A more powerful engine in the 100 @,@ 000 lbf (440 kN) and higher thrust class was required , leading to talks between Boeing and engine manufacturers . General Electric offered to develop the GE90 @-@ 115B engine , while Rolls @-@ Royce proposed developing the Trent 8104 engine . In 1999 , Boeing announced an agreement with General Electric , beating out rival proposals . Under the deal with General Electric , Boeing agreed to only offer GE90 engines on new 777 versions .

= = = Longer @-@ range models = = =

On February 29 , 2000 , Boeing launched its next @-@ generation twinjet program , initially called 777 @-@ X , and began issuing offers to airlines . Development was slowed by an industry downturn during the early 2000s . The first model to emerge from the program , the 777 @-@ 300ER , was launched with an order for ten aircraft from Air France , along with additional commitments . On February 24 , 2003 , the -300ER made its first flight , and the FAA and EASA (European Aviation Safety Agency , successor to the JAA) certified the model on March 16 , 2004 . The first delivery to Air France took place on April 29 , 2004 . The -300ER , which combined the -300 's added capacity with the -200ER 's range , became the top @-@ selling 777 variant in the late 2000s , benefitting as airlines replaced comparable four @-@ engine models with twinjets for their lower operating costs .

The second long @-@ range model , the 777 @-@ 200LR , rolled out on February 15 , 2005 , and completed its first flight on March 8 , 2005 . The -200LR was certified by both the FAA and EASA on February 2 , 2006 , and the first delivery to Pakistan International Airlines occurred on February 26 , 2006 . On November 10 , 2005 , the first -200LR set a record for the longest non @-@ stop flight of

a passenger airliner by flying 11 @, @ 664 nautical miles (21 @, @ 602 km) eastward from Hong Kong to London . Lasting 22 hours and 42 minutes , the flight surpassed the -200LR 's standard design range and was logged in the Guinness World Records .

The production freighter model , the 777F , rolled out on May 23 , 2008 . The maiden flight of the 777F , which used the structural design and engine specifications of the -200LR along with fuel tanks derived from the -300ER , occurred on July 14 , 2008 . FAA and EASA type certification for the freighter was received on February 6 , 2009 , and the first delivery to launch customer Air France took place on February 19 , 2009 .

Initially second to the 747 as Boeing 's most profitable jetliner , the 777 became the company 's most lucrative model in the 2000s . Program sales accounted for an estimated US \$ 400 million of Boeing 's pretax earnings in 2000 , US \$ 50 million more than the 747 . By 2004 , the airliner comprised the bulk of wide @-@ body revenues for the Boeing Commercial Airplanes division . In 2007 , orders for second @-@ generation 777 models approached 350 aircraft , and in November of that year , Boeing announced that all production slots were sold out to 2012 . The program backlog of 356 orders was valued at US \$ 95 billion at list prices in 2008 .

= = = Production updates and improvements = = =

In 2010 , Boeing announced plans to increase production from 5 aircraft per month to 7 aircraft per month by mid @-@ 2011 , and 8 @. @ 3 per month by early 2013 . Complete assembly of each 777 @-@ 300ER requires 49 days . In November 2011 , assembly began on the 1,000th 777 , a -300ER model for Emirates ; which was rolled out in March 2012 . In late 2011 , the FAA assigned a common type rating to the 787 and 777 , allowing pilots qualified on either aircraft to operate both models , due to related design features . The smaller 787 was the first stage of a replacement aircraft initiative called the Boeing Yellowstone Project . Reportedly , the 777 could eventually be replaced by a new aircraft family , Yellowstone 3 , which would draw upon technologies from the 787 .

By the late 2000s , the 777 was facing increased potential competition from Airbus ' planned A350 XWB and internally from proposed 787 variants , both airliners that promise fuel efficiency improvements . As a consequence , the 777 @-@ 300ER received an engine and aerodynamics improvement package for reduced drag and weight . In 2010 , the variant further received a 5 @, @ 000 lb (2 @, @ 300 kg) maximum zero @-@ fuel weight increase , equivalent to a higher payload of 20 ? 25 passengers ; its GE90 @-@ 115B1 engines received a 1 ? 2 @. @ 5 percent thrust enhancement for increased takeoff weights at higher @-@ altitude airports . More changes were targeted for late 2012 , including possible extension of the wingspan , along with other major changes , including a composite wing , new powerplant , and different fuselage lengths . Emirates was reportedly working closely with Boeing on the project , possibly being the launch customer for new 777 versions . China Airlines ordered ten 777 @-@ 300ER aircraft to replace 747 @-@ 400s on routes between Taipei and Los Angeles and New York City , telling Aviation Week and Space Technology that the 777 @-@ 300ER 's per seat cost is about 20 % lower than the 747 's costs (varying due to fuel prices) . Four of the 777 aircraft were already flying as of February 2015 .

Mindful of the long time required to bring the 777X to the market , Boeing continued to develop improvement packages which improve fuel efficiency , as well as lower prices for the existing product . As of February 2015 , the backlog of undelivered 777s totals 278 aircraft , representing just under three years of current production at 8 @. @ 3 aircraft per month , causing Boeing to ponder the 2018 @-@ 2020 time frame . In January 2015 , United Airlines ordered 10 Boeing 777 @-@ 300ERs , normally costing around \$ 150 million each but paid around \$ 130 million , a discount to bridge the production gap to the 777X . Boeing has worked with General Electric to offer a 2 % improvement in fuel efficiency to new aircraft beginning in 2016 . GE will improve the fan module and the high pressure compressor stage @-@ 1 blisk in the GE @-@ 90 @-@ 115 turbofan , as well as reduce clearances between the tips of the turbine blades and the shroud during cruise . These improvements , of which the latter is the most important and was derived from work to develop the 787 , will , GE says , lower fuel burn by 0 @. @ 5 % . Boeing 's wing modification will

deliver the remainder . Boeing stated that every 1 % improvement in the 777 @-@ 300ER 's fuel burn translates into being able to fly the aircraft another 75 nautical miles on the same load of fuel , or add ten passengers or 2 @,@ 400 lb of cargo to a " load limited " flight .

In March 2015 , additional details of the improvement package were published in Aviation Week & Space Technology . The 777 @-@ 300ER is to shed 1 @,@ 800 lb . Boeing will replace the fuselage crown with tie rods and composite integration panels , similar to those used on the 787 . New flight control software is to eliminate the need for the tail skid by keeping the tail off the runway surface regardless of the extent to which pilots command the elevators . Boeing is also redesigning the inboard flap fairings to reduce drag by reducing pressure on the underside of the wing . The outboard raked wingtip is to have a divergent trailing edge , described as a " poor man 's airfoil " by Boeing ; this originally developed for the McDonnell Douglas MD @-@ 12 project . Another change involves elevator trim bias . These changes are to increase fuel efficiency and allow airlines to add 14 additional seats to the airplane , increasing per seat fuel efficiency by 5 % .

= = = 777X program = = =

In September 2011 , Boeing released more details on proposed third @-@ generation 777 versions , collectively referred to as 777X and tentatively designated 777 @-@ 8 and 777 @-@ 9 . The 777 @-@ 9 was to feature a fuselage stretch of 7 @.@ 0 ft (2 @.@ 13 m) to a total length of 250 ft 11 in (76 @.@ 5 m) to accommodate 407 passengers , while the ultra long @-@ range 777 @-@ 8 , a replacement for the 777 @-@ 200LR , was slated to be 228 @.@ 17 ft (69 @.@ 5 m) in length . Wingspan for both models was expected to increase from the current 212 ft 7 in (64 @.@ 8 m) to 234 ft (71 @.@ 3 m) , and incorporate the use of carbon @-@ fiber @-@ reinforced polymer in its construction . In February 2012 , General Electric disclosed studies on a new engine , dubbed the GE9X , to power the 777X . Rolls @-@ Royce and Pratt & Whitney also proposed powerplants for the 777X , including the RB3025 concept , based on the Trent 1000 and Trent XWB engines , and an adaptation of PW1000G engine architecture to produce up to 100 @,@ 000 lbf (440 kN) of thrust . However , in March 2013 the General Electric GE9X was selected as the exclusive engine to power the 777X .

In May 2013 , Boeing 's board of directors gave formal permission for its Commercial Airplanes division to start offering the 777X to customers . The 777X program includes two models : the 777 @-@ 9 , which is stretched beyond the length of the 777 @-@ 300ER , and the 777 @-@ 8 , which is sized close to the 777 @-@ 300ER but with ultra @-@ long range capability . On September 19 , 2013 , Lufthansa 's supervisory board gave approval to order 34 Boeing 777 @-@ 9 aircraft to replace their 747 @-@ 400s , in advance of the program 's official launch . In October 2013 , Boeing announced that its U.S. facilities in Charleston , Huntsville , Long Beach , Philadelphia , and St. Louis as well as Russian facilities in Moscow would support the 777X design effort .

Boeing officially launched the 777X at the 2013 Dubai Airshow in November 2013 , announcing a total of 259 orders and commitments worth more than US \$ 95 billion , constituting the largest product launch by dollar value in the history of commercial aviation . These included orders for 150 aircraft from Emirates , 25 aircraft from Etihad Airways , and 50 aircraft from Qatar Airways ; the former two orders encompass both 777 @-@ 8 and 777 @-@ 9 variants and the latter is entirely for the 777 @-@ 9 . By April 2014 , with cumulative sales surpassing those of the 747 , the 777 became the best @-@ selling wide @-@ body airliner ; at existing production rates , the aircraft was on track to become the most @-@ delivered wide @-@ body airliner by mid @-@ 2016 .

= = Design = =

Boeing introduced a number of advanced technologies with the 777 design , including fully digital fly @-@ by @-@ wire controls , fully software @-@ configurable avionics , Honeywell LCD glass cockpit flight displays , and the first use of a fiber optic avionics network on a commercial airliner . Boeing made use of work done on the cancelled Boeing 7J7 regional jet , which utilized similar versions of the chosen technologies . In 2003 , Boeing began offering the option of cockpit

electronic flight bag computer displays . In 2013 , Boeing announced that the upgraded 777X models would incorporate airframe , systems , and interior technologies from the 787 .

== = Fly @-@ by @-@ wire == =

In designing the 777 as its first fly @-@ by @-@ wire commercial aircraft , Boeing decided to retain conventional control yokes rather than change to sidestick controllers as used in many fly @-@ by @-@ wire fighter aircraft and in many Airbus airliners . Along with traditional yoke and rudder controls , the cockpit features a simplified layout that retains similarities to previous Boeing models . The fly @-@ by @-@ wire system also incorporates flight envelope protection , a system that guides pilot inputs within a computer @-@ calculated framework of operating parameters , acting to prevent stalls , overspeeds , and excessively stressful maneuvers . This system can be overridden by the pilot if deemed necessary . The fly @-@ by @-@ wire system is supplemented by mechanical backup .

== = Airframe and systems == =

The wings on the 777 feature a supercritical airfoil design that is swept back at 31 @.@ 6 degrees and optimized for cruising at Mach 0 @.@ 83 (revised upward after flight tests to Mach 0 @.@ 84) . The wings are designed with increased thickness and a longer span than previous airliners , resulting in greater payload and range , improved takeoff performance , and a higher cruising altitude . The wings also serve as fuel storage , with longer @-@ range models able to carry up to 47 @,@ 890 US gallons (181 @,@ 300 L) of fuel . This capacity allows the 777 @-@ 200LR to operate ultra @-@ long @-@ distance , trans @-@ polar routes such as Toronto to Hong Kong . In 2013 , a new wing made of composite materials was introduced for the upgraded 777X , with a wider span and design features based on the 787 's wings .

Large folding wingtips , 21 feet (6 @.@ 40 m) long , were offered when the 777 was first launched , to appeal to airlines who might use gates made to accommodate smaller aircraft , but no airline purchased this option . Folding wingtips reemerged as a design feature at the announcement of the upgraded 777X in 2013 . Smaller folding wingtips of 11 feet (3 @.@ 35 m) in length will allow 777X models to use the same airport gates and taxiways as earlier 777s . These smaller folding wingtips are less complex than those proposed for earlier 777s , and internally only affect the wiring needed for wingtip lights .

The airframe incorporates the use of composite materials , which comprise nine percent of its original structural weight (all models outside the 777 @-@ 8 and 777 @-@ 9) . Elements made from composite material include the cabin floor and rudder . The main fuselage cross @-@ section is circular and tapers rearward into a blade @-@ shaped tail cone with a port @-@ facing auxiliary power unit . The aircraft also features the largest landing gear and the biggest tires ever used in a commercial jetliner . The six @-@ wheel bogies are designed to spread the load of the aircraft over a wide area without requiring an additional centerline gear . This helps reduce weight and simplifies the aircraft 's braking and hydraulic systems . Each tire of a 777 @-@ 300ER six @-@ wheel main landing gear can carry a load of 59 @,@ 490 lb (26 @,@ 980 kg) , which is heavier than other wide @-@ bodies such as the 747 @-@ 400 . The aircraft has triple redundant hydraulic systems with only one system required for landing . A ram air turbine ? a small retractable propeller which can provide emergency power ? is also fitted in the wing root fairing .

== = Interior == =

The original 777 interior , also known as the Boeing Signature Interior , features curved panels , larger overhead bins , and indirect lighting . Seating options range from six abreast in first class up to 10 across in economy . The 777 's windows were the largest of any current commercial airliner until the 787 , and measure 15 @-@ inch (380 mm) by 10 @-@ inch (250 mm) in size (all models outside the 777 @-@ 8 and -9) . The cabin also features " Flexibility Zones " , which entails

deliberate placement of water , electrical , pneumatic , and other connection points throughout the interior space , allowing airlines to move seats , galleys , and lavatories quickly and more easily when adjusting cabin arrangements . Several aircraft have also been fitted with VIP interiors for non @-@ airline use . Boeing designed a hydraulically damped toilet seat cover hinge that closes slowly .

In 2003 , Boeing introduced overhead crew rests as an option on the 777 . Located above the main cabin and connected via staircases , the forward flight crew rest contains two seats and two bunks , while the aft cabin crew rest features multiple bunks . The Signature Interior has since been adapted for other Boeing wide @-@ body and narrow @-@ body aircraft , including 737NG , 747 @-@ 400 , 757 @-@ 300 , and newer 767 models , including all 767 @-@ 400ER models . The 747 @-@ 8 and 767 @-@ 400ER have also adopted the larger , more rounded windows of the original 777 .

In 2011 , Flight International reported that Boeing is considering replacing the Signature Interior on the 777 with a new interior similar to that on the 787 , as part of a move towards a " common cabin experience " across all Boeing platforms . With the launch of the 777X in 2013 , Boeing confirmed that the aircraft would be receiving a new interior featuring 787 cabin elements and larger windows . Further details released in 2014 included re @-@ sculpted cabin sidewalls for greater interior room , noise @-@ dampening technology , and higher cabin humidity .

= = Variants = =

Boeing uses two characteristics , fuselage length and range , to define their 777 models . Fuselage length affects the number of passengers and amount of cargo that can be carried ; the 777 @-@ 200 and derivatives are the base size , and the aircraft was stretched into the 777 @-@ 300 in 1998 . In terms of range , the aircraft has been categorized into three segments based on design criteria . The A @-@ market would cover domestic and regional operations , the B @-@ market would cover routes from Europe to the US West coast and the C @-@ market the longest transpacific routes .

These were initially defined as the following :

A @-@ market : up to 4 @,@ 200 nautical miles (7 @,@ 800 km)

B @-@ market : 6 @,@ 600 nautical miles (12 @,@ 200 km)

C @-@ market : 7 @,@ 800 nautical miles (14 @,@ 400 km)

When referring to different variants , Boeing and airlines often collapse the model number (777) and the variant designator (-200 or -300) into a truncated form (e.g. , " 772 " or " 773 ") . The International Civil Aviation Organization (ICAO) aircraft type designator system adds a preceding manufacturer letter (e.g. , " B772 " or " B773 ") . Subsequent to the capacity number , designations may or may not append the range identifier (e.g. , 777 @-@ 300ER as " 773ER " , " 773B " , " 77W " , or " B77W ") . These notations may be found in aircraft manuals or airline timetables .

= = = 777 @-@ 200 = = =

The 777 @-@ 200 was the initial A @-@ market model . The first -200 was delivered to United Airlines on May 15 , 1995 . With a maximum range of 5 @,@ 240 nautical miles (9 @,@ 700 km) , the -200 was chiefly aimed at U.S. domestic airline operators . Nine different -200 customers have taken delivery of 88 aircraft , with 79 in airline service as of July 2015 . A British Airways 777 @-@ 200 became the fastest subsonic New York to London flight at 5 hours and 16 minutes in January 2015 due to strong winds . The competing aircraft from Airbus is the A330 @-@ 300 .

= = = 777 @-@ 200ER = = =

The 777 @-@ 200ER (" ER " for Extended Range) , the B @-@ market version of the -200 , was originally known as the 777 @-@ 200IGW (increased gross weight) . The -200ER has additional fuel capacity and an increased maximum takeoff weight (MTOW) over the -200 . Aimed at international airlines operating transatlantic routes , the -200ER 's maximum range is 7 @,@ 730 nautical miles (14 @,@ 320 km) . In addition to breaking the eastbound great circle " distance

without landing " record , the -200ER also holds the record for the longest ETOPS @-@ related emergency flight diversion (177 minutes under one engine) , on a United Airlines flight carrying 255 passengers on March 17 , 2003 , over the Pacific Ocean .

The first -200ER was delivered to British Airways on February 6 , 1997 . Singapore Airlines , one of the type 's largest customers , ordered over half of its -200ERs with reduced engine thrust specifications (de @-@ rated) for use on medium @-@ length routes . The de @-@ rated engines lower MTOW , which reduces the aircraft 's purchase price and landing fees , and can be re @-@ rated to full -200ER standard for long @-@ haul operations . As of June 2016 , -200ER deliveries to 33 different customers totaled 422 with no unfilled orders . As of July 2015 , 390 examples of the -200ER were in airline service . The competing aircraft from Airbus are the A340 @-@ 300 and the A350 @-@ 900 .

== = 777 @-@ 200LR == =

The 777 @-@ 200LR (" LR " for Longer Range) , the C @-@ market model , became the world 's longest @-@ range commercial airliner upon entering service in 2006 . Boeing named it Worldliner as it could connect almost any two airports in the world , although it remains subject to ETOPS restrictions . It holds the world record for the longest nonstop flight by a commercial airliner , having a maximum range of 9 @, @ 500 nautical miles (17 @, @ 600 km) . The -200LR was intended for ultra @-@ long @-@ haul routes such as Los Angeles to Singapore .

Developed alongside the -300ER , the -200LR features an increased MTOW and three optional auxiliary fuel tanks in the rear cargo hold . Other new features include raked wingtips , redesigned main landing gear , and additional structural strengthening . As with the -300ER and 777F , the -200LR is equipped with wingtip extensions of 12 @. @ 8 ft (3 @. @ 90 m) . The -200LR is powered by GE90 @-@ 110B1 or GE90 @-@ 115B turbofans . The first -200LR was delivered to Pakistan International Airlines on February 26 , 2006 . As of June 2016 , eleven different -200LR customers have taken delivery of 59 aircraft , with no unfilled orders . Airlines operated 55 of the -200LR variant as of July 2015 . The closest competing aircraft from Airbus was the A340 @-@ 500HGW .

== = 777 @-@ 300 == =

The stretched 777 @-@ 300 was designed as an A @-@ market replacement for 747 @-@ 100s and 747 @-@ 200s . Compared to the older 747s , the stretched 777 has comparable passenger capacity and range , but burns one @-@ third less fuel and has 40 percent lower maintenance costs . The -300 features a 33 @. @ 3 ft (10 @. @ 1 m) fuselage stretch over the baseline -200 . This allows seating for up to 550 passengers in a single class high @-@ density configuration , an arrangement adopted for heavily trafficked Japanese routes . Because of the aircraft 's length , the -300 is equipped with a tailskid and ground maneuvering cameras to aid pilots during taxi . The maximum range is 6 @, @ 015 nautical miles (11 @, @ 140 km) , allowing the -300 to operate trunk routes previously flown by older 747s .

After being certified simultaneously by the FAA and JAA , the first -300 was delivered to Cathay Pacific on May 21 , 1998 . Eight -300 customers have taken delivery of 60 aircraft , 58 of which were in service as of July 2015 . However , following the introduction of the longer @-@ range -300ER in 2004 , operators have selected that variant instead . The -300 has no direct Airbus rival , but the A340 @-@ 600 was offered in competition .

== = 777 @-@ 300ER == =

The 777 @-@ 300ER (" ER " for Extended Range) is the C @-@ market version of the -300 , its higher MTOW and increased fuel capacity permits a maximum range of 7 @, @ 370 nautical miles (13 @, @ 650 km) with 396 passengers in a two @-@ class seating arrangement . The 777 @-@ 300ER features raked and extended wingtips , a strengthened fuselage and wings and a modified main landing gear . Its wings have an aspect ratio of 9 @. @ 0 . It is powered by the GE90 @-@

115B turbofan , the most powerful jet engine with a maximum thrust of 115 @, @ 300 lbf (513 kN) . Following flight testing , aerodynamic refinements have reduced fuel burn by an additional 1 @. @ 4 % .

Since its launch , the model has been a primary driver of the twinjet 's sales past the rival A330 / 340 series , its direct competitors have included the Airbus A340 @-@ 600 and the A350 @-@ 1000 . Using two engines produces a typical operating cost advantage of around 8 ? 9 % for the -300ER over the A340 @-@ 600 . Several airlines have acquired the -300ER as a 747 @-@ 400 replacement amid rising fuel prices given its 20 % fuel burn advantage .

The first -300ER was delivered to Air France on April 29 , 2004 . The -300ER is the best @-@ selling 777 variant , having surpassed the -200ER in orders in 2010 and deliveries in 2013 . As of June 2016 , -300ER deliveries to 41 different customers totalled 660 , with 140 unfilled orders . In February 2016 , 619 -300ERs are in service within 35 operators .

== = 777 Freighter == =

The 777 Freighter (777F) is an all @-@ cargo version of the twinjet , and shares features with the -200LR ; these include its airframe , engines , and fuel capacity . With a maximum payload of 226 @, @ 000 lb (103 @, @ 000 kg) , cargo capacity is similar to the 243 @, @ 000 lb (110 @, @ 000 kg) of the 747 @-@ 200F . The freighter has a range of 4 @, @ 900 nmi (9 @, @ 070 km) at maximum payload , although greater range is possible if less cargo weight is carried .

As the aircraft promises improved operating economics compared to older freighters , airlines have viewed the 777F as a replacement for freighters such as the 747 @-@ 200F , MD @-@ 10 , and MD @-@ 11F . The first 777F was delivered to Air France on February 19 , 2009 . As of June 2016 , 123 freighters had been delivered to 16 different customers , with 35 unfilled orders . Operators had 108 of the 777F in service as of July 2015 .

In the 2000s , Boeing began studying the conversion of 777 @-@ 200ER and -200 passenger airliners into freighters , under the name 777 BCF (Boeing Converted Freighter) . The company has been in discussion with several airline customers , including FedEx Express , UPS Airlines , and GE Capital Aviation Services , to provide launch orders for a 777 BCF program .

== = 777 @-@ 8 and -9 == =

The 777 @-@ 8 and the larger 777 @-@ 9 , are the two variants which comprise the Boeing 777X program , launched in 2013 . Both models incorporate a new carbon @-@ fiber @-@ reinforced polymer wing with folding wingtips , a wider , more comfortable redesigned cabin , and other upgraded systems . Service entry of the first 777X variant , the 777 @-@ 9 , is scheduled for 2020 .

== = Government and corporate == =

Versions of the 777 have been acquired by government and private customers . The main purpose has been for VIP transport , including as an air transport for heads of state , although the aircraft has also been proposed for other military applications .

777 Business Jet (777 VIP) ? the Boeing Business Jet version of the 777 that is sold to corporate customers . Boeing has received orders for 777 VIP aircraft based on the 777 @-@ 200LR and 777 @-@ 300ER passenger models . The aircraft are fitted with private jet cabins by third party contractors , and completion may take 3 years .

777 Tanker (KC @-@ 777) ? the KC @-@ 777 is a proposed tanker version of the 777 . In September 2006 , Boeing announced that it would produce the KC @-@ 777 if the United States Air Force (USAF) required a larger tanker than the KC @-@ 767 , able to transport more cargo or personnel . In April 2007 , Boeing offered its 767 @-@ based KC @-@ 767 Advanced Tanker instead of the KC @-@ 777 to replace the smaller Boeing KC @-@ 135 Stratotanker under the USAF 's KC @-@ X program . Boeing officials have described the KC @-@ 777 as suitable for the related KC @-@ Z program to replace the wide @-@ body McDonnell Douglas KC @-@ 10

Extender .

In 2014 , the Japanese government chose to procure two 777 @-@ 300ERs to serve as the official air transport for the Emperor of Japan and Prime Minister of Japan . The aircraft , to be operated by the Japan Air Self @-@ Defense Force under the callsign Japanese Air Force One , are scheduled to enter service in 2019 and replace two 747 @-@ 400s . Besides VIP transport , the 777s are also intended for use in emergency relief missions .

777s have served as official government transports for nations including Gabon (VIP @-@ configured 777 @-@ 200ER) , Turkmenistan (VIP @-@ configured 777 @-@ 200LR) , and the United Arab Emirates (VIP @-@ configured 777 @-@ 200ER and 777 @-@ 300ER operated by Abu Dhabi Amiri Flight) . Prior to returning to power as Prime Minister of Lebanon , Rafic Hariri acquired a 777 @-@ 200ER as an official transport .

In 2014 , the USAF examined the possibility of adopting modified 777 @-@ 300ERs or 777 @-@ 9Xs to replace the Boeing 747 @-@ 200 aircraft used as Air Force One . Although the USAF had preferred a four engine aircraft , this was mainly due to precedent (the existing aircraft were purchased when the 767 was just beginning to prove itself with ETOPS ; decades later , the 777 and other twin jets established a comparable level of performance as quad @-@ jet aircraft) . Ultimately , the air force decided against the 777 , and selected instead the Boeing 747 @-@ 8 to be the next presidential aircraft .

= = Operators = =

Boeing customers that have received the most 777s are ILFC , Emirates , Singapore Airlines , United Airlines , and Air France . Emirates is the largest airline operator as of July 2015 , and is the only customer to have operated all 777 variants produced , including the -200 , -200ER , -200LR , -300 , -300ER , and 777F . The 1,000th 777 off the production line , a -300ER set to be Emirates ' 102nd 777 , was unveiled at a factory ceremony in March 2012 .

A total of 1 @, @ 265 aircraft (all variants) were in airline service as of July 2015 , with Emirates (144) , United Airlines (74) , Cathay Pacific (68) , Air France (66) , American Airlines (64) , British Airways (58) , All Nippon Airways (57) , Singapore Airlines (55) , and other operators with fewer aircraft of the type .

= = = Orders and deliveries = = =

Orders and deliveries through June 30 , 2016

Orders and deliveries through June 30 , 2016

Boeing 777 orders and deliveries (cumulative , by year) :

Orders

Deliveries

Orders and deliveries through June 30 , 2016

= = Incidents and accidents = =

As of October 2015 , the 777 has been in 14 aviation accidents and incidents , including four hull @-@ loss accidents , one hull @-@ loss due to criminal act , and three hijackings , for a total of 540 fatalities . Before 2013 , the only fatality involving the twinjet occurred in a refueling fire at Denver International Airport on September 5 , 2001 , during which a ground worker had sustained fatal burns . The aircraft , operated by British Airways , suffered fire damage to the lower wing panels and engine housing ; it was later repaired and returned to service .

The type 's first hull @-@ loss occurred on January 17 , 2008 , when British Airways Flight 38 , a 777 @-@ 200ER with Rolls @-@ Royce Trent 895 engines flying from Beijing to London , crash @-@ landed approximately 1 @, @ 000 feet (300 m) short of Heathrow Airport 's runway 27L and slid onto the runway 's threshold . There were 47 injuries and no fatalities . The impact damaged the landing gear , wing roots and engines . The aircraft was written off . Upon investigation , the

accident was blamed on ice crystals from the fuel system clogging the fuel @-@ oil heat exchanger (FOHE) . Two other minor momentary losses of thrust with Trent 895 engines occurred in 2008 . Investigators found these were also caused by ice in the fuel clogging the fuel @-@ oil heat exchanger . As a result , the heat exchanger was redesigned .

The type 's second hull @-@ loss occurred on July 29 , 2011 , when EgyptAir Flight 667 a 777 @-@ 200ER registered as SU @-@ GBP suffered a cockpit fire while parked at the gate at Cairo International Airport . The plane was successfully evacuated with no injuries , and airport fire teams extinguished the fire . The aircraft sustained structural , heat and smoke damage . This aircraft was written off . Investigators focused on a possible electrical fault with a supply hose in the cockpit crew oxygen system .

On July 6 , 2013 , Asiana Airlines Flight 214 , 777 @-@ 200ER registered HL7742 , crashed while landing at San Francisco International Airport after touching down short of the runway . Surviving passengers and crew evacuated before fire destroyed the aircraft . The crash led to the death of three of the 307 people on board . These were the first fatalities in a crash involving a 777 since entering service in 1995 . The NTSB accident investigation concluded in June 2014 that the pilots committed 20 to 30 minor to significant errors in their final approach , and that complexities of the automated controls contributed to the accident .

On March 8 , 2014 , Malaysia Airlines Flight 370 , 777 @-@ 200ER registered 9M @-@ MRO , carrying 227 passengers and 12 crew , en route from Kuala Lumpur to Beijing was reported missing . Air Traffic Control 's last reported coordinates for the aircraft were over the South China Sea at 6 ° 55 ? 15 ? N 103 ° 34 ? 43 ? E. After the search for the aircraft began , Malaysia 's prime minister announced on March 24 , 2014 that after analysis of new satellite data it is now to be assumed " beyond reasonable doubt " that the plane was lost and there were no survivors . As of July 2015 , the cause remains unknown , but the Malaysian Government declared it was an accident in January 2015 . On July 29 , 2015 an aircraft piece was found on the French island of Réunion . The piece was sent to France where it was later identified as the flaperon of a Boeing 777 . On August 5 , 2015 Malaysian authorities confirmed that the piece was in fact from Flight 370 .

On July 17 , 2014 , Malaysia Airlines Flight 17 , a 777 @-@ 200ER registered 9M @-@ MRD , bound for Kuala Lumpur from Amsterdam broke up in mid @-@ air and crashed in the Donetsk province in eastern Ukraine , after being hit by an anti @-@ aircraft missile . All 298 people (283 passengers and 15 crew) on board were killed . The incident was linked to the ongoing Donbass insurgency in the region . The official accident report , released in October 2015 , states that airliner was shot down by a Buk missile from pro @-@ Russian held territory .

On September 8 , 2015 , British Airways Flight 2276 , a 777 @-@ 200ER registered G @-@ VMO , caught fire during take @-@ off at Las Vegas McCarran International Airport after a General Electric GE90 @-@ 85B engine suffered a serious uncontained engine failure . Take @-@ off was aborted and all crew and passengers were evacuated with only minor injuries occurring . Investigators discovered that the engine case had ' multiple breaches ' .

On May 27 , 2016 , on Korean Air Flight 2708 , a 777 @-@ 300 , registered HL7534 , an engine caught fire before take off at Tokyo International Airport , commonly known as Haneda Airport . Shortly before take @-@ off , the number 1 engine , a Pratt & Whitney PW4000 engine , started to smoke and caught fire . All 17 crew members and 302 passengers evacuated safely . Fire fighters put out the fire within an hour . The incident is under investigation .

On June 27 , 2016 , Singapore Airlines Flight 368 , a Boeing 777 @-@ 300ER , suffered an oil leak in the right engine while en route from Singapore to Milan . It was diverted back to Singapore Changi Airport for an emergency landing . The right engine and wing caught fire during landing roll and sustained serious fire damage . There were no injuries .

= = Specifications = =

Sources : Boeing 777 specification pages , Boeing 777 Airport planning reports , initial 777X data and other sources .