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Boeing 787: The Dreamliner

On April 26, 2004, Boeing announced the launch of a new jetliner, which it named the Dreamliner (initially known as Boeing 7E7). The 7E7 was a much-awaited new family of planes that would begin operations in 2008. It would be the 25th commercial airplane model unveiled by the western world and the 11th jet from Boeing or McDonnell Douglas.

All Nippon Airways (ANA) became the launch customer with an order for 50 wide-body 7E7s with a reported list price of $6 billion—an announcement representing the single largest order ever for a new jet in Boeing's 88-year history. Reports indicated the estimates for the development costs for the new plane would be between $8 billion and $10 billion, with Boeing expected to spend $6 billion while the rest would be borne by strategic partners. (The comparable estimates for Airbus's new super-jumbo A380 plane were between $13 billion and $15 billion.) In January 2005, Boeing and the People's Republic of China announced an agreement for the purchase of 60 7E7s by Chinese Airlines valued at approximately $7.2 billion. With the announcement, Boeing formally renamed the 7E7 project the 787. Deliveries of the new planes to six Chinese carriers will begin prior to the 2008 Beijing Olympics. As of February 2005, Boeing had received 63 firm orders and 129 "less-binding" commitments for the new plane, four-fifths of which were from Asian airlines.

The 787 project came at a time when industry experts increasingly questioned the company's commitment to the commercial aircraft business. They believed Boeing's future in this business rested squarely on the successful design, marketing, and delivery of the 787 plane. Over the last two years, Airbus had delivered more airplanes than Boeing, and with its promised delivery of the A380 in 2006 the company was now officially recognized as the industry leader. With the successful launch of the 787, Boeing hoped to reassert its commitment to the industry and try to regain its leadership role. Despite its preoccupation with the A380, Airbus was planning its own response to the proposed 787 that could blunt the impact of this new plane offered by Boeing.

The Boeing Corporation

The Boeing Company, founded in 1916, operated three major groups of businesses with a total of six subsidiaries: commercial airplanes; integrated defense systems subsidiaries including aircraft weapon systems, network systems, support systems, and launch and orbital systems; and the Boeing Capital Corporation. Until very recently, the company had dominated the commercial airline industry since the introduction of the jet aircraft in the 1950s.

In 1997 Boeing acquired its largest U.S. competitor, McDonnell Douglas, and while it assimilated the McDonnell Douglas merger, Boeing's European competitor, 35 year-old EADS NV and its

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subsidiary Airbus, continued to grow to the point that, in 2003, Airbus sold more commercial airplanes during a year than Boeing for the first time. In 2004, Boeing's defense revenues exceeded its commercial airline revenues for the first time.

At the same time, Boeing's traditional airline customers continued to be financially challenged by high fuel and labor costs, union strife, the increasingly high fixed costs of airplanes, and the cutthroat price competition across the industry. Additionally, the emergences of low-cost airlines were challenging the business model used by traditional players such as United Airlines, Delta, Northwest, and American Airlines. Facing these industry dynamics and Airbus's expected launch of the super-jumbo A380, Boeing was seeking ways to reclaim the leadership role in the industry by launching the 787 airplane.

According to Alan Mulally, president of Boeing Commercial Airplanes: "The 7E7 was all about taking passengers where they want to go; when they want to go there more comfortably and affordably than ever before. . . . [It] would allow us to continue to set the standard for commercial aviation in the second century of flight."[1]

Setting the Standard for Commercial Aviation

In January 2003, Michael Bair, a 24-year Boeing veteran with strong engineering and business backgrounds, was appointed senior vice president of the Boeing 7E7 (now 787) program. He was to lead Boeing's 7E7 development effort and report directly to Mullaly. Prior to this appointment, Bair was responsible for developing the business case, marketing, and finding a suitable assembly site for the plane. A team of highly experienced Boeing executives—Walter Gillette, John Feren, and Craig Saddler—would assist Bair in making Boeing's vision a reality (see brief descriptions below).

Table A

The Dreamliner Management Team

Michael B. Bair, 46, was a 24-year Boeing veteran who most recently led the company's Commercial Aviation Services business. He also played a key role in development of the Boeing 777 and had served in a variety of senior marketing and sales positions. The following senior executives would report to Bair:

Walter B. Gillette, 61, would be responsible for full development of the airplane, including engineering, manufacturing, and partner alignment. Gillette led the company's development work on the Sonic Cruiser's enabling technologies, which form the foundation of the new super-efficient airplane. In his 37 years with the company, Gillette had worked on every new Boeing commercial jet.

John N. Feren, 47, would lead sales, marketing, and in-service support. Feren brings 25 years of commercial airplane sales, marketing, and program management experience to his new position. He most recently served as vice president of sales for airlines of the Americas and leasing companies worldwide.

Craig A. Saddler, 43, would lead finance and business operations. A 22-year company veteran, Saddler had an extensive background in financial operations, most recently serving as chief financial officer of the company's Shared Services Group, president of Boeing Travel Management Co., and interim president of Boeing Realty Corp.

Source: Boeing press release, January 29, 2003.

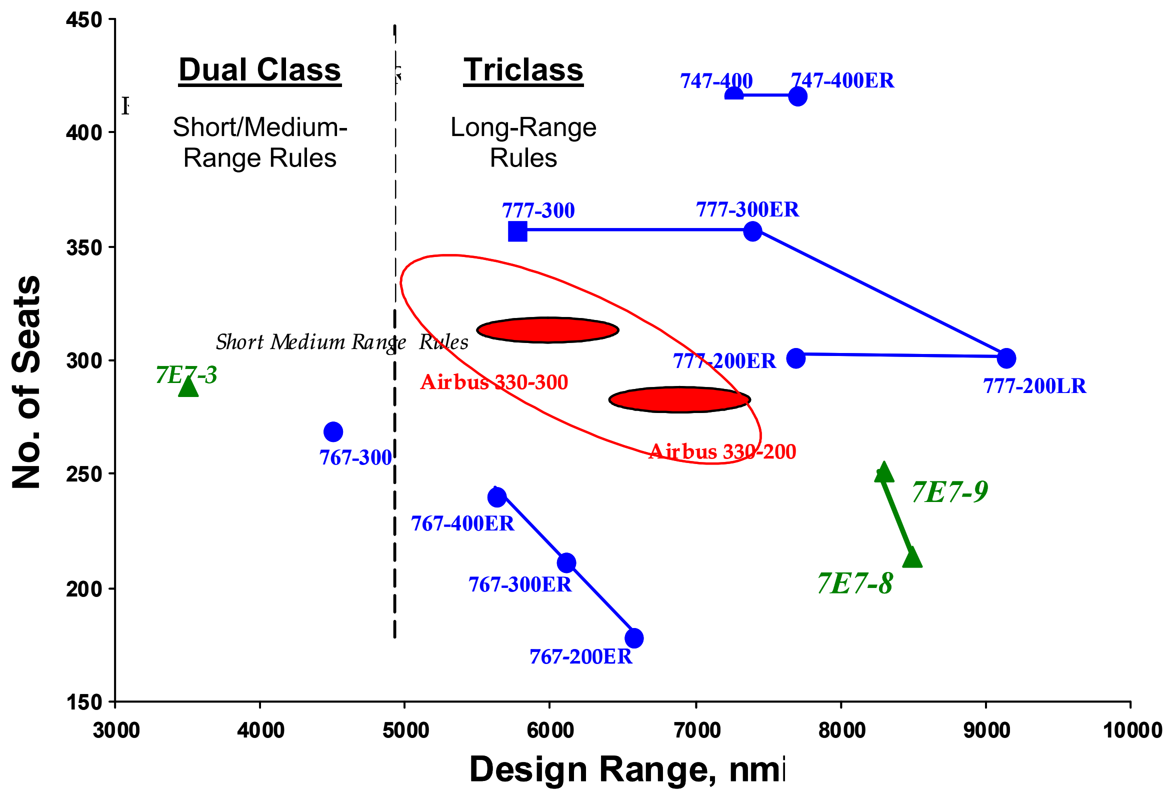
[1] "A smart bet," *Boeing Frontiers*, June 2003.

Making the Business Case

Boeing's business case for the 787 was simple: Design and deliver a super-efficient plane that would fly as fast as today's fastest commercial airplanes and encourage airlines to retire their Boeing 767s and Airbus A300s and A310s and replace them with 787s rather than Airbus's A330 planes. To many industry watchers, the decision to build this plane was a "no-brainer" because Boeing needed a new product to compete effectively against Airbus, which over the past decade had rolled out five new planes compared with Boeing's one (the Boeing 777). (See **Exhibit 1** for the history of orders and deliveries by both Boeing and Airbus.)

According to **Figure A** below, the 787 would be the first aircraft of its kind to bring long-range capabilities to a midsized airplane. For instance, it would enable airlines to provide nonstop service on routes that required long range but did not justify larger airplanes. The 787 was designed as a family of airplanes in the 200- to 300-seat class. The base airplane (787-8) and its stretch version (787-9) would carry 200–250 passengers in triclass configurations on routes between 8,300 and 8,500 nautical miles (14,500 to 15,400 kilometers), respectively. A third, shorter-range version (787-3) would carry nearly 300 passengers in a two-class configuration and be optimized for routes of 3,500 nautical miles (6,500 km). These configuration choices would also enable some customers to use denser seating (up to 400 passengers) for shorter-range missions. Noted Nicole Piasecki, senior vice president of Boeing commercial airplanes marketing and business strategies:

Figure A Serving a New Spot in the Market



Source: UW Dean's business breakfast presentation by Mike Bair, September 22, 2004.

> What we know today, and recognized years ago, was that as the airline industry deregulates and as air travel markets become more competitive, the world was moving toward smaller airplanes that take people point to point, or where they want to go. . . . That's what differentiates us from Airbus, which was focused on a really big airplane (the 550-seat A380) designed for the more traditional hub-and-spoke network.[2]

Concurred Bair: "We know that people prefer to fly directly to their destination. . . . The 7E7 would let more people do that. We estimate that there were more than 400 city pairs [connected cities], that could be served non-stop efficiently for the first time with the 7E7." Added Randy Baseler, Boeing's vice president of marketing: "There were only 13 city pairs between China and North America today, and 80% of the frequencies were to the West Coast. . . . As soon as you start opening up bilateral (agreements), and you have a new airplane with a smaller size that can fly the distance, it changes the whole game."[3] See **Figure B** for some examples of nonstop routes made possible by the introduction of the 787.

Figure B Creating New Point-to-Point Routes

Source: Mike Bair, Boeing Company, UW Dean's Breakfast Presentation, September 22, 2004.

Addressing Customer Concerns

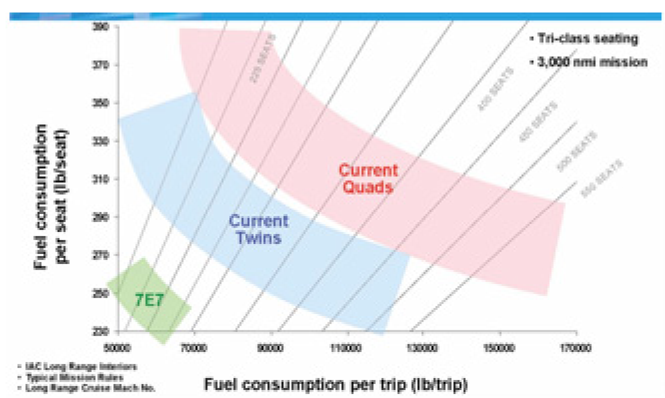
The Boeing 787 was being designed to respond to multiple challenges. First, for the airlines, the new airplane would use 20% less fuel than today's airplanes of comparable size (see **Figure C** below, which shows that Boeing engineers were attempting a breakthrough in terms of fuel efficiency for this new plane).

Noted John Burtz, a general manager of aircraft acquisitions and sales at Delta Air Lines: "What all airlines, and especially U.S.-based airlines, were looking for was superior if not compelling economics above and beyond the current offerings. . . . [A] 20% improvement in fuel efficiency should be a minimum rather than a stretch goal."[4]

As the Air Transport Association (ATA) asserted, the high price of jet fuel "continues to be the greatest threat to industry profitability."

Figure D below illustrates how jet fuel prices (average $0.69 per gallon) have risen over the last few years. Noted the ATA, the industry would break even if oil prices were at $33 a barrel, and if prices dropped to $30 a barrel, the industry

Figure C Achieving Breakthrough Efficiency



Source: Mike Bair, UW Dean's breakfast meeting, September 2004.

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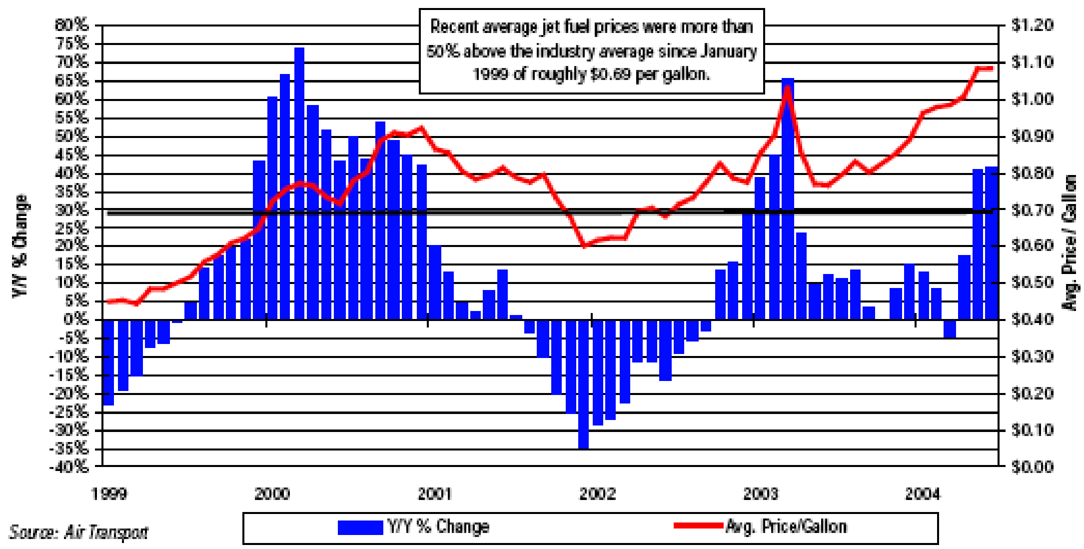
[2] "A smart bet," *Boeing Frontiers*, June 2003.

[3] "Boeing 7E7: If it flies, would airlines even buy it?" *The Seattle Times*, December 14, 2003.

[4] Quoted in *The Seattle Times*, December 14, 2003.

could make a $3 billion profit. In March 2005, the price of crude oil futures hit a 21-year high—over $54 a barrel—on the New York Mercantile Exchange. According to industry experts, crude oil prices were likely to remain high for the predictable future for a variety of reasons including the growing demand for crude oil in the rapidly industrializing economies of China and India. Prices were widely expected to reach over $80 a barrel during the summer of 2005 in the United States.

Figure D Rising Jet Fuel Prices



Source: A.G. Edwards, September 2004.

Second, the new 787 would provide airlines with more cargo revenue capacity. Noted Bair: "Cargo was an important part of the revenue stream for airlines. The cargo market was growing faster than the passenger market, and it tends to be more consistent during difficult times." The baseline 787, for instance, with room for five pallets of cargo and five standard LD-3 containers, would have 57% more cargo space than the A300-600, the Airbus product of roughly the same size.[5] Third, Boeing hoped the 787's environmental performance would be an added benefit. As Bair described it, "The 7E7 . . . has the smallest sound 'footprint,' with the quietest takeoffs and landings in its class."

Fourth, for the traveling public, Boeing was considering many improvements such as wider seats, wider aisles, larger lavatories, more spacious luggage bins, and larger 19- by 11-inch windows that would give passengers a view to the horizon (see **Figure E** below).

The plane's ceiling was expected to feature a calming simulated sky that enhanced the perception of spaciousness, and it would be e-enabled, with systems that provided in-flight entertainment and Internet access. The use of a lighter-weight composite structure (see the discussion below) would enable Boeing to keep the airplane weight down and make the installation of larger, higher windows less costly. Most importantly, to reduce travel fatigue during long flights Boeing was considering increased cabin humidity. According to *Popular Science*:

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[5] With room for six pallets of cargo and eight LD-3 containers, the 787-8 ha3 45% more cargo volume than the A330-200—2,865 cubic feet compared to 1,976.

Figure E Proposed 787 Interior

Source: Mike Bair, Boeing Company, UW Dean's Breakfast Presentation, September 22, 2004.

> The 7E7 would be pressurized to 6,000 feet altitude, rather than 8,000 feet; the extra 2,000 feet made a huge difference to volunteers who helped with the test. Another environmental consideration: Humidity. Airline cabins were typically kept to Death Valley humidity level—about 10%—to avoid moisture build up in the bilges, but composites don't corrode, so the 7E7 would be closer to the 20% to 30% minimum recommended by environmental health standards.[6]

The biggest wear and tear on the aluminum fuselages of current planes was the pressurizing and depressurizing done thousands of times over the life of the aircraft. Inflating the fuselage to achieve cabin pressure wears on the aluminum panels and the joints. Also, corrosive moisture builds up inside the fuselage. With noncorroding composite fuselages, airlines benefit from less airplane maintenance and longer plane lives, and passengers benefit by a significant decrease in fatigue during long-haul flights. Finally, to monitor the plane's structural integrity, Boeing would embed sensors in its main structure. These sensors would provide real-time data on the plane's structure and help monitor it. This, Boeing asserted, would enable airline operators to better schedule and manage their maintenance activities, thus reducing maintenance costs associated with operating the 787.[7]

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[6] William Sweetman, "Boeing, Boeing, Gone?" *Popular Science*, June 2004, p. 97.

[7] Interestingly, Bair noted that the generally accepted assumptions that composites would weigh significantly less and cost significantly more than aluminum were found not to be universally true. Noted Bair: "The aluminum companies did a great job of offering new alloys that were about as light as the composite materials . . . and the composite companies made a lot of progress on cost."

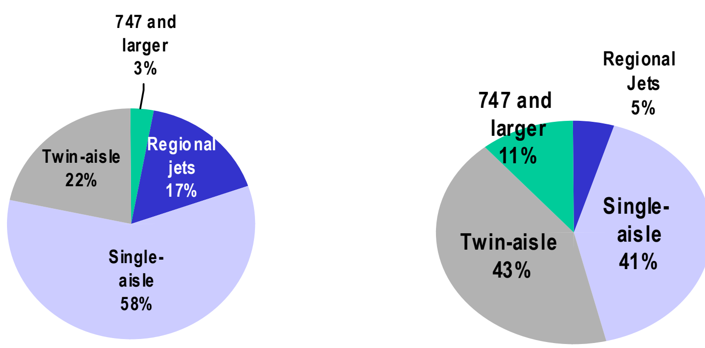
Forecasting Demand for 787

Noted *The Economist*:

> Boeing's strongest argument was that air-travel market was fragmenting. People want to travel direct to their long-haul destinations, not squeeze into huge planes before changing later to smaller ones at crowded hub airports in order to reach their final destination. The success of the 747 was ensured by the fact that its huge wings and fuel tanks allowed it to fly farther than any other plane. But smaller widebody jets half the size of the new Airbus can fly as far as the A380. These planes open up the long-haul market while reducing the airlines' risk, because they need to fill fewer seats to cover the trip.[8]

Based on this assumption, market forecasters at Boeing forecasted that airlines would need 25,000 new planes over the next 20 years. Specifically, they predicted that airplanes in the 100- to 200-seat, 200- to 300-seat, and 300- to 400-seat sizes would satisfy 80% of this future demand (see **Figure F** below).[9] They predicted that GDP growth around the world would be around 3% annually and that air travel would increase at an average yearly rate of 5.2%, an assessment that both Airbus and Boeing agreed upon. Boeing's forecasters attributed the additional growth above GDP of 2.2% to increased foreign trade and a more liberalized airline market around the world.

Figure F Boeing's 20-Year Forecasts



25,000 airplanes
In the next 20 years airlines would need 25,000 new planes, most of them single-aisle jets. Airplanes 747-size and larger were likely to make up only 3% of this market.

$2 trillion delivery dollars (in 2003 dollars)
Airlines were forecasted to spend $2 trillion on these airplanes. The vast majority would go toward single- and twin-aisle jets.

Source: Boeing. Taken from UW Dean's business breakfast presentation by Mike Bair, September 22, 2004.

Noted *The Seattle Times*:

> Boeing expects the world's airlines to purchase 2,520 small widebodies over the next 20 years. Boeing could capture the bulk of those sales if cost-obsessed airlines embrace a plane that can burn 20% less fuel than the A330-200, currently the best-selling small widebody. . . . Airbus forecasts only 1,372 deliveries of small widebodies by 2022, as passenger growth was

[8] "The Super-Jumbo of all gambles," *The Economist*, January 20, 2005.

[9] "Rebound Takes Flight," *Boeing Frontiers*, September 2004.

instead consumed by 1,138 planes with more than 500 seats. The A380 was the only plane of that size contemplated. Boeing expects just 320 deliveries of such mammoth jets. Independent industry experts, however, noted that Airbus could sell about 500 super-jumbos over this period.[10]

Over the next 20 years, China and, to a lesser extent, India were expected to drive the demand for commercial aircraft. While Airbus forecasted that Chinese carriers would require about 1,800 planes valued at $230 billion, Boeing predicted China would account for 2,293 planes valued at $183 billion. Differences in these forecasts stemmed from the fact that Airbus believed China would require 204 A380s, which Boeing disputed. Both agreed that passenger traffic in China would surge over 8.0% annually.[11] The Indian market, though promising, was expected to take longer to develop in the near term. Noted *The Economist:*

> There were conflicting signs as to which way the airline industry was going. There was a rash of new low-cost airlines, many of which want nimble, short-haul Boeing 737s, or something similar. As for long-haul flights, some airlines value the number of seats above all, others fuel efficiency. On Sunday July 18th, on the eve of Farnborough [Fair], Boeing was able to boast that it had received downpayments for 200 7E7s—from Japan's ANA, Air New Zealand, First Choice and Blue Panorama, among others. Two days later, Airbus crowed about a 24-strong order from Etihad Airways, the national airline of the United Arab Emirates, including four A380s.[12]

Both sides were using the occasion to convince the world that their version of demand forecasts were turning out to be true.

Designing and Building the 787

The Improved Engine Design

Boeing's 787 family would offer a standard engine interface for the two types of engines—the GE Next Generation engine and the Rolls Royce Trent 1000 engine—allowing the new plane to be fitted with either manufacturer's engine at any point in time. (The Trent 1000 built on the Trent 900 that Rolls Royce was developing for the Airbus A380.) The development team believed that engine interchangeability had made the 787 a flexible asset that could be moved easily among carriers and that this feature was attractive for financiers and leasing companies. This was the first time in commercial jet history that a plane had been offered with a common interface for two different engines.

Both engines would be capable of providing between 55,000 and 70,000 pounds of thrust, and all three proposed 787 models would be able to use the same basic engine. According to one report, the new designs would contribute as much as 8% of the increased efficiency envisioned for the airplane.

[10] "Boeing 7E7: If it flies, would airlines even buy it," *The Seattle Times*, December 14, 2003.

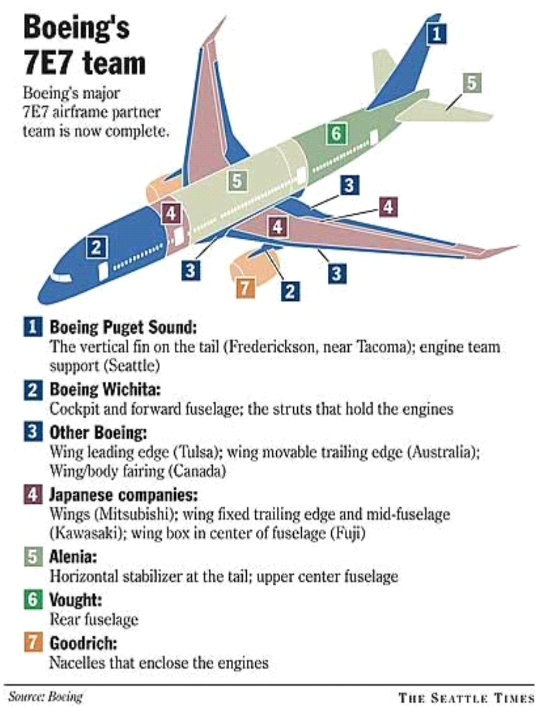
[11] "Airbus Predicts China's Airlines would Triple Fleet Size by 2023," *The Wall Street Journal*, March 9, 2005.

[12] "Another air show, another row," *The Economist*, July 20, 2004.

The New "Factory" Model: "Integrated Assemblies" from Global Partners

Boeing engineers, it was reported, worked for over a year and a half with a team made up of more than a dozen aerospace companies to look at advanced composites (titanium and graphite) and some new aluminum alloys as potential materials for the new plane's structure. The 787 would make commercial jet history by having the majority of its primary structure (the wings and fuselage) built from advanced composites. Moreover, it would allow Boeing to build larger, more "integrated assemblies," or work packages that would come from many different parts of the world.

Figure G Partners Producing the Structure



Boeing's approach was as follows: Boeing would supply approximately 35% of the plane's structure, Japan 35%, and Italy 26%. A team of 15 companies from at least 10 U.S. states and seven countries would be responsible for major structural sections of its proposed plane. **Figure G** provides details of what each partner's "integrated assemblies" would include. For example, Boeing would supply the vertical fin from Frederickson, the fixed and movable leading edges of the wing from Tulsa, Oklahoma, the flight deck and part of the forward fuselage section from Wichita, Kansas, the movable trailing edges from Australia, and the wing-to-body fairing from Winnipeg, Canada.

Additionally, Boeing's Wichita division would provide the jet's pylons, and Goodrich Corporation would provide the nacelles, including the thrust reverser. (The pylon holds the engine to the airplane, while the nacelle was the outer covering of an engine.) Boeing's Propulsion Systems Division (PSD), based in Tukwila, Washington, would manage the engine relationships with 787 engine partners General Electric and Rolls Royce.

Japan's Mitsubishi Heavy Industries would be responsible for the wing box. Kawasaki Heavy Industries would provide the remaining part of the forward fuselage, the main landing gear wheel well, and the main wing fixed trailing edge. Fuji Heavy Industries, also from Japan, would concentrate on the center wing box and integration of the center wing box with the main landing gear wheel well. Finally, Vought and Alenia (from Italy) were teaming up to build the 787's horizontal stabilizer and the center and aft fuselage.

The structures-team partners would build large sections of the airplane at different sites around the world and then transport them to the final assembly plant in the United States. For this project, Boeing had asked its structural suppliers to fund their own research and development (a first for a Boeing project) for the 787 project. This way, Boeing believed suppliers were likely to have a greater financial incentive to minimize their cost and, at the same time, assist Boeing market the new plane.[13] According to *The Seattle Times*:

[13] "Who would supply all the parts?" *The Seattle Times*, June 15, 2003.

> Boeing had long acknowledged that every plane it builds contains thousands of parts built by domestic and foreign suppliers. The "build vs. buy" ratio was normally 30% of parts built by Boeing and 70% built by suppliers. The 7E7 would take Boeing's reliance on outside suppliers to a new level as it embodies high-level engineering and "systems integration." That means its suppliers would assemble parts into major sections of the plane. 7E7 suppliers could even do more work that up to now had been closely guarded by Boeing, such as construction of the wings and assembly of large fuselage sections. [14]

To manage the global integration by which more than 70% of the 787 would be built globally with partners,[15] Boeing was implementing one of the largest project life-cycle management systems (PLM) ever created. Boeing selected IBM and French PLM software manufacturer Dassault Systems to provide the PLM, which was estimated as the largest PLM contract ever signed. All of Boeing's partners would use the same PLM digital tools and work off the same database to ensure the project could be completed on schedule and budget.

"Snapping" the 787 Together in Three Days

These large integrated assemblies would be "snap-fitted" in Everett, Washington, where the 747, 777, and 767 were assembled. The company decided, after an extensive 18-month nationwide search, that Everett was the location to assemble the 787. The Washington state legislature had passed an unprecedented $3.2 billion, 20-year tax break benefiting all aerospace companies located in Washington as part of its proposal to entice Boeing to locate the final assembly plant for the 787 in Everett.

Boeing estimated that the final assembly would be done in three days, saving valuable assembly time. All of this was possible because composites either contract or expand with changing temperatures, as metals do. The plane's body "barrel" sections would be built in one piece using robots that would wind fibers around a 20-foot-diameter tool.[16]

To speed up the time it took to transport sections to the final assembly site, Boeing would adopt air transportation as its primary method of parts delivery, a first for the company. The expected delivery time would be one day, rather than as many as 30 days when compared to other programs. This approach was expected to result in a savings of about 20% to 40% over traditional shipping approaches used in past programs. These savings, Boeing estimated, would allow the initial 787 investment in the air transportation assets to be recouped in the first few years of production. Boeing would rely on at least three modified 747-400s to move the 787 components.

The plane would be certified and delivered by 2008; the plane's configuration was to be finalized by the end of 2005, and the first flight test was set for 2007.

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[14] Ibid.

[15] Boeing estimates that approximately 75% of the 787 will be U.S. content.

[16] *Popular Science*, June 2004.

Challenges Facing Boeing

Turnover and Transformation

After the terrorist attack of 9/11 on the World Trade Center Buildings in New York, the demand for commercial airlines was hit hard, as air travel dropped significantly. During this period, Boeing's commercial aircraft business laid off 39,000 employees. The average age of Boeing engineers was 47. The company was looking for ways to stay profitable and grow at the same time, despite a significant drop in demand for commercial airplanes.

The aerospace industry dynamics after September 11 and competition from Airbus were not the only things that Boeing had to contend with. Fifteen months earlier, both Boeing's then CEO, Phil Condit, and the company's CFO, Mike Sears, departed after an inappropriate hiring of an Air Force employee who was influential in awarding the government's defense contracts to the company. More recently, in March 2005, Boeing's CEO, who was the previous McDonnell Douglas CEO, Harry Stonecipher, was asked to step down by Boeing's board of directors due to an infraction of the company's ethics code of conduct. The company's CFO, James Bell, was named the interim CEO while the board searched for a permanent CEO. Industry rumors suggested Alan Mulally from Boeing Commercial might be a serious contender for the CEO position. But that raised the question of who would replace him at Boeing Commercial, where the 787 project was in progress. And if he were passed over and left, the same question would still confront Boeing's board.[17] Noted *The Seattle Times*: "Boeing's board, caught off guard by events, needs to move quickly to find a new CEO. . . . [A]nd Congress still needing reassurance that the company was an upstanding corporate partner on the defense side, Boeing cannot long fly on automatic pilot."[18]

Additionally, Boeing was in the midst of a major transformation, and there was no going back. In February 2005 Boeing announced that it had sold its main manufacturing plants in Wichita, Tulsa, and McAlester, Oklahoma for $1.2 billion to Onex Corporation—a Canadian holding company. This move was described as part of a master plan based on Boeing 2016 vision to change Boeing from a wrench-turning manufacturer to a master planner, marketer, and snap-together assembler of high-tech airplanes (see **Exhibit 2**). A global network of supplier/strategic partners would now undertake the detailed design to heavy manufacturing, all coordinated by Boeing. The then Boeing CEO, Stonecipher, commented on the sale of the Wichita plants: "If Wichita belongs to Boeing, what do they build? Boeing parts. But if Wichita belonged to someone else, what can they build? Boeing parts, Airbus parts, Lockheed parts. Everybody parts."[19]

The one bright spot for the company was that it ended its fiscal-year 2004 with revenues up 4% to $52.46 billion, and net income from operations totaling $1.82 billion versus $685 million from the year before (see **Exhibit 2**). Given the successive leadership changes, many questioned whether Boeing could stay focused on generating more orders for the 787 and delivering it on time and on budget. According to Richard Aboulafia, an industry expert with the Teal Group, a consultancy, the only way Boeing could remain an important player when the A380 was delivered was to "make 7E7 happen as

[17] "With Stonecipher ouster, Boeing faces CEO dilemma," *The Seattle Times*, March 8, 2005.

[18] Ibid.

[19] *Knight-Ridder Tribune Business News*, February 23, 2005.

planned. 7E7 was shaping up and looks like it could be a winner—great costs, new technology, and terrific capabilities."[20]

Project Challenges

As noted above, up until the 787, Boeing worked with its suppliers in the mode of "build to print." Boeing engineers developed the design and the detailed drawings (often hundreds of pages) for the parts of the plane and then demanded that their partners build the parts to the exact specifications. This process engendered a culture in which Boeing engineers were quick to intervene when a supplier was not building to spec or needed technical assistance.

The 787 appeared to be a whole new ballgame in working with suppliers/partners. Now each of the supplier/partners was being asked to "build to performance," which might be described in tens of pages—not detailed drawings of hundreds of pages. The innovation, detailed drawings, and tooling were now the direct responsibility of the partner (along with the financial risk involved). The transition in concept, behavior, and Boeing engineering culture was huge.

Additionally, the 787 team faced a host of technical challenges and behavioral hurdles that had to be successfully overcome (see list below).

Table B

Partial List of Technical and Behavioral Hurdles Facing the 7E7 Team

- Long-range Dreamliners would have 197-foot wingspans; the shorter-range versions would be 20 feet narrower (165-170 feet). Problem: Designing a wing that works well in both sizes.
- High-bypass engines save fuel, but were larger in diameter. The trick would be mounting them on the airplane without adding weight—from a longer engine pylon, fatter nacelle and longer landing gear—that offset their efficiency.
- Electrically powered cabin-pressurization systems and hydraulic pumps would require extensive testing to convince airlines that they won't increase maintenance costs.
- The inboard skins of carbon fiber wing, where the loads were greatest, would be thick and would incorporate complex curves. So far, nobody had succeeded in mass-producing such parts.
- Some customers want a cockpit that looks and feels like the 20-year old 777, so pilots could be trained to fly both airplanes. Others want a more modern cockpit with bigger display screens.
- Some airlines want Boeing to give the pilots Airbus-like sidestick controls. Boeing thinks that old-style yokes were safer; most of its customers, who fly both Airbus and Boeing jets, don't agree.

Source: Company.

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[20] *Boeing Frontiers*, September 2004.

Also, past new-plane programs at Boeing (747, 777, among others) had been plagued by delays and cost overruns; hence, it was by no means certain that the 787 program would be on schedule, on budget, and meet all the airline's expectations. This time, however, with the Airbus aggressively waiting to grab a bigger share of the market, Boeing had no room for major mistakes.

Creating New Competitors

With the current "global systems integrator" strategy of moving over 70% of production to Boeing's global partners, the company was giving up its unique position of superior knowledge on "how to build a commercial aircraft." Since its inception, Boeing created and maintained, under lock and key, the company's crown jewels: A manual consisting of thousands of pages was titled, "How to Build a Commercial Airplane." With the approach used for delivering the 787, this manual would become obsolete. Importantly, strategic partners today could turn competitors tomorrow.

Previous contracts from Boeing had given the Japanese the know-how to build other parts of a commercial aircraft. With the 787, partners such as the Japanese were filling in a critical missing part: designing and building the highly technical wing—what many often contended was a crown jewel of Boeing. For example, Kawasaki's aerospace unit publicly stated its objective of developing and manufacturing commercial airplanes in the near future.

China had placed the second-largest order for 787s after Japan and was partnering with Boeing to build the rudder for the 787. China, as a country, had long declared its objective of developing a civil aerospace industry and, in fact, it had launched a long-term program to do so.

Boeing executives could not avoid being haunted by other similar situations in which new, hungry competitors entered their markets without much going for them, challenged and confronted the incumbent with bold innovation, and then went on to become the market leader, thus forcing the incumbent to struggle to survive. Could this be happening to Boeing? It was not clear whether the company's board and senior management were prepared for such a scenario.

Continuing to Deal with Airbus

Adam Brown, Airbus's vice president for market forecasts, claimed:

> Even if the 7E7 beats the A330 on fuel burn by 20%, that was equivalent to just 4% of the operating costs. Also, the baseline version of the 7E7 was smaller than the A330, which was bad for the bottom line because basic operating costs remain stable (for example, all airplanes have two pilots, regardless of size). "Crank all those numbers in, and you've got a 1.8% difference in cash operating costs. . . . That's not enough to set the world on fire."[21]

While Boeing's initial demand estimates were very optimistic, Baseler cautioned: "It depends on what Airbus does. . . . If they stay with the A330-200, we think we'll have a significant share. But we don't think they'll sit on the A330-200." Many analysts reckoned a revamped A330 could be used to challenge the 787 and should probably cost no more than $2 billion, which Airbus could fund out of cash flows. Airbus's R&D spending (mostly for the A380 launch) peaked in 2003 at $2.1 billion. These expenses were expected to decline steadily as the new A380 planes began to be delivered.[22] At the same time, the A380 was expected to begin producing a large revenue stream enabling it to

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[21] William Sweetman, "Boeing, Boeing, Gone?" *Popular Science*, June 2004.

[22] *The Wichita Eagle* (August 31, 2004) reports that both GE and Rolls Royce were expected to help Airbus with $2 billion in development costs toward the new A350.

finance the design and manufacture of a new model plane. Also, for the first half of fiscal 2004, Airbus posted sales revenues of $12.1 billion and a healthy operating margin of 9.1%. It could mount a program to challenge the 787 without additional government loans. However, a report by A.G. Edwards (emphasis original) noted:

> While . . . Airbus had dominated order intake since 1999, the company had sold only 13 aircraft combined in the A330 and A340 families so far in 2004. . . . [A] critical question here was whether or not the non-engine-related design changes Boeing was making, such as dramatically increased use of composite materials, would make the economics of the 7E7 so compelling that Airbus would be unable to compete without a total redesign. In other words, even if 10 points of the fuel efficiency improvement come from the power plants, if Airbus can't find a way to offset most of the other 10 points of fuel efficiency, it may still lose. Boeing believes that the engines would deliver no more than 40% of the total operating cost advantage of the 7E7, leaving Airbus to find a way to overcome the remaining 60% of the operating cost advantage. . . . *Given the sizable investment that Airbus was already making to launch the A380, we do not believe it would be able to concurrently launch another major development program to counter the 7E7 in the near term (without assistance).* It was not clear whether Airbus would aim at parity or attempt to leapfrog Boeing to achieve technological leadership. In our view, the 7E7 had less risk and a larger potential market than the A380, leading us to wonder if we did not recently witness a world-class bluff in this industry. Did Boeing wait until the A380 was far enough in development before announcing the 7E7 when a likely near-term response to that product would be much harder to muster? Time would tell.[23]

Perhaps it was this concern regarding continued "government assistance" that forced Boeing to recently attack the 1992 bilateral agreement between Europe and the United States, which permitted Airbus to receive billions in European government loans. The 1992 bilateral agreement limited Airbus's launch aid to 33% of the development costs of a new plane and at the same time limited the indirect support Boeing received from sources such as the Defense Department and NASA to 4% of sales revenues. According to *The Economist:*

> [T]he tit-for-tat accusations were once again escalating. Boeing reckons that Airbus had received some $15 billion in launch aid. To this, the European company replies that Boeing had for decades benefited from indirect aid from the huge American defense budget, and lately received tax breaks worth over $3 billion from the state of Washington to assemble its new 7E7 airliner there. Boeing was also in line for Japanese government subsidies via its partners in the project. But EADS and BAE Systems, the parent firms, which own Airbus, have a military turnover close to Boeing's, so they were probably deriving a similar, and similarly disguised, financial subsidy from military work. Moreover, Airbus's European factories also enjoy various forms of government support locally.[24]

On October 6, 2004, the U.S. trade representative, Robert Zoellick, on behalf of Boeing, filed a formal complaint to the World Trade Organization (WTO). He alleged that billions of dollars of "unfair" subsidies were paid to Airbus (see **Exhibit 4** for details). Now Boeing and the U.S. government wanted the 1992 bilateral agreement to be replaced with a new treaty that banned all state aid. The EU, in response, filed a counterclaim over equally large sums of unfair aid going to Airbus's rival, Boeing.[25] WTO rules specified that both sides hold talks to reach a settlement in 90

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[23] A. G. Edwards, September 1, 2004.

[24] "Enough was enough," *The Economist*, July 22, 2004.

[25] "America flies to war," *The Economist*, October 7, 2004.

days. If talks were not fruitful, the United States could request a panel to look into the complaint or extend the time period for talks.[26]

In December 2004, ending months of speculation, Airbus announced that it was offering two new models that would replace the aging Airbus A330. The new plane, named A350, was aimed squarely at blunting the potential impact of the 787 and was expected to use lighter-weight composite materials and the engines developed by Rolls Royce and GE for the 787. These planes were to be delivered as early as 2010. Airbus was now discussing the pursuit of the new jet, and the United States and Europe were discussing each other's subsidies. As Aboulafia, the analyst with Teal Group, saw it, "The 787 could be the basis for a major counter attack. . . . The problem was Boeing had taken such a long product development holiday that it really takes more than just one aircraft to reverse the Airbus tide."[27] Noted a recent report on BBC Online, "It was not clear whether Boeing would be able to win back the title of World's number one airline manufacturer. In part, that all depends on how well we like traveling on its rival Airbus's giant double-decker plane."[28]

Regarding the trade dispute talks, noted a report in *Reuters* in March 2005:

> A month from now an uneasy truce over the multi-billion-dollar subsidies which were paid to aircraft rivals Airbus and Boeing may be dead, unleashing one of the biggest transatlantic trade clashes in history. . . . Negotiators on both sides were keeping their cards close to their chest as the clock ticks towards the April 11 deadline they set themselves in January for an agreement on eliminating the state aid enjoyed by the world's top two plane makers.[29]

Boeing's Bet was Made; No Winner Yet

Developing a new plane was often compared to high-stakes poker, and Boeing had placed its bet. And so had Airbus. Sitting down at the table were two new skilled poker players: Japan and China. The new players thought differently than the incumbents. It was unclear that the incumbents really understood the new players' strategies, capabilities, and motivations. It was a dangerous game, a high-stakes game, and one in which the winner might take all. One thing was clear, however; to be the winner Boeing's top management and the 787 project teams had their work cut out for them as they pondered their next moves in the face of multiple uncertainties.

[26] "Aircraft subsidies trigger trans-Atlantic trade fight," *The Seattle Times*, October 7, 2004, p. E1.

[27] "Boeing Faces up to Airbus Challenge," BBC News, February 10, 2005.

[28] Ibid.

[29] "One month left to aver clash of aircraft titans," *Reuters*, March 10, 2005.

Exhibit 1 Orders and Deliveries of Select Passenger Aircraft (1967–2006)

	Boeing					Airbus				
	737	747-1/2/300	767-2/3/400	747-400	777-2/300	A-300	A-310	A-320	A-330	A-340
Average number of seats	140	390	220	410	350	265	220	150	310	300
Actual Deliveries										
1967–1976	468	174	-	-	-	7	-	-	-	-
1977–1986	842	346	153	-	-	204	87	-	-	-
1987–1996	1,517	61	478	371	45	190	158	548	50	93
1997–2006[a]	1,717	0	242	212	400	62	8	757	234	195
Total	**4,544**	**581**	**873**	**583**	**445**	**463**	**253**	**1,305**	**284**	**288**

Source: Compiled by authors from Boeing Company's and Airbus Company's Web sites.

[a]Based on order positions for future years.

Exhibit 2 Boeing 2016 Vision Created before the Boeing-McDonnell Merger in 1997

Exhibit 3 Selected Boeing Financial Statements

	1999	2000	2001	2002	2003	2004
Balance Sheet ($ million)						
Cash and short-term Investments	$3,554	$1,010	$633	$2,333	$4,633	$3,204
Total Assets	36,147	42,677	48,978	52,342	53,035	52,500
Total Long-Term Debts	5,980	7,567	10,866	12,589	13,299	10,879
Income Statement ($ million)						
Sales	57,993	51,321	58,198	54,061	50,485	52,457
EBIT	3,324	2,999	3,564	3,180	500	1,960
Net Income	2,309	2,128	2,827	492	718	1,872
Market Value						
Number of Shares (million)	871	836	798	800	809	813
Stock Price (year-end)	$41	$66	$39	$33	$42	
R&D ($ million)			1,900	1,600	1,651	1,879
Free Cash Flow ($ million)	4,800	5,200	2,500	3,300	3,100	3,700
Airplane (units)						
Deliveries			527	381	281	285

Source: Boeing annual reports.

Exhibit 4 The 1992 United States and EU Bilateral Agreement for Commercial Airplanes

What did the 1992 U.S.-EU bilateral agreement allow?

It allowed Boeing and Airbus to receive two different forms of government aid. Airbus took direct launch aid equaling up to 33% of new airplane development costs. Boeing annually took indirect support equaling up to 3% of the total revenue of the U.S. large civil-aircraft industry. On October 7, 2004, the U.S. unilaterally pulled out of the 1992 agreement.

What does the WTO prohibit?

It bans subsidies that disrupt trade and defines a subsidy as a financial contribution by a government. That includes tax breaks, as well as grants or loans, and subsidies to industries, as well as companies.

What subsidies does the U.S. claim Airbus was receiving?

- Launch aid. A total of $15 billion over all Airbus programs, including most recently about $3.7 billion to develop the super-jumbo A380, which would fly in 2006.
- Regional government support. The U.S. trade representative said the A380 had received over $1.5 billion in such aid.

What subsidies does the EU claim Boeing was receiving?

- Tax breaks and other incentives for Boeing's 7E7 program from Washington state ($3.2 billion), Kansas ($500 million), Oklahoma ($350 million), and Japan (around $1.6 billion).
- U.S. military and NASA contracts. The EU claims that since 1992, Boeing had received around $23 billion in this form.
- R&D expenditures from NASA and Defense Department programs. In 2003 alone, the EU claims, Boeing received $2.74 billion, including around $2 billion from the Department of Defense and more than $600 million from NASA.
- Federal corporate tax breaks, through the use of offshore "foreign sales corporations." The EU claims that since 1990 Boeing had avoided paying more than $1.2 billion.

Source: Adapted from *The Seattle Times*, October 7, 2004.