$2.7 Trillion Up In The Air:

Aircraft manufacturer's predictions;
with an infrastructure reanalysis.

Andrew Parker
Honors/Economics Senior Thesis

Introduction

In a market with a potential for $2.6 – $2.8 trillion as well as between 22,600-28,000 new passenger and freighter planes forecasted to be delivered over the next 20 years, there is little doubt the marketplace for Large Commercial Airplanes (LCA) will continue to show strong growth (Boeing, 2007/Airbus, 2007). This is according to the world's only two producers of LCA: Boeing and Airbus. The two industry giants released marketing forecasts for the next two decades which analyzes seven different regions to find the next big marketplace: North America, Latin America, Europe, Commonwealth of Independent States (CIS), Africa, Middle East, and Asia-Pacific. Each company is staking its claim on getting the largest portion of the potential market, pitting Boeing's 787 and Airbus' A380 against each other according to each company's economic projections into what the airline and passenger industry desire is for the future of travel. Currently, passenger travel increases world-wide about 4.8-5% a year and cargo traffic increasing at about 6-6.1% per year. However, a problem that can plague any large industry (and even countries) is producing faster than can be supported. Airbus and Boeing have the ability to produce more than the number of planes projected; an example is Boeing's goal of 31 737s produced each month producing around 372 a year (Boeing.com, 2007); which has the potential to double some of the region's fleets over a few years (Table 1). But what happens when you take 1,000 plus planes a year and put them into the skies above countries that have only just begun to upgrade their infrastructure? Even acknowledged by several governments like China, India, and the US, the infrastructure is not currently in place to support the rate of growth for 21st century flight. The US currently runs a system that coordinates all airplanes in its

Comment [AP1]: Examples of companies who saturated markets…

airspace that was developed in the 1950s, and it has only recently received $1 billion to begin a decade long $40 billion overhaul (Schalch, 2007). China acknowledged its problems by stopping new airlines from being formed until 2011 while its infrastructure can be improved (Perett, 2007). The current state of infrastructure in the primary regions of growth, illustrated by Airbus and Boeing in their forecasts, is not sufficient to handle the estimated influx of airplanes or keep pace with the projected growth of the global fleet. This infrastructure problem is a limiting factor on the number of planes that will be sold in the next 20 years and pulling back on the LCA manufacturers' forecast by billion of dollars. This paper will look at reasons why their forecasts overlook the significance of infrastructure, the global impact that these producers have, industry limitations, and a possible reanalysis of the forecast.

Table 1. Current Regional Fleets[1]

Region / **Company**	North America	Asia-Pacific	Europe	Middle East	Latin America	Africa	CIS
Boeing	6900	3370	4250	670	1000	640	1400
Airbus	5139	3010	3544	490	892	640[2]	716

Incentives and Information

Airbus and Boeing both have incentives to project larger than feasible growth in some regions, specifically Asia-Pacific, based on how airplanes are purchased and delivered. The incentive could lead them to give forecasts that would favor their company

[1] A 'regional fleet' is defined as the number of planes owned by any airline based out of one country in that region.
[2] Airbus did not provide a count or estimate for Africa, hereon out Airbus's Africa estimates will be Boeing's estimates.

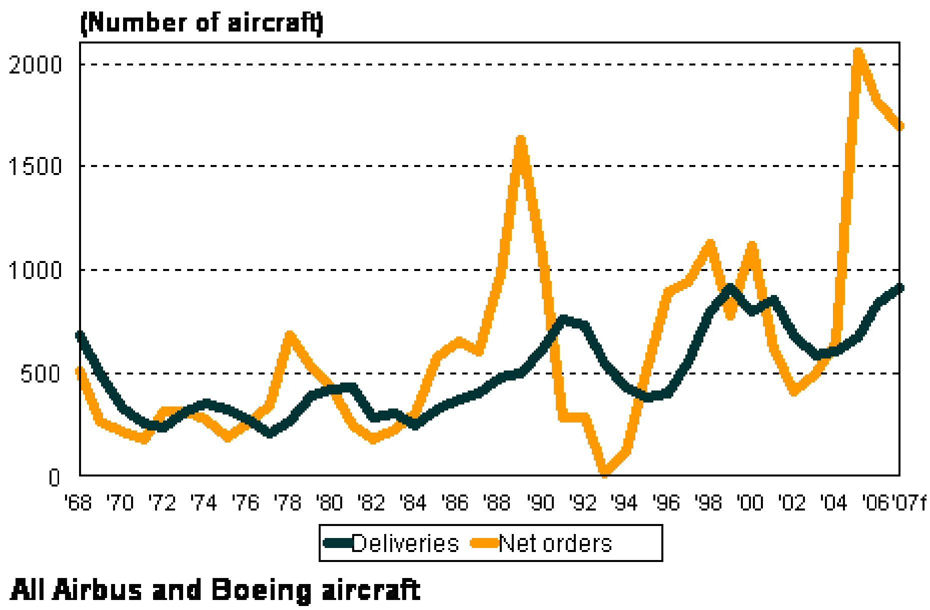
and not necessarily reflect the true outcome of each region's marketplace. When an airline purchases a plane, the airline gives the producer a down payment. This payment is a contracting fee as well as a placeholder for a delivery spot. Airplanes generally take long periods of time to produce, and the production time varies and is controlled solely by the producer. This strategy keeps a steady stream of sales and output and reduces stagnant factory time and other transaction costs associated with adjusting production which are undesirable for both Boeing and Airbus. An example is how the Boeing 787 has sold; with an estimated first delivery in 2008, the orders currently extend out into 2013 assuming production estimates hold (Boeing.com, 2007). Boeing has received down payments on each plane and receive the rest of the payment when the airplane is delivered. These airlines that buy from Airbus and Boeing use market information to plan these future acquisitions of planes. If an airline incorporates the growth that Boeing and Airbus predict (Table 2) into their own industry forecasts, they will purchase more planes for future deployment, but if the marketplace doesn't reach expected levels of sales or demand, the airlines will cancel their contracts and order fewer or no planes in that year.

Table 2. Projected 2026 Regional Fleets

Region / **Company**	North America	Asia-Pacific	Europe	Middle East	Latin America	Africa	CIS
Boeing	11950	10400	7660	1320	2410	1010	1670
Airbus	9350	8765	7610	1231	2117	1010	1187

This is where Boeing and Airbus enter and present their findings to airlines. Both companies benefit by the large growth if the information is near perfect. It is important to note that Boeing and Airbus are not lying in their projections; they would risk brand tarnishing and economic sanctions if found to be falsifying information to the international public. The companies have incentive to consider certain economic limiting variables to be insignificant; in this case, infrastructure limitations. With global expansion of potential airline markets and these two companies having an international duopoly, there is little risk associated with over-projections and much benefit to the producers.

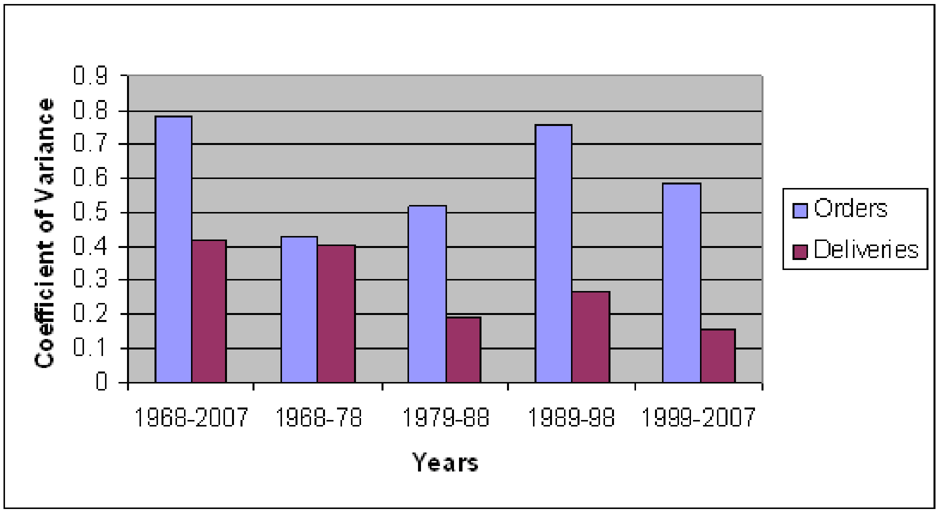
Figure 2. Boeing and Airbus Orders and Delivery Schedule



Source: Teal Group Corporation (2007)

The benefit to the producers is that they have the ability to smooth out the order fluctuations in the market and save money on the transaction costs of having to drastically adjust production levels, like idle factories and employee layoffs, every time the number of orders of airplanes dramatically shifts as in figure 2. Note the large difference between the volatility of deliveries and orders. Looking at the coefficient of variance[3] for all 39 years and also looking at several other time increments, figure 3, we can see smoothing occurring as the coefficient of variance for orders is consistently higher than deliveries, except in the 1968-78 range.

Figure 3. Coefficient of Variation of Deliveries vs Orders, 1968-2007



Source: Calculated from Figure 2, Teal Group (2007)

The implication of this is that the production strategy of Airbus and Boeing of having a backlog of orders is greatly beneficial to the companies. It provides a shield against the volatility of airlines' orders year to year. As mentioned before, there are large transaction costs to adjusting production to synchronize with demand. Instead of incurring these costs, Boeing and Airbus smooth out the number of deliveries. As a result of smoothing, the percentage changes seen in deliveries are significantly reduced. In times of economic recession this is good, but in times of economic growth smoothing will shrink potential

[3] The coefficient of variance is the percentage of the mean that is caused by standard deviation – It is between zero and one with one being that the data is completely comprised of variance while zero represents data that is solely the mean.

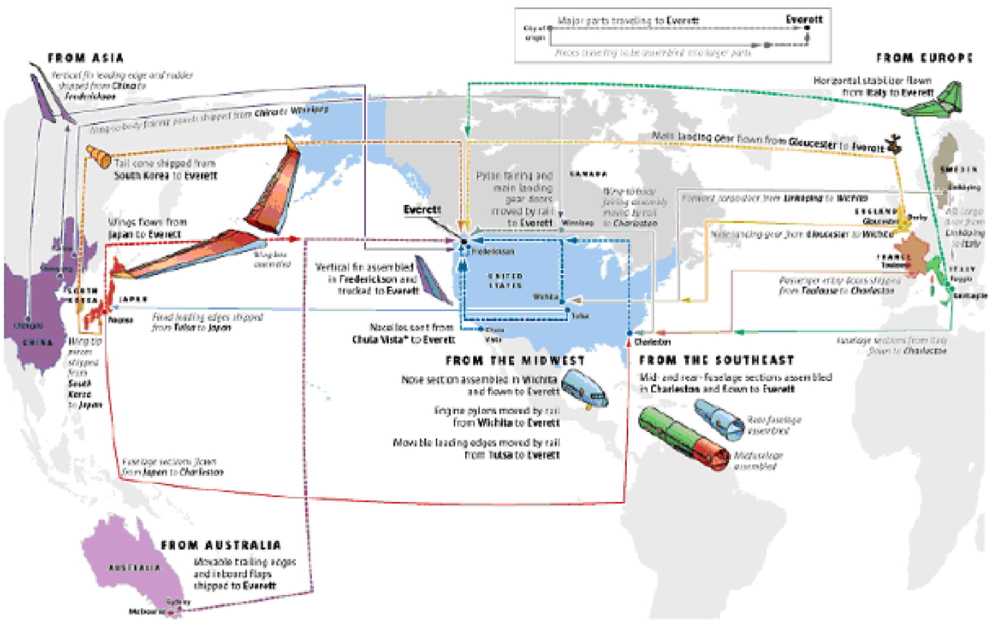
gains. Boeing and Airbus, however, would not benefit from changing this strategy because there might be unforeseen global issues and they need the shield of backorders to continue delivering planes. In order to overcome the reduced percentage gains as a result of smoothing, Boeing and Airbus have the incentive to induce more orders than should, in reality, be made; this will cause orders to stay high and allow the producers to increase their output while keeping with their original strategy. Even if the orders drop a decade from now like from 1989 to 1993, Boeing and Airbus will have built a backlog that will generate revenue through temporary downturns while infrastructure or any other limiting factors are dealt with.

Economic Impact of Airlines and LCA Manufacturers

The health of the airline industry in America and in several other countries directly impacts the overall strength of each respective economy. With the terrorist attacks of 9/11, the United States saw a recession that was closely correlated with the downturn faced by Boeing. As consumer confidence in the market returned and international aerospace markets began to swell, the economy, as well as Boeing, began to see steady improvements in GDP and employment levels (Newhouse, 2007). In addition, Boeing recently announced a delay in the delivery of their 787 and MSN Money (2007) attributes them for “stall[ing] the rally” that the economy had been experiencing. As passenger traffic recovered, airports started feeling the strain of congestion that hadn’t been noticed before the five year lull, caused by the terrorist attacks, disappeared. As one of the single largest exporters of goods from the US, Boeing’s economic success has a large impact on the health of the US’s economy (Newhouse, 2007). Boeing and Airbus have both introduced improved products for two needed areas of the market; point-to-point efficiency and super-jumbo jets. These new products accompanied with the successes of aerospace nationally and internationally have created the forecasts of more than $2 trillion in sales and over 22,000 new planes needed.

Airplane manufacturing influences the economies of countries all over the world. Boeing and Airbus, however, are commonly perceived to contain all their processes in a central area; Boeing in the US and Airbus in France and Germany. While all final assemblies[4] occur within those countries, both companies have expanded their production process into several different continents and regions.

Figure 4. International Parts Production Map



Source: Seattle Times (2006)

[4] Final assembly is the last stage in building the aircraft. This term came about when airplane manufacturers started to expand their manufacturing processes to other cities or states and then into other countries, and a term was needed to describe the area or act of bringing those pieces together for the final product.

Boeing (Figure 4) has outsourced the production of many parts of the 787 to several regions; Asia (specifically China and Japan), Australia, and Europe.[5] This has created a large global network in which the success of Boeing's products directly impacts many companies worldwide. Airbus also has created a comparable global network to produce its planes. Sixteen manufacturing plants are located in Europe while, in total, there are 1,500 suppliers in 30 different countries in several different regions; Europe, Middle East, Asia, US, and some in Latin America (Airbus.com, 2007). Overall, Boeing and Airbus have invested production heavily in every continent, except Africa. This is significant in that the forecasts and sales that Boeing and Airbus produce impact these suppliers and not just the airline industry. There are incentives for Boeing and Airbus to predict higher numbers in order to keep their suppliers from contracting with competitors; if the market is lucrative now and is predicted to in the future a supplier has no reason to leave their current contracts. However, even though Boeing and Airbus may gain supplier loyalty, the impacts from over estimating sales will be seen in many different economies outside of the just the United States and Europe.

This impact can potentially be measured against the forecasted growth of airplanes in different regions. Looking at the growth of air travel and region's economies there is predicted growth that might not be realized and the impact of fewer sales would be felt by Boeing and Airbus suppliers around the world with reduced demand. Passenger and cargo traffic in many countries have been growing at rates that exceed each country's GDP growth: China's GDP is growing at 9.9% and Revenue-Passanger-Kilometers

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[5] Appendix A shows a country by country listing of parts produced.

(RPKs)[6] are growing at 11.0% or Europe's GDP growth 2.0% while RPKs growth is at 5.7% over the last 20 years (Boeing, 2007). Several Asia-Pacific countries have started to accumulate fleets of planes and open up international routes to increase traffic. Airbus (2007) and Boeing (2007) do not disclose how they counted regional fleets and the total global fleets so there is discrepancy in regional fleet sizes, however, Boeing's current global fleet is at 18,230 planes and Airbus's is at 17,153.[7] With the current GDP growth trends, and unhindered infrastructure development, the forecasts disclosed this year should be reasonable and are represented in table 3.

Table 3. Projected 2006-2026 Regional Growth of Fleet Size

Region / **Company**	North America	Asia-Pacific	Europe	Middle East	Latin America	Africa	CIS
Boeing	73.2%	208.3%	80.2%	97.0%	141.0%	57.8%	19.3%
Airbus	81.9%	191.2%	114.7%	151.2%	137.3%	57.8%	65.8%

Industry Limitations and Its Effects

The problem with these growth forecasts is that, in this booming market, infrastructure issues appear to have been neglected as a significant constraint on growth. Without the proper infrastructure, airplane accidents occur, revenue-producing flights are delayed or cancelled, breakdowns in a country's economy can happen as bottlenecks occur delaying the whole flight control system, and global freight can be seriously impeded (Pundit, 2007). Infrastructure for the airline industry in this paper is regarded as the tools and utilities needed to run a single airline; this includes adequate pilots and

[6] Revenue-passenger-kilometers (RPK) is a passenger carried one kilometer on a flight in which he has commercially enumerated the airline, exludes airline employee deals, babies, or free flights.
[7] Airbus's global fleet count is not completely represented in its forecast in table 1.

mechanics to fly and maintain the airplanes, airports to embark and disembark passangers and handle ground operations effectively, external controls to safely coordinate the planes while on the ground and in the air, and government structures that promote or limit airline operations. As an example, with current radar systems, air traffic controllers have only general knowledge of the locations of planes in relation to others and the information they get is updated only during long radar sweeps. Accidents of planes bumping into each other on the ground are still more frequent than FAA regulations require, and according to the FAA (2007) the US failed to meet its goal of reducing the number of fatal accidents by nearly double the target (FAA, 2006).[8] Without the proper infrastructure in place, planes that have been recently purchased potentially would go unused as airports are unable to accomidate the increased number of planes. The worst result of lacking infrastructure is if saturation occurs but more planes are forced into airports; safety figures will get worse in countries open to heavy airline traffic; similar to the safety issues in the US. In the forecasts produced by Airbus and Boeing, consideration of infrastructure issues was noted as a potential problem, but reduced to the assumption that all infrastructure requirements would be met as planes were demanded (Boeing, 2007/Airbus, 2007). The difficulty in resolving the infrastructure for forecasting results from difficulty measuring the infrastructure currently and then calculating the improvements that would need to occur to reach adequate levels that could support the number of planes that Airbus and Boeing predict. For example, the US is a poor example of adequate infrastructure with its outdated air traffic control system and rampant delay issues, and Great Britain’s Heathrow International Airport is renowned world-wide as the worst airport to go to as it is plagued by delays, lost luggage, airline turf wars, and

[8] FAA reported 0.022 fatal accidents per 100,000 departures, missing goal of 0.010.

customer service qualms. These airports are located in developed countries that have been unable to build their infrastructure at the pace needed in order to support the volume of planes they currently see.

Not only developed countries are susceptible to infrastructure problems: Taiwan recently had a Boeing 737-800 engine explode on a runway from a bolt-made gash in a fuel tank due to negligent maintenance. The amount that the US, UK, and other LDCs will expand their airline capacities is based on their abilities to build upon and improve the aspects aforementioned and others systems that are essential to aerospace infrastructure. Roads must be built to and from airports to major cities. Pilots must undergo rigorous national or international certification processes. Mechanics must be trained to maintain large fleets of airplanes and to prevent catastrophes like the 737-800 explosion. Airports need to be financed and built, runways improved, air traffic controls updated, terminals enhanced, and hundreds of thousands of employees hired and trained. The number of employees at JFK International Airport is around 37,000, and with populations in countries like China and India located in metropolises, many airports will need to be as large as JFK or even bigger. This is evident when comparing key areas of population growth (Appendix B). The number and locations of megacities are predicted to increase greatly from 1985 to 2026 causing this need for infrastructure to improve the airports that will be servicing these large population centers. The US currently operates 14,000 airports for its fleet and its population is not located in megacities. This is not the case for Latin America, Middle East, and Asia-Pacific regions. Specifically, India, China, and Brazil have several megacities in close proximity. The need for advanced infrastructure comes from the complexity of handling the traffic that these megacities will create as more planes are added to their fleets. These megacities even create saturation problems. Beyond collisions, accidents, or disrepair, even at optimal capacity there are only so many planes that can fly in and out of an airport in a 24 hour period. Airlines must also factor in externalities such as delays at other airports or weather problems; when they occur, entire systems are thrown out of sync. In the United States major airports in New York and California are experiencing huge delay issues, in 2007, from January to June only 72.7% of flights arrived on time down from a 83% on time rate in 2003 (FAA, 2007).

Another infrastructure strain that has been a phenomenon in recent years is the attraction of passengers and airlines to smaller planes. While it makes practical sense to fly one A380 with 800 passengers on some of the most heavily traveled routes; consumers don't want to (McCartney, 2007). The preference of passengers is oriented towards smaller airplanes and away from large high capacity aircraft. In the United States, the average flight has 137 seats which is down from 160 seats in the mid 1990s (McCartney, 2007). In addition, both Airbus and Boeing predict that the bulk of the planes demanded will be single aisle (125-230 seats). Table 3 illustrates this consumer preference in Boeing's and Airbus's projected future fleet ratios. This demand will perpetuate the problem of low average seats and the congestion and infrastructure strains that are already present in the United States. With airlines choosing smaller single-aisle planes over larger twin aisles, there is more demand and strain on space as they have to fly more often to keep up with demand. Abroad, the problem doesn't currently exist but with the growth expected, its likely the same trend will occur.

Table 3. Future Global Fleet Size Ratios

Boeing	Airbus

747 or larger	3%	Large Aircraft	6%
Twin Aisle	22%	Medium Twin Aisle	7%
Single Aisle	62%	Small Twin Aisle	17%
Regional	13%	Single Aisle	70%

Source: Boeing (2007), Airbus (2007)

Comment [AP2]: Need to cite Boeing

With the size of airplanes being predominately single aisle, there is another infrastructure issue:

> "…as single-aisle airplanes operate a high number of short flights each day, increasing their interaction with airports and air traffic control services. … [The] airplanes tend to return to their home base more frequently, often overnighting there…" (Boeing, 2007)

With thousands of new airplanes, specifically the 17,700 Boeing predicted new single-aisle planes in the global fleet, there is the necessity to invest in and build thousands of hangers on the airport properties. Larger planes don't need to be housed in a specific location for long durations because they are generally utilized in long-haul flights and are in the air during the night time while most single-aisle planes are 'overnighting' in a hanger. The FAA has considered setting size restrictions to raise the average seat count back up under the philosophy that with more average seats, fewer planes will be needed, and less congestion and delays (McCartney, 2007). However, airlines view this as too much government control and restriction in the airline industry. Boeing and Airbus both discuss the progress of liberalization[9] as a main driver in the current boom of airline growth. Internationally, liberalization is seen to be occurring on a massive scale, and, in some cases like Brazil, very rapidly. Brazil originally started a public entity, Embraer, as a university for aerospace development. Since then it has become, first, a state run

[9] Liberalization in the aerospace sense is the removal of government from the actions and policies of airlines. It has implications on domestic travel but is most beneficial for international flights as foreign governments relinquish more and more control of the aviation industry. In addition, liberalization reduces the involvement of public airlines in a country's aviation market; encouraging competition to benefit consumers.

producer of regional jets[10], and then a privately run jet production company. Some countries, however, have trouble liberalizing based on cultural and/or political opposition to it; several island states won't allow large airplanes to fly into them, and China's General Administration of Civil Aviation of China (CAAC) still provides bureaucratic process and limits to many aspects of aviation (Perrett, 2007).

The Big Two

As the largest producer, with over 60% of currently flying aircraft Boeing made, of aircraft since 1916, Boeing has made critical advances in the realm of aerospace engineering. For national defense, they have produced advanced machinery like the V-22 Osprey rotorcraft, the Apache Longbow, and several generations of ICBMs. They also created the first fleet of space shuttles for NASA and have continually supplied technological achievements to aiviation: the first jumbo jet, the 747, first large cargo freighter, and the most produced airplane in the world, the 737. With the background established by Boeing with airlines around the world, they have a large voice in the marketplace. Tying into the incentives mentioned previously, this allows Boeing to potentially work the global economy in its favor.

How Boeing has addressed the infrastructure issues in LDCs drives this paper's question about the feasibility of its forecast.

> "While the assumption is made that all necessary additional airports and skilled personnel will be available over the course of the forecast period, short-term growth rates underlying the forecast fully consider the rate at which these resources will become available." (Boeing, 2007)

[10] Regional jets such as Embraers and Bombardiers are classified as having around 125 or less seats. Boeing and Airbus produce LCAs that have the smallest version dipping below the 125 seat line but are not considered regional jets.

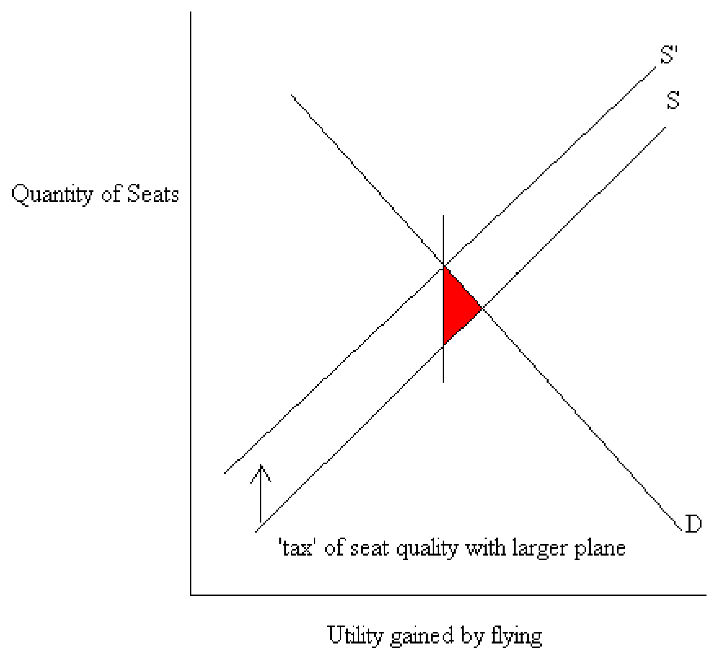
There is little mentioned about the long-run stability of their models and how growth could be affected if infrastructure expectations are not met; this is vital information for airlines for buying a place in line for the future delivery of the plane. Boeing has also proposed different aspects of aid to infrastructures, including government incentives for aid, joint ventures, and training programs (Boeing, 2007). In addition to their comments on LDCs, Boeing also talks about the infrastructure delays at Heathrow International Airport, but it is not disclosed how they predicted the delays will impact their European expansion numbers (Boeing, 2007). Also, Boeing did not mention the air traffic control or congestion issues that North America is facing.

Airbus, as the new player in the game, has been the first, and only, successful entrant into the LCA manufacturing business since Lockheed and Martin's failed attempt with the L-1011. They started as a semi-public company and have since become a fully private part of the European Aeronautic Defense and Space Company (EADs) that is based mostly in France and Germany. Early in its career, Airbus quickly gained market share as Boeing was caught up in "a strategy of non-combative, and slightly arrogant, sales" (Newhouse, 2007) allowing Airbus to quickly win customer loyalty. Currently, their market forecast holds the same vague descriptions of infrastructure as a potential problem and sounds remarkably similar to Boeing.

> "The [forecast] assumes that all planned and required infrastructure improvements will be undertaken during the forecast period. However, given the substantial investments and time required to carry out such developments, there is the possibility that not all the changes necessary may be achieved. … average aircraft size could go higher than anticipated levels and airlines could… be forced to acquire larger aircraft in order to meet demand." (Airbus, 2007)

Airbus acknowledges that infrastructure has the potential to inhibit growth. It also mentions that airplane size could increase; pushing its A380 as the alternative to not meeting passenger demands. Airbus has a valid point concerning the increase of aircraft size to meet the growth of demand; however, this does not coincide with customer preference of smaller planes. If there was a push towards larger planes, fewer flights per route would be needed, grounds crews could be consolidated, there would only be a need to upgrade and not expand current terminals. These benefits would make sense to airport owners, but not to airlines and customers.

Figure 5. Utility Derived from a Flight Based on Plane Size



If we view the increased size caused by high demand as a sort of tax, passengers would view the seat market in planes like Figure 5; that quantity is a measure of utility and price is the number of seats on the plane that a consumer has to pay for by flying on a particular flight. When the ‘tax’ is imposed and the quantity of seats is forced higher than they should be at equilibrium we see a dead weight loss that represents lost passengers who would choose not to fly over being uncomfortable in a larger aircraft. This is not a satisfactory picture in the future for airlines as we can see their preferences and responses to similar situations in the US to still provide smaller airplanes even though it causes congestion. Airbus expects any short falls in infrastructure to result in the purchase of their new super-jumbo A380, when in actuality it may occur that airlines will chose to not buy extra planes and differ the passengers who would have been dead weight loss on the larger planes to other flights and hope they still choose to fly. The result is the problem mentioned before of high congestion with more flights in a day because airlines want to capture as much demand as possible by flying smaller aircraft.

What Happens with a Third LCA Manufacturer Arises?

[B and A can undercut prices with their assets, incentives to join, issues to overcome – unlikely entry anytime soon. If a company survived startup, what would happen: Impacts on infrastructure, impacts on B and A incentives (relate to above!)]

Reanalysis

In looking at the regions that have the greatest potential for infrastructure limitations (North America, Europe, Asia-Pacific, and South America) we can perform a new analysis to try and create a different view of a 20 year forecast. Analysis of the information given in Boeing's and Airbus's forecasts presents a few mitigating factors to consider. Firstly, the exact nature and pace of infrastructure development is unknown. There is no indication if they refer to infrastructure projects currently planned, currently underway, or ones that they believe will happen sometime. Secondly, financing can either come from private institutions in liberalized markets or from public funding established through various means of taxation (Task Force, 2007). This creates variability in access to funds; for example government subsidies take much longer to obtain than private investment, if the forecasts predicted the ratios of investment methods incorrectly this could distort the timeframe that their predictions use. Also, there are liberalization issues. The United States and most European countries have airspace and aviation industries are mainly private financing and open, however there are many countries in which the government still has the majority of control or have just recently begun liberalization. China and India are two of the largest focuses of these issues in this paper due to their recent liberalization and the large growth forecasted by Boeing and Airbus creating the potential for variance from original predictions. While India attempts to privatize its aviation industries, there are obstacles that it must overcome; one is that the current state of infrastructure is not sufficient for further liberalization of its airspace and airports because it would not be able to handle a dramatic increase in traffic at two airports, Mumbai and Delhi, which receive 52.1% of all traffic already (Task Force, 2007). India isn’t the only country that is facing liberalization issues. China’s airline industry is overseen by the government, the CAAC, and has limits that prevent unbridled expansion. CAAC current concern over consumer safety and their acknowledgement that their networking and airport structures need to be drastically improved are the most notable infrastructure issues (Russell, 2007). Another problem for Chinese airlines is the need for about 6,500 new pilots by 2010[11]; otherwise they will have to settle for more expensive foreign pilots who would increase prices and lower demand (Russell, 2007). China also has a unique problem that is a result of their government structure and large military; they have a large portion of airspace which is reserved solely for military use (Ready, 2007).

[11] Pilots must be trained and certified for each kind of airplane; a pilot’s commercial license doesn’t allow them to fly any plane they are assigned to. The FAA requires hundreds of hours and dozens of practice landings in each kind of plane before they are allowed to fly one. The process for training well certified pilots is long and, for most countries who expect to fly internationally, thorough.

This drastically reduces the number of flight patterns that airplanes can take to approach and leave several airports. India is not faring much better, as its airline industry has aggregate losses of about $500 million for the year to March 31, 2007 (Pandit, 2007). The Indian government has created a special public non-governmental task force to take into consideration the current and desired future states and establish ground rules for change, the NHAI. They have recognized and recommended the removal of some governmental structures, such as the property tax levied on the properties of the Airports Authority of India (AAI) which is the public body that currently manages India's Airports (Task Force, 2007). With these mitigating factors afflicting the two areas that both Airbus and Boeing predict to be the next big market it is unlikely that either market will be able to provide the growth that is forecasted. While India and China undergo liberalization issues and other infrastructure shortfalls, North America and Europe have to deal with the previously discussed infrastructure problems that have arisen from the processes and physical structures used in each region.

Consider the current state of the world's airplane infrastructure. The global fleet currently operates at either operating in regions with sufficient capacity or is suffering undergoing infrastructure issues; the US, UK, India, and China specifically. In Tables 4 and 5, we take a modified approach to calculating the possible growth of the capacity of planes as a ratio of airport development based on long term estimated GDP growth. This analysis will look at a possible factor that could limit the available capacity for planes to operate. Airlines could potentially purchase more than the optimal level of airplanes, however, this would further strain airport infrastructures as few, if any, regions have excess capacity currently.

Table 4. Boeing Reanalysis

Boeing	Present vs Forecasted Numbers					
Region	Airports[12]	Airports 2026	Airplanes	Airplanes 2026		
North America	16239	28211	6900	11950		
Europe	3871	5866	4250	7660		
Asia-Pacific	**4050**	**8376**	**3370**	**10400**		
Latin America	13395	28242	1000	2410		
Middle East	1271	2785	670	1320		
CIS	2669	6195	1400	1670		
Africa	4022	10470	640	1010		
	Airplane Changes		Airport Changes		Reanalysis	
Region	% Growth	# Added	% Growth	# Added	Projection	Var
North America	73.20%	5050	73.70%	11972	11987	-37
Europe	80.20%	3410	51.50%	1995	6440	1220
Asia-Pacific	**208.60%**	**7030**	**106.80%**	4326	6970	3430
Latin America	141.00%	1410	110.80%	14847	2108	302
Middle East	97.00%	650	119.10%	1514	1468	-148
CIS	19.30%	270	132.10%	3526	1670	0
Africa	57.80%	370	160.30%	6448	1010	0
Global Fleet					**31653**	**4767**

Table 5. Airbus Reanalysis

Airbus	Present vs Forecasted Numbers					
Region	Airports	Airports 2026	Airplanes	Airplanes 2026		
North America	16239	28211	5139	9350		
Europe	3871	5866	3544	7610		
Asia-Pacific	**4050**	**8376**	**3010**	**8765**		
Latin America	13395	28242	892	2117		
Middle East	1271	2785	490	1231		
CIS	2669	6195	716	1187		
Africa[13]	4022	10470	640	1010		
	Airplane Changes		Airport Changes		Reanalysis	
Region	% Growth	# Added	% Growth	# Added	Projection	Var
North America	81.90%	4211	73.70%	11972	8928	422
Europe	114.70%	4066	51.50%	1995	5370	2240
Asia-Pacific	**191.20%**	**5755**	**106.80%**	4326	6225	2540
Latin America	137.30%	1225	110.80%	14847	1881	236
Middle East	151.20%	741	119.10%	1514	1074	157
CIS	65.80%	471	132.10%	3526	1187	0
Africa	57.80%	370	160.30%	6448	1010	0
Global Fleet					**20842**	**5595**

[12] CIA World Factbook
[13] Airbus did not provide numbers for Africa. Boeing's Africa numbers are used in the analysis.

Tables 5 and 6 use Airports as the measure of infrastructure. How the figures are constructed is by counting the number of airports by region and extrapolating growth by the estimated growth of GDP for each region over the 20 year forecasted period[14]; this produces the projected probable level of airports in these regions by 2026. GDP is the pace which tables 5 and 6 are measured against, this is because estimated GDP growth is the estimated growth of the economic success of a country and would closely model the availability of resources to invest in airport infrastructure. The total growth is summarized under the "Airport Changes" category which displays the overall difference in numbers as well as the aggregate growth over the 20 years. In addition, under the "Airplane Changes" category the growth according to each manufacturer based on their projections is organized by aggregate growth and overall difference. Note that nearly every region in both company's forecasts vary greatly in aggregate growth between airports and airplanes. Analysis of a more controlled growth, as might be expected with current government restrictions and non-government task force recommendations, gives the "Reanalysis" category calculated using GDP. The projected number of planes in the future global fleet is the utilization of the estimated 20 year growth rate of GDP calculated previously, looking at airports, multiplied with the current fleet totals. The final reanalysis is "Var" (Variance) where the "Projection" is subtracted from Boeing's and Airbus's own analysis. This is a good measure for infrastructure and how it might limit capacity from the data available for several reasons. Firstly, aerospace technologies are extremely advanced compared to normal infrastructures; the needed resources, training, buildings, and control systems many times need to be imported even by

[14] Boeing provided these GDP growth estimates in their forecast but Airbus did not, both models use Boeing's estimated GDP growth (Boeing, 2007).

countries with large fleets. Secondly, significant effort must be made to build and finance the terminals including the transportation costs associated with moving high volumes of people in and out. Note that CIS and Africa have a zero variance result; this is due to the limiting factors of those two regions being more political than infrastructure related. The other regions do not possesses capable infrastructures to support their current state, and the result is that these regions will experience growth that is encumbered by infrastructure; they will have to expand their fleets in sync with the construction of infrastructure or, not only do that, perform significant catch up work. Finally, Airports take into account supporting systems. A fully functional airport incorporates national and international networking, a fully trained and qualified maintenance and pilot crew[15] allocated to it, external support networks that supply the airports with goods needed to function and raise revenue. If an airport were to be lacking in any of these areas, the impact would be noticeable and airlines would opt either to boycott the airport for fear of mishandling their assets or assist with investments to improve the airport leaving few, if any, with insufficient infrastructure and systems. The reanalysis in tables 5 and 6 are also by region. This allows the analysis to look at which regions are the most likely sources of shortfalls; there are many countries in each region that add significant amounts of alternate routes, alternate hubs, and alternate hanger locations. This method should improve the capacity of each individual country as it has extra resources close by who may not experience, directly, the same growth.

[15] Maintenance, pilots, and airplane crews must adhere to strict regulations within their country. In addition, if an airline wants to fly an airplane into another country, that specific airplane would need to pass the receiving country's standards for safety. Nearly every country expects to fly to the UK and the US which hold some of the most stringent requirements for aircraft maintenance and pilot qualifications. This ensures all around improved maintenance and training for fear of not passing other country's requirements.

Looking at the results of the variance, Boeing overestimated 4767 airplanes and Airbus overestimated 5595 airplanes. Considering the average cost of an airplane to be about $100 million, Boeing is short $476.7 billion and Airbus is short $559.5 billion in airplane revenue over the 20 years forecasted. This comes to (if Boeing and Airbus are averaged) approximately $26 billion a year in revenue. The impact of a shortage of revenue like this will impacts many of the world's markets based on the interconnectivity of the supply chains that Boeing and Airbus use.

With the CAAC's concerns about too much growth in China, and NHAI's concerns and critiques of the infrastructure issues at present in India we can critique the market forecasts done by Boeing and Airbus and try to align regional growth with the information about policy concerns and implications provided by each country's government. Governments in these countries are trying to balance liberalization with centralized control in order to find the level at which airlines and airports will operate in the most efficient manner. However, the CAAC made a statement in September of 2007 that "the civil aviation industry's capacity of infrastructure, available space resources, supporting technical staff and overall management can not fully match the sector's current growth rate" (CAPA, 2007). Current measures in one of the two countries cited for having the most growth in airplanes, China, are being taken to reduce the number of flights over 24% per day at the country's busiest airport in Beijing (CAPA, 2007).[16] Its policies of control over the halted approval of new airlines is based on the period between 1990-1993 in which China's aviation industry recorded extraordinary growth; this period also contained the highest number of recorded accidents in the country's history (CAPA, 2007). CAAC does not want to have the same thing occur again, so they will attempt to

[16] From the current 1368 flights per day to 1050 flights per day at Beijing airport.

reduce unsafe infrastructure issues. Another notable country hindered in its growth is India. The public group NHAI issued a document discussing the roles of the Indian government and private investors in producing adequate infrastructure. They state that “the objectives of the policy are… to provide airport capacity ahead of demand, in order to handle an increasing volume of air traffic” (NHAI, 2007). However, they also recognize that the government and private sectors need to bridge the “resource gap” and notes that there are “also deficiencies in repect of ground handling facilities, night landing systems, cargo handling, etc., at some airports (NHAI, 2007). These issues are reminiscent of the problems faced at Heathrow and JFK which garner more media attention due to the volume of travelers they receive. These problems outline the current insufficient state of infrastructure in India and the public policy that encourages much needed improvement and growth. Without proper private investment, the GDP reanalysis would reflect the limiting factors in India as government tax revenues would increase with GDP and, in turn, be allocated to airport investment appropriately. Unfortunately, even this government spending isn’t fully supported in India. Currently of the revenues gained from taxes imposed on the aviation sector have only 10% are returned to the AAI and the NHAI cites the “even this 10% IS NOW SOUGHT TO BE TAKEN BACK” (NHAI, 2007). With this potential cut in government spending and the general associated risks of private investment, there is reason to suspect that their growth will mirror more the reanalysis above and not the analysis of Boeing and Airbus.

These specific examples of the two largest areas of growth (in terms of percentage according to Boeing and Airbus) acknowledging and even having government action taken in attempting to resolve their current issues shows the projections of Boeing and

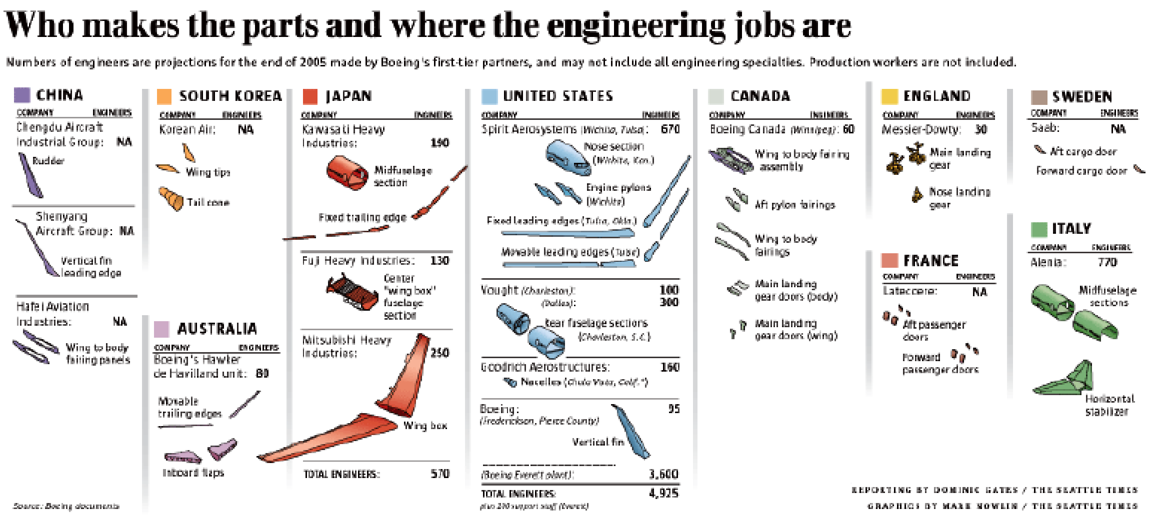
Airbus are not likely to be realized. The inflated forecasts of growth in these reasons seems likely to be attributed to the benefits they receive of building large backlogs which allows them to smooth out the volatile order trends seen in figure 2. With these large backlogs they will be able to increase production steadily even if there are periods of downturns specifically in the Asia-Pacific region when airplane purchases outpace infrastructure development and there is a lull in purchases while infrastructure catches up.

Conclusion

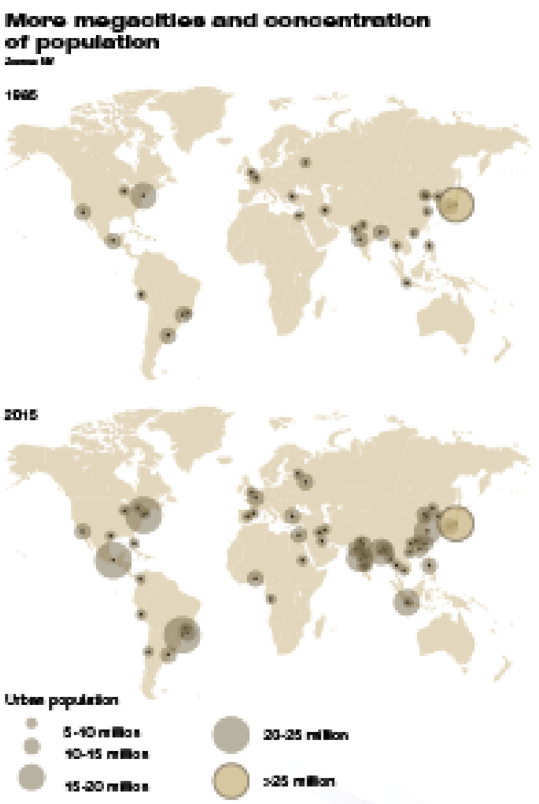
Currently, Boeing and Airbus predict $2.6-2.8 trillion dollars in sales over the next 20 years by selling 22,600-28,000 airplanes. Taking into account the limitations that infrastructure problems in many key regions will create, expect that there is going to be significantly fewer sold. While there is the chance that airlines may choose to replace older planes with newer ones if they are unable to expand their fleets, there will not be the large expansion that Boeing and Airbus are predicting. Why Boeing and Airbus produced a forecast that underestimates the significance of infrastructure issues as a limiting factor might be seen in their smoothing of deliveries. Airlines have always ordered aircraft in a seemingly unpredictable manner which could cost the LCA manufacturers millions of dollars through lost business, reorganizations of their labor force, and loss of business confidence by investors. Countering this problem with smoothing, Boeing and Airbus have significantly reduced the impact of negative market fluctuations on themselves and their suppliers. They have the incentive to overestimate in order to build up their backlogs and slowly increase their production over time. The impact of this overestimation affects many countries as the supply networks of these airplane producers stretches into nearly every continent. With around $500 billion (about

20% of original forecasts) potentially not entering the marketplace, these suppliers will be adversely affected if their forecasts rely on the accuracy of Boeing's and Airbus's predictions. Airlines will be adversely affected as well, although with their ability to work with the producers to adjust their consumption as well, they reduce some of their risk. However, given that nearly all planes are purchased through financing agencies or leased through another company, many airlines will suffer refinancing fees and lose credit. With the adverse effects that could be generated by the overestimates of Boeing and Airbus on these aspects of the global economy, caution must be exercised when regarding their forecasts. Approaching the forecasts given with more scrutiny about the limiting affects of infrastructure in LDCs as well as in countries with highly utilized aerospace systems can reduce the possible negative effects.

Appendix A: (Source: Gates & Nowlin, 2007)



Appendix B: (Source: Airbus, 2007)



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