Boeing 787 Dreamliner

Transports
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787-8

Program Briefing

The Boeing 787 (originally 7E7) Dreamliner is a twin engine twin aisle commercial transport designed for medium and long range flights. Just above the size class as the 220/260-seat 767, the 787 features advanced technologies such as a largely composite airframe and mostly electric systems.

Boeing first announced the 787 in early 2003, and decided to offer the 787 to airlines in December 2003. Launched in 2004 by ANA, the 787 entered service in November 2011, three and a half years later than the original plan. Over 500 have been delivered.

Manufacturer

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Subsystems

Airframe

The 787 is the first jetliner with composite material primary structures. The main material is graphite combined with a toughened epoxy resin. The wing also uses TiGr, titanium/graphite composite. The current composition of the airframe, by weight, is 50% carbon fiber laminated composites (CFRP), with the remainder comprising 20% aluminum, 15% titanium, 10% steel, and 5% other.

In terms of design, the 787 resembles most twin aisle jetliner, only with a swept fin and a more tapered nose. Controls are largely electric.

Final assembly takes place in Everett and Charleston. The 787-8 and some -9s are built in Everett, while some -9s and all -10s are built in Charleston.

Boeing (pre-Wichita divestiture) was to supply 35% of the 787 structure, including the vertical fin (Frederickson), the fixed and movable leading edges of the wing (Tulsa), the flight deck and part of the forward fuselage (the Wichita facility, now Spirit AeroSystems), movable trailing edges (Hawker De Havilland, Australia), and the wing-to-body fairing (Winnipeg).

Various suppliers provide another 4% of the airframe. The rest comes from Japan, Italy, and South Carolina.

Seating is eight or nine abreast. The majority have been ordered with nine abreast interiors.

Airframe Subcontractors

- Alcan Rolled Products: aluminum
- Alenia/Vought Aircraft (Triumph)/Boeing: Working together in Charleston, SC as Global Aeronautica, the two companies were to provide 26% of the 787 structure including the center and aft fuselage and the horizontal stabilizer. In March 2008, Boeing purchased Vought's share of Global, and in December 2009 it acquired Alenia's share as well. Thus, some of this work is now performed by Boeing, although Alenia has retained its production share (horizontal stabilizer and the central and aft sections, amounting to 14% of the 787 structure). In June 2011 Boeing announced an agreement with Alenia under which Alenia will

act as a second source for production of the horizontal stabilizers for 787-9 beginning in 2013. Boeing said it will develop the stabilizers for the 787-9 itself, and will transition the primary stabilizer production when mature to a location yet to be determined. Alenia will be a secondary source. The remainder of Vought has been sold to Triumph Group.
- Asco Aerospace Canada: Section 48 upper fin deck, bulkheads
- Avcorp: composite structural components for Fuji
- BHA Aero Composites: vertical fin panels
- Boeing Aerostructures Australia (formerly ASTA): trailing edges
- Chengdu Aircraft (AVIC): rudder
- Curtiss-Wright: structural fittings and mechanical system for large cargo door (for Saab)
- Ducommun AeroStructures: titanium detail components and subassemblies
- EADS: aft pressure bulkhead
- M.C. Gill: floor panels
- GKN Aerospace: Composite mat for wing ice protection system, titanium wing to body and wing to nacelle fittings; complex machined titanium and aluminum parts and assemblies for horizontal stabilizer on 787-9
- Hafei Aviation Industries (AVIC): wing to body fairing panels
- Hexcel: pre-preg composite materials
- Hitco Carbon Composites: composite floor beams (for Kawasaki); passenger floor and cargo header beams (for Spirit)
- Israel Aerospace Industries: Section 47 passenger cabin and cargo compartment floors, passenger and cargo door surrounds
- Jamco: flight deck bulkhead
- Japan Aircraft Development. Japanese industry provides 35% of the 787 structure, including the wing. Main companies will include Mitsubishi (responsible for the main wing box), Fuji (CFRP center wing box, integration of the wing box and main landing gear wheel well), and Kawasaki Heavy Industries (remainder of forward fuselage, main landing gear wheel well, main wing fixed trailing edge).
- Korean Aerospace Industries: front and rear spars, three transverse beams in Section II center wingbox (for Fuji); wing fixed trailing edges (for Kawasaki); Section 41 nose wheel well (for Spirit)
- Korean Air Aerospace: aft body structural assembly; wingtips
- Latécoère: passenger doors
- LMI Aerospace: wing tooling and components
- Norsk Titanium: D-printed structural titanium components
- Orbital ATK: composite frames for -9 and -10 center and aft fuselages
- PlasticFab: composite and metal panels
- RTI International Metals: titanium components (for Fuji and Kawasaki)
- Saab Aerostructures: large cargo doors, bulk cargo door, access doors
- Safran (Messier-Dowty): main and nose landing gear (including design)
- Saint-Gobain: nose radomes (for Spirit)
- Shenyang Aircraft Group (AVIC): vertical fin leading edge
- Souriau: composite connectors
- Stellex: Section 41 pax floor assembly (for Spirit)
- Strata Manufacturing (UAE): vertical fin ribs on -9
- TAL Manufacturing (Tata Motors): floor beams on -9
- Toray Industries: TORAYCA prepreg composite material for Japanese contractors and Boeing
- Triumph: long support spars (for Shenyang)
- Turkish Aerospace Industries: elevator, cargo barrier, body seal
- VSMPO-Avisma: titanium forgings

Propulsion

Engines

In April 2004 Boeing selected a choice of two engine contractors. General Electric is offering its GEnx-1B70, related to the GE90-94B, while Rolls-Royce is offering its Trent 1000, a Trent 900 variant. These are in the 70,000 lbst class.

In mid-2016 Rolls introduced the Trent 1000-TEN, an upgraded version.

The losing engine was Pratt & Whitney's PW-EXX.

Propulsion System Subcontractors

- Aermacchi: nacelle fan cowls (for Goodrich)
- Aernnova: engine cowlings
- Avio: gear boxes, lp turbine static components and casing, lubrication system on GEnx (12% program stake)
- FACC: thrust reverser components and movable blocker doors on GEnx thrust reverser (for Goodrich)
- GKN Aerospace: composite fan containment case on GEnx; titanium thrust links; outer guide vane mount ring and rear fan case for Trent 1000
- GKN (Volvo Aero): fan hub frame, turbine rear frame, booster spool on GEnx (6% program stake)
- Goodrich: thrust reversers, nacelles
- Ishikawajima-Harima/Mitsubishi Heavy Industries: lp turbine rotating components and module

assembly on GEnx (15% program stake)
- Kreisler Manufacturing: Trent 1000 fuel manifolds (for Parker Aerospace)
- Mitsubishi Heavy Industries: LPT blades, IP turbine discs, combustor parts on Trent 1000
- Spirit AeroSystems: engine pylons
- Sumitomo Precision Products: Trent 1000 heat management system (with Parker Aerospace)
- Techspace Aero: booster stator on GEnx (3% program stake)
- Woodward Governor: GEnx fuel system integrator

Electronics

The 787 has a 777-compatible flight deck. Rockwell Collins provide liquid crystal and HUD displays and communications and surveillance system packages, including VHF radios, TCAS, WXR-2100 weather radar, and terrain awareness and warning systems. Smiths Aerospace is providing the Common Core system. Honeywell is providing the navigation and aircraft health management systems. Thales is providing the integrated standby flight display and offers a wireless IFE system (Panasonic is an alternative IFE provider). Korry Electronics is providing flight deck control panels.

Other Systems

Other Suppliers

- Astronautics Corp: electronic flight bags
- Avtron Manufacturing: starter generator dynamometer test stands
- B/E Aerospace: seating, food and beverage preparation and storage equipment, oxygen systems
- Bridgestone: tires
- CTT Systems: zonal drying system
- Carleton: life support systems
- Crane Aerospace: power conditioning modules for Smiths common core processors, brake control and monitoring system
- Dassault Systèmes: product development software
- Deutsch: connectors
- Diehl Luftfahrt Elektronik: main cabin lighting
- Diethelm Keller Aviation: rotable food service equipment and carrier boxes
- Donaldson Co: cabin air purification system
- Doncasters: turbine components for Hamilton Sundstrand APU
- Eaton: couplings, hoses
- FR-HiTemp: fuel pumps, valves
- Goodrich: cargo handling system, electric brake system, proximity sensing system, fuel quantity indicating system, fuel management software, flight deck lighting system, flight attendant seats, optional flight deck entry video surveillance system
- Goodrich Hella: exterior lighting
- GS Yuasa: lithium-ion batteries (for Thales)
- Hamilton Sundstrand (United Technologies Corp): APS5000 APU, electrical power generation and start system, environmental control system, remote power distribution units, DC electric motor hydraulic pump subsystem, ram air turbine emergency power system, nitrogen generating system
- Heroux-Devtek: torque tubes (starting 2015)
- Honeywell: LED navigation/anti-collision lighting system, crew information system, cargo bay lighting
- Ipeco: flight deck seats
- Jamco: lavatories
- Kidde Technologies: fire detection/extinguishing system
- Lord Corp: integrated APU mounting
- Magellan Aerospace: steering assembly, landing gear torsion link assemblies, NLG drag brace assembly
- Marquez: thermoplastic air ducts for personal service units
- McKechnie (Hartwell): crew escape door latching
- Michelin: second source for aftermarket nose and main tires
- Moog: flight control actuation system
- MTI Global: thermal and acoustic interior insulation (for Spirit)
- Northwest Composites: sidewalls and linings
- Panasonic (Matsushita Avionics): cabin services system
- Parker Aerospace: hydraulic subsystem, pumps/reservoirs, filter modules, sensors, flow control devices
- Pfalz-Flugzeugwerke: metallic tubing and ducting, fuel line tubes
- Porvair: filter kit and Differential Pressure Indicator
- PPG Aerospace: dimmable passenger cabin windows
- Rockwell Collins (Kaiser Electroprecision): pilot controls (including wheel, column, rudder pedals)
- Saab: high lift actuation systems (for Smiths Aerospace)
- Securaplane: emergency lighting system
- Smiths Aerospace: landing gear actuation system, nose gear steering, brake control actuation and

indication, high lift actuation system, leading/trailing edge power drive unit
- Safran (Labinal): electrical wiring system, fiber optics, high speed databus
- Safran (Messier-Bugatti): electric brake system
- Securaplane: wireless emergency lighting system
- TAT Technologies: electrical system cooling elements
- Thermion: heater elements
- Triumph Composite Systems: ducting, metal parts, fittings, window assemblies, insulation, tubing (for Vought)
- Triumph (Frisby): large cargo door actuation system (for Saab)
- Ultra Electronics: electro-thermal wing ice protection
- Western Filter: hysraulic system filters
- Zodiac (Air Cruisers): emergency evacuation slides
- Zodiac (ECE): primary onboard electrical distribution system
- Zodiac (Monogram Systems): water and waste system

Specifications

	787-8	*787-9*	*787-10*
Length overall:	186 ft (57 m)	206 ft (63 m)	224 ft (68 m)
Height overall:	56 ft (17 m)	same	same
Wing span:	197 ft (60 m)	204 ft (62 m)	197 ft (60 m)
Max. T-O weight:	502,500 lb (228,000 kg)	557,000 lb (252,651 kg)	553,000 lb (250,836 kg)
Max. range:	8,200 nm (15,200 km)	8,300 nm	7,000 nm (12,900 km)
Cruise speed:	Mach 0.85	same	same
Passengers (3-class):	224-242	259-289	300-323

Costs

787 development was expected to cost between $7 and $9 billion. About half of that will come from the supplier/partner base. In reality, cost overruns boosted this to around $20-25 billion.

Boeing's 2017 list price for the 787-8 averages $229.5 million; 787-9 prices average $270.4 million; 787-10 prices average $312.8 million. Discounting should bring those numbers down to the $115-170 million range, although launch customers may be paying somewhat less. The -8 average realized price is around $115-120 million, the -9 is around $135-145 million, while the -10 is around $150-155 million.

Sales/Delivery Data

Orders

	2004	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
787	52	197	199	269	59	24	25	45	38	181	50

2015	***2016***	***Total***
99	80	1,200

Deliveries

	2011	***2012***	***2013***	***2014***	***2015***	***2016***	***Total***
787-8	3	46	65	104	71	60	349
787-9	—	—	—	10	64	77	151

Order Book

User	Version	Ord/Del	Note
Aeroflot	-8	18/—	
Aeroflot	-9	4/—	
Aeromexico	-8	2/2	General Electric
Aeromexico	-9	6/4	General Electric

Air Astana	-8	3/—	Rolls-Royce
Air Austral	-8	2/2	Rolls-Royce
Air Canada	-8	8/8	General Electric
Air Canada	-9	29/17	General Electric
Air China	-9	15/8	Rolls-Royce
Air Europa	-8	8/6	Rolls-Royce
Air Europa	-9	14/—	Rolls-Royce
Air France/KLM	-9	18/2	General Electric
Air France/KLM	-10	7/—	General Electric
Air India	-8	27/23	General Electric
Air New Zealand	-9	12/9	Rolls-Royce
Air Niugini	-8	1/—	Rolls-Royce
Air Tahiti Nui	-9	2/—	
ALAFCO	-8	8/—	General Electric
ALC	-9	21/3	General Electric/Rolls
ALC	-10	25/—	General Electric
All Nippon AW	-8	36/36	Rolls-Royce
All Nippon AW	-9	44/22	Rolls-Royce
All Nippon AW	-10	3/—	Rolls-Royce
American Airlines	-8	20/20	General Electric
American Airlines	-9	22/6	General Electric
Arik Air	-9	9/—	General Electric
Avianca	-8	15/11	Rolls-Royce
Aviation Capital Group	-9	5/—	Rolls-Royce
Avolon	-9	6/—	
Azerbaijan Airlines	-8	2/2	General Electric
Biman Bangladesh AL	-8	4/—	
Boeing Business Jets	-8	8/5	General Electric/Rolls
Boeing Business Jets	-9	2/2	General Electric
British Airways	-8	12/8	Rolls-Royce
British Airways	-9	18/16	Rolls-Royce
British Airways	-10	12/—	Rolls-Royce
China Southern	-8	10/10	General Electric
CIT Leasing	-8	4/4	General Electric
CIT Leasing	-9	16/2	General Electric/Rolls
ECAir (Congo)	-8	1/—	Rolls-Royce
El Al Israel	-9	3/—	Rolls-Royce
Ethiopian Airlines	-8	16/14	General Electric/Rolls
Etihad AW	-9	41/12	General Electric
Etihad AW	-10	30/—	General Electric
EVA Air	-10	18/—	General Electric
GECAS	-10	10/—	General Electric
Gulf Air	-9	16/—	Rolls-Royce
Hainan Airlines	-8	10/10	General Electric
Hainan Airlines	-9	7/7	General Electric
Icelandair	-8	1/—	Rolls-Royce
ILFC	-8	24/23	Includes former Aercap
ILFC	-9	50/18	Includes former Aercap
Japan Airlines	-8	25/25	General Electric
Japan Airlines	-9	20/8	General Electric
Jet Airways	-9	10/—	
Kenya AW	-8	9/9	General Electric
Korean Air	-8	1/1	General Electric
Korean Air	-9	10/2	General Electric

LATAM	-8	10/10	Rolls-Royce
LATAM	-9	16/7	Rolls-Royce
LOT Polish Airlines	-8	8/6	Rolls-Royce
MG Aviation	-9	4/4	Rolls-Royce
Norwegian	-8	3/3	Rolls-Royce
Norwegian	-9	19/—	Rolls-Royce
Oman Air	-8	6/2	General Electric
PrivatAir	-8	1/1	Rolls-Royce
Qantas	-8	11/11	General Electric
Qantas	-9	8/—	General Electric
Qatar Airways	-8	30/30	General Electric
Qatar Airways	-9	30/—	
Republic of Iraq	-8	10/—	
Royal Air Maroc	-8	5/5	General Electric
Royal Brunei	-8	5/4	Rolls-Royce
Royal Jordanian	-8	7/3	General Electric
Ruili Airlines	-9	6/—	
Saudi Arabian	-9	8/6	General Electric
Scoot	-8	10/7	Rolls-Royce
Scoot	-9	10/6	Rolls-Royce
Singapore Airlines	-10	30/—	Rolls-Royce
Tazania	-8	1/—	
TUI Travel	-8	13/13	General Electric
TUI Travel	-9	4/1	General Electric
Unidentified Customers	-8	4/—	General Electric
Unidentified Customers	-9	82/3	General Electric
United Airlines	-8	12/12	General Electric
United Airlines	-9	23/18	General Electric
United Airlines	-10	14/—	General Electric
Uzbekistan AW	-8	6/2	General Electric
Vietnam AL	-9	8/7	General Electric
Virgin Atlantic	-9	17/14	Rolls-Royce
Xiamen AL	-8	6/6	General Electric
Xiamen AL	-9	6/3	General Electric
Total 787-8		**423/334**	
Total 787-9		**641/207**	
Total 787-10		**149/—**	
Total 787		**1,213/541**	

Program Overview

History

Middle Market Origins

After Boeing cancelled the 747 Major Derivative family proposal in the late 1990s, it turned its attention towards the middle market, the 200/300-seat widebody range just below the 777 (see report). The first design Boeing focused on was the much-hyped Sonic Cruiser, announced in March 2001.

In December 2002 Boeing announced that it was shelving its Sonic Cruiser proposal. For months, Boeing's announcements concerning the new Mach 0.95-0.98 fast jetliner had been couched in qualifiers and uncertainties, a far cry from early 2001, when the concept was enthusiastically promoted as the Next Big Thing. The Sonic Cruiser program was plagued from the start by doubts about the technological feasibility. And the relentless downward trend in airline yields and profits, exacerbated by the September 11 attacks, made a performance-driven jet look like a non-starter.

To soften the impact of the shelving, Boeing also announced a new program designed to create a conventional, highly efficient new jetliner in the 767-size class, arriving in 2008. It

will feature a 777-style cockpit (something the basic 767 never got), Mach 0.85 speed, and operating costs up to 20% lower than current generation jetliners in this class (767-300ER for the 787-8's comparison, 767-300 for the 787-3). Originally studied as Project Yellowstone, the new plane was christened 7E7.

The year 2003 also saw numerous announcements concerning production arrangements for the new aircraft. The company announced that large structures would be delivered by air, in modified 747 freighters. It also began a site selection process, searching for the best place to build the plane. After surveying numerous alternatives in the US, including South Carolina, Texas, and Alabama, Boeing selected Everett, Washington (where all Boeing widebodies have always been built) in December 2003.

For an alternative view of the site selection process, please see the August 2003 monthly newsletter in www.richardaboulafia.com.

However, Boeing later decided to establish a second production line in Charleston, South Carolina. In 2013, 14 of the 65 787s built were assembled in Charleston.

Also in 2003, Boeing announced that it was recruiting Japan's aeronautical heavy industries as partners. It also recruited Alenia and Vought as major airframe partners, and numerous potential subcontractors to join in the design process.

The Name Game

The E in 7E7 stood for "efficient," although Boeing also maintained that "e-enabled" and "environmental" were good words too. The final designation, however, was not decided until January 2005, when the plane was re-designated 787.

As if the site selection process wasn't splashy enough, Boeing also teamed with AOL Time Warner to create a competition to name the 7E7. Some 280,000 votes were counted, with the largest group reportedly preferring Global Cruiser. At the June 2003 Paris Air Show, however, Boeing went with Dreamliner.

For an alternative view of the naming process, please see the July 2003 monthly newsletter at www.richardaboulafia.com.

Production

Some 65% of the 787 airframe workshare went to industrial partners and vendors, although this figure rose after Boeing divested its Wichita facility, and then fell after the company acquired Vought's workshare. Boeing's goal is to retain responsibility for only 15% of the 787's assembly, with the rest handled by partners. Structures are delivered by modified 747-400 freighters, designated Large Cargo Freighters (LCFs). The first LCF flew in September 2006.

ANA Provides Launch Order

In April 2004 All Nippon Airways placed the 787 launch order. The Japanese carrier ordered 50 787s, comprising a mix of short-range 787-3s and long-range 787-8s. The first delivery will be a –8, followed by a –3 five to six months later. Anticipated delivery rate to ANA is eight per year.

ATO

On December 15, 2003, Boeing's board authorized Boeing Commercial Airplanes to offer the 787 for sale to airlines. In September 2005 the 787's firm configuration was announced.

The first 787 test aircraft was to fly in mid-2007. Anticipated in-service date was mid-2008. As of September 2007, there were two 787s on the assembly line—the first flight test aircraft, and one static test plane.

Program Restructured, Followed by More Trouble

In September and October 2007 Boeing made two significant announcements concerning the 787 program. These were followed by additional bad news.

In September 2007 the company announced a first flight slip from September to either November or December. However, the May 2008 in-service date was retained, calling for a new aggressive 5- to 6-month flight test schedule. Inevitably, the news in October was worse. The company announced a significant restructuring, with service entry delayed until November or December 2008. All except three planned 2008 aircraft deliveries would be shifted into 2009, for a total of 109 aircraft through the end of 2009.

The delay was largely blamed on flight control software integration and traveled work, the latter resulting partly from an industry-wide fastener shortage. By the end of the month, program manager Mike Bair was replaced with Pat Shanahan, formerly with Boeing's IDS unit.

In December another announcement shifted the first flight until around the end of the second quarter of 2008. Certification and first deliveries were shifted to early 2009.

In March 2008 Boeing also announced that additional design work was necessary to strengthen the composite center wing box.

In April 2008 Boeing announced another six-month delay, with first deliveries then scheduled for the third quarter of 2009. Boeing officials said this schedule was relatively conservative. Anticipated 2009 deliveries were reduced to 25 aircraft.

This was followed by yet another delay, due in part to the IAM strike in the third quarter of 2008. In December 2008 Boeing released a new schedule. The 787 was to fly in the second quarter of 2009, with first deliveries scheduled for the first quarter of 2010.

First Flight, A Few Program Changes, And Another Schedule

In December 2009 the 787 made its successful first flight. By the end of the year, Boeing had assembled 16 787s, including two ground test aircraft, six flight test aircraft (two of which were flying), and eight production aircraft.

This was followed by a Boeing announcement that it would establish a second production line, in Charleston, South Carolina. This line was scheduled to deliver its first 787-8 in the first quarter of 2012, but the first SC-built plane flew in May 2012.

Another change has been the death of the -3 variant. In 2009 the two Japanese airline customers switched their -3 orders to -8s, leaving the -3 without customers and with little hope of being revived. In December 2010 it was cancelled altogether.

The new schedule called for first deliveries (still to ANA) in November 2010 (see below).

Fire, And Another Delay

In November 2010 a 787 on a test flight suffered an onboard fire. While non-fatal, it caused the program schedule to slip since the test fleet was grounded until a fix was found. Flight tests resumed in December, after a six-week hiatus. The new plan called for first deliveries in July 2011.

Certification and EIS

The 787 was certified by the FAA in August 2011. The first one was delivered in September. In October the 787 entered service with ANA.

The GE-powered version was certified in March 2012.

Certification Pulled After Several Battery-Related Incidents

In 2013 the 787 became the third jetliner in history to have its commercial certification temporarily revoked. The entire fleet was grounded in January after lithium-ion batteries aboard two planes overheated, causing one of them to catch fire. The battery on a Japan Airlines 787 caught fire after landing in Boston, while the battery on an All Nippon Airways 787 began producing smoke while in flight out of Japan, forcing an emergency landing.

Boeing began working on a solution while the cause was under investigation. It came up with a battery cell isolation and containment system. Ethiopian was the first airline to return the 787 to service, in April 2013; the other operators followed by May.

Variants

Original Plans

Boeing originally planned four 787 versions. The base version, a long-range 224-242 seat design, has been designated the 787-8. Another was an SR (Short-Range) version designed to replace the 757, with transcon range and later designated 787-3. It was to seat 296 in two classes. A 787-STR (Stretch) version will carry 259-289 passengers (in three classes) over very long range and is now designated 787-9. (See Specifications, above.)

Until the delays, the –3 Short Range and –8 Baseline version were both expected to arrive in 2008. The –9 stretch variant was to be delivered in late 2010, but rollout was delayed until September 2013. First delivery, to launch customer Air New Zealand, took place in July 2014. It was FAA/EASA certified in June 2014.

In March 2006 Boeing announced a -10 version. This simple stretch will seat 310 with a 6,500-7,000 nmi range and will enter service in 2012. It will basically replace the 777-200ER in Boeing's product line.

Also, Boeing offers a VIP version. This has been ordered by several customers in both -8 and -9 configuration. Order details can be found in the Order Book under Boeing Business Jets.

Boeing Launches 787-10

At the June 2013 Paris Air Show Boeing launched the long-awaited -10 variant. First commitments for the 787-10 include Air Lease Corp. (30), GECAS (10) IAG/British Airways (12), Singapore (30), and United (20). The -10 is a relatively simple stretch of the -9, with 95% commonality.

The 787-10 will fly up to 7,000 n m (12,964 km) with 300-330 passengers. The first -10, with Rolls-Royce engines, was rolled out in February 2017. Final assembly and flight tests of the 787-10 began in 2017. The second of three test aircraft, the first with GE engines, flew in May 2017. Deliveries will begin in 2018.

Teal Group Evaluation

Keeping The Faith, Despite Boeing's Best Efforts

For the first time in history, a new Boeing jetliner had extremely serious development and manufacturing problems. This will likely also be the first Boeing jet with significant performance shortfalls, at least for the first production batch, and possibly for a significant part of -8 variant production. The mantra of "We're going to be Eleven for Eleven" has given way to "We're marginally better than Airbus…maybe." Management placed entirely too much trust in the design, integration, and financial capabilities of its risk-sharing partners. This compounded the problems inherent in a very aggressive up-front program schedule. These problems were worsened by a degree of hubris and an atmosphere of secrecy.

New management at BCA helped the program turn the corner. Then management changed again. Worse,

the plane's battery-related glitches resulted in a grounding. Boeing's fix involved containing the problem, but without truly understanding it.

But despite this, the program is now in positive territory. Orders have started to arrive again, despite a twin aisle glut. This remains a potentially transformational product, and all customers are keeping the faith. Deliveries of the 787-10 will begin next year, and it will likely become the 777-200ER replacement of choice.

The 787's success shows that building a better mousetrap can make a difference. The 787 is a very ambitious product that's focused on the most active market segment. This is the exact opposite of the A380, a relatively low-tech plane focused on a shrinking segment.

It's not just the A300/310/767 replacement market, which in itself is big. It's route fragmentation, which is happening as fast as deregulation, ETOPS, and other factors allow. Technology, in the form of new long-range twinjets with low seat mile costs, is stimulating this fragmentation. Even in Asia, average aircraft sizes are shrinking.

However, Airbus is now a much smarter company than it was when it launched the A380. Execution on the A350XWB has been very good, even if the ramp is much slower than expected. Better still, the company has finally decided that the A330neo is a far better way to go after the 787-8/9 than the doomed A350-800. While the Dreamliner will be the plane of choice for the long-range market, there will be plenty of customers who think A330neo is just fine for 4,000 mile routes, and many 5,000 nmi ones too. And of course it's cheaper to buy than the 787.

In the long run, we estimate demand at around 2,500-3,000 planes over the program's first 25 years. This is a good, and even necessary thing for Boeing, because the company deferred $28 billion worth of production costs to future production aircraft. The only positive is that as of last year recurring losses had stopped, and Boeing is now booking a modest profit on each plane. But again, there's still about $27 billion in deferred costs.

Clearly, it will take much longer than expected for this plane to do great things for Boeing's balance sheet.

Production Forecast

User (Variant)	Through 2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total
Boeing Commercial Airplanes												
All users (787-8*)	349	42	26	10	4	1	—	—	—	—	—	432
All users (787-9)	151	100	97	84	76	69	60	55	50	45	45	832
All users (787-10)	—	—	12	34	40	45	45	45	40	45	45	351
Total*	**500**	**142**	**135**	**128**	**120**	**115**	**105**	**100**	**90**	**90**	**90**	**1,615**

**excludes six test aircraft*