Dawn of the Super-Jumbo

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Abstract

This paper examines the introduction of the new super-jumbo aircraft in the air transportation industry and its initial acceptance and utilization by airlines. The paper's primary purpose is to determine if the super-jumbo provides airlines with a product that will maintain or increase revenue while meeting the forecasted demands of explosive passenger growth and at the same time lending itself to decreasing airport and airspace congestion. The paper attempts to determine the long term success of the super-jumbo by exploring the history and development of the super-jumbo concept, the two primary manufactures and their products, and future follow on aircraft. The paper provides a close examination of how airlines have utilized the only currently available super-jumbo, the Airbus A380, over the last four years as well as reviewing passenger's initial impressions. The paper concludes that super-jumbos will play an important role in the future of airline travel if utilized in markets and on routes that exploit the aircraft's full potential. Greater utilization of code sharing and airline alliances among air carriers will further leverage the profit potential of super-jumbos on traditional trunk routes.

Dawn of the Super-Jumbo

In 2005 the Airbus A380 became the largest passenger airliner in the world, unseating rival Boeing's 747. For over 35 years the 747 stood alone as the "Queen of the skies" of the jumbo jets. With the first flight of the A380 a new era of super-jumbo aircraft was ushered in. Boeing's response to the A380 has been the development of the 747-8 Intercontinental. These two new mammoth planes can carry hundreds of passengers and are poised to revolutionize long-haul air carrier operations. How the airlines exploit the capabilities of the super-jumbos will ultimately determine the success of the air transportation industry and the two aircraft manufacturers. The super-jumbos not only hold the promise of improving airline profits but also lessening airport and airspace congestion. This paper seeks the answers to questions that will ultimately determine the success of the super-jumbo. Specifically are super-jumbo aircraft the way of the future for long-haul routes? What are the advantages of super-jumbos? Will this new aircraft type increase profitability for the airlines? How have air carriers modified their long term strategies to acquire and exploit the capabilities of the super-jumbo? Has the use of super-jumbos given early adopters and edge over their rivals who still use legacy aircraft? Will US carriers adopt the European built A380 or wait for the domestic 747-8i? And finally and equally as important what has been the passenger's response to this new type of aircraft? The answers to these questions will provide valuable insight into what the future will hold for the airlines and super-jumbos.

On February 9, 1969 a new era in air travel began with the first successful flight of a new category of passenger aircraft called the jumbo jet. On that day Boeing's 747 took flight for the first time in Everett, Washington (Maslen, 2010). Boeing had staked the entire company on the success of this new type of airliner, one designed for long-haul high-capacity routes. The

genesis of the idea was rooted in Boeing's involvement in bidding for the US Air Force's CX-HLS (C-5 Galaxy) project (Norris & Wagner, 1997). Boeing had benefited from studying the large aircraft concept while working on its proposal for the C-5 contract. Lockheed won the contract, but Boeing took the research and development and rolled it into the commercial 747 design (Lucas, 1988). This was not a new strategy for Boeing and followed a history of military airframe development that was later leveraged for commercial use. Boeing had done this first with the B-9 which became the Model 247, the B-17 became the 307 Stratoliner, the B-29 became the 377 Stratocruiser, and the KC-135 Stratotanker became the 707 (Lucas, 1988). The 747 would be the largest passenger aircraft in the world, dwarfing all airliners that had preceded her. Boeing took the 747 from concept to first flight in only five years. The aircraft became an overnight success with airlines globally. The 747 filled the airlines need for a high capacity, long haul aircraft to service heavily traveled trunk routes across the Atlantic and Pacific Oceans (Lucas, 1988).

The 747 would remain "Queen of the skies" dominating the jumbo jet market for an astonishing 36 years. Before the halting of production in 2010 over 1,400 747 aircraft were sold to airlines around the world (Rigby, 2011). The 747 lost its crown on April 27, 2005 when the Airbus A380 took to the skies over Toulouse, France for the first time (Norris & Wagner, 2005). Boeing would not wait another 36 years to challenge the new queen. The answer to the Airbus super-jumbo was not a totally new design but instead the modification of the original 747 airframe that had served Boeing so well for so many years.

The Perceived Need

Twenty years after the introduction of the Boeing 747 momentum for a larger replacement aircraft began to build. Before an aircraft manufacturer will embark on a new aircraft design there must be a perceived need from the marketplace. For Boeing and Airbus this perceived need by the airlines for the super-jumbo began at the start of the 1990s. The decade dawned with the western world breathing a collective sigh of relief at the end to the Cold War. In the east Asian-Pacific countries were still enjoying a major economic boom that had started in the 80's. Many in the airline industry were speculating that travel and trade would increase substantially in this new world environment. Statistics showed that travel in Asia, with their expanding economies, was increasing at greater than 10% each year (Norris & Wagner, 2005). More travelers equated to an increased demand for additional aircraft with greater capacity. For airlines and aircraft manufactures the question was how to meet this new demand; greater number of mid-size aircraft or fewer high capacity aircraft. The biggest airliner, the Boeing 747, was selling very well with the airlines at the time with over 122 orders placed in 1990 alone (Maslen, 2010). This led many to believe that even larger aircraft were needed.

The perceived need materialized into reality in June 1991 when United Airlines asked Boeing to commission a study on the development of a 650 seat trans-Pacific aircraft (Norris & Wagner, 1997). At the time United was flying two 747-400 aircraft within ten minutes of each other on the New York to Tokyo trunk route (Norris & Wagner, 2005). Following the highly publicized United request both Airbus and Boeing accelerated their early efforts toward developing a Ultra High Capacity Aircraft (UHCA). With the amount of airline traffic worldwide increasing rapidly and the issue of airport and airspace congestion becoming acute it was becoming obvious that the need for a 600+ seat aircraft was going to be inevitable. Towards

the end of 1991 both Boeing and Airbus dispatched fact finding teams to meet with airlines around the world in an effort to confirm their market assumptions (Norris & Wagner, 2005). Most of the team's efforts were focused on the Asian-Pacific airlines where the demand was highest. In addition to the traditional Asian airlines such as JAL, ANA, and Thai, both Airbus and Boeing saw a huge potential untapped market in China. China's economy was on a sharp upward trajectory in the 1990's. The country's state owned air carriers were outfitted with a fleet of aging and obsolete Russian aircraft. There was massive potential for the super-jumbo in China. The fact-finding meetings only further solidified Boeing and Airbus' assumption that the airlines needed a super-jumbo.

In 1992 both Boeing and Airbus were taken by surprise when McDonnell Douglas announced the design of its own super-jumbo the MD-12. The MD-12 was designed as a double-decker aircraft that could seat 512 in a high-capacity configuration (Norris & Wagner, 2005). Unfortunately for McDonnell Douglas not one airline placed an order for the new aircraft. American Airlines and other carriers realized that McDonnell Douglas was financially weak and were leery of purchasing an aircraft from a manufacture whose future existence was questionable (Norris & Wagner, 2005). One year later McDonnell Douglas canceled development of the MD-12. Airbus and Boeing were not deterred by the lack of orders and ultimate failure of the MD-12. The event did however remind the manufactures that aircraft development was a highly competitive task and that the first company to deliver a product to the market was going to gain a major advantage over its competitors. By 1993 serious research into the super-jumbo at Boeing had uncovered a sobering fact, the new aircraft would cost in excess of $10 billion USD to develop (Norris & Wagner, 2005). Boeing began showing the first signs of faltering with the super-jumbo concept. At the same time the global economy was beginning

to slow and updated Boeing projections of the market demand for a super-jumbo could no longer justify the company recouping its investments in the aircraft (Norris & Wagner, 1997). Conversely Airbus' updated market projections predicted that 25% of all new aircraft orders would be for aircraft with seating for 759 passengers (Norris & Wagner, 2005).

By the mid-point of the decade the heady optimism that marked the start of the decade was checked by global economic recession. Those in the Boeing camp opposed to building a super-jumbo were bolstered in March 1994 when American Airlines chairman Robert Crandall stated "we don't think that bigger airplanes are the way to go. Smaller aircraft with longer ranges are the way to go" (Norris & Wagner, 2005, p. 39). Crandall was a major influential figure in the airline industry and Boeing took note. Boeing's president of the Boeing Commercial Airplane Group, Ron Woodard, said in May 1996 "The challenge is: will the Pacific marketplace fragment? History has shown that the Atlantic fragmented when the twinjets appeared-nearly all of them 767s" (Norris & Wagner, 2005, p. 40). At the time of the statement Boeing was developing the long range 777 which was positioned to do to the Pacific market what the 767 had done to the Atlantic. This was a hinge moment in the race to develop a new super-jumbo and the point where Airbus and Boeing diverged on their philosophy of how the future super-jumbo airline market would develop.

Fragmentation was a phenomenon that had begun with the introduction of long range twin aircraft like the 767 and A310 and the introduction of Extended Range Twin Operations (ETOPS) in 1985 for trans-Atlantic flights. Traditionally airlines had served overseas destinations on trunk routes linking city pairs like New York to London using large four engine aircraft. These flights were conduits fed by a nationwide hub-spoke system and were almost always overbooked. With the advent of ETOPS and the new longer range twin engine aircraft it

became possible for airlines to offer point to point overseas service from secondary airports. This resulted in less hub concentration, trunk flights going unfilled, and a downsizing of the aircraft used on trunk routes (Norris & Wagner, 1997). With the advent of the 777 and the A330/A340 Boeing started to see fragmentation occurring on the Pacific routes. Airlines were ditching their 747s in favor of direct flights to secondary cities (Kingsley-Jones, 2007). At the same time Boeing was designing its 787 Dreamliner which would become in its eyes the ultimate "fragmentor" (Kingsley-Jones, 2007).

In 1997 Boeing decided to formally end development of a super-jumbo believing that fragmentation and the ability of their existing and emerging product line would meet the needs of this new market dynamic. Boeing looked at other areas where a competitive edge could be gained. They would settle on speed and briefly expend effort at designing a Mach 0.95 passenger aircraft called the Sonic Cruiser (Bickers, 2001). This effort would ultimately be canceled as well. To outsiders Boeing appeared confused about which direction to take for the future. Meanwhile Airbus steadily moved forward with development of the A380. As late as 2001 Boeing still remained convinced that its projections were correct. A Boeing spokesperson commented "we continue to believe the market for a plane the size of the A380 is very small-too small to recoup the enormous cost of developing the plane" (Krause, 2001, p. 22). Airbus projections remained much more optimistic with a projected market for 1200 aircraft over 20 years (Krause, 2001). This was triple Boeing's projection of 400 aircraft (Krause, 2001). With Airbus requiring the sale of 250 aircraft to recoup development cost the risk level of moving forward with development of the A380 appeared low.

A380 Development History

The first efforts by Airbus to design a super-jumbo began in the summer of 1988. At the time Airbus had nothing in its product line that could compete with Boeing's 747 in the long haul, high capacity market. The company's four engine A340 would provide the starting point from which the A380 design evolved. At first attempts were made to stretch and double deck the existing 340 design (Norris & Wagner, 2005). This ultimately did not work out. It would take 12 years of engineering work to eventually arrive at the final design for the aircraft. On December 19, 2000 Airbus decided to move forward with building the officially designated A380 (Norris & Wagner, 2005). Interestingly the eight in the model number represents the cross section double deck feature of the aircraft (Norris & Wagner, 2005). Production of the first A380 began on January 23, 2002 (Norris & Wagner, 2005). Airbus executives originally planned for first customer deliveries to occur in 2005 but the production schedule was plagued by multiple delays due to the complexity and enormity of the project. The aircraft was finally rolled out publically on January 18, 2005 and took its maiden flight on April 27th of that year (Norris & Wagner, 2005). Certification occurred in December 2006 by the European Aviation Safety Agency (EASA) and the US Federal Aviation Administration (FAA). After almost another year of delays the first production aircraft was delivered to Singapore Airlines in October 2007 (Gershon, 2008).

The technical specifications of the A380 are quite remarkable. In a one class economy seating arrangement the A380 is capable of accommodating an astonishing 850 passengers (Vogel, 2009). It can cruise at Mach 0.85 with an operating range of 8,000 nautical miles. As illustrated in Figure 1 the aircraft's overall length is 239 feet with a wingspan of 261 feet and a maximum takeoff weight of 1,256,000 lbs (Vogel, 2009). The aircraft is composed of 25%

composite material which substantially reduces weight while not compromising structural integrity. As of August 2008 Airbus had sold or received orders for over 200 aircraft charging between 200 and 300 million per copy (Gershon, 2008).

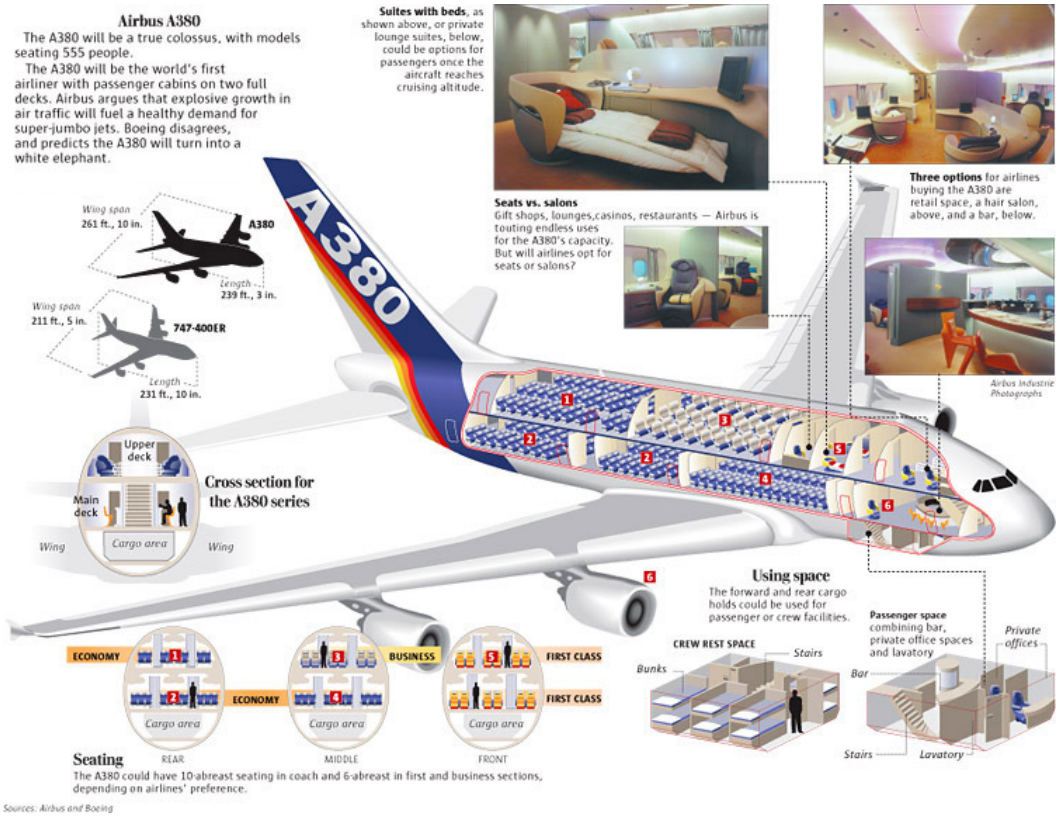

Figure 1. Airbus A380 generic seating and cabin configuration.

Note: Airbus A380. (2010). Retrieved from http://seattletimes.nwsource.com/news/business/links/airbusa380_18.html

747-8i Development History

Boeing had looked at stretching the original 747 design since the 1970s. Multiple feasibility studies ended without action. The last effort ended in early 1997 when Boeing ceased development of the 747-500X/600X and instead opted to pursue development of the Sonic Cruiser (Bickers, 2001). In November 2002, with awareness of the Airbus effort to build the A380, Boeing once again began researching how to make the 747-400 more capable (Trimble,

2008). On November 14, 2005, less than six months after the A380's maiden flight, Boeing publicly announced the development of the 747-8 Intercontinental, a 450+ passenger aircraft. The 747-8i was projected to enter service in 2009. The design called for stretching the 747-400 by 18 feet, designing a new wing, and installing new General Electric GEnx-2B67 engines (Trimble, 2008).

Boeing decided to build both a cargo and passenger variant of the 747-8. The cargo version was the focus for initial delivery followed later by a passenger version. Much like the A380 the 747-8 was plagued with numerous production delays that pushed the first delivery date from 2009 to 2010 and finally 2011. The 747-8F, the F designating freighter, completed its first flight on February 8, 2010 (Winters, 2011). The changes were numerous and profound enough that Flight International remarked that the 747-8 was "unrecognizable from that first jumbo jetliner" (Rigby, 2011). Cargolux received the first 747-8F on October 12, 2011 (Mecham, 2011). The passenger variant of the aircraft has yet to receive FAA certification. Boeing now plans to deliver its first 747-8i in the first quarter of 2012 to an unnamed VIP customer (Mecham, 2011). The first airline to receive the 747-8i will be Lufthansa which placed an initial order on 6 December 2006 (Trimble, 2008). The list price of the 747-8 is $317.5 million (Rigby, 2011). As of June 2011 Boeing had a backlog of 50 orders for the 747-8i (Winters, 2011).

The final production 747-8i depicted in Figure 2 is projected to seat a total of 467 passengers in a standard three-class configuration. This is 51 more seats than the earlier 747s and 58 seats less than a typically configured A380. The range of the aircraft will be 8,000 nautical miles at a cruise speed of Mach 0.855 ("747-8 Specs," 2011). The maximum takeoff weight is projected to be 975,000 lbs. With a wingspan of 224ft, 12 feet longer than the 747-400, and a length of 250ft the 747-8i will not unseat the A380 as the largest passenger aircraft

but it will regain the title of the longest being three feet longer than the A340-600 ("747-8 Specs," 2011). One of the key advantages of the 747-8i that Boeing is hoping will attract potential customers is the aircraft's fuel efficiency. The 747-8i will be 11% more fuel efficient than its Airbus rival (Trimble, 2008). The new engines will also be 30% quieter than the 747-400 ("Boeing Unveils," 2011). In addition Boeing claimed that the aircraft will have the lowest seat-mile cost of any large commercial jet ("Boeing Unveils," 2011). For air carriers trying to improve efficiency and the bottom line this could be a very attractive selling point.

Figure 2. Boeing 747-8i design and key technical specifications

Note: Boeing 747-8i key facts. (2011). Retrieved from http://en.rian.ru/infographics/20110223/162718035.html

The Air Carriers

As of 24 June 2011 Airbus had delivered a total of 64 aircraft to airline customers (A380 First Deliveries, 2011). There are currently seven airlines flying the A380. They include Singapore Airlines, Emirates, Qantas, Air France, Lufthansa, Korean Airlines, and China Southern Airlines (A380 First Deliveries, 2011). Singapore Airlines was the launch customer for Airbus and received its first A380 in 2007. Most of the carriers opted to have the aircraft configured for three classes with seating for an average of 485 passengers. While these configurations are nowhere near the A380s maximum capacity of 850 passengers they still remain substantially higher than the 747-400's maximum capacity. Air France currently utilizes the highest density seating among the airlines with a 538 seat configuration which is depicted in Figure 3 (Jones, 2011). Singapore Airlines has a 471 seat, three class layout while Qantas seats 450 in a four class configuration which includes premium economy. Emirates has configured their A380 for 489 passengers in a three class configuration with 90 of those seats being earmarked for first and business class (Gershon, 2008). The space provided by the super-jumbo equates not only to additional seats overall but also to the size and quality of premium class seats. Premium accommodations are one way that airlines can distinguish themselves from the competition and the A380 provides an excellent platform from which to do this. These seats attract the travelers who provide the highest-yield for airlines. A380 carriers provide some of the most luxurious first class accommodations in the industry.

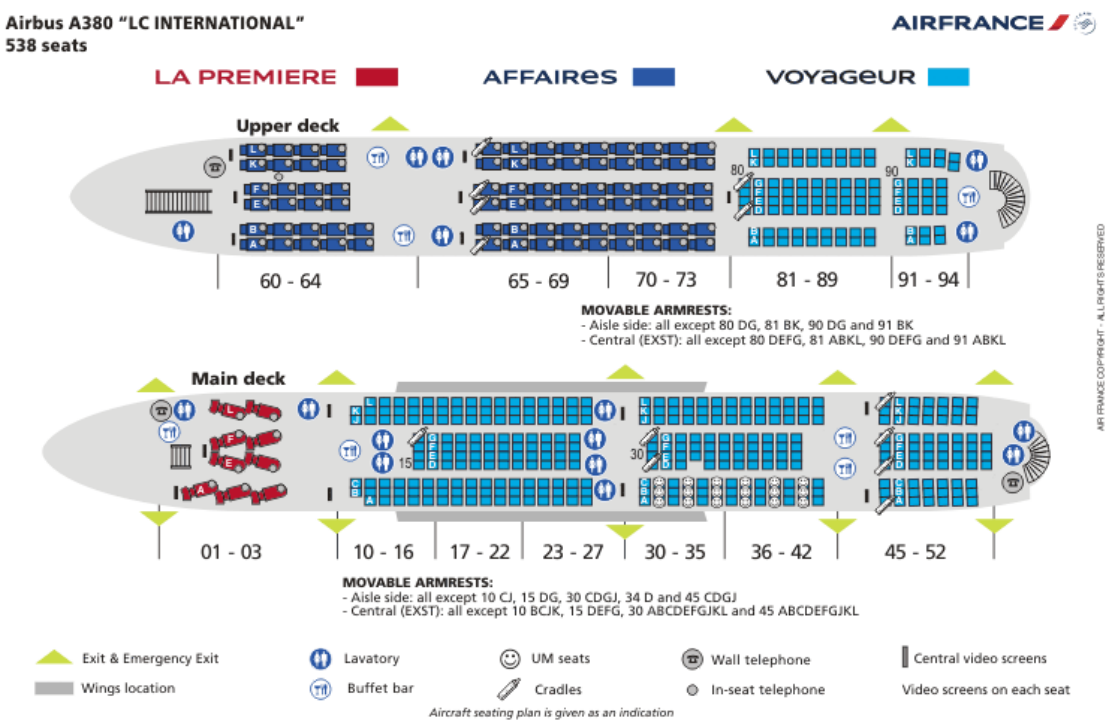

Figure 3. Air France Airbus A380 seating layout for 538 passengers in a three class configuration

Note: Air France A380 seating configuration. (2011). Retrieved from http://www.airfrance.ie/IE/en/local/guidevoyageur/destination/A380.htm

The airlines are utilizing the super-jumbo on a variety of routes. A380 routes include long haul Pacific routes used by Australia based Qantas as well as Korean Airlines. Lufthansa utilizes the A380 for Atlantic crossings to US destinations including Miami, Los Angeles, New York, San Francisco, and Washington DC ("A380 Routes," 2011). Air France, originating out of Paris, also flies to many of the same destinations within the United States. In the last six months air carriers have added eight new routes to the US ("A380 Routes," 2011). In addition to long haul routes air carriers are also utilizing the A380 for shorter routes that have heavy passenger volume. Korean Airlines flies from Seoul to Tokyo, Hong Kong, and Bangkok. Emirates being centrally located in the Middle East is flying medium range routes to destinations across Europe

and Asia. Emirates was the first to land an A380 in the United States arriving on 1 August 2008 at New York's John F. Kennedy International Airport (Gershon, 2008). The longest non-stop flight currently being flown with the A380 is Qantas' Melbourne to Los Angeles route, a distance of 7,921 nautical miles ("A380 Routes," 2011). As of June 2011 Airbus has orders for 234 additional aircraft from 18 customers (Jones, 2011). Those airlines already operating the aircraft want more including Lufthansa which has placed orders for eight additional aircraft (Lufthansa, 2011).

Obviously lacking from the list of super-jumbo airlines is US flagged carriers. When the 747 was released in 1970 US carriers were first in line to acquire the aircraft (Lucas, 1988). To date no US carriers currently operate or plan to acquire the A380. Most US carriers are no longer even using the 747 for international flights. United and Delta remain the sole exceptions. Why the lack of US interest in the super-jumbo? Some say this is an indicator of the decline of US carriers. Others argue that the US does not need the super-jumbo aircraft (Gershon, 2008). Industry experts believe the reason is very simple, the strategy of US airlines has been to make more frequent departures with smaller aircraft (Gershon, 2008). Of course this strategy does nothing to help relieve airport congestion concerns. Landing slots and gate allocations are not a concern for US carriers as the hub-spoke system usually has an airline operating at fortress hubs where the local airport authority is bending over backward to accommodate the dominant airline. On the other hand foreign carriers who may receive a limited number of landing slots at congested major US airports must maximize the passenger load on every flight. The A380 is a perfect fit for this requirement.

Typical aircraft used by US airlines for international routes include the Boeing 777, 767, and Airbus A340. Even United's future upgrade plans are for Boeing 787 Dreamliners not

A380s or the 747-8i (Moreno, 2011). These smaller wide-body aircraft normally seat between 210 and 330 passengers. US airlines believe frequent departures provide passengers with more travel options. More departures allow greater flexibility especially for the airlines most sought after passenger the business traveler. The business traveler usually pays the highest cost per seat and generates the most revenue for the airline. For the airlines it is critical that they can market flexibility as a key selling point to this passenger segment. Richard Aboulafia, vice president of analysis at the Teal Group summed it up when he stated "The market has spoken, U.S. carriers, like many other world businesses, are focused on profit, not market share" (Jones, 2011, p. B.1).

With the two dominant aircraft manufactures split between the US and Europe it is natural to assume that national loyalties may play a part in aircraft acquisition for the airlines. Unfortunately it is impossible to conclusively make a determination as to if this is the case using only publically available documents. For now the super-jumbo market is pretty black and white. In the case of A380 purchases, airlines currently have had no alternate choice due to the monopoly Airbus has enjoyed for the last four years. US airlines are not purchasing super-jumbos regardless of who manufactures them. They are just too weak financially to make such large capital investments. On the European side the fact that Lufthansa, a German company, will be the launch customer for the 747-8i does not lend credence to the argument that purchase decisions are based on national loyalties. Germany is one of the leading manufactures within the Airbus conglomerate (Norris & Wagner, 2005). It appears currently that airlines are acquiring super-jumbos based purely on what makes financial sense for them.

Advantages of the Super-Jumbo

It is becoming quickly obvious to everyone in the industry that super-jumbos provide a marked advantage over traditional wide-body aircraft. A short example illustrates the difference for air carriers. In this real world example a Lufthansa A380 flight is compared with an equivalent number of United Boeing 767 flights flying from New York's John F. Kennedy International Airport (KJFK) to Munich, Germany (EDDM). The Lufthansa A380 is configured to carry 526 passengers and departs once daily at 5:35PM (Lufthansa, 2011). The United Boeing 767 seats 183 passengers. It will take approximately 2.87 trips in the 767 to haul the equivalent capacity of one A380. The advantage to United passengers is that multiple departure times are available for the flight throughout the day. Running the numbers distills the economic advantages of operating only one flight with the super-jumbo. Fuel economy for the 767 is .23NM per gallon almost twice as efficient as the A380's fuel economy of .12NM per gallon (Aircraftcompare.com, 2011). The flight distance is 3,840 nautical miles. This equates to 32,000 gallons of fuel consumed by the A380 and 16,696 gal for the 767, however it will take 2.87 trips for United to haul the same number of passengers resulting in the expenditure of 47,917 gal total. When fuel consumption is distributed across the total passenger load each seat on the A380 consumes 60.8 gal while the equivalent number of passengers flown in multiple 767 would consume 91 gal per seat. This comparison looks exclusively at only the direct cost of fuel, it does not take into account additional cost factors of crewing and maintaining three aircraft compared to one which would further increase the total cost delta.

This example illustrates the financial advantages of the super-jumbo over traditional wide bodies and makes it difficult to support Boeing's theory of fracturing. While passengers are presented with fewer options for departure times the airlines benefit from a much more efficient

revenue generating flight, the air space is less crowded, and airports save spots, gates and on reduced infrastructure support cost as well as reduced congestion. Air France CEO Pierre-Henri Gourgeon commented that "In our calculations, when we replace two average-size aircraft of 250 to 300 passengers, with [the A380], which is 538 passengers, we estimate our savings yearly is $20 million, which is very significant" (Jones, 2011, p. B.1). By all accounts this is a win-win situation however it only works when the plane is at or near seating capacity which means only certain routes will be profitable for the use of a super-jumbo. So far this has not been an issue with Lufthansa reporting 85% fill rates on most flights (Jones, 2011).

Passenger Impressions

While airlines will decide on which aircraft to purchase based on tangible technical specifications in the end it is the customer who must be satisfied with his/her experience in the aircraft. If frequent flyers do not enjoy the aircraft experience they will steer clear of booking flight segments that utilize that particular aircraft. This will ultimately affect ticket sales and impact the profitability of the airline. It is currently not possible to glean passenger satisfaction with the 747-8i because the aircraft has not yet been placed in service with the airlines. Gauging satisfaction with the A380 is possible however because the aircraft has been in service for four years.

Each airline decides how they will outfit their aircraft's interior and configure seating. It is one of many variables that make each airline unique even though they utilize the same product. These decisions have a major impact on how customers perceive their experience with the aircraft. Because of its title as the world's largest passenger airliner the A380 has enjoyed a huge amount of popularity with the flying public. Much of this interest can be attributed to the

A380 being new and unique. Everyone wants to see the aircraft and get inside it. Lufthansa spokesman Martin Reicken captured the current mood best when he stated "There's still hype about the aircraft. People sometimes even fly a day later to make sure they get an A380. We see if people have a choice between two aircraft, and one is an A380, they definitely steer toward the A380" (Jones, 2011, p. B.1). Only after the newness wears off will the industry know if passengers will remain enamored with the A380.

I have been very fortunate in that I have had the opportunity to tour the inside of the original prototype A380 at the Experimental Aviation Associations' 2009 AirVenture in Oshkosh, Wisconsin. I have also ridden as a coach passenger in a Lufthansa A380 from San Francisco to Frankfurt, Germany. These multiple exposures to the aircraft have allowed me to formulate my own opinion. On the plus side the ride is very quiet and the windows are large. The in-seat entertainment center is first class with a large selection of movies, music, games, and the ability to view external video feeds from cameras positioned in the nose and tail of the aircraft. On the negative side the economy seats are not as comfortable and feel narrow. This was a surprise as seat size and quality on every other Lufthansa Airbus I have flown from the A319 to the A340 has always been far superior to Boeing aircraft. In addition window seats have a one foot space separating them from the cabin wall. This is due to the aircraft's oval shaped cross-section and negates any traditional advantages found with a window seat. My personal observations appear to be in line with what others are saying. Others have been disappointed with the coach seats as well. One passenger commented "when you sit down in the coach seats….it's a little disappointing. You're in a tight little coach seat just like you've been in before…if this flight was packed, it would feel very crowded, very claustrophobic" (Montagne, 2007).

Beyond Super-Jumbos

The world's traveling population continues to experience explosive growth while the problem of airport congestion becomes more acute with each passing year. If these same factors which created the requirement for a super-jumbo continue it is logical to assume an even larger aircraft on the scale of a mega-jumbo will be required as early as the next decade. Is it even possible to build aircraft larger than the A380 and 747-8i that can provide the performance and profitability required by the airlines? The square-cube law was initially thought to be a limiter to aircraft size. The law states that when an object increases in size, its weight multiplies faster than the strength of the structure that supports it (Milstein, 2006). With an airplane this equates to the weight of the aircraft growing faster than the wings ability to generate lift. The physical structure of a wing required to generate the necessary lift would be impossible to build long enough and at the same time sturdy enough for the aircraft. But recent scientific study into the law found that basic aerodynamics and structure do not limit the size of aircraft that can be operated economically (Kroo, 1995). More likely to be limiting factors in the size of a mega-jumbo aircraft are airport infrastructure and passenger emergency evacuation regulations.

In the chess game being played by Boeing and Airbus it appears that Airbus holds the upper hand in the development of a mega-jumbo. The A380 was designed from the beginning to be stretched. Airbus designed the wing of the A380 to support a much larger fuselage than the current -800. The planned -900 variant, as depicted in Figure 4, would extend the airframe 6.4 meters allowing for an additional 100 seats in current configurations or up to 1,000 total passengers in a one-class configuration (Wallace, 2007). Many experts believe the -900 will easily outsell the -800 once introduced (Wallace, 2007). Ironically the Airbus plan to stretch the A380 is a page stolen right out of Boeing's own playbook. Boeing has exercised the stretch

option with many of their aircraft including the 747. This time around however Airbus has the option of stretching the A380 while Boeing has already fully exploited the 747 airframe in the 747-8i. Another advantage Airbus holds over Boeing is having the A380 already firmly established in the market. As more and more Boeing 747-400s are retired from service airlines looking strategically at the future may opt to move to the A380-900. Airlines familiar with -800 will find many similarities and advantages in the -900 including commonality of parts, similar maintenance requirements and limited transition training for flight deck crews. The airlines will be less inclined to purchase an aircraft of totally new design.

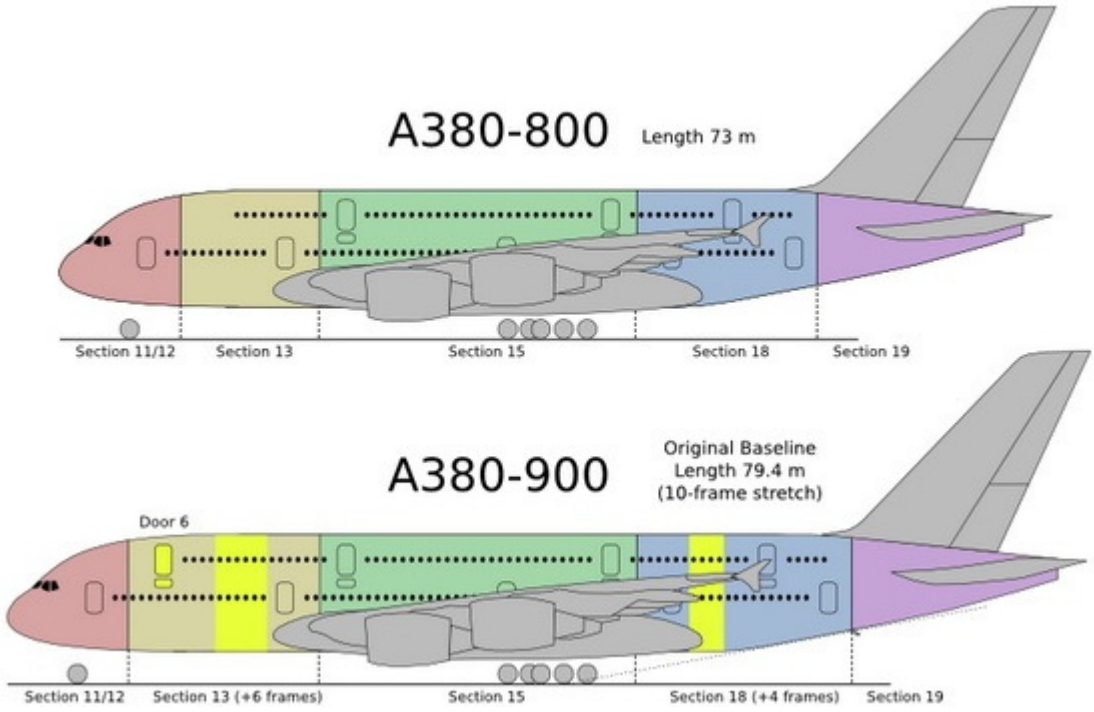

Figure 4. Airbus A380-800 and -900 variants compared. Airbus A380-900 stretch locations are highlighted in yellow along with additional door.

Note: Airbus A380-900. (2011). Retrieved from http://www.airliners.net

When the time comes to develop a mega-jumbo aircraft Boeing will be forced to develop an entirely new aircraft. The cost for such an endeavor will be extraordinarily expensive and it is

doubtful that Boeing can finance a project of such size and scope on its own. Even in the 1990s Boeing scoffed at the idea of pursuing a new super jumbo due to the cost. Development cost and aircraft sophistication have only increased several magnitudes in the 20 years since. In addition Boeings once dominate share of the marketplace has been eroded by Airbus. The company now holds only 48% of the market (Airbus beats Boeing in 2010 plane orders). This will make it more difficult for Boeing to generate the capital needed to research and develop a new aircraft. Boeings only real hope may be a US Department of Defense (DOD) partnership. It has leveraged DOD projects many times in the past to substantially reduce the R&D cost for bringing new civilian aircraft to market. But even this hope is a long shot with the DOD's budget being slashed and no plans for replacing the aging C-5 Galaxy or B-52 Stratofortress any time within the next 25 years. It very well appears that Airbus will be the dominate if not the only manufacturer of a mega-jumbo in the future.

Analysis and Recommendations

Both the A380 and the 747-8i have been developed to meet the high-capacity needs of airlines in certain markets and on certain routes. By incorporating the latest in engine technology and aerodynamic design both Boeing and Airbus have created very fuel efficient aircraft which will provide airlines with the lowest seat-mile cost possible. Soaring oil prices have only heightened the need for greater efficiency. While both aircraft boast ranges of 8,000 nautical miles the super-jumbo does not have to be exclusively used for long-distance overseas routes. Trading fuel for seats the super-jumbos can move a large number of passengers over shorter distances very economically. At the same time airlines must be careful to balance the advantages of seating capacity with passenger perception of the super-jumbo experience. By carefully utilizing the additional space for comfort and amenities not available on smaller aircraft airlines

can maintain the currently enjoyed allure of the super-jumbo with the traveling public and more importantly attract the high-yield business and first class customers. To exploit the full profit potential of the super-jumbo airlines must choose routes carefully in order to maintain load factors at 85% or higher. To date this has not been an issue for the seven airlines currently utilizing the A380. Additionally fragmentation and the growth of point-to-point secondary city routes do not necessarily negate the need for super-jumbos either. The super-jumbo can provide profitable service on these routes as well. With the number of travelers increasing yearly, even these secondary markets have the potential to rival hub traffic volume from just 10 years ago.

The airlines that have been early adopters of the super-jumbo such as Lufthansa, Qantas, Singapore Airlines, and Air France have gained a competitive edge in the industry. This edge may be further exploited in future years when the market requires shifting to a mega-jumbo aircraft. As noted in this paper Airbus stands as the lone potential manufacturer of a mega-jumbo, the A380-900. Because the A380-900 is only a stretch version of the -800 current operators will see minimal transition cost. For US air carriers, who have so far failed to embrace the super-jumbo due to their weak financial positions and belief in fragmentation, their inability to operate efficiently, especially on trans-Pacific and tras-Atlantic routes, will result in a continued loss of market share and competiveness.

It is important for airlines to work together as much as possible within the constraints of anti-trust laws if they are to remain profitable. The self-destructive activities of high frequency flights and excess capacity will only lead to reduced load factors, huge losses, and eventual bankruptcy. The New York to Munich example provided in this paper comparing the single A380 flight to multiple B767 flights clearly shows the advantages of consolidation from a business perspective. Airline alliances and code sharing have provided the potential to once

again provide profitability on high density city pair markets without the need for carriers to stop serving these markets. By reducing the frequency of flights from key cities such as New York, Los Angeles, London, and Hong Kong the airlines can bolster super-jumbo load factors to near capacity while at the same time reducing congestion. At some point in the future congestion at many airports will become so acute that government regulation will mandate fewer flights regardless of airline intentions. When this occurs the super-jumbo will stand as the perfect solution to the problem. Airbus and Boeing have provided the airline industry with a tool that can bring them back from the brink. It is up to the airlines to collectively decide if they will create the conditions to make this tool work for them or continue down a path of self-destruction.

The super-jumbo is an idea whose time has come. Airbus took a gamble but never wavered once committed to the idea of building a super-jumbo. Boeing was first to conceive of the idea but lost the initiative after years of starts and stops with expanding on the design of the 747. It took the release of the A380 and the loss of the title of largest airliner to motivate Boeing to reenter the market. Airbus always believed that a demand existed and by all initial indications they have been proven correct with pending orders for 234 aircraft and current customers demanding more. The addition of Boeing's 747-8i will offer another option for airlines looking to add super-jumbos to their fleets. The airlines have found the super-jumbo to be a revenue generator. New routes are being added with each passing year as more airports upgrade their infrastructure to accept and support the new type of aircraft. Passengers are enamored with the new aircraft and the amenities they offer in flight. The super-jumbo is also contributing to the solution of reducing airport and airspace congestion. As the travel population explodes over the next decade super-jumbos will provide the expanded capacity to meet the demand while not adding to congestion. By all accounts it is a win-win situation for air carriers, airports, and

passengers. How much further technology can take the idea of mega-jumbos only time will tell, but bigger appears to be better when it comes to the international air transportation industry.

References

747-8 Technical Characteristics. (2011). Retrieved from http://www.boeing.com/commercial/747family/747-8_fact_sheet.html

A380 First Deliveries. (2011). http://www.a380delivery.com/

Air France A380 seating configuration. (2011). Retrieved from http://www.airfrance.ie/IE/en/local/guidevoyageur/destination/A380.htm

Airbus A380. (2010). Retrieved from http://seattletimes.nwsource.com/news/business/links/airbusa380_18.html

Airbus A380-900. (2011). Retrieved from http://www.airliners.net

Aircraftcompare.com. (2011). http://www.aircraftcompare.com/

All A380 routes. (2011). Retrieved October 26, 2011, from http://boardingarea.com/blogs/theglobaltraveller/2010/07/all-a380-routes/

Aviation Week. (Producer). (2011). *Paris Air Show 2011: Boeing 747-8I pilot program* [Streaming Video]. Available from http://www.youtube.com/watch?v=LmVhrMy5_Dk.

Bickers, C. (2001, April 12). Superfast versus super-jumbo. *Far Eastern Economic Review*, *164*(14), 34.

Boeing 747-8i key facts. (2011). Retrieved from http://en.rian.ru/infographics/20110223/162718035.html

Boeing unveils 747-8 Intercontinental, the newest 747. (2011, February 14). *Airline Industry Information*.

Gershon, E. (2008, August 1). A super-jumbo first. *Hartford Courant*.

Gesell, L. E., & Dempsey, P. S. (2005). *Air transportation: foundations for the 21st Century* (2nd ed.). Chandler, AZ: Coast Aire.

Jones, C. (2011, July 11). A380 lands at more airports, but will it fly for U.S. airlines? *USA Today*, p. B.1.

Kemp, K. (2006). *Flight of the titans: Boeing, Airbus and the battle for the future of air travel*. London, England: Virgin Books.

Kingsley-Jones, M. (2007, July 10). Mid-sizers outrun super-jumbos. *Flight International*, *172*(5095), 15.

Krause, A. (2001, April). Super jumbo. *Europe*, 20-23.

Kroo, I. (1995, September). *The effect of aircraft size on performance* (Preliminary Draft). Stanford, CA: Stanford University Department of Aeronautics and Astronautics .

Lucas, J. (1988). *Boeing 747: the first twenty years*. Middlesex, England: Browcom Group.

Lufthansa. (2011). http://www.lufthansa.com/us/en/homepage

Maslen, R. (2010, November). The jumbo jet. *Airliner Classics*, 90-98.

Mecham, M. (2011, October 27). More delays ahead for Boeing 787, 747-8. *Aviation Week Intelligence Network*.

Milstein, M. (2006, May). Super duper jumbo. *Air & Space Smithsonian*, *21*(2), 22.

Montagne, R. (Producer). (2007, March 21). *Morning Edition* [Television transcript]. Washington, D.C.: National Public Radio.

Moreno, J. (2011). United to be first to get Dreamliner. Retrieved from http://www.mysanantonio.com/business/article/United-to-be-first-to-get-Dreamliner-2189970.php

Norris, G., & Wagner, M. (1997). *Boeing 747: design and development since 1969*. Osceola, WI: Motorbooks International.

Norris, G., & Wagner, M. (2005). *Airbus A380: superjumbo of the 21st century*. Minneapolis, MN: Zenith Press.

Rigby, B. (2011, February 14). Boeing hopes new 747-8 hits big time. *Chicago Tribune*, p. 35.

Trimble, S. (2008, November 25). The 747-8 schedule unravels. *Flight International*, *174*(5166), 16.

Vogel, G. (2009). *Flying the Airbus A380*. Wiltshire, England: The Crowood Press.

Wallace, J. (2007, October 24). A stretch version of the A380? It's in the plans: some customers interested in jet that could carry 1,000. *Seattle Post - Intelligencer*, p. A12.

Winters, P. (2011, June). Boeing announces 747-8 orders. *Airfinance Journal*.